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SOS: E4E Edible Landscapes
UD Readings Review
Week 6 Winter

This week's upper division lit review is a two-week special. This paper combines my readings from week 5 and week 6. In Week 5 I read about phyto accumulators and soil toxins. This week I read about climate change. While I've kind of hit the necessities with soil toxins, climate change still leaves a lot of questions unanswered, specifically about what climate change means for plant ranges and growth. I'm reading about climate change in response to what prospective customers have voiced to be a stumbling block in purchasing my service: they are unsure if I know how to plan for climate change. While it is part of my mental processes to consider climate change in my planning process, I figured backing up my decision making with some peer-reviewed articles would help clients feel more confident.

Modelling long-term carbon dynamics in soils reconstituted with large quantities of organic matter, Vidal-Beaudet et. al, 2012 asks the question: what happens to urban soils (technosoils) when they are amended with organic matter compost? This is a legitimate question for my line of work being that I'll probably be designing compost piles to enliven homeowners' soils. So, as the paper asks, how long does it take for a technosoil to mineralize or humificate organic carbon throughout its profile? How much of that carbon is bioavailable and how much is resistant/stable? By enriching different samples of technosoils with either sphagnum peat, sewage sludge, wood chip compost, or green waste compost, and letting the soil age, the scientists were able to monitor biological activity, mineralization rates, nitrogen content, and found that the different compost amendments decomposed at different rates to have some fraction of their carbon content become stable and resistant to degradation, and some fraction bioavailable and mineralizable. They found that peat and sludge compost readily decomposed and integrated into the soil by the first year because they were stable compounds by the time they reached the soil. The green waste however, needed two years to destabilize (decompose) into the soil. They found that the time it takes for the organic matter to decompose has less to do with the quantity of organic matter, or even the targeted substrate, but by how stable the compost was at application, and how big the carbon particle fractions were. The scientists found that a portion of the compost was still decomposing, and thus bioavailable five years after the initial application. For my business this means that the compost feed-stock and stage of curing is going to affect how often I have the clients amend their plants with compost,and how long that compost will remain effective in situ before reapplication is necessary. It also makes me wonder how much of the compost is off-gassing carbon by sitting on top of the soil if the carbon is not yet stable?

Moving on to the next article- earthworms are soil engineers. Their activities through the soil promotes good aeration, creates water channels for deep soil-water percolation, cycles nutrients throughout the food webs, and helps keep carbon bioavailable. Earthworms help make soil with good *tilth*. This paper, Effects of endogeic earthworms on the soil organic matter dynamics and the soil structure in urban and alluvial soil materials, by Amossé et al, 2015 compares two types of soils: the urban soil (technosoil) used as the variable soil, and the alluvial soil used as the control. They took samples of these soils and put them in a lab setting and inoculated them with worms. They then inventoried the worm populations, x-rayed the worms' channels, and extrapolated observational data from there. Urban soils are similar to alluvial soils because both soils are frequently disturbed. Because of this the actions of worms play a critical role in maintaining soil health and are thus more dramatic. In this experiment the scientists found that soil respiration was higher in the alluvial soils due to the worms' activities, but that same effect was more transformative in the urban soils. They found that the earthworms had a harder time finding food in the urban soils, which equated to less reproduction and a dropping off of the population numbers. They found that between the two types of worms tested (earthworm [A. *rosea*] and green worm [A *chlorotica*], the green worm did better in the urban soil environment than the earthworm, and both succeeded in the alluvial soil environment. This is because earthworms are “grazers” and live where vegetative food is easily available, and greenworms can eat and live off of soil, they are “geophagous”. So, when applied to my business, greenworms would be more effective at improving the technosoil already present on site, and earthworms would be more effective in the applied compost amendment. Good to know.

The next article, Lead and Arsenic Uptake by Leafy Vegetables Grown on Contaminated Soils: Effects of Mineral and Organic Amendments by McBride et al, 2013, explored what would happen to the phytoaccumulated levels of lead (Pb) and arsenic (As) if the contaminated soil was amended with stabilizing materials, such as composts, peat, Ca phosphate, gypsum, and Fe oxide. These materials would ideally prevent the plant from taking up Pb and As because they would chelate, or bind, to the metals. This question is important- what amendments are appropriate and successful for my future clients if they’re worried about soil contamination? The answer- nothing worked. The only amendment that came close to working was Fe oxide, which had a limited effect which was not long-lived. The scientists mention that lead uptake is neutralized in soils with near-neutral pH and high organic matter content. They also explain that while gypsum and phosphate are used to sweeten the soil and prevent toxin contamination of food, what usually happens is that Pb is immobilized while As is mobilized, meaning As is more bioavailable. So, in my business, I’m going to need to find either the appropriate plant which does not bioaccumulate these metals as an evolutionary advantage, or avoid putting edible crops in naturally acidic soils, because there is no one particular amendment to fix the contamination problem.

I ended my week 5 readings with a primer to climate change. The article, Winter climate change effects on soil C and N cycles in urban grasslands, by Durán et al, 2014, follows the growth pattern of a prairie field found within city limits throughout two years to understand what a winter without snow would do to the vegitation during the following growing season. Urban prairies exist in large numbers in the United States and with urban sprawl expected to increase, these prairies will have more of an effect on climate change than previously realized. These systems are typically managed by city workers and are not usually managed “organically”. If urban prairies cannot cycle the “cides” and “ferts” throughout the soil because their biorhythms have been altered due to climate change, this could have detrimental effects, literally downstream of the application zone. Being that climate change has been seen to decrease the snow precipitation levels of some cities, particularly in the examined city of Millbrook, NY, the scientists decided to test out the vegetation there. They protected some plots from the snow with a roof and let other plots go unprotected, and recorded the difference. They found that the snow acted as an insolation from the freezing temperatures and protected the organisms in the soil from daily temperature fluxes. They found that the unsheltered plots had a higher moisture content in the soil during the growing season than the protected plots, and that the soil was hotter in the unsheltered plots during the growing season. Soil NH_4^+ was lower in the protected plots than the unprotected plots, NO_3^- was higher in the unprotected plots, microbial biomass, nitrification, and denitrification rates were lower in the protected plots, meaning that typical soil processes were stunted when the snow was prevented from falling on the soil. However, soil respiration rates were “better” in the plots with no snow. Basically, without the snow, the soil is subject to more frequent, more dramatic freezes, which interferes with the soil life therein. Also, bacteria are more susceptible to freezing disturbances than fungi. Additionally, as they say:

> “ ... we observed decreases in microbial biomass and potential net N mineralization and nitrification in our laboratory measurements that suggest that reduced snowpack and enhanced soil freezing stressed and/or killed microbial populations, providing substrate that stimulated in situ mineralization and nitrification during the growing season. These results are consistent with our studies that have found that winter soil freezing can increase microbial and fine root mortality and the disruption of soil litter and aggregates, resulting in the release of labile C and N which then increases mineralization rates by the surviving microorganisms during the growing

season (Fitzhugh et al., 2001; Cleavitt et al., 2008; Christenson et al., 2010). Soil freezing during winter can therefore increase N concentrations in the soil solution of urban grasslands following snow melt, potentially resulting in enhanced nutrient losses (Groffman et al., 2006; Callesen et al., 2007; Austnes & Vestgarden, 2008; Goldberg et al., 2010), especially when it is likely that plant uptake was also negatively affected by winter frost-induced root mortality (Fitzhugh et al., 2001; Tierney et al., 2001).” -page 2832, paragraph 2.

In short, what this means for my business is that the soil needs some type of over-winter protection so that the plant roots don’t get frostbitten and damage plant growth, so that the bacterial populations stay stable, and so that nutrients can continued to be cycled vs bleached out of the soil profile and become unavailable for biological processes. Mulch your plants, essentially.

Week 6 started with an easy read: Carbon storage and sequestration by urban trees in the USA by Nowak et al, 2002. Carbon sequestration in and of itself is a climate change issue. The scientists did a bunch of math and by their calculations, “individual urban trees contain approximately four times more carbon than individual trees in forest stands...large trees can store 1000 times more carbon than small trees.” Being that urban environments have less tree competition, urban trees have the potential to store lots of carbon through near continuous growth and large diameters, whereas forest stands are in constant competition with each other and produce trees of various sizes in various stages of growth and thus with irregular carbon sequestration rates. Additionally urban trees can reduce the amount of emissions necessary to heat or cool a building, and thus save carbon that way. However, this assumption does not include the necessary fossil fuels required to maintain the trees, so it’d be interesting to see that counter-calculation. This doesn’t really effect my edible landscaping business, but the article was worth the read.

I used the next article, Integrated assessment of Hadley Centre (HadCM2) climate change projections on agricultural productivity and irrigation water supply in the conterminous

United States by Rosenberg et al, 2003, to take a broad look at the expected changes in the Pacific Northwest's temperature, precipitation, and water resources for the next century. Agroforestry requires a planning out of scenarios based on the lifespan of the intended plants, which can reach far into the future. The plants I recommend now might not be the appropriate plants later. After using the above stated climate change scenario, the scientists demonstrated that the PNW temperatures will swing between -1.8C cooler to .6C hotter in ten years, and between .9C and 3.0C hotter in 2095. They calculate the PWN between 16% to 59% more precipitation in ten years, and by 2095 the PNW will have between 6% to 44% more precipitation. The PNW will have summers and fall temperature ~2C cooler, and winters as much as 4C warmer. By 2095 the PNW will have very dry summers comparatively. What does all this mean for my business? I need to incorporate plants which can handle drier, hotter summers, and warmer, wetter winters. That shouldn't be too hard as what this translates to me is a northern migration of the hardiness zones, which opens up a lot of plants to almost year around growth. This does not permit the production of sugar maples, or apple trees sensitive to frost days. However, being that apples are a hot commodity I'm not too worried because breeding programs are most likely already underway.

I finished week 6's stand-alone articles with Pfeifer-Meister's et al (2013) article, Pushing the limit: Experimental evidence of climate effects on plant range distributions. They took a broad look at native prairies plants and what their responses would be to expected climate change conditions, like increased temperature and precipitation. They found that the biggest hurdle for continued plant community well-being were drought conditions brought on by hotter temperatures, which interfered with the establishment phase of the germinated seedling. This effect however was minimized the further north the plant species was tested at. The heat helped the plant put on more biomass and the increased precipitation reduced the effects of the hotter temperatures. On page 2134, paragraph 1, the scientists say that "Nutrient availability was also greater in heated treatments, suggesting that that size response is mediated by an indirect positive effect of heating on nutrients." essentially these prairie spp will migrate north with the coming climate change. This kind of pertains to my edible landscaping business, in that maybe I can plan for the new and expected weed/colonizer niche and prevent that niche from going to pestilent plants? Just more to think about.

I'll conclude this paper with bits of information I've taken from the new book I'm reading, Tree-Crop Interactions, edited by Peter Huxley and Ong. I love this book, each chapter presents loads of articles to support the subject of the chapter. Huxley is a well known plant scientist and has a lot to say about agroforestry. Here's a few quotes I've noted and have been pondering about ever since:

Page 27 "Spatial and temporal complementarity is achieved by cropping spp with different growth curves"

If you think about the life of a plant and separate its functions and then chart their functions with an activity level on the y axis and the calendar year on the x axis, it's possible to get a visual representation of what the plant is doing at what time at what level. This means that plants can be coordinately planted together with limited competition.

Page 28 "In mixed cropping one crop cannot be considered independently of the other and measures of yield advantage must express the yield of one crop as a function of the other, so as to determine when more production of one crop and less of the other is more advantageous."

It's the whole idea of biointegration. Take fodder tree crops for example: If the yield of the mulberry tree because the food for the pigs, than both yields are advantageous to each other. If the yield of the mulberry tree is ignored because the pigs take precedence during that time, the yield of one becomes a detriment to the other. The same idea as the above quote- the growth curves must be noted and coordinated. These growth curves can be calculated through the Production Possibility Frontier equation, which calculates at what densities two crops can be plants together for the most production. This is a very powerful and liberating equation because it gives you a range of results and lets you choose wisely.

However there's another dimension that needs to be evaluated when choosing crops - the Market evaluation. Due to the competitive effects of growing two crops together, typically an annual in between perennials, the yield of the marketable product may decrease. So there's a formula to calculate what that decrease might be.

Page 36 "Berendse (1979) studied the coexistence of species, some with the ability to exploit refugium (resources not available to the others). He showed that in order to coexist, spp without the refugium had to be the stronger competitor for common resources. In mixtures of annuals and perennials, the perennial is able to exploit the refugium because of its longer growth period and extensive root system. In the second and/or subsequent years of intercropping it has, therefore, a competitive edge over the annual"

This gives me another thing to consider. If the perennial roots are exploiting different sources of nutrients, how effective would compost be at limiting the competition between annuals and perennials? How do I minimize the competition? I don't want to baby the annuals through their growing season every year. With climate change however, I can just choose plants which will self seed in the same plants and let them self-thin. Also, using the Replacement series on page 37, which shows the timeline that biomass from one plant decreases as biomass in another increases, it's easy to see that perennial systems are the natural step after annuals. Fighting that succession will be an uphill battle. I need to look into purely perennial systems.

The rest of my notes are too technical for this paper, so I'll end it here. Where do these readings leave me? I have a general idea of what to expect with climate change. I have a general idea of how to deal with toxins in the soil. I'm very interested in the growth curves I read about in Huxley, maybe I'll focus on those. Until Next week-

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References

Amossé, J., Turberg, P., Kohler-Milleret, R., Gobat, J., & Bayon, R. L. (2015, 04). Effects of endogeic earthworms on the soil organic matter dynamics and the soil structure in urban and alluvial soil materials. *Geoderma, 243-244*, 50-57. doi:10.1016/j.geoderma.2014.12.007

Durán, J., Rodríguez, A., Morse, J. L., & Groffman, P. M. (2013, 05). Winter climate change effects on soil C and N cycles in urban grasslands. *Global Change Biology, 19*(9), 2826-2837. doi:10.1111/gcb.12238

Mcbride, M. B., Simon, T., Tam, G., & Wharton, S. (2012, 11). Lead and Arsenic Uptake by Leafy Vegetables Grown on Contaminated Soils: Effects of Mineral and Organic Amendments. *Water, Air, & Soil Pollution, 224*(1). doi:10.1007/s11270-012-1378-z

Nowak, D. J., & Crane, D. E. (2002, 03). Carbon storage and sequestration by urban trees in the USA. *Environmental Pollution, 116*(3), 381-389. doi:10.1016/s0269-7491(01)00214-7

Ong, C. K., Wilson, J., Deans, J. D., Mulatya, J., Rausen, T., & Wajja-Musukwe, N. (2002). *Tree-crop interactions: Manipulation of water use and root function*.

Pfeifer-Meister, L., Bridgham, S. D., Little, C. J., Reynolds, L. L., Goklany, M. E., & Johnson, B.

R. (2013, 10). Pushing the limit: Experimental evidence of climate effects on plant range distributions. *Ecology, 94*(10), 2131-2137. doi:10.1890/13-0284.1

Rosenberg, N. J., Brown, R. A., Izaurralde, R., & Thomson, A. M. (2003, 06). Integrated assessment of Hadley Centre (HadCM2) climate change projections on agricultural productivity and irrigation water supply in the conterminous United States. *Agricultural and Forest Meteorology, 117*(1-2), 73-96. doi:10.1016/s0168-1923(03)00025-x

Vidal-Beaudet, L., Grosbellet, C., Forget-Caubel, V., & Charpentier, S. (2012, 11). Modelling long-term carbon dynamics in soils reconstituted with large quantities of organic matter. *European Journal of Soil Science, 63*(6), 787-797. doi:10.1111/j.1365-2389.2012.01494.x