Successional Agroforestry Trip to Denmark, October 2022

Joshua Finch

Serie R: Rapporter

Successional Agroforestry Trip to Denmark, October 2022

Joshua Finch, Novia University of Applied Sciences

Publisher: Yrkeshögskolan Novia (Novia UAS), Wolffskavägen 33, 65200 Vasa, Finland
Novia Publikation och produktion, serie R: Serie: R Rapporter 2/2023
ISBN: 978-952-7048-97-9 (Online) ISSN: 1799-4179

Preface

Hello dear reader! I'd like to warmly welcome you to my first article for Novia UAS. My name is Joshua Finch and I'm working for Novia as the Lill-Nägels Agroforestry Project manager.

The Lill-Nägels Agroforestry Pilot Project is an 8000m2 successional agroforestry project, which, among other goals, is aimed at utilizing phytoremediation to restore soil fertility on a degraded agricultural field. The project is generously funded by Stiftelsen Finlandssvenska Jordfondens and Novia University of Applied Sciences from June - December 2022 as an initial startup phase. The project's location in Kirkkonummi, Finland, has been kindly made available by Rikard Korkman and his family farm. More information on the project is forthcoming on an Novia UAS webpage, this article will be updated with a link once it is online.

I am be reached for comment or inquiries at joshua.finch (at) novia.fi

Today I will share with you what I learned on a exceptional opportunity that arose through this collaboration: a sudden trip to Denmark where I got to work and learn side-by-side with Ernst Götsch for three days, a world renowned agroecologist and agroforestry specialist.

(Please note that the term "syntropic" will be put in quotations throughout this post because the usage of the term needs to be addressed, and will be, at the end of this article)

Josipa's agroforestry system summer 2022. Credit: Josipa Bićanić.

Ernst had been invited to Denmark by Josipa Bićanić, a friend from my private work as an agroecology consultant, to help troubleshoot and guide her successional agroforestry pilot farm's next steps. Josipa's project (Skywoman Syntropy, n.d.) is situated at Grantoftegaard (Fonden Grantoftegaard, n.d.), a social farming trust just outside of Copenhagen in Ballerup. Their community is interested in continuing to develop their organic operations and was delighted to have the opportunity to host Ernst. Through Josipa's work and Ernst's guidance they are beginning to envision what farming might look like if they were to embrace successional agroforestry.

Novia's Lill-Nägels Agroforestry Project has been designed along similar lines as Josipa's. As such, it is potentially unique in Finland due to its employment of successional agroforestry dynamics. With Ernst traveling to Denmark, with its similar ecoregion to Finland, this was a welcome chance to gain valuable insights from a world leader in the field to strengthen our design and management. It was also an ideal opportunity to network with other agroforesters and organizations around this emerging subject.

Ernst's visit to our region of the world is perhaps a first of its kind. There is a lot of excitement about agroforestry generally and interest in Ernst's style of farming in particular. My trip was a rare opportunity for someone with a strong acquaintance with his work and a long history dealing with agroecological topics to gain first hand experience. As such, I have produced this article not just to write for the sake of writing but to lay it down as part of the expanding foundation of a new era of agroforestry in our region.

Background

There is growing recognition that agriculture must change from being a human activity with a net negative impact on our biosphere to one that is net positive. Different people have different ideas as to how to make this happen. But one thing is beyond doubt: agriculture cannot be beneficial if the farmers themselves don't believe that *they* can be beneficial. Agriculture doesn't "just happen." Agriculture is a human choice. Recognizing the importance of psychological factors in farming is vital towards shifting paradigms.

Ernst Götsch, like many pioneers in what is widely known as "regenerative agriculture" is at once both an innovator in the field in terms of technical know-how and a philosopher (Agenda Götsch, n.d.). If you are going to do something radically different from your neighbors, it helps to have thought about *why* you are following a different route. And since his emergence on the world stage, Ernst has been inspiring farmers globally with his phrase:

> "Working to create areas of permanent inclusion of humans instead of areas of permanent protection from humans." (6:19, Life in Syntropy, 2015)

Ernst appears to believe, and so do I, that humans are part of this world, just like all other organisms and phenomena, *and* that we can be beneficial to the world if we desire. No, perhaps that is not really it. Perhaps, if we dare to be bold, the world could *be better* with the presence of humans than it would be without us. That is an inspiring message. And with 60 years of experience, Ernst has not just said inspiring things. He has put himself at the service of the ecosystem and thrived both as a large-scale farmer (Agenda Götsch, n.d.) and, more importantly, as a person.

In this article I will be sharing insights into Ernsts' process as I understand it. Be aware that I am presenting my experience and I will not be claiming that "Ernst Götsch said to do this." No, this piece is my interpretation of my time with him and is not a substitute for his work and teaching. Still, I think these notes are important ways of how to work with natural functions and, crucially, what that can look like in our part of the world.

Agroecology & Agroforestry

I believe that agricultural systems need to mimic natural ecosystems in order to thrive. People who operate with this mentality are often collectively called agroecologists (Food and Agriculture Organization of the United Nations, n.d.). For me, working from an agroecological mindset means tracing earth systems back to a beginning and embarking from there.

That beginning is often asking, “What ecosystem(s) prevailed in my region before substantial human interaction?”

In southern Finland where our project is located, this history is quite young in comparison to other parts of the world since, at the start of the “agricultural revolution(s)” far to the south, we were just emerging from around 10,000 years of glacial cover. Humans were already living on the edges of these glaciers and followed their retreat north. In this regard Finland is a rare place where the land and its peoples were one from the start of this interglacial cycle. Thus it is perhaps not plausible to ask that question here. Still, most of us would recognize that over the intervening millenia, as temperatures rose, the land we know as Finland became mostly covered by forests of different kinds (The Biodiversity Information System for Europe, n.d.).

As plants, animals, fungi, bacteria, and viruses- life- began to organize itself here over that time frame, their kinds and numbers were in large part determined by the ability of different species of plants to become well established across quite different soil types and hydrological conditions. Despite the varying conditions, a forested ecosystem emerged as the community that best supported the whole (Rutledge et al., 2022).

A forest emerges even on the edge of the sea in Finland. Credit: Joshua Finch

It should be noted that plants, like people, are not simply multicellular life forms. Indeed, they are identifiable by a genetic code, but- and this is extremely important to keep in mind-plants do not operate alone. They have a microbiome- every part of a plant, from the leaves and stems down to the roots, host an array of different microorganisms, many of which help the plant survive (Lyu et al. 2021). In fact, without some symbioses, some species of plants simply cannot live: the relationship is obligatory. In my estimation it appears that for any plant to *thrive* these relationships are nonnegotiable.

Without belaboring the point, it bears repeating that a forest is not just a place with a closed canopy of trees, but rather the whole of these dynamic relationships between all of the organisms and elements that call this place home; a home *characterized* by the strong presence of trees and shrubs (Kimmins, 2003). If you are in southern Finland, no matter where you are, you are likely in a forest at one stage of its development or another. If Helsinki- the most urban environment in Finland- were to be abandoned tomorrow and people returned in a hundred years, they'd likely find a forest growing amongst the ruins. That is how strong the proclivity for the ecosystem to become a forest is.

Forests in this sense are not static, dark places. Forests *include* places that appear static and dark, but also include places with rapid colonization by different plants and animals following disturbance events. These cycles and patchworks of different habitats created over time are together a forest. And it is these cycles that we want to understand and potentially recreate in our agroecosystems. I believe it is eminently reasonable to turn to the forest ecosystem as a model for successful farm design in Finland.

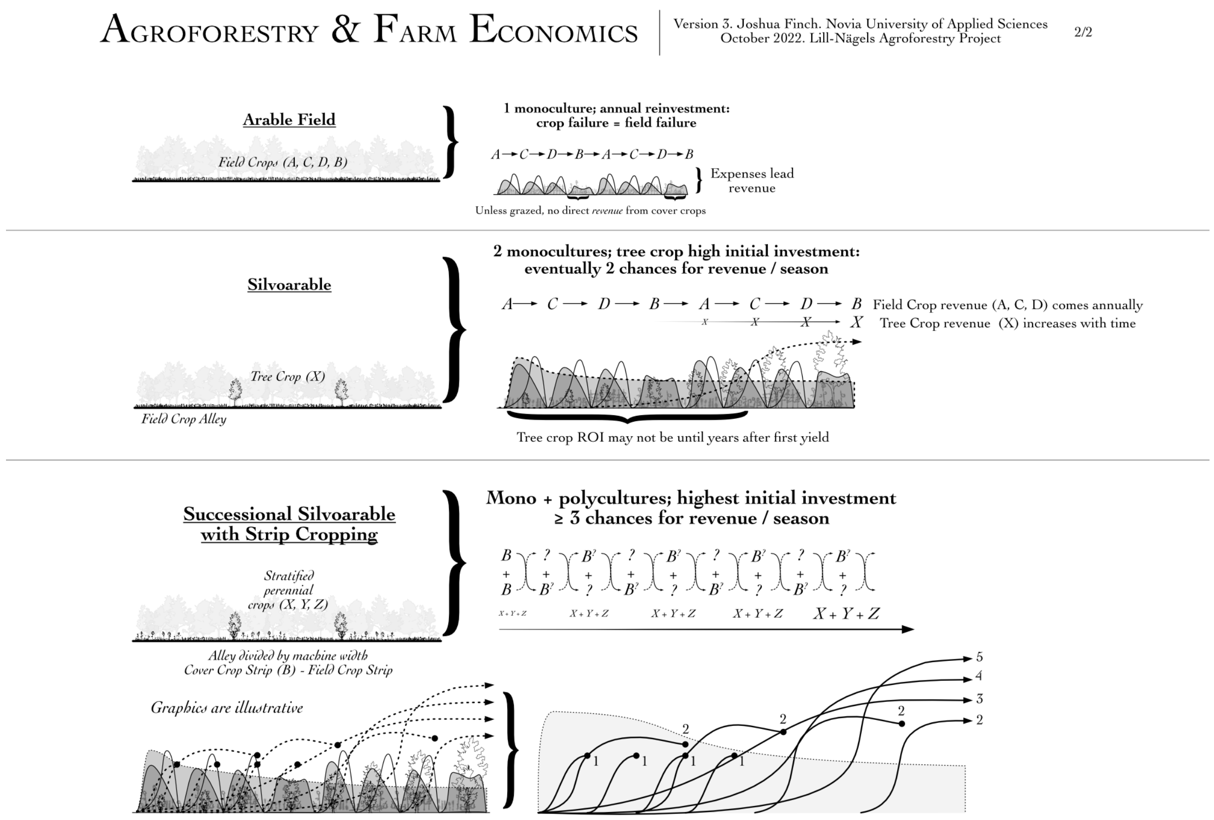
To do so is to create what are called agroforestry systems. Agroforestry is the deliberate inclusion of woody plants into agricultural systems (European Agroforestry Federation, n.d.). The reasons to do so are long and will be addressed elsewhere at length. In an agroecosystem we want as much life as possible because biodiverse habitats (in our case, a farm) are the most resilient and perhaps antifragile places. Nothing is guaranteed but change, so actively assisting the creation of strong relations with the inhabitants of our region is essential for securing a farm's place into the future.

What is Successional Agroforestry?

Agroforestry shows significant promise as a means to better adapt our agricultural systems to change. However, it does have some serious complications. And not just the initial hurdle of “why do we need more trees?” which, while a good question, is one I will ignore for now to address the next challenge: the long return on investment that is typically present in agroforestry.

I will deliberately and grossly oversimplify Ernst’s style of agroforestry almost beyond recognition in a deliberate effort to focus our attention on a common theme of his: utilize the power of succession to produce a marketable yield at every conceivable stage of the system. Above, I described the patchwork-like pattern of shifting habitats that make up forest ecosystems. The process that drives the development of each site in the forest is commonly called “succession.” Plants have site preferences not just in terms of light, water, and nutrient availability, but also in *time*. That is because the availability and quality of those things I just listed change as time goes on. Life itself changes them to a very large degree. Therefore, when planning an agroforestry system, we should assess the location in terms of both succession and degree of healthy function. We need to be able to do both because “advanced” stages of succession, depending on one’s definition of each phase, do not necessarily mean that the habitat is thriving. For example, a closed canopy pine plantation with very little biodiversity may tick the boxes for a later stage of succession but when assessed for factors other than structure and age, it reveals a diminished state.

When we do this, we can design and integrate cash crops which will thrive from the start through to a “finish line” we are bold enough to imagine. One or more crops change (or, *succeed*) from one to another through time, each one serving a purpose to create better life conditions for the next. If we do this intelligently (as Ernst might say) the long return on investment (ROI) period that farmers dread can be shortened significantly. Think of the difference between starting a savings account with compounding interest *now* versus waiting ten, twenty, or thirty years to begin. If you start immediately you will undeniably be in an appreciably better financial position. This is perhaps the characteristic of Ernst’s successional agroforestry model that is most attractive to farmers.



Comparing and contrasting revenue streams from different systems. Credit: Joshua Finch for Novia UAS

Even my simplistic approach to successional agroforestry already comes a long way towards incentivizing farmers to try it out. But it is in the complexity of design, implementation, and management where most farmers ultimately back down. I wouldn't say they lose interest, no, but that the sheer number of unknowns that present themselves upon further investigation drives many farmers away.

The Lill-Nägels Agroforestry Project is, in large part, *a pilot project* intended to venture into the unknowns of applying this system in our bioregional and socioeconomic context. We are not just exploring some of the claims made by regenerative agriculture proponents (myself included), but also to see if we can discover reproducible patterns for other farmers to adopt. Or, perhaps, many more things to avoid! Helping others avoid failures by taking on the risks in the form of a pilot project is a prudent move.

My Trip

I do apologize for taking so much time providing background to my trip, but successional agroforestry- or "Syntropic Agriculture" as Ernst's approach is often labeled- is not a commonly understood topic. Neither is agroforestry for that matter. If you were rebellious and skipped the previous section, you might thank me for writing it later! Now let's get into the trip.

I flew into Copenhagen the day before we were set to begin at Josipa's agroforestry site with Ernst Götsch and made my way to the hotel. Copenhagen is quite similar to Helsinki in that it boasts a strong public transport system. While riding the train and attempting to blend in, I made the mistake of gawking at the biodiversity we passed as the train made its leisurely way towards Ballerup. Anyone who stares at trees and plants immediately marks themselves as an outsider, luggage or no. Fortunately, I was left to my plant-watching in peace. Oak after oak, ash trees galore, more than one species of maple... pears reaching above the tops of homes, and a suspected walnut or two flashed before my eyes. I must confess my jealousy and how I coveted those pears. I had to remind myself that despite the similarities between Denmark and southern Finland there are also significant differences that need to be taken into account.

In Denmark it is quite common for hotels to rent bicycles to their guests and so I promptly acquired the key to one of the two available before anyone else could get their hands on it. We chose the hotel due to it being only about 15 minutes away from the field by bike and I wasn't going to be beholden to the bus. Nor would I want to subject any fine Danes to the mud, blood, sweat, and tears that can follow a day in the field with Ernst Götsch!

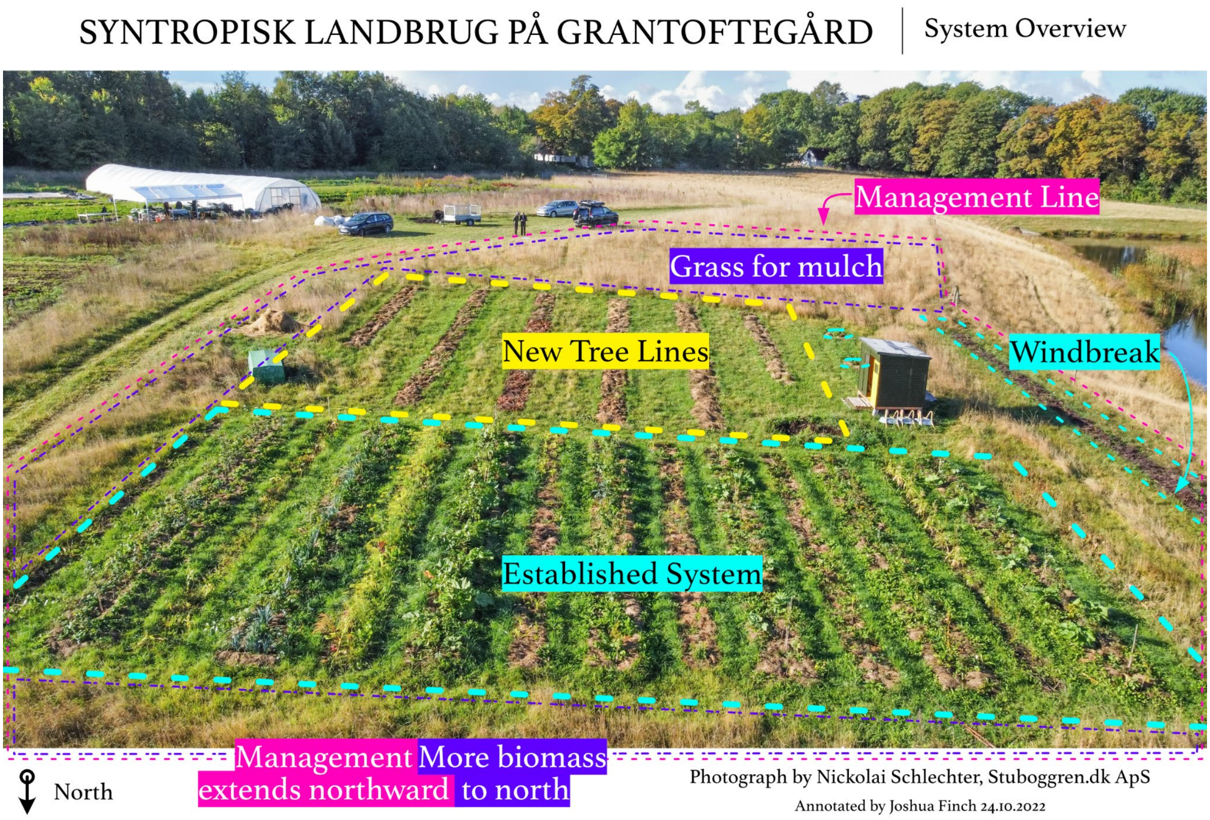
The plan was to spend almost three full days doing a variety of things with Ernst with a focus on hands-on training with Josipa's established system (still in its infancy, aptly called the "placenta" by Ernst). With his input we would course correct where prudent with a new set of tree beds. We would also take a stroll around the farm to pick his brain about the potential different sites had- the place is large and offers a large array of microclimates and niches- before the public lecture that Wednesday.

Josipa's Forest: Successional Agroforestry Pilot Site

Since Josipa's first course with Ernst in 2016, she has been searching for a place to start her very own agroforestry site. She became acquainted with Grantoftegaard in the spring of 2021 and was assigned a small plot of about 800m2 where she could experiment freely.

She used the spring and summer of 2021 to plant some vegetables and plan out the tree rows which she planted in October 2021. She designed her system according to the patterns from Ernst's courses and has worked diligently to follow the concepts exactingly. The two of us have been working together privately since late 2021, with my role as an advisor on agroecological practices in our climate.

Josipa's Site Design



At first glance, Josipa's system follows a common layout of what is often considered to be a "syntropic" agroforestry system: the space has straight tree lines in which the polyculture assemblies of each tree line (also known as *consortia*) have been distributed (*patterned*) to filter light throughout the whole (the *macroorgansim*). Keep in mind that her site resides on about 800 square meters and is less than two years old. Before diving into some of the theory about the design, I think that it is important to briefly talk about "pattern language."

Pattern Language

Understanding the pattern languages at play is essential towards interacting with and interpreting agroforestry systems (Center for Environmental Structure, n.d.). A pattern language is a "network of patterns that call upon one another." Well designed agroecosystems work with broad patterns that are modified by site conditions to order the principles of ecological site succession for human use. Since agroecosystems mimic ecology, different "schools" of thought may use similar patterns and thus it becomes tempting to infer equivalence.

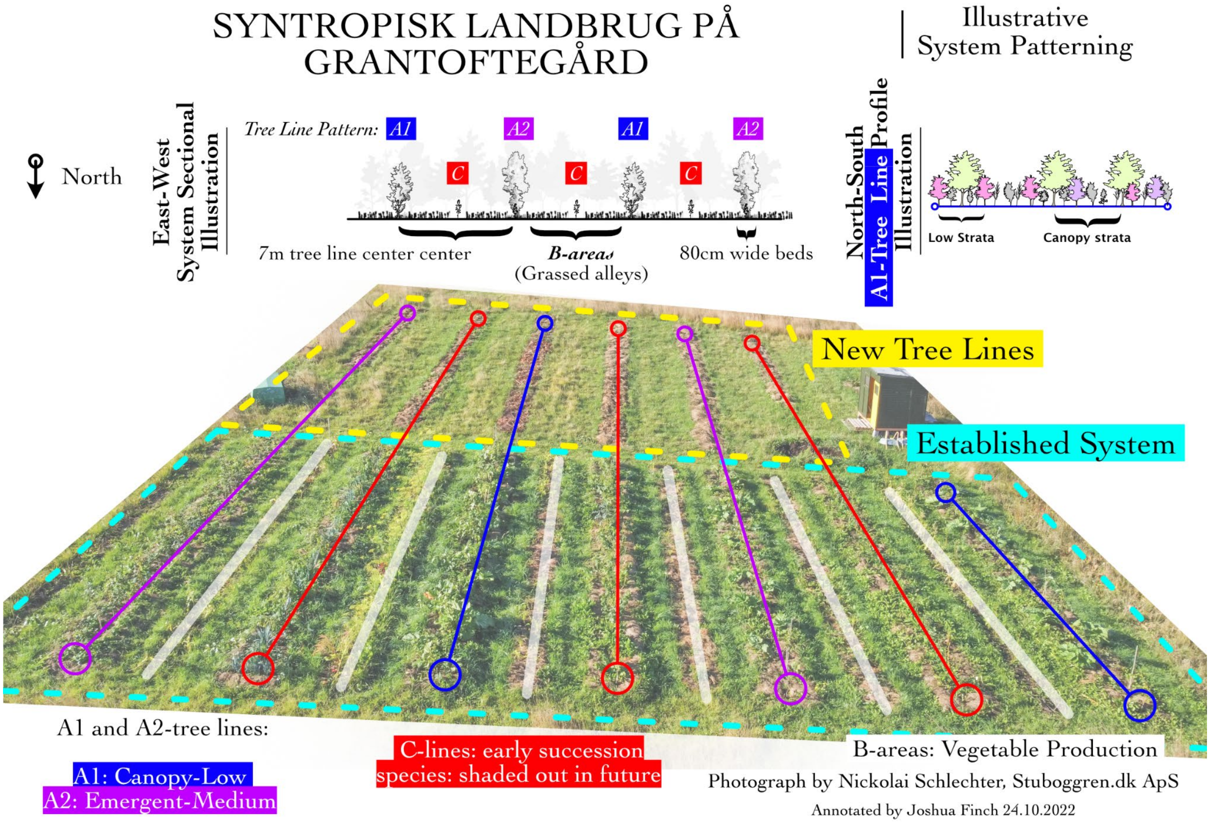
If you have seen a Miyawaki Forest, you may get the idea that a "syntropic" agroforestry system is the same, but with the trees drawn out into neat rows (Nargi, 2019, July 24). Likewise, if you come from a permaculture background, you might consider that this is "just a forest garden put into rows" (Edible Forest Gardens, n.d.). While there are similarities between all of these approaches, this is not the case. The underlying community dynamics and attempts to recreate robust agroecosystems are there, but the devil is in the details.

Miyawaki Forests are usually not intended to produce food for people and they are rarely planted on a large scale- say, 100+ hectares. Likewise, forest gardens are highly biodiverse but their spatial distribution of plants is more often designed with an aesthetic and domestic scale in mind. A "syntropic" agroforestry system, on the other hand, can be (and often are) scaled to hundreds of hectares and are almost always designed to provide an economic ROI. These are *farming* systems and the typical comparisons like I did above are only cogent with a surface level understanding.

Still, approaching a "syntropic" system from other perspectives is useful! Many people struggle to comprehend the pattern because they have not studied various forms of agroforestry and are coming from a conventional agricultural background in which diversity all too often means weeds. Complex systems like this require study to implement and a high degree of skill to manage. Making sense of them in person is easier to do when you've become acquainted with the pattern language of the design.

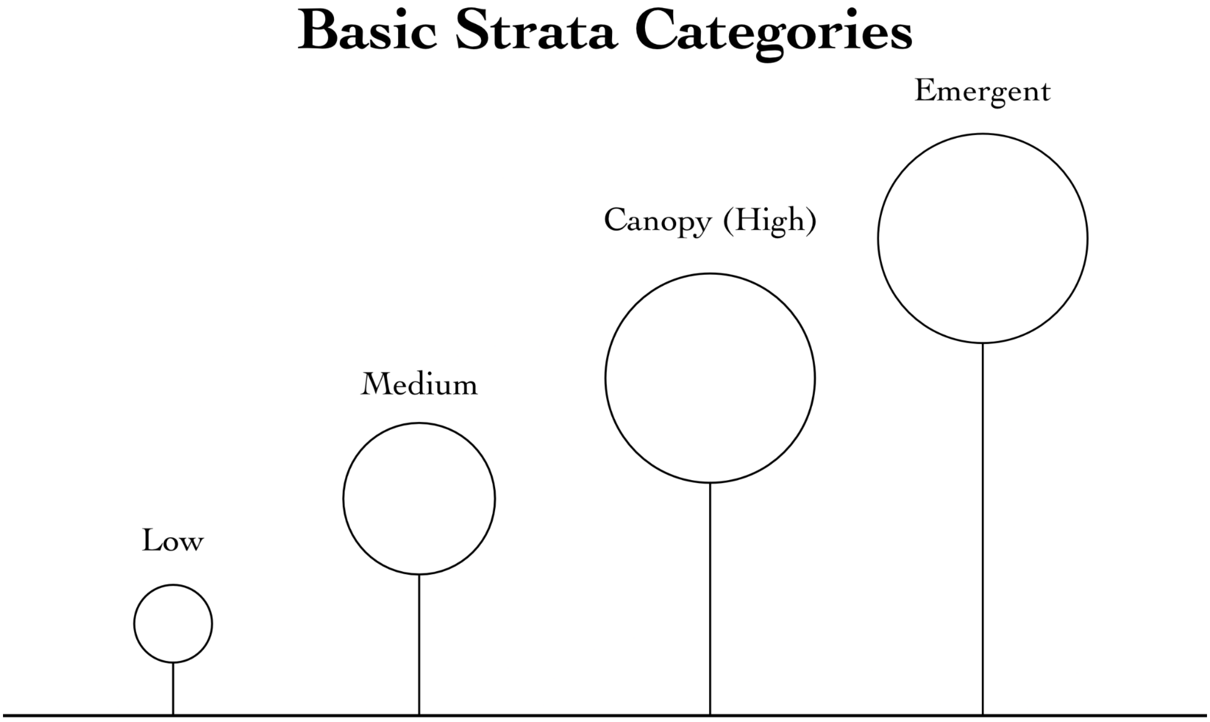
The design of these systems is context dependent: they can and should vary depending on where they are put into play. This particular system may not be scalable to 100+ hectares without a very well thought out organizational mind behind it, but that does not detract from the ability of this language to be scaled up.

A Simplified Successional Agriculture Pattern Language



A quick glance at this annotated photograph reveals an alternating pattern in which each tree line has a rational pairing of desired long term strata species. As mentioned before, this is common in successional agroforestry: by changing the strata as you move across the system, the amount of light being intercepted and used by the whole system increases due to the complimentary habits of the species. A monoculture, or even a polyculture, of the same strata will invariably be unable to utilize as much of the solar energy as a diversified system (Feng et al., 2022 & Bongers et al., 2021) This is evidenced by the fact that ecosystems have evolved with increasing numbers of plant species that occupy every conceivable niche: this testifies that no single species is able to use all of the resources in the system.

Stratification *as a pattern* refers to designing the agroforestry system according to the niche requirements of each species in space and time. In permaculture design this is typically referred to as “layering” and there are seven layers to be combined based on the different size, light, and other niche requirements of the desired species.

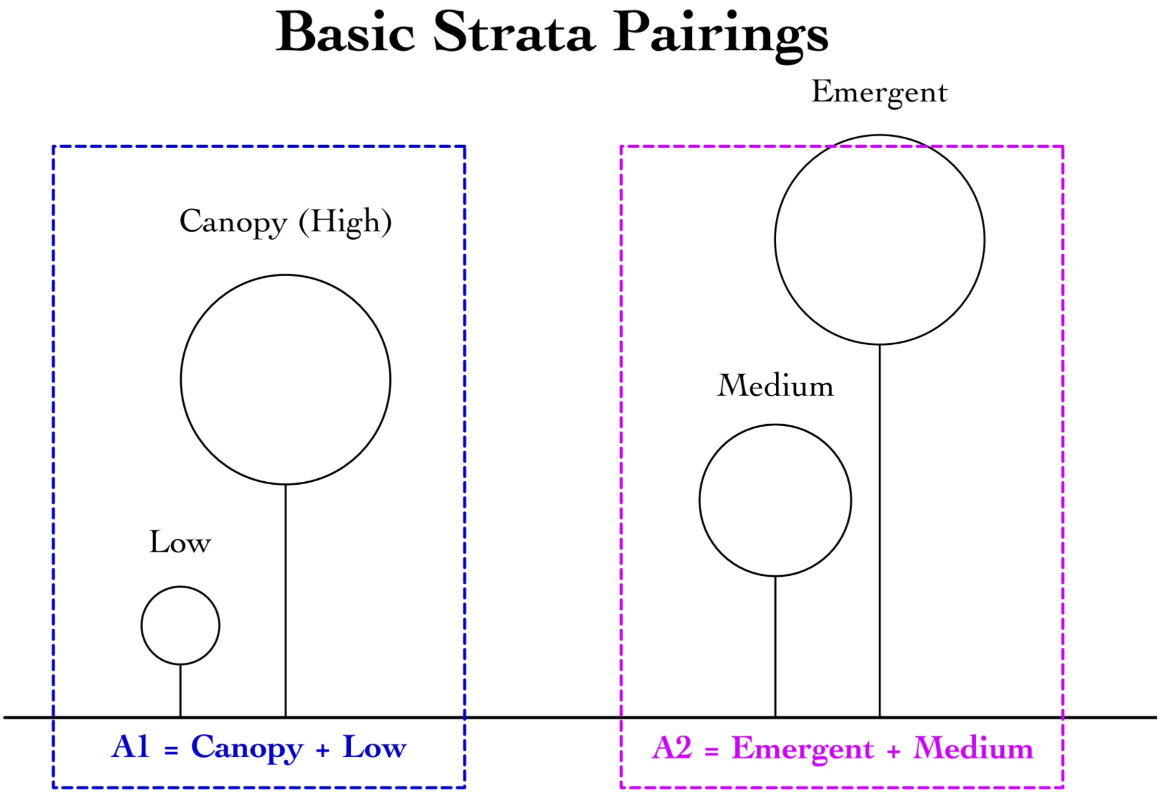


Strata categories without target area occupancy for simplification. Credit: Joshua Finch for Novia UAS

In successional agroforestry the different layers become four groups: emergent, canopy (high), medium, and low. It is important to note that there are no set parameters for defining each of these strata. This is because the answer to “what is medium” is context dependent: the strata are internally self referencing to site conditions. For example, an oak tree planted by an acorn may, eventually, occupy the emergent or canopy strata of the system, but by no means is it in that position during its formative years. In a successional agroforestry system, other species are occupying those strata during the time it takes for the oak to grow into the strata we have planned it for. A successional agroforester, therefore, doesn’t only plant the “final” target plants in an effort to create an agroecosystem. Instead, such a system incorporates other species- alongside the desired oak- to co-develop the agroecosystem with their particular talents and needs in a concerted manner through space and time.

Sometimes the alternating pattern of consortia follows an identification nomenclature of A1-, A2- and C- lines. Josipa’s system is more complex and diverse than this and thus the pattern does not fit precisely, but it is still a valuable tool for comprehending how different polycultures can interact with one another in a mutually reinforcing way. To help understand this, some basic definitions follow:

- **A1-tree lines** combine target crop species which occupy the canopy (high) and low strata at maturity
- **A2-tree lines** combine target crop species which occupy the emergent and medium strata at maturity
- **C-lines** can focus on early succession perennial cash crops and biomass producing species
    - These are intended to be shaded out once the A-tree lines close canopy
- **B-areas** are the alleys between lines of trees and can often be used to grow annual crops and short lived perennial cash crops while the tree systems are maturing
- The width of the **cultivation bed** of each tree line is 80cm
    - The cultivation beds are 80cm wide so that they can accommodate additional plantings and mulching alongside each line of trees running down the middle of the bed
    - In this way each tree line is like an annual “market garden” bed with the clear difference being that the beds are planted with species from each stage of succession, from an open field to late climax
- **Simplified Stratification:**
    - **Emergent** plants do not dominate the system at maturity, but grow above what forms the majority of the canopy at any stage of the system’s lifecycle
    - **Canopy** species occupy more than half, but not all, of the system and in some sense “form the roof” of the whole
    - **Medium** plants fill in the niche between the canopy and lower growing plants
    - **Low** species occupy the ground layer and towards the lower part of the medium species



Combining plants by skipping a strata helps reduce aboveground competition and fills ecological niches. Colors correspond to annotated photographs provided earlier. Credit: Joshua Finch for Novia UAS

The tree lines are not laid out across the field in an A1-A2-C pattern, but rather an A1-C-A2-C-A1 [...] pattern. When laid out like this, succession does not only serve as a means to employ different cash crops at different stages of system development: the dynamics inherent in ecological progression are collaborated with to alter site conditions to such an extent that “problematic” species, like raspberries, can be planted in lines which will be shaded out by higher stratification and longer life cycle species. In other words, species that are quite vigorous in the early stages of the system’s development can be readily incorporated if you have a system plan that removes their niche over time.

In addition, the mature stage target crop species are designed to coexist together through spacing and using “skips” between strata. By combining a species that grows taller and needs more light with those that grow lower and tolerate or prefer less light, one partitions the space aboveground. The species have different niches and thus will not physically interfere with one another above ground. If you combine them well, not only will they not physically occupy the same space, but they will complement each other’s growth by more fully utilizing the resources available.

While some people worry about competition between these plants for belowground resources, despite the species having different ecological niches, this is alleviated in part, but not solely, through the high amount of biodiversity included in the system. Evidence from grassland studies and on-farm trials across the globe point to sufficient functional biodiversity playing a very important role in switching the behavior of the plants and their microbiomes from a competitive strategy to a cooperative one (Jochum et al., 2020).

The same relationship dynamics which allow a sufficiently biodiverse cover crop in an annual based agriculture system to cooperate and build soil faster are mimicked through diversifying the macroorganism with a wide range of plant species with different life cycles and niche requirements. The concern about competition for resources between species is largely a result of monoculture practices. Monocultures both occur in- and are a large part the cause of- degraded soils which encourage species to express genetic patterns for competitive life strategies that allow the individual to reproduce under poor conditions. Organisms are equipped with these strategies because they have helped in the past. They are also equipped with other growth strategies which also utilize cooperation, which, in a natural system, is more common than monoculture agriculture.

The space between the tree lines is known in agroforestry as an *"alley."* In successional agroforestry these are often called B-areas, I will call them alleys. The width of this space and where you decide to start measuring it varies from system to system. A common spacing determinant in agroforestry is the working width of the largest piece of equipment. In Josipa's system, she designed alleys measuring 7 meters from A-tree line to A-tree line. Once you subtract the two 40cm spaces that are designated for the cultivation beds, the alleys become 6,2m.

Growing crops in the alleys is called "alley cropping." Josipa included *vegetable beds* in each alley. The species grown here were also planted as stratified polycultures. Instead of stratifying the plants years into the future, they are combined with a kind of crop planning more relatable to most farmers: time to maturity. The vegetable beds were implemented in part to provide additional cash flow. Growing vegetables in polycultures is easier said than done! The decision to include these vegetable rows contributed to a number of management challenges that Ernst was, in part, brought in to address.

In typical "syntropic" systems, the alleys are often also sown with fast growing grass species (C4 if possible) to be used for biomass production. They are cut and used as mulch on a regular basis. I will discuss the implications of this approach, as I understand it, later. In this case, the existing perennial couch grass, dandelion, and others, were left to grow with the intention of producing mulch material for the tree lines.

What can be called C-lines are situated halfway between two A-tree lines (3,5m tree to tree in either direction). Again, the measurement is not taken from the edge of the 80-cm wide cultivation bed. This measurement convention is characteristic of "syntropic" agroforestry in part because the use of alleys as cultivation zones are set to “disappear” as the system progresses through time. Once the trees from the A-lines close the canopy and there is a large amount of organized mulch on the ground, it can become difficult to discern where the edges of the original tree beds were. What is left that is easily distinguishable are the trees. Establishing the distance across the alley between them is important for proper spacing. Although it is a common way to do things, I personally find it harder to wrap my head around the dimensions when the system is measured this way. Using the distance between the cultivation beds to describe the alley is clearer for me.

If the A1-A2-A1-A2 planting pattern was implemented rigidly, then species of the same strata can be up to 14 meters apart across the system. As the system matures, an undulating pattern will emerge that is regular and appealing to the eye. In Josipa’s system, species diversity is quite high: pear, apple, walnut, plum, elderberry, quince, hazel, rasp and blackberries, currants, rhubarb, and strawberries are just some of the edible perennials already growing in her forest. These species are accompanied by a large number of other species such as oak, alder, willow, and poplar, in order to draw on biomass generation opportunities as well as the relationships that develop between biodiverse plantings.

Josipa’s planting pattern is not as rigid as the A1-A2 pattern might suggest. In addition, although we have a good idea as to the life cycle of most of these species, how the system actually develops as it matures is in large part up to the decisions of the farmer: how they choose to prune (or not) certain species and which ones to “favor” and which ones to cut out- these things are dynamic and only time will tell.

Josipa amidst the diversity of her young forest. Credit: Josipa Bićanić

Ernst's Feedback on the Established System

Ernst's Swiss German heritage reminded me of a German professor I had during my university days studying History. Straight and to the point with language that, devoid of context, appears more harsh than it is. With over forty years of farming experience on multiple continents, Ernst has developed a strong eye for what makes a system tick along or fail. One part of his philosophy that I have not discussed thus far is his embrace of "unconditional love" inspiring relationships between all organisms. You could tell that he is a person with an unshakable connection to his life purpose. He moves with a steady hand and inexhaustible deliberate energy all day long. At times Ernst appears to live wholly in the present moment, a practice that is facilitated by how strongly his actions are aligned with his purpose, as stated earlier, to help modern people reconcile themselves with the whole. So although his comments can sometimes sound harsh, his actions as a whole (in context) provides ample evidence that criticism is not the goal: facilitating understanding and change is.

Although I will focus on the challenges Josipa faced, I have to balance this by telling you that her forest is *beautiful*. And the plants that began to thrive in the initial season were quite healthy and continued to bear fruit (literally) in October. Under the deep mulch of grass cuttings, worms and fungi were proliferating rapidly and making the most of the disturbance event she created by planting the system. To focus on the challenges and Ernst's feedback, as I understood it, is not to take away from the successes she has and will continue to experience. Instead I look to the challenges because they are the ones we will learn the most from.

Some of the challenges Josipa encountered during the first year of establishment were:

1. Slugs caused significant crop loss
2. Less than desired growth on some perennial species, including garlic
3. Effectively managing the grass in the alleys

1 Slugs

In our climate most gardeners and farmers take the presence of slugs (and snails) for granted. There are strategies to reduce their population that include things like habitat management and of course the use of pesticides, even organic. Ernst understands that like all organisms, slugs have a function. My understanding is that he sees an overabundance of them as an indication that the system is unhealthy: that it is providing the right kinds of conditions for their proliferation. The difficulty in managing the grass in the alleys, for example, leads to an increase in their habitat immediately adjacent to the tree lines and the vulnerable vegetables. It isn't that the design is "wrong," but rather the design is out of context with the current state of the system.

Ernst giving advice on how to reverse the slug grazing operation. Credit: Saul Avery

According to his observations, despite being largely sandy, the soil was compacted due to previous land use. Soil compaction, lack of biodiversity, and mismanagement (that is, management that does not actively improve the functioning of life), were all present *before* Josipa implemented her system. And although she took well advised steps to alleviate many of these problems, nothing gets fixed overnight.

Also, by edging her cultivation beds with small imported logs, she created protected spaces where the rhizomes of the couch grass could proliferate up and down the system. Without removing the logs, because Josipa understood the benefits of including them, the grass was harder to manage. Thus a habitat conducive to producing food for slugs (older material on the grass crowns, for example) and the sheltered conditions for laying eggs (under the logs and inside the bark) was created as well.

Ernst called this a “slug farming operation” which we quickly dubbed a “holistic slug grazing operation” to make light of the significant headache these species caused Josipa during this past year. In order to rectify this situation, a few things needed to be done:

1. Recognize that the alleys were too small to produce sufficient biomass due to the poor state of the grass and ecosystem
2. Cut the alleys closer to the ground to reduce the amount of old material for slugs to eat
3. Use this material for mulch
4. Remove any undesired species from the cultivation beds (dandelion, for example)
5. Remove the logs that edged the beds to make #'s 2-4 easier in the future
6. Address #1 further by utilizing the biomass growing elsewhere in the area under Josipa's care
7. Potentially use geese or ducks accustomed to eating slugs and snails to hunt them around sunrise and again at sunset, a challenge we all understood at our high latitude (dawn is around 3:30 in the morning in June)

Most of this made a lot of sense to me. I also farmed a place with a lot of slugs and snails. Since I did not use pesticides and did not have the context for ducks, it was only through reducing their habitat (and humbly removing lots of log edging) that I could reduce their population. I'm still interested to see whether the deep mulch on the tree lines will accommodate slugs even with these changes, so time will tell.

2 Less than Desired Growth

As mentioned in the design section, Josipa has more than 14 species of edible perennials in her system. Once you count in the annuals and some of the perennial herbs the count goes much higher. So it is perhaps without much surprise that not everything grew as well as she'd have liked. Now, weather does play a big role but even more so is the state of the system at establishment. Even with the addition of compost, wood chips, organic fertilizers, and other soil amendments (like mycorrhizae), any new farming operation on degraded pasture is going to face challenges. In comparison to other new farming operations, such as no-dig market gardening, the amount of inputs used in Josipa's system was low. We'd be well to keep in mind how tough the first years can be with the Lill-Nägels project.

To treat these deficiencies, Ernst recommended adding more biomass and paying attention to the specific displays of issues and addressing them with locally sourced solutions. Note that I did not say "go buy fertilizer" even though the use of chicken manure pellets was one of his suggestions. Ernst pays a lot of attention to the words that he uses. He consciously chooses to reframe his language as he tries to more accurately describe the world.

[For example, he does not say that such and such a species "yields" such and such an amount of production. He very carefully will not only qualify the yield from a species as not being constant, but also makes sure to note that said production is harvested by people. Trees do the production and we are the ones doing the harvesting. It is when this nuance is removed from our conversation, often in order to cater to the "too long, didn't read" crowd, that people think Ernst is making fantastical claims about his systems. You really have to listen to him very carefully- not that he isn't fluent in English (and many other languages, because he is)- and try to look at things from his perspective.]

Let me give another example of this that ties this discussion back into “less than desired growth.” If we are talking about “fertilizer,” we already have started on the wrong path. What we need, instead of treating symptoms, is to facilitate life processes- relationships- in order to rectify the improper function of the macroorganism. The ecosystem is not just made up of individuals, as discussed earlier, but also all of those relationships. Ernst talks about choosing something with a “tighter relationship between carbon and nitrogen.” In this context, he wants a material with a higher amount of nitrogen so that the microorganisms- the decomposers- can put the mulched material to faster use. Composting in situ. His first choice is not to fertilize the plants. His first choice is to facilitate the process by which soil organisms utilize organic matter, which ultimately benefits the plants.

So if you have an issue with less than desired growth, it seems to me the last thing Ernst is going to do is mindlessly say “add fertilizer.” Instead he wants you to think about the whole system, including inspecting the decomposition rate of your mulch, and how you can intervene to improve the natural functions. Only after you have done what you can to support processes would he suggest, for example, side dressing potatoes and garlic with chicken pellets. Even so, Ernst is very aware that even the use of compost can throw the soil relationships out of balance. He prefers to work with processes only- no outside inputs whatsoever besides the seeds & tools to manage those processes- whenever possible. But everything depends on context: just because this is his preference and within his ability (and resources) doesn’t mean everyone must rely solely upon processes.

Supporting natural processes for soil fertility through use of organic materials. Credit: Josipa Bićanić

3 Effectively Managing Grass in the Alleys

Growing predominantly grasses in the alleys between tree rows for mulch is a hallmark of this type of agroforestry. Ernst is quite fond of saying that there "is never sufficient organic material." With an alley width of ±7 meters, mulch management could be both quick and effective. The degraded pasture grass that was already on the experimental field was not the ideal start but was left because of financial and time reasons. The intention was that this grass would serve as the biomass producing component of the system.

To manage it, one should follow the growth pattern of the grass and cut it at the peak of that growth curve, similar to the guidelines for responsible grazing. The "grass" should not be "overgrazed" in the traditional sense, that is, cut again before it has time to fully recover. A more contemporary understanding of overgrazing is that overgrazing occurs when a plant is cut or eaten to the point of severe root stoppage which begins at >50% removal (Biodiversity for a Livable Climate, 2014).

Learning the growth habits of different species of grass takes time and experience, but a commonality is paying attention to the formation of flowering stems. As a rule of thumb, he suggested being prepared to harvest the grass on a three or four week rotation.

Cutting requires a specific motion, either using your body in addition to a biomass harvesting tool like a scythe, or the same kind of raking motion from a mechanical implement which simultaneously cuts the grass and forms a windrow. This kind of motion is most efficient when you can use the whole sweep of your body or employ a larger tool. When done by hand, short, half turns do not allow for as much speed or efficiency, not to mention being less-than-ergonomic.

Devoting alley space to vegetable production resulted in the system resembling a market garden with living pathways: instead of ±3 meters of grass between an A-line and a C-line, the space was diminished down to two ±105cm strips. The amount of space dedicated to growing edible plants was increased, but the amount of biomass available to augment the tree lines' decomposition cycle was decreased. I'll touch on differences of opinion regarding the management of biomass production areas later, but suffice to say that cutting a larger number of narrow alleys made for slow going.

The use of logs alongside the tree beds- which bring benefits for soil development and habitat for beneficials- also slowed this work. Even if the alley biomass was cut mechanically there would be the additional steps to move the biomass up and over the logs into the beds and subsequent "edging" of the system. Ideally the windrow would not need to be moved at all; instead, it would be piled right where the mulch needs to be. The negative interaction between logs and efficacy of mulch management is an example of how experience can inform changes to desired system patterning: Ernst quickly noticed the disharmony and offered approaches to correction.

Without asserting that this was the case for Josipa, I will share from my experience that when things go slower than anticipated it is very easy to begin to do a poorer job because of the mounting frustration. I think that too often the mind-body connection gets overlooked in farming discussions so it is important to bring up how design impacts our feeling of advancement towards a goal and the impact that has on our nervous system.

An agroforestry system in which you can effectively accomplish each task is one that has removed obstacles during the design phase *or* after feedback. While catching the error in the design phase is preferable, being open to adaptive management is even more important because no design will ever remove all hiccups. Ernst is a master of adaptive management.

To facilitate the management of this system, Ernst recommended that:

1. Large amounts of mulch should be harvested from elsewhere in the area under Josipa's management where no trees have been planted
    a. This would greatly increase the depth of mulch near the trees
    b. More mulch helps reduce the encroachment of undesired species into the cultivation beds

    c. Harvesting the biomass from elsewhere in her area will reduce the habitat for slugs which migrate into the agroforestry system proper
    d. As a note, this was Josipa's original idea but she had been initially advised against it!
        i. If anything highlights the need for contextual advice, this is it
2. Edge the log-lined beds with hoes or the brush cutter (less than ideal as that tool can hit the logs and cause issues)
    a. Most likely the logs will be removed to eliminate a step in management that brings more costs than benefits at this point in time
3. Stay on top of the growth curve of the biomass plants in the alley ("grass")
    a. Prevent plants from becoming senescent (plants that are no longer actively growing and are sending what might be called "status quo" information into the ecosystem)
4. Use a higher grade brush cutter with a larger blade to handle the amount of work
    a. In this system, a brush cutter is a versatile tool that can be used to:
        i. harvest biomass into windrows,
        ii. quickly edge beds,
        iii. reduce woody mulch material into a finer texture,
        iv. set back unwanted perennials during bed preparation,
        v. and even act as a shallow soil tilther for incorporating seeds.
    b. Ernst recognizes the time gains from using power tools when appropriate and definitely does not shy away from mechanization.

Walking windrows made by a double pass with the brush cutter; organizing and moving biomass produced on site makes for an honest production system. Credit: Joshua Finch

As you can tell from this section, the idea that Ernst believes all the biomass needs to be produced from "only within the system itself" perhaps is off the mark. Ernst encourages people to look at the whole area under their management. As a farmer used to working on hundreds of hectares at a time, Ernst definitely understands the implausibility of purchasing enough organic material to power these systems, hence the emphasis on self-sufficiency. "Self" does not imply "in-situ."

With Josipa's system, she is currently creating a miniature forest. If there are materials at hand- in our case less than 50 meters away- under her management, why not use them? Especially when managing that resource would *also* 1) reduce the habitat for slugs and snails and 2) reduce the amount of time spent weeding by using deeper mulch more effectively. Where the "macroorganism" begins and ends is one of the age old challenges of holistic management. Certainly, though, considering all the resources at your disposal on site is a fair move.

<u>Established System's Feedback Conclusion</u>

I'm going to conclude this section with a discussion on how I interpreted Ernst's overall approach to troubleshooting Josipa's agroforestry system. The first thing I noticed is that, although Ernst can be very direct and blunt in his feedback, he directs it skillfully. Yes, there were some "errors" in design of the original system that caused some significant headaches. But instead of focusing on the errors and dwelling on them as a "failure," he understood that the errors were the result of very good intentions. He could obviously see how much work and effort had been put in over the past year, he could see the attentiveness to detail, and that the soil was improving alongside the growth of all the plants.

Not everyone started gardening at the same age as he (about two years old). Not everyone has farmed and lived a lifetime engaging with this kind of system. So I appreciated his desire to use that wisdom to focus on the critical points where intervention would bring about the most positive change. Again, drawing on a lifetime of experience means that he could ascertain what those were and assess what to do about them *with the resources on hand*. Ernst said that we should not plan on what we don't have. He is not fond of ideas that will not be carried out: "if only we had this, if we could do that, maybe I could…" are phrases that will bring out Ernst's persistence to act on what is known.

Far from being someone to just tell people what to do, Ernst personally took up every single step of the operation to make adjustments and demonstrated them to each and every one of us. Of course, it was helpful that there were rarely more than four of us there at a time- this was not an open course- but it showed his commitment to those who are open to learning. If you ask Ernst to "show you his method" he will stand side by side with you for as long as it takes. In this way, he identified not only issues with the set up of one of the brush cutters, but he also fixed what appeared like minute issues with my technique that were actually key mistakes. Namely, don't do any lifting with the cutter or the material will fail to "rake" as you harvest biomass. It was a subtle change, a very little bit of lifting, that was causing me to mow rather than gather the grass. A teacher who isn't interested in constructive criticism wouldn't have taken the time to train me.

Ernst Götsch up and at it in the early hours cutting mulch for the system. Credit: Josipa Bićanić

The last thing I will say is that his recommendations were based not just on what he saw, but also on what the farmer wants and needs. He doesn't work with recipes. Nothing I have said above is "what Ernst would do everywhere." His specific recommendations were aimed at helping Josipa, ***not*** at providing a blueprint for temperate climate agroforestry worldwide. Keep this in mind especially with regards to mulch. Learning the pattern language of ecosystems is critical: the specific bits of information are only useful if you know how they relate to the big picture.

Establishing New Tree Lines

Beyond course correcting with her established system, Josipa also wanted Ernst's hands on the wheel when setting up new tree lines. Josipa had already laid out some new rows, running in the same direction and continuing the same A1-C-A2-C pattern, in July with deep mulch on top of the existing old pasture grass. Prior to Ernst's arrival, she and her friends helped prepare some of them to a higher state of readiness by broadforking, shallow cultivation, and adding compost to the surface.

Josipa had also gone ahead and purchased a number of young fruit and nut trees along with collecting cuttings and seed. The idea was to hit the ground running with Ernst's ability to design with materials on hand.

Putting the work into context

At this point I think it would be worth returning to the idea of succession and its relationship to "syntropic" agriculture. I want to do this because, once you hear about how much time we spent setting up these beds- even after taking into consideration that our lack of speed was in part due to the learning that was taking place- you might begin to wonder how any of this could be worth the time invested. From discussions over the years, the question of labor- especially manual labor- continues to be one of the top reasons people turn away from more complex systems. While I sympathize with the concern, especially about setting up systems that require enormous amounts of labor on a never ending basis, I do feel as though mechanization of farming has led to an unbalanced attitude towards working with your hands.

Everyone pitching in to initiate the new rows. Credit: Josipa Bićanić

In most gardening and crop farming people are working on an annual or at most biennial basis. Most things get repeated regularly: preparing, planting, tending, harvesting, planting, weeding, tending, irrigating. Over and over again the same thing with perhaps a different cast of characters. The return plateaus or peaks at a discrete point in the year and whatever that return is must cover the cost you put in as well as provide a surplus for you to continue into the next annual cycle. It is possible to do this well and reach new heights for your plateaus and peaks, but it is still a short cycle.

With agroforestry you are working on longer cycles. In many cases agroforestry systems are designed to provide a singular economic return with, perhaps, some additional attention paid to increasing the inherent benefits like habitat or wind break formation. If you design a system like that, you will be waiting a while- years- before the returns start to come in. But in some sense it is meant to be very predictable, just like other forms of simplified agriculture.

In contrast, *successional* agroforestry systems start producing returns as soon as the context allows. A key insight that Ernst has had is that setting a system like this up for success means including all the possible players from the very beginning. The initial work to prepare the beds in a traditional manner- tilling, subsoiling, applying soil amendments- is the same whether you plant a willow coppice or a multi strata, highly diverse system. The difference is that in the latter system you are incorporating more return from the start. In other words, making better use of the investment and disturbance event.

Yes, it does require having more on hand- plants, seeds, and cuttings- and that is more work and expense. Successional agroforestry also requires a considerable amount of planning. All very true. Still, one needs to consider more than the upfront costs: going back to succession and ecological concepts, the effort to have the species available from the start means that you are filling in the niches that are available and *will become available as the site changes* with desired species. You aren't leaving it up to chance that "nature" is going to fill the niches with what you want. A simple willow windbreak does cost less at the start, but *it will leave every niche that the willow does not occupy open* for chance occupation. Then we say we have weeds and complain that managing the system is a cost with a long, delayed ROI.

Such a reductionist approach to creating (and evaluating) agroecosystems is simple minded. It reflects a lack of interest in how nature operates. So when you hear about our planting pattern for carrots, potatoes, and garlic, try not to imagine deducting the "cost" of implementing the whole against "Season One's" cast of characters. Try to understand that the processes we set into motion are part and parcel of developing the agroforestry system. Incorporating annuals incentivizes care and attention from day one through the eventual harvest of cherries, hazelnuts, and whatever else comes in 20 years from the very same row.

Every time Josipa interacts with her system she will be gaining knowledge, experience, and information. Every time she interacts in a thoughtful way, supporting ecosystem processes, she improves the likelihood of success for the later crops. That starts with the "placenta." When you know how many agroforestry systems flop because they were too "top heavy" and couldn't justify their existence, the plain honesty and comprehension of ecological function of Ernst's work starts to show through.

Lastly, let's keep in mind that we were working with the tools, supplies, and resources we had on hand. Josipa's system is a pilot project. It is less than 1000 square meters. There's no reason to assume that we would have front loader tractors, hay making equipment, and other machines on hand to support a project like this. Just because what you see here isn't mechanized doesn't mean that it couldn't be fully or partially tooled for a larger scale. Recall that Ernst's farm in Brazil is over 400 hectares. Ernst regularly uses machines and is actively involved in developing new ones.

Still image from the film 'Life in Syntropy' (10:53) depicting a large scale agroecosystem implemented at Fazenda da Toca, Brazil. Credit: Agenda Götsch with Dayana Andrade & Felipe Pasini + Team . Farm: https://fazendadatoca.com.br/imersao-em-agrofloresta/

Establishing a Tree Line with Potted Plants

One of the new tree lines was intended to be planted out with purchased plant materials. The three key species Josipa had on hand for this were cherry, plum, and hazelnut. As this wasn't a course per se, Ernst did not grab a white board and draw out the system. The tree lines were longer and we had an actual place to pace out and put down the plants to get a sense of space. Having some knowledge of the plants was crucial to understand the planting pattern we used.

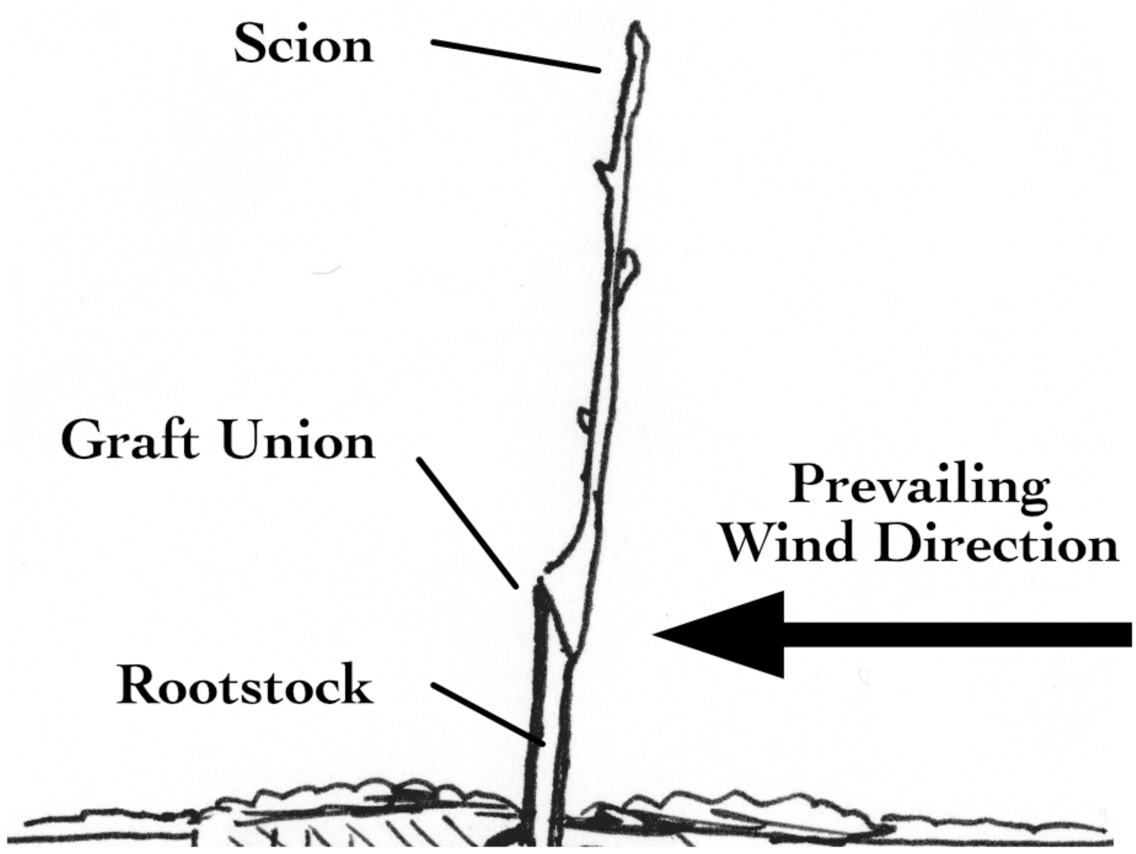
Although Josipa had hoped to use bare root plants, those were not available at the time so she invested in potted ones. Ernst was not happy with the quality of the plants. As he says, potted fruit trees in particular are often those bare rooted plants that did not get sold during the winter to professional growers and were put into containers, loaded with fertilizer, and otherwise encouraged to grow rapidly in order to impress an untrained eye. If you weren't wise to the poor graft, you probably weren't going to lift the plant out of its pot either. If you were to inspect the roots you would see how they were circling in on themselves, which can reduce the tree's vigor or even eventually strangle it.

Despite the plants' poor start at the nursery we wanted to plant them anyway. So Ernst gave direction on how to prune the circled roots and make a "balancing" prune of the top growth so that the reduced root system would not have to support as many stems and leaves. The next thing we needed to do was plant them in an intelligent pattern.

Stratification is relative to the species used in each polyculture- not to theory. In this scenario, Josipa's cherry will occupy the emergent strata while the plums and hazelnuts will occupy the medium to medium-canopy strata. How the plants are pruned will affect their total size, but overall you want to think about what the plants will grow to naturally (or given a rootstock limitation) and plan from there. Focusing on the natural growth patterns, largely affected by the amount of sunlight the species requires, also means that Ernst likes to work exclusively with same-species-rootstocks and not graft onto dwarfing rootstocks or onto entirely different species (like pear on rowan).

We planted a plum first at the south end of the bed. I believe this is in order to allow more light to enter the system because if you plant a canopy or emergent strata there it will intercept a lot of light and cast shade, so perhaps it is better to plant a shorter species at the start of a tree row. This is also how we've planned the species assemblies for the project at Lill-Nägels from the start.

When you plant a grafted plant, Ernst suggests that you take into account the prevailing wind direction. Just like in southern Finland the wind typically comes from the west or west south west. So we placed the grafted part of the plant (not the root stock) facing that way. If you place the graft to the "leeward" of the prevailing wind direction, the wind will push the unsupported graft and it can snap off. If you plant the graft facing the wind, then the wind will push the grafted scion against the rootstock and it will be less likely to break. This is one of those little details that is often left out of planting guides and which experienced gardeners and farmers learn over time.



Basic sketch showing how to orient a basic graft towards the prevailing wind direction to reduce risk of breakage. Credit: Joshua Finch

The sandy soil in Josipa's field meant that we could approach planting with established trees. In high clay content soils, or totally clay, Ernst most definitely favors planting almost everything by seed. But we had sand to work with and we began digging. First, Ernst is careful to rake away any compost or mulch from the soil surface and place it into equal piles on either side. Next, Ernst will dig vertically: the first spadeful of soil is set aside in its own pile. This is to ensure that the topsoil is kept separate from the incoming subsoil. Yes, this is rather common practice, but Ernst is *very* careful about this. There are different microbial communities in the different layers of the soil and we want to return them to where they came from. Respecting the organisms extends to those unseen in addition to the plants: so set the subsoil in its own distinct pile. Loosen the soil piles to make backfilling easier. Instead of digging a hole 2x or more the size of the root ball, we dug just a little bit larger. We did, however, dig much deeper than I've usually seen.

As you dig into the subsoil you will probably find a compaction layer. This is often about 25cm deep in our region due to how plowing is typically done. A plow pan can last a very long time even after plowing has ceased. Since we only dig a hole for a tree once, we need to dig down and break through this to (hopefully) looser layers below. After you break through, Ernst showed a method on how to continuously lift the shovel up and down to backfill any air pockets formed while digging. Next, reduce the depth of the hole to an appropriate size for the new plant with your reserved subsoil. This also needs to have the air pockets removed.

Now that the hole is the appropriate size, it is time to get the tree in the ground. Be careful to arrange the roots so that they aren't oriented into a circle, especially if you have just pruned to help alleviate this. In my opinion smaller specimens are always easier to work with in this regard! Carefully backfill with the reserved topsoil. That backfilling is followed by using the air pocket technique in a circling motion around the rim of the planting hole to get the topsoil into all the gaps between the roots. One thing we *didn't* do is push with our hands, although he showed how you can use your fingers to backfill in a similar manner. Once the hole is filled you can bring the compost back around the tree and perhaps mix some of the leftover subsoil with it.

Note that we did not add any soil amendments to the hole! There was no fertilizer, no micronutrients, no mycorrhizal inoculants, no lime. The technique is about supporting the tree by taking into account its strengths and weaknesses and facilitating its ability to reorganize itself underground. With care taken to alleviate soil compaction and integrate other species to work in concert, the tree can begin building new relationships. Compost and mulch belong on the soil surface. Through the decomposition cycle, those parts of the material that can be transferred or leached into the soil profile will do so naturally.

Next we moved about 4 meters north of the plum and planted a cherry tree together with a saskatoon (juneberry, *Amelanchier*). This was in part to demonstrate, not without justification, how you can use "one hole" to plant species from different strata and niches together. Saskatoons are multi stemmed fruiting shrubs that can grow to the size of a small tree.

They are rapidly growing and provide a crop sooner than the cherry. The saskatoon, however, won't grow as tall as the cherry, nor will it live as long, and together they will make the new agroforestry system more robust. They were planted root ball to root ball with the saskatoon taking the "favored" location to the south.

Afterwards we planted the rest of the plums and hazelnuts to the north (behind in relation to the sun) giving about 3-4 meters between. The gaps between species we had on hand would be filled by tree seeds, cuttings of willow, elder, and poplar, but also have additional cash crops of currants. Ernst suggested that the currants be planted according to their different light preferences: red currants where partial shade would prevail in the afternoons (the east side of the bed) and black currants with a warmer and sunnier aspect (the west side of the bed).

Strawberries join the system alongside trees planted in another row. Credit: Josipa Bićanić

For a lot of people that level of diversity is hard to comprehend. But we went one step further. Any successional system worth its salt also includes other species with very different life cycles.

Adding annual species to the tree system

One problem that Josipa faced in her established tree systems were slugs and snails eating emerging vegetables but also trees and shrubs from seed. Ernst suggested that another way to avoid this herbivory is to plant susceptible species at different times of the year.

As an example, Josipa chose carrots. In order to plant them Ernst had us create a ridge out of the compost right down the middle of the bed, which we then added a small furrow to. In effect we created a little ridge with a shallow, concave, furrow perched above the rest of the compost. This is where we would plant the seeds, giving ample spacing between them. Now, our trip coincided with the onset of autumn in Denmark and perhaps these carrots may not have the best chance of survival. However, we wanted to do it anyway because a large part of our learning was to see how he would approach things. In any event, planting dates are always adjusted based on experience. The carrots were seeded by hand along the length of the furrow. Interestingly, they were not yet covered or pushed into the compost. Ernst was very adamant not to disturb the seeds yet.

Although the crew is planting tree seeds in a different tree line than I've been describing, you can see how the polyculture is taking shape with potatoes, garlic, carrots (covered), and tree seeds. Credit: Joshua Finch

So now we have a tree row with plums, cherries, juneberries, hazelnuts and carrots. Things are starting to get quite interesting. All of these plants are in a straight line down the middle of the row. That means we had about 30-40 cm to either side which had been decompacted and covered with some compost. It was here that Ernst wanted to add garlic and potatoes into the mix.

As far as we know, no one commercially plants potatoes in the autumn in Denmark or in Finland. That said, potatoes left in the ground in our climate often do survive and sprout again. It is one reason for a long crop rotation in conventional systems to avoid pathogens and such. When combined with the deep mulch system I am about to describe, Ernst was confident that the potatoes would not only survive the winter, but they would do very well. I tend to agree with him because, "as a Finn," Denmark is a southern country with a mild winter where anything is possible.

Potatoes are special in that each spud is a really large reservoir of energy and potential. So if you want to plant something that can hold its own against potential weeds, potatoes are at the top of the list. They also produce a prodigious amount of root exudates. Ernst's planting method was to not "plant" them at all. We would take advantage of the fact that potatoes don't need to be buried to start growing by simply firming them into the compost along the outer edge of the bed. He encouraged us to think of them as a shallow root crop: by not burying them the harvest will be easier as well. We spaced the potatoes widely, varying depending on their size a bit, but more or less regularly at 25-30cm or so. These big potatoes will serve, in some sense, as guards against infiltration from unwanted species coming into the cultivation bed next season. They will be aided by a very thick layer of mulch that also doubles as a means to prevent greening of the potatoes.

For Ernst, though, potatoes and carrots weren't enough. Josipa, in part due to my encouragement, has taken up the cultivation of garlic. Her "garlic from the forest" was a real winner at a local market and she was keen to plant it again. We planted her own seed garlic in a double line straddling the carrot bed, roughly 10-15cm apart. Like potatoes, garlic starts with a lot of energy in each clove and doesn't really care about being put underground (provided it is mulched). Ernst directed us to push the cloves into the loosened soil as far as they would go without worrying too much about depth. I've always planted twice as deep as they are large, but in Denmark's relatively mild climate, together with a thick mulch, Ernst believed that they'd be just fine.

In a typical market garden, or even an atypical one like my old farm, this would have been close to the end of preparing a bed for winter. But Ernst has another strategy up his sleeve: a very careful layering of mulch materials to create a microclimate to shelter the seedlings in the middle of the bed from wind, capture solar energy in a warm pocket, and also help direct moisture to the seeds.

This is where the significant amounts of grass that were being cut would come into play. His approach resembles lasagna gardening in which you layer different kinds of biomass, but without the pesky cardboard or newspaper. First we covered the potatoes and garlic- but not the carrots- with a ±40cm deep layer of grass. Grass, especially aged material, has a "loose" relationship between carbon and nitrogen (it has a lot more carbon than nitrogen). It can take a while to begin decomposition on its own. Microbes need proteins and sugars (and fats) to help them consume material and if you consider nitrogen in this form to be more like a protein, then you'll understand why undernourished microbes take a while to eat through the grass.
Layered mulch begins to form a central valley: grass layered with pumpkin vines would accelerate the decomposition process. Credit: Joshua Finch

In this case we could provide a high protein diet for the microbes and earthworms by using waste pumpkin residue from the neighboring organic market garden. Their pumpkins had recently died from frost and were now in need of removal for composting, so Josipa got permission to harvest their waste and use it herself. Pumpkin vines not only have a lot of nitrogen left in them, but also have a lot of water. Once the cell walls begin to break down that water will be released and put to use by the system. Using high water content mulches is also a hallmark of Ernst's systems with banana often being the most recognized species. Clearly bananas don't grow here but we have analogues of a sort, such as zucchini vines or if you want a perennial it might be rhubarb or comfrey.

We hauled pumpkin vines for hours and placed them alongside the rapidly diversifying and complexifying tree lines. Once we had enough material, the pumpkins were carefully placed on top of the grass in a modest layer, say 10-15cm deep. That was covered once again by another 25-30 cm of grass. Our concave cradle of carrots that had risen above the plain of compost was now dwarfed by towering lasagna-layered composting mountains. Note that I will elaborate on this context specific system more in my commentary section on mulch.

Ernst is very particular about sculpting these mountains. You have to ensure that they thickly cover the outside edges of the cultivation bed- that is, you have a good 10cm or so of mulch protecting those potatoes. Then the hills need to gradually slope inwards towards the saddle of seeds but they should not cover them. This concave shape has been experimented with by him and others over decades and has shown lots of merit as mentioned previously.

Upon completion the system takes on a very unique shape with the layered deep mulch and precise arrangement of biomass. Credit: Josipa Bićanić

While we were building out this bed I also want to mention we were working on another project: a tree line from seeds without potted plants.

Establishing a Tree Line by Seed

Ernst's approach to agriculture is clearly coming from a different paradigm than the norm. His frequent exhortation to forgo wasting time and resources on potted plants and instead focus on establishing systems with seeds and cuttings is one of those things that divides the community of people interested in his ideas. Especially people who live in "less favorable climates" like Denmark or Finland. The idea of planting apples and pears from seed and then grafting desired cultivars on them later is seen as a big step in the wrong direction by many.

Ernst carefully mixes the tree seeds with a fine compost, which aids sowing. Credit: Josipa Bićanić

There are a lot of reasons why nursery stock exists, but some of those reasons are perhaps a bit exaggerated. The expectation of most nurseries- whether they cater to hobbyists or farmers- is that the trees are going to be planted in monocultures (or near monocultures) and managed without much thought to bolstering ecosystem processes like photosynthesis or encouraging diverse soil organisms to exchange nutrients for root exudates. Likely the trees will be subjected to chemical interventions of all kinds and the idea of a tree not needing those interventions is seen as either implausible or downright impossible.

The intellectual relationship between “commercially viable” disease resistant cultivars of perennial species and annual hybrids is readily apparent. The benefits of using these varieties can be quite clear at times. Especially those circumstances mentioned above: unhealthy soil, truncated agroecosystems, and high outside input use. In much the same way that many medications treat symptoms of illness rather than the root cause itself, these kinds of highly bred plants have a purpose. Sometimes you do have a scenario where the system is very ill and having a specific disease resistant type makes a lot of sense.

However, it begs the question: what if we change the setting such that the soil is actively improving? Such that there is increasing habitat for beneficial organisms? The list of other possible beneficial ecological changes goes on and on. Let's use a proxy indicator: is an agroecosystem whose soil only has 3% soil organic matter really the same as the same site if it had, say, 8% or higher? Beyond the increased water storage capacity, just think of the difference in nutrient cycling taking place.

It is in the light of *potential for improvement* that we need to consider what Ernst is saying about planting systems from seed as much as possible. To take a step back and consider the habitat- that agroecosystem- and how healthy it is as a whole rather than immediately start to ask questions about disease (usually its disease with perennials) or other fears. In fact, it was this very realization that turned Ernst away from his research with the Swiss Federal Research Center for Agricultural Crop Production (FAP Zürich-Reckenholz):

> "Wouldn't we achieve greater results if we sought ways of cultivation that favor the development of plants, rather than creating genotypes that support the bad conditions we impose on them?" - Ernst Götsch (Agenda Götsch, n.d.)

Another big question farmers have about growing trees from seed is how to control their overall size. Much of modern farming is based around homogenizing the size of plants. Uniformity means that the system is easier to mechanize with current affordable technologies. In addition, an orchard with a homogenous population theoretically means that applying inputs and conducting other work is streamlined: everything happens in a very narrow window (ideally) and that allows you to be efficient. Conventional orchardists in particular favor dwarf and semi-dwarf trees because of their reduced vigor and therefore reduced pruning costs.

The "pruning is trees is a cost" mindset needs reconsideration as well. Using monetary cost as the sole measuring stick for whether an action is appropriate or not is a very poor way to manage any agroecosystem. Why? In part because all actions have either positive or negative "compounding and cascading effects" on the organism and its surroundings (National Center for Appropriate Technology, 2021). To compress complex reality to a single factor like "labor/machine cost" fails to capture what is actually happening. If we conduct an inputs and outputs analysis on pruning, we will find that "controlling the size of a plant" has other effects that we might find desirable for one reason or another.

Pruning plants provides organic matter, the vast majority of which is carbon from the air and not "fertilizer" from the soil, which is critical for both keeping the soil covered and for a functioning necrosphere. Pruning plants to avoid senescence- a stage of the life cycle of a plant in which the information it communicates to soil organisms shifts away from accumulation- can keep plants in a growth pattern. When plants are actively growing and not channeling their efforts into reproduction they provide different kinds of root exudates to the soil microbiome (Zhao et al, 2020). A macroorganism working in concert is "synchronized" and perhaps, as Ernst suggests, increases its biological efficiency. Ernst's methods, developed over decades, indicate that he can produce about 5 times the biomass as an untended "natural" forest in his ecosystem. This focus on actively channeling the macroorganism towards your goals and participating in the flow of information inside the agroecosystem is in some sense one of the core components of "syntropic" agriculture.

Ernst performing a balancing prune on a hazelnut bush. Credit: Joshua Finch

When a plant senses that it has been cut, it will change its behavior to compensate for the loss. Learning how much to take, when to take it, and how to orchestrate the resulting change in information flow is a key element of Ernst's system. Pruning plants well- whether by the human hand, a machine, or through the use of domesticated herbivores- has an enormous impact on the plant's vitality and the production capacity of the system. Saying so should not be controversial in 2022. Any experienced market gardener knows that, if the goal is the highest productivity over the longest period of time, there is a "right" way to harvest annuals in continuous production and a "wrong way." Any adaptive grazing operation knows that timing the animal impact is essential towards keeping the system in a state of growth rather than shocking it through overgrazing. That both annual and perennial species react to how they are pruned or grazed is a positive nod to undertaking pruning in agroforestry systems with an attentive eye for the knock on effects.

Understanding that “farming” is actually a stand in for “humans cooperating with terrestrial ecosystems to meet their wants and needs” helps us reframe our actions to align more with reality. Don’t get me wrong- cost matters- but using it as the sole frame of reference is even, financially speaking, a poor decision because what matters most to the farmer in our economic system is *total profit*, not cost. Profit is a (slightly) more sophisticated concept than monetary cost alone. If we look at the reality of what is happening when we manage a diverse agroecosystem, especially one grown from seed, we realize that we gain a lot of benefits that can become quite profitable. This may very well hold true even if we take the recommendation to sow 100 seeds for each tree we’d like: mimicking natural survival rates.

Allow me to give just a few examples of how this comes together in the profit calculation. First of all, planting stock is very expensive in comparison to seed. Secondly, seeds avoid all the issues with nursery production. Third, when grown in situ, a plant grown from seed immediately begins its life with connections to the existing soil ecology. Some of this communication can take place even before the root emerges from the seed. The plant immediately begins to adapt to the conditions and begins the process of connecting to the soil microbiome, which it is altering in partnership with other plants nearby. A tree from seed does not experience transplant shock nor will those who plant it need to consider which direction was facing the sun in the nursery or many of the other tricks needed to avoid harming transplanted trees. Obviously not all seeds will germinate, many will be eaten and some will rot, but the cost savings is also bolstered by the fact that planting seeds takes a fraction of the time than it does to plant even a small bare rooted tree.

Those seeds that do grow are observed and managed by the farmer. The agroecosystem will “select” those individuals which have proven themselves to be best suited to the site. The farmer who is paying attention can reduce the population by culling out underperforming plants. When a clear choice emerges, if it provides good products, it can be kept. If not, for example an apple from seed with undesirable fruit quality can be grafted with as many known cultivars as the farmer sees fit. Trees grown in situ from seeds can match and exceed the overall health and vigor of transplanted trees. All of the benefits that come with a “more natural” start in life compound upon each other over time to result in a tree that is simply better suited for the place.

Add to this list of benefits the fact that many species of trees and shrubs are simply unavailable locally as nursery stock and you can see why going to seeds is an idea worth considering. Using seeds for desired species in all stages of succession means that you can frontload the seedbank with potential. Many seeds will stay dormant for years waiting for the right signals to emerge. And when they do, you will likely be happy to see them and grateful for spending the few euros it took to sow them concurrently with earlier succession plants!

Now you may say that, but what do you do while you wait? If someone plants an older, healthy grafted tree they can often expect the start of an economic benefit within a few years of planting. This is true. It is also true that this is an article on successional agroforestry. In such a system the "gaps" in production are filled by other species; the cultivation of these other species results in better soil conditions for the trees growing patiently from seed. Remember those carrots, potatoes, and garlic? They were also planted in the tree row we established from seed. Josipa will harvest three cash crops from that row already next season and can follow up with other species as context requires. The mulching, planting, and diverse interactions underground will benefit the whole system. In a well planned and managed successional agroforestry system you are never "just waiting" for a species to come online!

Ultimately there's no rule that says you should never plant anything from nursery stock. A farmer has to design and implement a system that makes sense in their context. I think that we too often overlook ideas not because we have considered them, but because convention has excluded them from discussion. For farmers to begin to experiment and change their systems they will need to return to basics and question each action. Doing so *may* bring the farmer back to convention, but at least they took the time to question their beliefs and practices and likely have come to a better understanding of their operation.

Planting the tree seed mixture. Credit: Joshua Finch

Last words on Establishing New Tree Lines Chapter

Finally I would like to say that it is one thing to read (or watch on video) about Ernst's careful attention to aspect, wind direction, life cycle, and stratification. It is another to see him work in real time, making a plan and remaking a plan based upon Josipa's interests and questions. This was really helpful because I think that too often we start to imagine that these systems need special knowledge to be planned with "the best" planting pattern. Obviously we have to pay attention to relevant aspects of a plant's character, but we also need to understand that planting is just the initial stage. It isn't simply that Ernst plants in polycultures that give his systems such amazing productive powers, but it is the management from that moment on that really sets his systems apart.

Commentary

Labor and Mechanization

At the start of the previous part of the article (Establishing New Tree Lines) I mentioned how much work all of this was. Hours. For a few cultivation beds 18 meters long and 80cm across. I enjoyed every minute of it, but part of my mind kept asking how this would ever pay for itself if we weren't volunteering. Even with the full knowledge that there would be fruit and nut trees, berries and whatnot in the years to come. And that the system would not be "fed" external inputs that cost quite a lot of money but also burden the environment unduly. Or, as Ernst puts it, "stealing from one place and bringing to another."

In part it was impossible not to think these thoughts as, just across a narrow grassy tractor lane, an organic market garden was overflowing with vegetables and flowers even in mid October. Having "market gardened" with no dig, high diversity cover crops, and even polycultures over the past 5 years, I know how much "work" I can accomplish in a single day. The difference between the system we were implementing and that which I was used to was huge.

The most straightforward challenge, as I see it, is adapting machinery to this work. A lot of the organization of materials could be done with hay making equipment. Seeding obviously can also be done with a mechanical seeder. Speeding up the work may not be a draw for everyone, but for scaling up it is essential given the economic system and socioeconomic expectations in the Nordics.

This is where my own lack of experience with larger scale systems really shows. I just don't have that relationship with tractors and farm implements to know what would be most appropriate. I lack the vocabulary and skill set. Still, I'm quite confident that with a system to experiment on, like the Lill-Nägels Agroforestry Project, we can get those people who have the skills and engineering mindset to interact with the system and offer ideas on how to make it work. That is one reason why the system we are designing is a bit simpler, to make it easier to comprehend and streamline. I will readily admit that we are taking baby steps in that direction and that it is only through growing one of these systems that any real advances in technology can be made.

In fact, this is how Ernst has developed improved machines as well as new ones for his work in Brazil and elsewhere. From grass cutting and biomass organizing tools to tree bed preparation machines that combine multiple functions into one pass, Ernst is actively developing the technology to manage these systems. We should also begin to adopt these innovations and make ones of our own. If we never get started we will never know what we need!

On Mulch

I will finally discuss the depth of mulch often used in this system. While disagreeing with someone who has almost twice as much farming experience as I have years being alive might be foolish, I am not sure that systems in our climate demand the same depth of mulch as warmer places do. The total amount of biomass we used was astounding. I feel that this amount of material only makes sense if the system can cycle it without unintended negative consequences, such as habitat creation for mice and such when plants are young and vulnerable.

At what depth does the effect of the mulch begin to actively cool the soil, reduce soil respiration, and provide shelter for slugs/snails and other organisms that will eat our crops? How deep does it actually need to be in order to provide a long term ground cover that maintains soil temperature in a healthy range while also suppressing weeds? I know from my own experience that biologically active soil warms up sooner and stays warmer longer, even with mulch, but is there a point in which the depth does start to negatively impact the soil ecosystem? I think it is important to always consider that we have made the wrong choice and to keep a close eye on the ecosystem processes on site to see whether the system we are managing is moving in the direction we thought it would. Holistic Management as a cohesive decision making framework once again shines through as a system that, even if one chooses not to adopt it whole cloth, is worth looking at in depth.

In the recent past, organic and so-called alternative systems (like no-dig gardening and forest gardening) have focused on the import or in-situ creation of biomass to use as mulch and compost. I think this was largely because having an intact organic layer (the O-layer in soil horizons) has demonstrable beneficial impacts on the system. However, I think that this focus was also due to the fact that we can actively manage the O-layer. We can see it, we can add to it, we can change its composition. On the other hand, the rhizosphere was something that remained beyond the literal vision and comprehension of farmers and gardeners. It hasn't been until recent years that advanced imaging/measuring techniques, alongside a growing interest in what is occurring there, have begun to change how we see soil dynamics.

I subscribe to the view that it is actively photosynthesizing plants, diverse in their plant family composition, *supported* by a healthy O-layer which builds soil most rapidly in tandem with their soil organism associates. Most estimates that I have seen in recent years point to around ⅔ of total soil carbon being the result of plant root exudates and the biological activity in the rhizosphere. The remaining ⅓, while still a significant proportion, can be traced to biomass decomposing on the soil surface.

So how deep is satisfactory in our climate? I think the only way to find out is to try different depths and compositions and observe. Let's think back to the real life example I described in the previous section.

The lasagna-style mulch we implemented was in part composed to begin rapid decomposition through the addition of nitrogen rich pumpkin vines. The total volume should actually diminish quickly. In addition, Ernst also increased the depth of the mulch as a strategy to reduce work during the next season when Josipa is expecting to have less time available to work there.

Still, the maxim that there is "never sufficient organic matter" will have real implications on the overall design of other systems in our region. Because if we set up one of these systems and ask that it produce its own organic material, and we get the design wrong, we may not catch the error until years down the line. Forest nutrient cycling and dynamics are not exactly easy to predict: did you generate enough biomass during the early stages of succession to allow late succession species to thrive or did you not? We don't have a time machine to find out.

The only answer I can provide is one that Ernst would perhaps agree with as well: everything comes down to management. Looking for a recipe, how deep should the mulch be, what materials to use, how many species of trees should I include, etc are all detail-level questions that are impossible to answer without actually having a living, breathing system in front of you. Even then an answer might change depending on other factors- such as time available and other resources at your disposal. There are just too many things to consider if you are following agroecological principles. I think we need to stop ourselves every time we turn to prescriptions and rote behavior. That kind of mindset does not work with ecology. And the sooner we accept that we have to be present, that these systems are human systems and require humans, the sooner we can get on with the actual work of trying them out.

A Walk with Ernst

Wednesday was our last day together. We'd planned to split the day into thirds: working in the morning, exploring part of Grantoftegaard's fields in the early afternoon, and finally taking a short break before Ernst was set to give a lecture on his farming experiences that evening. In this section I'll talk about our walk with Ernst in which he laid out ideas for developing a five hectare field with a number of different design challenges. The patterns he suggested as starting points for design were quite different from the typical "north-south" row orientation and conventional cash crop species, so I thought it would be worthwhile to touch on those.

Grantoftegaard Trust has a growing interest in how to adapt their operations and there are few better individuals to query for ideas than Ernst Götsch. The place we walked is currently used for organic row cropping. It has an unusual shape: like a very large lower-case "r," the field is perhaps best thought of as two fields that were merged at the joint rather than a single entity. There is a mature shelterbelt of mixed deciduous tree species running along the south and southeastern sides of the field that creates stark differences the total energy available for fueling any farming system. Although Denmark is further south than Finland, it is still a high latitude country with extreme changes in solar angle throughout the year. Ernst suggested that we figure out where the sun shines all day in mid-February, which for 25-30 meter tall trees, is about 50 meters northward of the shelterbelt. With this parameter in mind much of the field would be oriented towards shade tolerant species.

Agroforestry in the Shade

Not one to shy away from a challenge- and not one to ever waste resources- Ernst suggested that in the shade it would be possible to establish a special Christmas tree growing operation that also produces blackberries, amongst other things. Ernst has consulted with at least one other Northern European farm with such a system and it is rather intriguing. The Christmas trees are grown not for a single harvest, but are managed, surprisingly as a *pollard*. Pruning the trees so that they resprout and carefully managing the energy balance of the tree means a single individual tree can produce multiple Christmas trees over a longer period of time. Managing that trick requires some training and attention to detail because the nature of working with evergreen trees like spruce or firs is a bit different than managing the more commonly pollarded (or coppiced) deciduous trees like willow. For the sake of time- as well as not wanting to plant the seeds of a poorly communicated (by me) idea about how to grow Christmas trees this way- I won't go into the details he provided. Still, I can roughly sketch the idea for you: between the tightly growing rows of pollarded Christmas trees one could cultivate blackberries in their own rows. Blackberries need a fair bit of sun but can tolerate a degree of shade during the spring and autumn months. The key here is to understand where the light is- as many permaculture designers will be familiar- and utilize it to the fullest extent.

The idea is fascinating and offers a way in which we can apply his concepts to "less than desirable" areas where our first thought might not be to even practice agroforestry. Although, upon reflection, practicing agroforestry in the shade even in our northern climates makes a lot of sense as annual crops are, for the most part, not adapted to shady niches. It takes turning away from conventional notions of what to grow in a field and looking for what would thrive as opposed to trying to force the plants out of context.

Paying Attention

As we walked along Ernst was constantly reading the landscape and paying particular attention to the weeds in the field. We sampled many of them raw and he praised them one after another as the perfect plants to partner with in order to build an agroforestry system. Often we wonder “what plants will work here” and turn inwards- to our minds (or, increasingly, the internet)- for answers when nature has already begun the work. This despite the answers being right in front of us. Unless the field has recently been plowed or sprayed with an herbicide chances are high that something has emerged from the seedbank. Rarely will even the “weed” seedbank produce a monoculture so we can take notes of what is growing together. This information can help us guide our research and conversations about how to go about aiding succession.

Paying attention to the situation at hand rather than living in the world of “what ifs” is a characteristic of Ernst’s process that I really appreciated. With a background in permaculture design, I can say that a lot of time is spent planning and thinking on paper. Which is good and necessary: but, it can also lead to a design process that ignores what is readily available. This is in part because folks like to develop lists of plants that are “good or bad” for one thing or another. People then debate endlessly about how to rank these plants and which ones are “must haves.” We get so focused on what is “best” that we ignore that what is present is probably best, all things considered! Again, some of this debate is healthy and useful. Obviously we need to know something about plants- for example, what is their niche in succession or strata- in order to work with them. But in the end the desire to bring in something new, whether it is a plant or an endless stream of compost and woodchips, hampers us from working with succession in place.

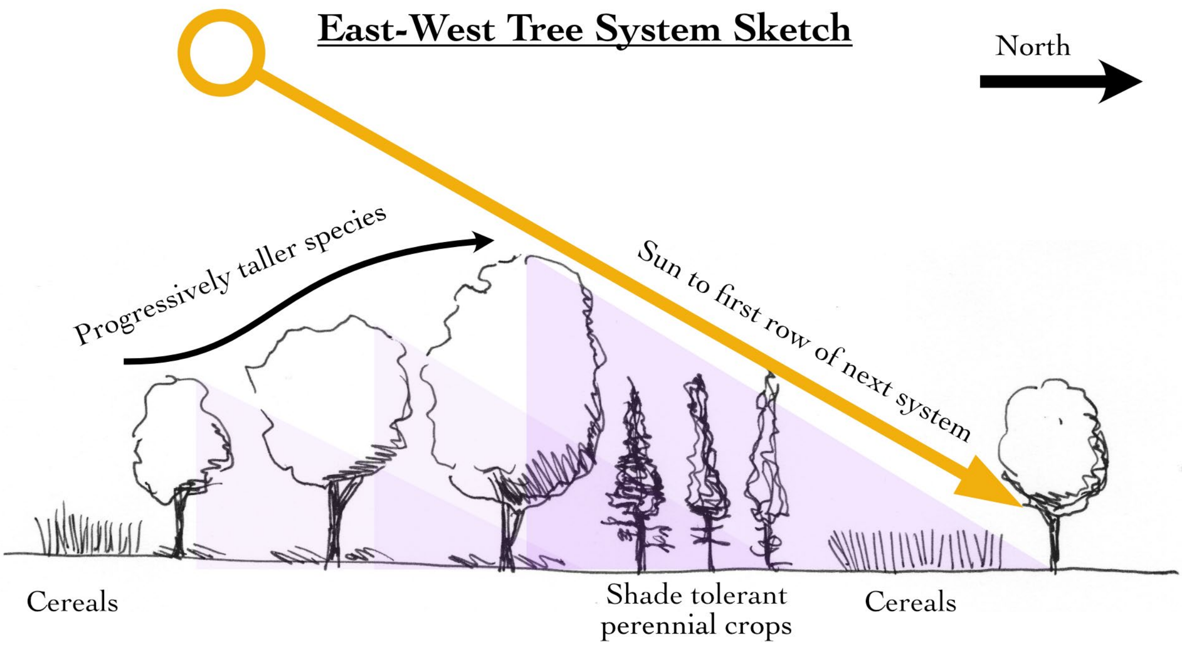
The deeper understanding is that there are no “good” or “bad” plants. Plants are plants. They and their microscopic partners can be observed and studied, hopefully not in isolation (plants behave differently in monocultures than in polycultures), and then managed by people for a particular aim. The very idea of a destructive or invasive plant is detested by Ernst who maintains that he has never seen an invasive plant, only invasive people. It is essential to highlight just how important it is for people to manage the landscapes under their care! Ernst is not recommending allowing “invasive weeds” to grow rampantly and calling it “syntropy.” Successional agroforestry systems only work if they are taken care of.

Orienting Tree Lines

Soon we were starting to take the bend towards the south. The shelterbelt turns to accompany the field on its eastern rather than southern edge. This transition means a lot in terms of sunlight availability- much of the field will be dark and cool in the morning, but once the sun moves past the trees it will be basked in energy all day. These kinds of abrupt shifts are common in our agricultural landscapes and will be familiar to many farmers. Here, Ernst suggested that it would be possible to move away from the north-south orientation of tree lines in favor of east-west systems.

The key element is to know what size you want your trees to grow in each tree line and then to calculate the distance northward to the next row. In other words, the alley width between east-west tree lines needs to be decided based on what date you want sunlight to reach the next tree line to the north. Structuring the agroforestry pattern like this, in this particular field, would connect the *agroecology* to the adjacent *urban ecology* of the shelterbelt and soften the transition. Agroforestry systems standing in as wildlife corridors and transition zones between habitats are just two of the multiple, concurrent benefits that agroforestry systems inherently create.

Another interesting aspect of this kind of pattern, which I have seen before elsewhere but haven't heard elaborated for a while, is that you in some sense pull the strata- which normally would occupy just one tree line in a north-south orientation- apart and create wider tree lines. The lower strata plants occupy the southern part of a wider tree line. Then you plant successively higher strata northwards such that you form a tapered system. Once you reach the pinnacle of this triangle, you can extend northwards- into the shade cast by this system- with shade tolerant species.



A simple illustration of east-west oriented tree systems. This is not to scale and is simply meant to support the text. Loosely based on a sketch made by Ernst in the field and my own notes from the trip. Credit: Joshua Finch

Some of the taller or emergent species one might include could be trees with high value, furniture-grade wood that can be pollarded (topped) for continuous harvest. Poplar, cherry, beech, maple, and black locust may fit the bill depending on your context. At one point in his later talk Ernst remarked that growing timber in these systems is a very valuable aspect not to be overlooked: in his systems trees develop straight, strong wood that hasn't been weakened by artificial fertilizers. And they do this without hampering other species in the macroorganism by considering stratification and continuous pruning.

The alleys can be cultivated with older varieties of cereals like spelt. He highly suggests that multiple cultivars of cereals be grown simultaneously, including those out-of-fashion long stemmed varieties that have been replaced by short hybrids, in order to help support each other against wind. In addition, he says to try timing the planting of the cereals such that they flower at the same time that the tree/shrub species in the agroforestry system also flower. I haven't talked as much about synchronizing the whole macroorganism in this paper but take this as one example of trying to get the biological information (which drives so much about ecosystem processes) flowing in concert.

I'd also like to add that Ernst sees value in arranging the tree lines in curved, rather than straight, lines. For example, arranging tree lines in a rainbow-like pattern creates different microclimates which, in a sense, decides where to plant certain species for you. This can be very useful if you have irregularly shaped fields or a desire to make something a bit different. You can absolutely combine the arrangement of stratified successional agroforestry with other systems like Keyline design (at least as far as the parallel layout of the system) or contour planting.

Conclusion

I think it is imperative to stress that Ernst's system *isn't* defined by something as simple as the orientation of tree rows. Or even what species are used. Ernst's system is about observation of nature and fitting human beings back into the ecosystem, about designing and managing agroecosystems that reconcile the needs of people with ecology.

Patterns do emerge from this that are quite useful. Ernst has done an incredible amount of work developing the nomenclature around "syntropic" agriculture. But a lot like permaculture design, a "syntropic" approach to agriculture is *not* a set of things. It is a mindset, not a checklist! If one becomes more concerned with ensuring they have "all the things" but don't understand *why* they are included in the first place the system will likely struggle.

Walking with Ernst hammered home just how much experience lies behind the choices he makes. This is someone who has farmed across continents and climate zones, up mountains and down on the valley floor. There is, indeed, a lifetime of memory, observation, and practice at work when he speaks. You may have noticed that I have continued to put quotation marks around syntropy throughout this article. It is now time to address that question and make final remarks about what I learned from my time in Denmark.

Ernst Götsch: Live and Uncut

Throughout the trip we constantly remarked at Ernst's indefatigable energy. Yes, indefatigable: I've finally found a context in which that word makes sense! Even after three days of long hours in the field handling the brush cutter, hauling mulch, digging holes, and having his patience tried by a bunch of urban whippersnappers, Ernst was game for a public lecture. His talk "the forest ecosystem as a model for future agriculture" was filled to capacity (and then some, I think there were folks standing outside at one point) and the room was in a state of high anticipation. The mood was very much one of "what, Ernst Götsch here, in Denmark?!" The excitement to hear the Swiss Brazilian exotic species talk about farming in our context was palpable.

Ernst during his talk at Grantoftegaard.
Credit: Josipa Bićanić

As the talk is publicly available from Grantoftegaard Fonden's YouTube Channel, I will refrain from providing a full breakdown of what I heard (Fonden Grantoftegaard, 2022). Instead, I am going to focus on two things:

1) What is "syntropic" agriculture?
2) What influence does his talk and my time with him have on the project at Lill-Nägels?

What is Syntropic Agriculture?

By now I'm sure you wish this to be over and the dreaded quotation marks around Syntropy cast aside. Believe me, I understand. We are approaching the finish line, I promise. During the question and answer session, one of the guests asked Ernst a question and used the phrase "syntropic food forest." Although Ernst did eventually answer the question, he addressed the ubiquitous use of "syntropic agriculture" and its affiliation with his work for about eight minutes.

In his own words, Ernst answered (question starts at 2:06:00):

> "From the one side, I don't use the word syntropic agriculture. I created the word, when in '16, 2016, I had a visit of two very world wide famous scientists. And I showed them a place I'm [sic] working.

[Ernst continues by describing the place at length. After he shows the scientists the difference between an agroforestry system planted with exotics and one without, he gives the following statement at 2:10:13:]

Then I said to those two scientists: if, one day, when you come to the point that we are really able to produce what we need for our day to day- in order to satisfy- our day to day metabolism, in a way so that we get a positive energetic balance and also a positive balance in terms of quantity and quality of [established?] life… on a place once again and also considering the whole macroorganism, planet earth, that is to say not stealing from one place and bringing to another place- no- in the same place, then we could say that we would have a syntropic agriculture."

Syntropic agriculture would be, and here I paraphrase part of his answer, "a system that moves from simple to more complex forms, complexifying -grasping- energy from the outside and storing it in more complex forms."

Ernst then talks in dismay about how, immediately following his use of this phrase, that all across the globe people started to sell the idea of "syntropic agriculture." So although Ernst was positing a concept that perhaps does not yet exist- see the quote from above about "one day," his farming methods and philosophical approach were almost universally labeled as "Syntropic Agriculture."

Earlier in this piece I mentioned how Ernst is very careful with his words because he is of the opinion that the way we describe the world around us matters deeply. So much so that he is compelled to find new ways of expressing his processes. Spending a few days with him I got the impression that he is weary, to no small degree, with the way in which his work has been expropriated. It was not just this one question either. Ernst is used to being misunderstood and taken out of context, which is one reason why I have treated writing this article with care and explicitly saying that I am in no way saying that my words are Ernst's. I'm sure that if he ever reads this piece that he will be sending me to eat grass alongside Saul.

As I've said over and over again, Ernst's approach to agriculture is not a set of things. It isn't "bananas plus eucalyptus plus grass." It isn't stratification or placenta species or even the "nests" that he uses to help establish baby plants. I'm not claiming that I know for sure what Ernst wants- three days is a short time- but I think I get that he doesn't want people to just copy things and label them as "syntropic." To see something, make assumptions, and then run with the idea proclaiming that it is "syntropic" and that it was "heard from the man himself!" is not proper. Like many pioneers, Ernst has seen the commodification of his life's work and wrestles with how the world has generally reduced complexity into sound bytes and fads.

Ernst is an enigma. He is one of the most (top three) most opinionated people I have ever met in my life. And I've got the mirror up for that one. At the same time he is, without a doubt, a master of taking those strong opinions- and the knowledge that they are based on- and adapting them to local conditions. He is intimidating on many levels. His intellect cuts in all directions just as fast as he can wield a machete. Yet even someone of his caliber is humble enough to admit that syntropic agriculture is something we should be striving for, not something we have attained and can boil down to a recipe. Let alone something to be learned and subsequently capitalized on after a short course on someone else's farm.

Ernst's Influence on the Lill-Nägels Agroforestry Project

Far from being discouraged by the lack of recipes in Ernst's teaching, I feel as if we are more free than ever to move forward with our own project. I had always felt a bit strange calling anything I was doing "syntropic" in large part because I have a deep sense of propriety. It never sat right to take that word and append it to my own work when I had never studied it deeply. Even if, sometimes, I had fallen prey to temptation and added a syntropic hashtag to the odd social media post, I've always tried to say that I'm inspired by Ernst's work, not implementing it faithfully.

Now, after hearing how Ernst does not use the word lightly either, there is a feeling of relief.

What is left for me to understand and learn is greater than anything I could get from a course- even if one would certainly help. What is left to understand and learn is precisely everything that I need to do for myself in the appropriate space and time. Having been steeped in agroecology for most of my adult life, there was not very much in these three days that was entirely alien to me. Obviously I learned a lot and many pieces came together- this article couldn't be this long without having learned something- but what I find most compelling is Ernst's insistence on doing the work, observing carefully, trying new things, and being open to being totally wrong. We are the ones who need to understand nature, not the other way around.

I never got to ask him one burning question- what were his biggest mistakes?- but that is fine. He taught me so much that I can leave that question open for, hopefully, another time.

In terms of how the project at Lill-Nägels will change, I can say this: I draw confidence from his talk in which he described the rural landscape of Switzerland he knew as a child and young adult. One in which hedgerows were still prevalent, where trees and their underground biological networks were never far away. A system designed- intuitively and through the generations- to harvest and distribute solar energy in many forms.

As he described these systems of fields and agroforestry systems, it sounded very much like what we have planned at Lill-Nägels. Not identical, no, not at all, but very much like. We have modestly sized alleys- 12 meters- in which to grow row crops using "novel" regenerative ideas. And we have diverse perennial tree systems dispersed throughout in order to provide the inherent benefits of agroforestry alongside the active ones inspired by his work. It isn't going to look like a "typical syntropic system" and, more importantly, it doesn't have to.

Working side by side in Josipa's field, seeing how Ernst adeptly arranged species and drew our attention to various details, showed me that there is not going to be any singularly "right" arrangement. Even though I've understood that there's no such thing as a perfect design for a very long time now, I *had* felt a lot of pressure about the combinations of plants I was positing during my tenure as project manager. After noticing how quickly the plans can change depending on what you want, I have come away from my experience in Denmark with an overwhelming sense that we can do this if we try.

This isn't to say that we don't hope to develop some kinds of patterns of plant combinations that others can try- in fact, I'm sure we can come up with some- but it is to say that at this early stage of trialing successional agroforestry the most important thing is to get plants in the ground and manage them. That's it.

All in all I feel that our decision to create a pilot project was the right one. This isn't something that has been done before. It requires careful consideration and study. That investment in the theoretical and design underpinnings of the system is one that many farmers, probably most, would find hard to justify. But in the context of a partnership between Novia University of Applied Sciences, the farmer's family, Jordfonden- and any other potential players- a pilot project is exactly the kind of thing we need.

Acknowledgements

I remain deeply indebted to Josipa Bićanić for her willingness to have me along for these three amazing days. I promised to keep quiet while I was there as I knew I would have plenty to say afterwards. Little did she know!

To Ernst, I'd simply like to say that spending a few days with you on Josipa's farm has been a highlight of my farming career. I hope that my writing has not committed too many errors in representing what you taught us. If so, you'll just have to come visit us again and set the record straight!

Rikard Korkman: thank you not only for the project's existence but your insistence that I go to Denmark while Ernst was visiting. And right there with him, Marianne Fred's immediate apprehension that this was an opportunity worth grasping. Without their appraisal of the value of this trip I would never have imagined I could go. I thank them both for their encouragement not only for this trip but throughout this project's first summer.

I also want to thank Saul Avery for his generosity of spirit and time. Saul kindly packed up the bicycle and saved me a whole load of weariness by driving me back to the hotel on multiple occasions, one of which allowed me some invaluable face time with my daughter back in Finland. Saul, for this and your willingness to ask tough questions, I want to thank you!

Finally, I'd like to thank the institutions that created the conditions for this trip. To Grantoftegaard for their forward looking vision- and practice- along with their overwhelming generosity of lunch, coats, and understanding! Last but not least, Novia University of Applied Sciences and Stiftelsen Finlandssvenska Jordfonden for their magnanimous support for our project at Lill-Nägels. My time as project leader has been one of tremendous self growth and has been a real positive influence during a time of great change.

Reference List

Agenda Götsch (n.d.) *Ernst Götsch*. Retrieved 2022, November 21 from https://agendagotsch.com/en/ernst-gotsch/

Agenda Götsch. (2015, December 2). *Life in Syntropy* [Video]. Retrieved 2022, November 21 from https://www.youtube.com/watch?v=gSPNRu4ZPvE

Biodiversity for a Livable Climate. (2014, November 27). *Grazing Down the Carbon: The Scientific Case for Grassland Restoration with Richard Teague* [Video]. Retrieved 2019, November 4 from https://youtu.be/rhDq_VBhMWg

Bongers, F.J., Schmid, B., Bruelheide, H., Bongers, F., Li, S., von Oheimb, G., ... , & Liu, X. (2021). Functional diversity effects on productivity increase with age in a forest biodiversity experiment. *Nature Ecology & Evolution 5,* 1594–1603. https://doi.org/10.1038/s41559-021-01564-3

Center for Environmental Structure. (n.d.) *Patterns*. Retrieved 2022, November 21 from https://www.patternlanguage.com/aims/intro.html#patterns

Edible Forest Gardens. (n.d.) *About Forest Gardening*. Retrieved 2022, November 21 from https://www.edibleforestgardens.com/about-forest-gardening

European Agroforestry Federation. (n.d.) *Agroforestry in Europe*. Retrieved 2022, November 21 from https://euraf.isa.utl.pt/about/agroforestry-europe

Feng, Y., Schmid, B., Loreau, M., Forrester, D., Fei, S., Zhu, J., ..., & Fang, J. (2022). Multispecies forest plantations outyield monocultures across a broad range of conditions. *Science, 376(6595),* 865-868. https://doi.org/10.1126/science.abm6363

Fonden Grantoftegaard. (2022, October 21). *TALK Ernst Götsch | The forest ecosystem as a model for future agriculture* [Video]. Retrieved 2022, November 3 from https://youtu.be/1OB7RzlVOsk

Fonden Grantoftegaard. (n.d.) Retrieved 2022, November 21 from https://grantoftegaard.dk/

Food and Agriculture Organization of the United Nations. (n.d.) *Agroecology Definitions*. Retrieved 2022, November 21 from https://www.fao.org/agroecology/knowledge/definitions/en/

Jochum, M., Fischer, M., Isbell, F., Roscher, C., van der Plas, F., Boch, S., ..., & Manning, P. (2020). The results of biodiversity-ecosystem functioning experiments are realistic. *Nature Ecology & Evolution 4*, 1485-1494. https://doi.org/10.1038/s41559-020-1280-9

Kimmins, J.P. (2003). *Forest Ecosystem Management: An Environmental Necessity, but is it a Practical Reality or Simply an Ecotopian Ideal?* [Invited Paper]. Retrieved 2022, November 21, from https://www.fao.org/3/xii/ms18-e.htm#P10_151

Lyu, D., Zajonc, J., Pagé, A., Tanney, C., Shah, A., Monjezi, N., ..., & Smith D. (2021). Plant Holobiont Theory: The Phytomicrobiome Plays a Central Role in Evolution and Success. *Microorganisms 9(4),* 675. https://doi.org/10.3390/microorganisms9040675

Nargi, Lela. (2019, July 24). *The Miyawaki Method: A Better Way to Build Forests?* [Blog Post]. Retrieved 2022, November 21 from https://daily.jstor.org/the-miyawaki-method-a-better-way-to-build-forests/

National Center for Appropriate Technology. (2021, August 28). *Demystifying Regenerative Grazing and Soil Health with Dr. Allen Williams* [Video]. Retrieved 2022, November 23 from https://youtu.be/82phxArSFFU

Rutledge, K., McDaniel M., Teng, S., Hall, H., Ramroop, T., Sprout, E., ..., & Costa, H. (2022). Ecosystem. In: *National Geographic Resource Library*. Retrieved 2022, November 21 from https://education.nationalgeographic.org/resource/ecosystem

Skywoman Syntropy. (n.d.) Retrieved 2022, November 21 from https://www.skywomansyntropy.com

The Biodiversity Information System for Europe. (n.d.) *Finland*. Retrieved 2022, November 21 from https://biodiversity.europa.eu/countries/finland

Zhao, M., Zhao, J., Yuan, J., Hale, L., Wen, T., Huang, Q., ..., & Shen, Q. (2020). Root exudates drive soil-microbe-nutrient feedbacks in response to plant growth. *Plant Cell Environment, 44*, 613– 628. https://doi.org/10.1111/pce.13928

YRKESHÖGSKOLAN NOVIA

Yrkeshögskolan Novia har ca 4500 studerande och personalstyrkan uppgår till ca 320 personer. Novia är den största svenskspråkiga yrkeshögskolan i Finland som har examensinriktad ungdoms- och vuxenutbildning, utbildning som leder till högre yrkeshögskoleexamen samt fortbildning och specialiseringsutbildning. Novia har utbildningsverksamhet i Vasa, Jakobstad, Raseborg och Åbo.

Yrkeshögskolan Novia är en internationell yrkeshögskola, via samarbetsavtal utomlands och internationalisering på hemmaplan. Novias styrka ligger i närvaron och nätverket i hela Svenskfinland.

Novia representerar med sitt breda utbildningsutbud de flesta samhällssektorer. Det är få organisationer som kan uppvisa en sådan kompetensmässig och geografisk täckning. Högklassiga och moderna utbildningsprogram ger studerande en bra plattform för sina framtida yrkeskarriärer.

Yrkeshögskolan Novia
Rektorat
Wolffskavägen 31
65200 Vasa, Finland
Tfn +358 (0)6 328 5000 (växel),
www.novia.fi

Antagningsservice
Wolffskavägen 33
65200 Vasa
antagningsservice@novia.fi
admissions@novia.fi

Yrkeshögskolan Novia upprätthåller en publikations- och produktionsserie för att sprida information och kunskap om verksamheten såväl regionalt, nationellt som internationellt. Publikations- och produktionsserien är indelad i sex kategorier:

R - Rapporter • P - Produktioner • A - Artiklar • L - Läromedel • S - Studerandes arbete • RS - Reseskildring

Läs våra senaste publikationer på www.novia.fi/forskning/novias-publikationsserie

ISSN: 1799-4179 • ISBN: 978-952-7048-97-9