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SOS - E4E Edible Landscaping
Lit Review Week 7
Huxley

This week, week 7 of winter quarter, the time I would have devoted to reading peer-reviewed articles I spent on reading a few chapters of Huxley and Ong's Tree-Crop Interactions. If you've ever read Huxley you'll know that the time I spent trying to understand the chapters is equal to the time I could have spent reading ten peer reviewed articles. The nature and quality of Huxley's work permit his book to be counted towards upper division credit. So, without further ado, this week I read chapters 3 and 4 out of Tree-Crop Interactions which focused on mulch and shading of intercrops, and water and irradiance charing between intercrops. In this review I'll take you through most of the notes I've recorded without getting too technical.

The first note I took was about figure 3.1 on page 52 which charts different agroforestry systems in relation to the degree of overlap in time and space between the trees and crops of the same system. Meaning, rotational alley-cropping is one of the most effective systems of agroforestry in regards to space utilization in timely manners, whereas monocrops are not efficient systems in regards to temporal or spatial overlap because the space being utilized is utilized for only one crop for part of the year, and left fallow for the rest of the time. See Fig 1 to the right. Different systems perform different services for the targeted habitat. In relation to my Edible Landscaping

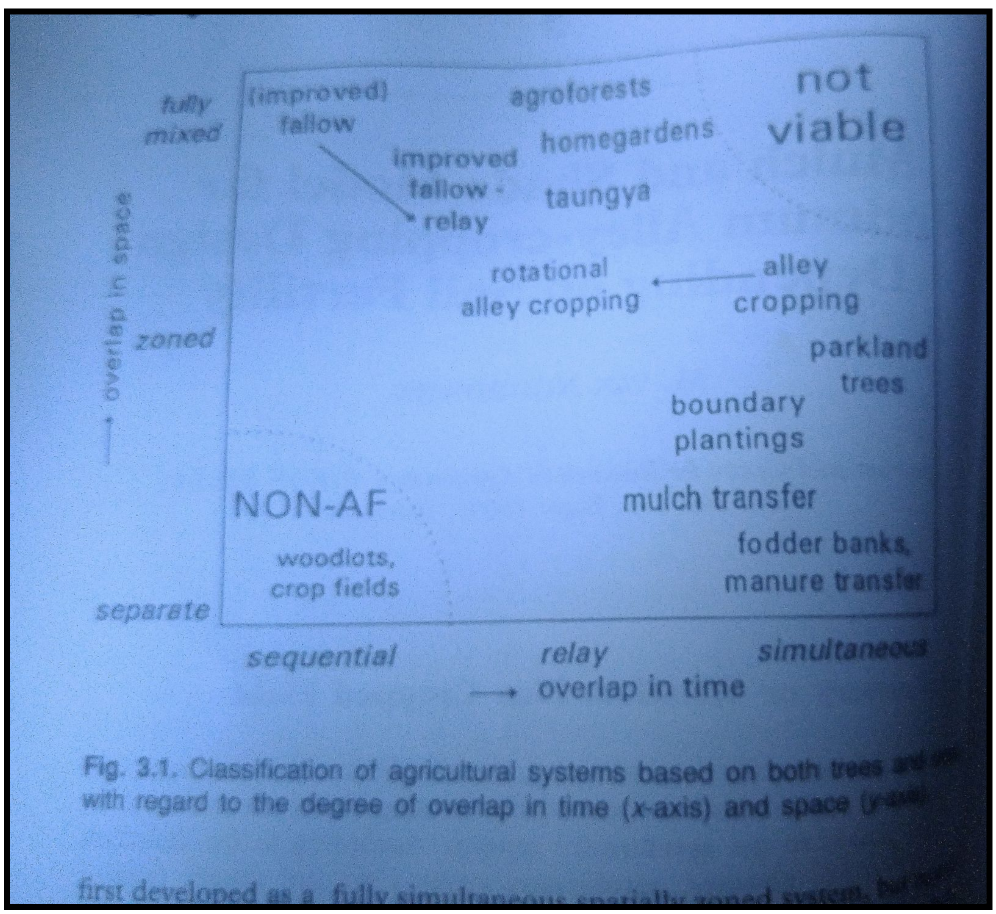

Fig. 3.1. Classification of agricultural systems based on both trees and ... with regard to the degree of overlap in time (x-axis) and space (y-axis)

business, I can chart my client's level of maintenance to the system based on how critical it is to the client to have a crop in the ground year round, or to have multiple crops sharing the same space separated by different strata. If the client isn't too dedicated to maintaining the system for most of the year, then maybe, according to fig 1, I should focus on crops and hedgerows. Likewise, if the client is interested in dedicating their lives to the plot, than rotational alley-cropping is the way to go.

On the same page Huxley introduces a formula to calculate the total yield of any agroforestry system based on the sum of the crop yield, the yield of the tree products, the yield of the animal products, and the change in land quality over time. Together these factors help to quantify the "sustainability" of the land practice in terms of yield units. The importance of a formula like this, is hopefully, self-explanatory. It's all about how you're using your land. If the goal is to get the most yield out of all of the components, it doesn't hurt to quantify where you're at in relation to where you want to be.

Page 53 talks about space allocation for trees vs crops. The question is, how many trees can you plant on how much land and density to get the return on investment (ROI) vs the highest value monoculture on the same space. What's the yield and what's its worth? If the tree crop is worth its value, then plant the trees. It's essentially a Land Equivalency Ratio.

Page 54 reminds us to consider this when we consider trees: trees improve the soil in multip-le ways, especially leguminous trees. However, trees, when treated as a crop, can deplete the soil. When trees are short rotation crops, they mine nutrients from the soil on a regular basis and those nutrients are largely removed from the system. Pair their harvest frequency with the method of harvest and its effects on the soil (compaction), and then in some ways, trees do more harm than good. This just reminds us that just because trees are involved in the harvest, it doesn't mean the land is being treated responsibly.

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Page 55 talks about hedgerow tree-crop interactions. The hedgerows produce mulch for the crops, thus, increasing the available nitrogen supply and supply of other nutrients. The hedgerows also shade the crops and reduce the light intensity of the light penetrating the canopy and reaching the crops. The tree hedgerow are very competitive to the crop roots in relation to nutrients and h2o. However, tree roots provide frequent doses of slow release nitrogen through root death/shedding following pruning event, or via direct nitrogen transfer from the root nodules of nitrogen fixing trees to the crop roots. The tree crops can have multiple and varied effects on weeds, pests, and diseases. And finally, tree hedgerows can control or prevent erosion and maintain SOM. These interactions are just something to think about when considering hedgerows.

On page 57 huxley talks about a few more considerations when dealing with trees as hedgerow crops.

1) What tree spp are you considering?
2) What is the smartest distance between the trees in the hedgerows?
3) What pruning regime are you going to use? Specifically height and frequency.
4) What crop cultivars will you use in between the tree hedgerows? At what density? At what spacing?
5) What additional fert or soil amendment will be necessary?

I'm going to quote the next bit of notes because Huxley explains them succinctly. This is in relation to quantifying crop responses to hedgerow distance and shading, and noting the turning point from beneficial to less beneficial.

"Decreasing the distance in between hedgerows may lead to increased N uptake, as well as increasing shade. As N limitation becomes less severe but shading increases, crop yields may show an optimum response curve to distance in between hedgerows."

- page 58-59 last paragraph.

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Additionally, on page 68, Huxley highlights that the greatest effects of nitrogen producing trees used as hedgerows on crops will be seen on soils with little N present. This is pretty straightforward: I'll get a more dramatic result from a thirsty plant given water than a hydrated plant given water.

Page 68, paragraph 3 - "...The best hedgerow tree is one with a high M:S [mulch:shade] ratio, which can be based on a combination of narrow, but compact hedgerow canopy, thick leaves, the major part of the tree canopy not exceeding that of the crop, a high N content and a suitable N release pattern from the prunings, coinciding with crop demand."
Simple enough. This essentially means that when I'm deciding on a tree crop as a hedgerow, in addition to the other considerations mentioned on prior pages, I should aim for a tree with high biomass content, that regenerates quickly but doesn't compete for light with the crops between the hedgerows, and can tolerate pruning.

Moving on to chapter 4, the longest and probably most technical chapter so far, Huxley focuses here on the principles of resource capture and utilization of light and water. Jumping right in, on page 74 Huxley explains that there are multiple forms of competition which look different depending on the spp being used. If the intercrop is intraspecific, meaning the same spp is competing against itself, than the nutritional demands will be on the same nutrients, the competition is based on the same limiting resources (outside light and water). If the competition is interspecific than different spp are being used, meaning the nutrient demands will be call on different nutrients. This should be both a liberating and eye-roll inducing statement. If Sulfur is the limiting resource, than brassica spp will be competing against themselves vs other spp who don't need sulfur as much. The competitive strategy at play here is: "to increase the productivity in situations with high population densities, the plants must either capture more resources or use them more efficiently."

Page 75 talks about how important it is to plant your crops at the right densities, especially if an intercropping plan is anticipated, as competition will be the greatest factor at play. These values can be determined through Land Equivalency Ratios (LERs), Crop Performance Ratios (CPRs), and Area-Time Equivalency Ratios (ATERs). Which these equations help to quantify resource uses and yields, there is a basic principle at play: “The basic principle underlying the concepts of resource capture is that complementary or competitive interactions between spp depend on their ability to capture and use the most limiting essential growth resources effectively.” Meaning that if I want to limit competition between crops, I need to differentiate between R and K spp, and possibly focus on scavengers in between the perennial crops.

Page 78 reminds me to consider root zone competition, and that competition could be the cause of symptoms of overyielding and under yielding crops. If one crop is over yielding, it’s probably taking nutrients from the crop that is under yielding.

Page 79 starts the conversation of water resources. The capture of water depends on the amount of water (rainfall, irrigation), and the plants conversion coefficient, or ability to use the available water. The Conversion coefficient is based on transpiration and evapotranspiration rates because plants operate as thru-puts, or straws.

Page 81 talks about complementarity in resource capture. Complementarity looks like spatial complementarity, and temporal complementarity. Spp can be separated from each other’s demands through space and time.

Page 85 talks about the capture of light which depends on two factors:

- PAR, or the incidence of photosynthetically active radiation and
- The efficiency of conversion of the intercepted radiation via photosynthesis.

Page 86 mentions that light penetration into the canopy is greatest when the leaves are erect and horizontally oriented. Pretty straightforward stuff.

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Page 90 and 91 talk about how dry matter production is linearly correlated with the quantity of radiation absorbed by the canopy: meaning the more light that is captured, more biomass is produced, up until the point the leaves are saturated with too much sunlight.

The above is why page 92 talks about the canopy architecture and how it's important in determining the distribution of radiation within the canopy and its influences on the whole canopy conversion coefficients. So, while it's important to take note of each leafs' contribution to the radiation capture, the structure of the canopy is going to affect how much radiation is converted where.

Page 94 mentions that water use can be thought about in the same way radiation use is: based on supply and conversion rates. Page 94 also asks us to think about this: whenever the stomata open for gas exchange, $H2O$ is lost via transpiration. Plants have evolved for effective gas exchange at the expense of $H2O$ losses, specifically the mesophytic plants. This is why lots of mesophytic plants have broad leaves; to allow for large surface areas for gas exchange.

Page 95 explains that the rate of transpiration from the leaf depends on intracellular interactions and atmospheric concentrations of water vapor and the diffusive resistance of water in the leaf, which is the same idea that holds true for $CO2$ uptake.

Page 96 goes into the short and long term regulatory mechanisms of $H2O$ use by the canopy. Short term mechanisms operate over minutes or hours to reduce transpiration per unit area, like stomatal closure, leaf movements, and leaf rolling. Long term mechanisms happen over days or weeks and include the early termination of older leaves or slowing down the production/development of new leaves. Essentially less transpiration = less growth.

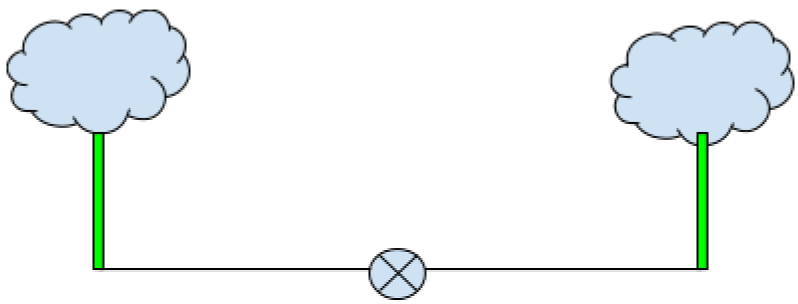
Page 97 had a brief sentence that demonstrates the importance of evolutionary rapid adaptation: "Species capable of extensive osmotic adjustment can dry the soil further." Meaning when water is a scarce resource, those spp which can adjust the osmotic pressure in their roots can remove water that's even harder to reach, up until the soil's moisture level of the wilting point.

The above might help to explain what Huxley talks about on page 99 when he says that the principle limitation on water uptake by annual crops growing on stored moisture in the soil is the rate at which roots grow and extend, which puts them at a disadvantage with already established trees .This might also help explain Huxley's statement on page 101, "There are several field experiments which suggest that total water use by intercrops may be little different from sole crops". This is a big statement, because one of the appeals of agroforestry is that intercrops use water more efficiently. However, by this statement Huxley says there's very little field data to support this hypothesis.

Moving on, on page 104 Huxley says what I already knew, but says it better than I can: Soil evaporation dominates early in the season, followed by evapotranspiration as the canopy closes. Dry matter production is often linearly related to the quantity of water transpired."

When applied to intercropping, water use, as explained on page 107, may be increased by intercropping so long as the canopy closes before too much water is evaporated from the soil surface. This could also be a detriment as the available moisture might be used too early through the canopy growth, and thus become prematurely depleted. Water use can be increased if the crop growing between the trees grows at a vigorous rate and can utilize the water, like an intercrop of C3 and C4 plants. Finally, remember that these effects can be adjusted depending on the implemented microclimate.

The above paragraphs are at odds with themselves. If intercrops haven't been shown to utilize water more efficiently than sole crops, but...theoretically that is the case, than maybe what we're missing is the appropriate application of new technologies on field experiment. Either, the main stumbling block of water use in annual crop production is that they only grow for a fraction of the year, whereas Agroforestry systems ideally have something growing throughout the whole year, as explained on page 108. Page 111 explains that in the case of agroforestry where trees are separated by an appropriate distance, the least amount of competition between the annual crops and the tree roots will be in the direct center of the tree spacing. Or, as Fig 2 below shows, the least competition is marked by the X.



I found pages 111-112 very interesting. Here Huxley talks about the quantity and quality of light penetrating the canopy. Plants are green because they absorb wavelengths in the red and blue sections while they reflect the green wavelengths. The upper canopy is absorbing the useable wavelengths up until the leaves are light saturated. They refract the rest of the spectrum in every direction, including down the vegetative strata. Thus the plants on the ground level have to evolve to a diffused quality of light. This is why, I think, the ground level plants have evolved to spread out and cover the ground: because they need to capture that light and it's more energy efficient to not fight gravity.

This is where I'll end my review this week. I'm still making my way through Huxley's <u>Tree-Crop Interactions</u>. This is a dense book and I'm not sure I'll be able to finish it this quarter, as there are still a few articles I'd like to read. All in all, Huxley is giving me a lot to think about and I hope I can find more gems in this book.

Until next time!

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References

Ong, C. K., & Huxley, P. (1996). *Tree-crop interactions: A physiological approach*. Oxon (UK): CAB International.