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A Year in Syntropy: Exploring Syntropic Agriculture

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Submitted May 5th, 2021, to the College of the Holy Cross

This thesis is submitted in order to fulfill the requirements of College Honors

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ABSTRACT:

Syntropic agriculture is a form of sustainable agriculture that originated in Brazil around 25 years ago. Although it has since spread throughout Brazil and Australia, there has yet to be a comprehensive study of the driving scientific principles behind syntropy. For my thesis, I conducted literature research and interviews with farmers, with the goal of describing the ecological principles on which syntropy is based, including its primary goal to improve soil health. Much of my thesis contrasted syntropic agriculture with conventional agriculture as practiced in the United States today, but I also explored the differences between syntropic agriculture and other forms of sustainable agriculture, as well as the current economic agricultural landscape in the United States. I wrote my thesis in the form of a blog, with weekly posts examining different aspects of syntropy, agricultural systems, and U.S. agricultural economics. By using the blog format, I aimed to make the information accessible for a non-scientific audience, using colloquial language and a casual tone. From my research, I conclude that syntropic agriculture could reasonably replace conventional farming as practiced in the United States today.

INTRODUCTION:

When I first began planning my thesis a year and a half ago, I had no idea the complex journey it would take me on. I had initially planned to do a hands-on experiment on campus, but when students were unexpectedly sent home, I gradually realized that my thesis plan would have to adapt to the times. Since I no longer had access to physical resources of the school, I pivoted to a virtual exploration of syntropy—my chosen topic—instead. Thinking about this lack of resources made me realize just how much scientific information is locked behind paywalls, journal access fees, and complex language that acts as a barrier to those looking to learn more. I wanted my thesis to be inclusive, something that any literate adult could read and understand, with full explanations of complex topics. I didn't want to trade readability for complexity, I wanted both. This drive to make my research accessible led to the petition and subsequent approval to write my thesis as a blog, with weekly installments exploring and explaining different aspects of syntropic agriculture. My blog can be found at <https://medium.com/a-year-in-syntropy>, or by searching "A Year in Syntropy-Medium". Although I did not build up a very large following on my blog site, I did receive 10 followers over the course of the project, and over 50 "kudos" (the Medium term for "likes") on my blog posts. I believe this is the first thesis ever done in blog format in the Holy Cross Honors Program, and my advisor and I worked together to make it happen. I will be splitting the blog posts into two thesis "Chapters". Chapter One contains the blog posts specifically discussing the scientific reasons why syntropic agriculture is needed and how it works, and Chapter Two contains blog posts that discuss the non-scientific side of syntropy and its potential implementation in the United States. Other than some

small adjustments, these blogs appear in chronological order, with the date the original blog was posted listed next to the title. I have chosen to keep all of the blog titles in this thesis as well, because I believe they are an important part of the authenticity of this project. They are in bold at the beginning of each blog post. However, I have chosen to take away my sign-offs on my blogs. Except for one at the very end. Without further ado, let me present to you: **A Year in Syntropy**.

CHAPTER ONE: THE SCIENCE OF SYNTROPY

Let's Get Started (9/10/2020):

What does your ideal world look like? Maybe there is no poverty, or child hunger, or global climate change. Maybe you own a yacht or private island and spend each day sipping cocktails in a cliffside pool before sitting down to a dinner of local, freshly caught fish. The fish, you think, pairs quite nicely with the fresh arugula and tomato salad your chef whipped up. Focus on that moment, as you consume the salad fork-full by fork-full. The cutlery is heavy in your hand as you push it past your lips, the metal cool on your tongue. The fish is freshly caught, sure. But the tomatoes? They have no doubt traveled a very long way for the honor of becoming your salad. One bursts on your tongue and the pleasure of the sweet tanginess distracts you from contemplating the intricates of produce production travel. It's a good thing too-thinking about the CO₂ emissions produced, the harmful pesticide used, the waste of water, and the human rights abuses might just put you off your dinner. But wait. Those things aren't supposed to exist. This is your ideal world, after all. Oh, what's that? You want both salads AND a healthy planet? Well, aren't you demanding. But fine, if you insist, I will tell you about a system of agricultural reform that could make it happen. Be sure to integrate it into your ideal world.

The words "sustainable agriculture" get tossed around a lot these days, but practically, what does "sustainable" mean? Many different kinds of agriculture claim to be sustainable, what are the differences between them, and do they really matter? And perhaps the most important set of questions: how do we know which one is best? And once we know, how can we implement it? Over the next year, I will introduce you to

syntropic agriculture, a type of sustainable agriculture that draws techniques from forest restoration, permaculture (the process of growing multiple plants together), and other types of sustainable agriculture, along with utilizing the farmer's own knowledge of regional growth patterns and soil type. With syntropic agriculture, you can enjoy guilt-free salads. I will discuss everything from the science behind syntropy to the current agricultural economic tariffs. Please, I would love questions, feedback, critiques, and support, so please leave a comment!

Big Agriculture Problems #1: Not to be dramatic, but we're all gonna die

(9/18/2020):

When people talk about global warming, the phrase "we are killing the earth" comes up quite a bit. It is, of course, patently untrue: we are not killing the earth. The earth has an astounding ability to bounce back from all types of environmental disaster -- from massive earthquakes, and solar flares, to meteors and volcanic eruptions. We are not killing the earth. We are killing ourselves. In no industry is this as true as the agricultural industry. For decades, we have mass produced food at an unsustainable pace, causing some of the worst environmental crises in history¹. The use of monocropping, pesticides, herbicides, tilling, intellectual patents, and general land degradation have been combined in insidious, profitable ways, encouraging further environmental destruction.

Before going further, it is important to note that farmers themselves are largely not to blame for the destructiveness of conventional farming. It is incredibly time

¹Richardson, Sarah. *The Land Blew Away*. History.net LLC, 2015.

consuming and expensive to transition to environmentally friendly ways, as we will discuss later in the year, and the benefits and tariffs at play on the economic side of agriculture make it even more confusing and difficult. I am not playing the blame game here; I am just talking about how horrible conventional agriculture is. So, let's talk.

Horribleness number one: Monocropping

Monocropping is the practice of growing one crop in the same field year after year. Think “amber waves of grain” style farming. Think “Jenny running through the corn in Forrest Gump” style farming. For those who prefer a more contemporary reference, think “Maeve from Westworld running her hands through the wheat fields” style farming. Monocropping doesn't seem terrible on the surface. Monocropping allows farmers to spend less money on field management, while providing more profits. It is a relatively simple way to farm, and the benefits of monocropping are immediate-sow 100 acres of potato in the spring, harvest 100 acres of potatoes in the fall. America is a country of mass production-why shouldn't it be the same for food? For one key reason: Food is not made, it is grown. Growing plants, as any gardening enthusiast would tell you, is a little bit like having a child. They need care, shelter, water, the right soil, the right sunlight, and the right management strategy. Monocropping robs the plants of the right care. It decreases soil fertility², and drains the soil of key nutrients³, such as potassium and nitrogen. How does this happen? Plants all need slightly different levels

² Zhou, Xianhui, Wenjuan Wu, Kechang Niu, and Guozhen Du. 2019. *Realistic Loss of Plant Species Diversity Decreases Soil Quality in a Tibetan Alpine Meadow*. Agriculture, Ecosystem, and the Environment. Vol. 279. doi:10.1016/j.agee.2019.03.019. <https://holycross.idm.oclc.org/login?auth=cas&url=http://search.ebscohost.com/login.aspx?direct=true&db=8gh&AN=136389190&site=eds-live&scope=site>.

³ Yang, Pu, Yan Luo, Yang Gao, Xiaoli Gao, Jinfeng Gao, Pengke Wang, and Baili Feng. "Soil Properties, Bacterial and Fungal Community Compositions and the Key Factors After 5-Year Continuous Monocropping of Three Minor Crops." *PLoS ONE* 8 (2020).

of nutrients, and slightly different levels of care, and they also provide different levels of nutrients. There are specific groups of bacteria and fungi who contribute to the balance of the soil by helping to process and make these nutrients available to other plants in the system. Let's say that I was to plant a monocrop of kale, which needs a lot of nitrogen. If I planted nothing but kale year after year, it would use up all the nitrogen in the soil. There are no other plants around to help restore the nitrogen to the soil (remember some plants provide nutrients to the soil) and eventually the soil becomes extremely nitrogen deficient. This leads to a decrease in the number of helpful bacteria, making it even harder for the plants to find available nutrients. So, if the plant was a child, monocropping would essentially be putting all children into state run facility with completely non-individualized care from ages zero to five, and then never letting renovations be done on the building where the children live, and never letting the caregivers of the children retire, AND also never hiring new caregivers. Now, the first couple rounds of kids ages one to five, they might be okay (we'll ignore the trauma of being separated from your family--it's not a perfect metaphor). They have a newly built building and the caregivers are full of energy. The later children to enter this program might not be so lucky. They are going to grow up in a dilapidated old building with caregivers who are exhausted and overworked. In this metaphor, the building is the soil, and the caregivers are the bacteria. It's worth noting that many farmers know that monocropping is bad for the soil and plants, but they are simply unable to make a living through other means of farming. So, to recap, monocropping results in horrible soil conditions that will eventually result in limited plant growth.

You may be saying, “okay, I get it, it’s terrible. But if it’s been in use for so long, then how come it still seems to work? I still can go out and buy kale.”

This is true, you can go buy kale. It will taste awful, but that’s more because kale is gross than the way it was grown. The reason you can keep buying kale is because monocropping is not happening in a vacuum. It is combined with intense fertilizers, and pesticide and herbicide usage so that the kale still grows. However, these additions don’t stop the damage of monocropping, they simply mask it, while wreaking havoc on their own. Which brings me to...

Horribleness number two: Pesticides

~ A quick note before I begin: Pesticides are dangerous chemicals that are sprayed on farms and gardens to kill harmful pests. Herbicides are a type of pesticide that is sprayed to specifically kill the plants in a given area. Herbicides and pesticides harm the environment through the same methods, so I will not be talking about them individually in this blog, but please be aware that anytime I say “pesticide”, herbicides are included within that framework. ~

Okay, hands up if you read *Silent Spring* by Rachel Carson. If your hand is up right now you already know the harmful effects of pesticides, so go ahead and skip this section. If your hand is down right now, please read *Silent Spring*! And the rest of this section, which will explain why pesticides are terrible. First, all you pesticide defenders: I see you. Pesticides have changed a lot in the last few years. They have grown more specialized, are a lot safer now than they have been in the past, and they do a fantastic job of preventing bugs from eating plants. But they still suck.

Pesticides have been proven to harm wildlife in multiple ways. Typically, harm to wildlife can be split into four different categories⁴: Acute, chronic, secondary, and indirect. Acute harm, also called acute poisoning, is when wildlife is directly poisoned by an application of pesticides. For example, if a farmer applied pesticides to a field, and then a heavy storm occurred, the water flowing through the farm would pick up and carry the pesticides through ground water or to a local stream. This runoff then causes the local fish to be inadvertently poisoned by the pesticides as it infects the water. In some cases, this can also happen without rain, as the pesticides could mix with the ground water if the water table is high. Acute exposure also happens commonly to birds, who eat pesticide-covered insects. Farmers can mitigate these risks by planning pesticide usage for non-rainy weeks, but the vast swaths of farmland in America ensure that no matter how careful the farmers are, some acute poisoning will occur. A quick specific example of acute harm: the pesticide imidacloprid is known to cause direct harm to honeybees, fungi, and other aquatic and terrestrial wildlife.⁵

Chronic harm occurs when wildlife has been exposed to pesticides for a long time, and detrimental effects develop over time. Perhaps the most well-known cases of this is DDT effects on bald eagles.⁶ DDT is a pesticide that had widespread use before regulations in the 1970's. It caused the shells of large birds of prey, including bald eagles, to be extremely fragile, resulting in mass death⁷. Since the regulations, birds of prey

⁴ Purdue University Cooperative Extension Service. *PESTICIDES AND WILDLIFE: An Introduction to Testing, Registration, and Risk Management*. 2019.

⁵ Washburn, Mary, and Ashlee McCaskill. Poster Abstract. "Effect of Imidacloprid on Mycelial Growth Rate of Soil Fungi." *University of Northern Georgia* (2019).

⁶ Purdue University Cooperative Extension Service. *Pesticides and Wildlife: An Introduction to Testing, Registration, and Risk Management*. 2019.

⁷ Carson, Rachel. *Silent Spring*. 40th ed. London: Penguin Classics, 2012.

species affected by DDT have largely recovered. It is a challenge to track long term effects of pesticides as the ecology of water sources and marshlands is extremely complicated, and have many conflating variables. The fear in using pesticides is that we will not be able to track all the possible chronic effects on wildlife, and will end up irreparably harming nearby ecosystems. Although the United States federal government does do extensive testing of pesticides before approving them for commercial usage, and generates guidelines and regulations to follow, it is impossible to know exactly how the surrounding wildlife will be affected. Because pesticides have already been proven to be harmful, the relative ambiguity of the chronic effects is dangerous.

Secondary harm occurs when wildlife is indirectly poisoned from pesticides. One example of this is when predators feed on an animal dying from acute exposures. The predator, eating these dying animals, consumes the same pesticides, and also dies or is extremely harmed. Secondary poisoning can also occur from the accumulation of pesticides through the food chain. This happens in the same way that mercury poisoning from fish happens. The wildlife at the bottom of the food chain-let's say a worm chilling out in some pesticide sprayed dirt-ends up with some small amount of pesticides in its little worm body. Then, a toad comes along, and eats the worm. Now, the frog has both the worm (yay for food!) and the pesticide (ugh, no thank you!) in its body. This wouldn't necessarily be a problem; if the small amount of pesticides didn't cause adverse harm to the little worm body, then it most likely won't in the bigger frog body. Except the toad is hungry that day. So, instead of eating the one worm, the toad eats three. Now, the toad has three times the amount of pesticides in its body than one worm did. But-GASP! A snake is coming! And not only does it eat the toad, ingesting both the

toad and the pesticide, it eats two toads. Now, the snake has six times the amount of pesticides in its system than the worm did. Eventually, as the pesticides move up the food chain, they accumulate to dangerous levels. Pesticides have a truly frightening ability to stick around in an ecosystem long after they have been used, and they can be extremely hard to break down. This makes sense--pesticides are designed to be durable chemicals that target wildlife in some form--and it increases the danger of pesticide use.

The fourth category of pesticidal impact on wildlife is indirect effects. As the name implies, indirect harm from pesticides does not involve direct contact between pesticides and wildlife. Instead, indirect harm is when the use of a pesticides depletes a resource for wildlife. For example, use of herbicides may reduce food sources and nesting grounds for birds, small mammals, and insects. Use of insectile pesticides reduces food sources for bats, birds, and other wildlife that eats insects. This change of resource availability can cause ripple effects throughout an ecosystem, resulting in food and habitat shortages.

I have been talking about these four effects (acute, chronic, secondary, and indirect) individually, but they happen simultaneously. Anywhere that pesticides are used, all four effects have to be considered. When used in tandem with monocropping, as they often are, pesticides can have even worse affects, as poor soil quality increases runoff in an area⁸. Nothing happens in a vacuum, all of these problems from conventional agriculture affect each other.

⁸ *Pers. Comm.* Hawes, Neil. September 13th, 2019.

Conventional agriculture has a multitude of problems. Monocropping and pesticides use are simply two of many. Next week, I am going to discuss some others, including tilling practices, and intellectual patent law. Yes, patent law is one of the worst offenders of agricultural destruction. Tune in next week to learn how.

Big Agriculture Problems #2: The Plow and the Patent (9/24/2020):

The Plow:

Ahh, the plow. The mere act of uttering this simple word creates a world of sleek wooden lines, roughened from labor. It is the simpleness of a man and animal coming together to work the land, the push and pull of human and nature exemplified by the quick passes through hard dirt. The smell of new earth in the rising sun, only to give way to a glorious spring morning...the image certainly lifts my spirits. Perhaps there are dandelions near here, and the seeds gently float across the farmers vision, gently landing on...a huge metal machine with knives on sticks?

Oops, for a second there I lived in a world where plowing was an act of communing with nature, instead a horrible, no good, very bad act that kills the long-term fertility of the soil. Sorry folks, that's on me.

The reality of plowing, and other tilling practices, is far from bucolic. The plow is traditionally used to turn and open soil, break up weeds and roots, and incorporate soil residues and organic matter.⁹ And it does all these jobs quite well. No fault for that. However, doing these jobs well means also ripping apart the layer of top soil, the most

⁹ Creech, Elizabeth. "Park Your Plow: 5 Tips for the no -Till-Curious." Nov 5, 2018. *Farmers.gov*. U.S Department of Agriculture. Accessed Sept. 23, 2020. <https://www.farmers.gov/connect/blog/conservation/park-your-plow-5-tips-no-till-curious>

important and nutrient dense layer for plants. Disturbing the soil structure in this way has some big consequences: it disturbs the carbon layer and soil structure, the microorganisms in the soil, and causes mass amounts of erosion. Okay, so that's a lot of bad things. Let's tackle them one at a time, shall we?

1. Carbon layer disturbance, with a side of structural failure!

In order to grow and thrive, plants need ample amount of carbon in the soil.

“Wait!” I hear the peanut gallery saying, “Wait, I thought that plants needed carbon dioxide to grow.... you know, carbon from the air?”

Yes, well done peanuts, that is correct. Plants do need carbon dioxide, to convert it into energy and organic matter. The carbon in the soil is just as important, but serves a different role. Organic carbon in soil is incredibly important for soil structure, increasing the physical stability of the soil. Carbon in soil helps aerate it, and improves water drainage and retention, which again improves the stability of the soil.¹⁰ It also reduces the risk of erosion. When a plow is dragged through the soil, it mixes the carbon in the top soil deeper into the ground, slowly deflating the soil stability. If this happens once or twice, it may not be a big deal.¹¹ Just like repairing a broken support beam in a house can be repaired, carbon can be restored to the soil. However, if plowing happens year and year, and the soil is never given the chance to recover, it will become compacted and hard, with limited structure and support for plants. Imagine if instead of repairing a

¹⁰ Corning, Eli, Amir Sadeghpour, Quirine Ketterings, and Karl Czymmek. "The Carbon Cycle and Soil Organic Carbon." *Cornell University Cooperative Extension* 91, no. Agronomy Fact Sheet Series (2016).

¹¹ Comis, Don. "To Plow Or Not to Plow? Balancing Slug Populations with Environmental Concerns and Soil Health." *Agricultural Research (Washington)* 52, no. 10 (Oct 1, 2004): 16

broken beam, every year you slowly cut another one. Over time, your house would collapse. There would be less air, less space, and it would develop a tendency to flood. The same thing happens to soil without carbon. Plowing takes away some of the top-level carbon, and renders the soil structure untenable.

2. The death of microorganisms 😞

Picture this: you are very, very small, and you live in soil as a microorganism, happily processing nutrients and improving soil quality and fertility. One day, you are chugging along, munching on some tiny particles of nitrogen, and a huge metal shaft violently rips you away from your patch of dirt and deposits you at random somewhere else. Ouch. Welcome to the life of a microorganism in a tilling system.

Microorganisms are incredibly important for the fertility of soil. Sometimes referred to as “the cows underground” these hard workers break down crop residue and cycle important nutrients, such as nitrogen, potassium and phosphate, into the soil so they are available for plant use. Good, healthy soil includes a diverse array of microbial communities that contribute to this process and improve the soil, so much so that enzymatic activity levels are commonly used as a stand in for soil health. The more activity, the healthier the soil. With tilling and plowing practices, the microbes are being highly disturbed, resulting in less activity, and unhealthy soil.¹² In comparison, no-till soil is very active, resulting in healthy microbes, healthy soil, and healthy plants. Again, this makes sense, with no plow to disturb it, the community of microorganisms are

¹² Zuber, Stacy M. and María B. Villamil. "Meta-Analysis Approach to Assess Effect of Tillage on Microbial Biomass and Enzyme Activities." *Soil Biology and Biochemistry* 97, (2016): 176-187. doi:<https://doi.org/10.1016/j.soilbio.2016.03.011>. <http://www.sciencedirect.com/science/article/pii/S0038071716300190>.

allowed to thrive and work in peace, bringing lasting peace to the world. Jk. But they do build healthy soil.

3. Erosion

Erosion wants to kill you. It also wants to kill me, so don't feel special or anything. Erosion is sneaky. It happens gradually, over years and years, and then one day you look around and the entire layer of top soil has disappeared from the United States. Well, not the entire layer. But enough of it to scare you. In each given year, the world loses over 24 billion tons of soil. 24 BILLION TONS. It's literally too much to properly comprehend. In the United States, soil erosion is linked to degradation of land, oceans, and freshwater, along with a decrease in agricultural productivity.¹³ It is dangerous for the environment as sediment washes away helpful microbes and nutrients into streams and other sources of groundwater, removing them from field and farms. The washed-up soil can no longer be used for crops, and often results in unhealthy local waterways. Over the next 50 years, there is potential for erosion to increase by as much as ten percent.¹⁴

Three guesses as to what causes a vast majority of this dreaded erosion? If you needed three, I truly feel that you should reread this article. For all those who only needed one, congrats! You're right, it is plowing. Our old enemy, the plow, is responsible for the slow-killer, erosion. The primary purpose of plowing is to break up

¹³ Borrelli, Pasquale, David A. Robinson, Panos Panagos, Emanuele Lugato, Jae E. Yang, Christine Alewell, David Wuepper, Luca Montanarella, and Cristiano Ballabio. "Land use and Climate Change Impacts on Global Soil Erosion by Water (2015-2070)." *Proceedings of the National Academy of Sciences* 117, no. 36 (2020): 21994-22001.

¹⁴ Quine, Timothy A. and Kristof Van Oost. "Insights into the Future of Soil Erosion." *Proceedings of the National Academy of Sciences* 117, no. 38 (2020): 23205-23207.

and loosen top soil in order to plant more effectively. However, the loosening of soil, in addition to the two negative effects discussed above, also leads to the degradation of soil stability. Plowing rips the roots of weeds and other plants, which serve as a sort of glue for soil. Without these roots to bind it, and with it being already loose and exposed to the elements from the plow, the soil washes away in any type of wind or rain. This extended soil loss will, and some say already has, result in decreased agricultural potential.¹⁵

The Patent:

I'm not going to lie; I don't have a cute story for patents in the way I did for the plow. This is because patents are complicated, confusing, and throughout my research for this section I repeatedly and fervently thanked my parents for fostering my critical reading skills. Basically, the deal is this: Large agrotech companies, such as the German firm Bayer or the U.S firm PepsiCo, often develop specific lines of agricultural crops that are the best for their products. For example, PepsiCo, who owns Lays, developed a type of potato called the FC5, which is a variety that specifically thrives in low moisture.

However, the development of these patents can result in restriction to innovation.¹⁶ This is where it gets tricky, so stay with me. In 2011, there was a law passed by congress called the Leahy-Smith American Invents Act, often shorted to AIA. This seems great, right? Yay, more American inventions! Except no. Instead of fostering

¹⁵ Montgomery, David R. "Soil Erosion and Agricultural Sustainability." *Proceedings of the National Academy of Sciences* 104, no. 33 (2007): 13268-13272.

¹⁶ Schimmelpennig, David. "Agricultural Patents: Are they Developing Bad Habits?" *Choices: The Magazine of Food, Farm and Resource Issues* 19, no. 1. American Agricultural Economic Association. (Mar 1, 2004): 19-23

innovation, the passing of this act knee-caped it. There are a few reasons why the passing of this law did have that effect, but I am just going to talk about one of the most important ones for our purposes: the objection effect.¹⁷

The base structure of the AIA enables repeated objections of patent applications. Again, this may seem like not such a big deal—why shouldn't the people be able to object to a patent that may possibly infringe upon their own? Except, again, no. In almost all cases of objections related to agricultural patents, it is not “the people” objecting. It is private sector companies, likely Bayer or PepsiCo, who drag patent appliers through expensive and exhausting legal battles, with the goal of stopping the patent. And if you are making a new agricultural biotechnology, you don't just have to worry about one of these companies objecting to your patent. No, all of the companies can object, and they can do it back to back. So, picture this: You are trying to develop a new drought resistant seed. Finally, after years of research and failure, you made it! This seed will help feed the world's population, and help provide assurance that the entire planet may not starve because of climate change. You feel pretty proud. Time to patent your hard work and make sure that you get credit, and make sure that it is available to those who need it. Except...when you go to patent it, PepsiCo raises an objection. It seems to them like your drought-resistant seed is too similar to one of their drought resistant seeds.

“But I developed it completely separately.”

¹⁷ “Objection effect” is my word for the phenomenon that results from this bill, and as far as I know it has not been used in any kind of formal setting or legal paper.

Doesn't matter. PepsiCo has the right to drag you into court time and time again, forcing you to pay exorbitant fees for even the chance of getting a patent. But let's say that you do. You, the little guy, fight off PepsiCo's objection, and can move forward with your patent! What a relief, you think. Until the next day, when you learn that Bayer has raised an objection to your seed. That horrible, long, expensive fight you just won with PepsiCo? Yeah, you have to go fight Bayer too. Tell me, just how long do you think you could get funding for? How long will your university or company continue to support you? I'm guessing not as long as Bayer. Or the next one that will object. Or the next one. Eventually, you run out of funding, and you have to shelve your seed. Your university or company tells you to focus on something other than new agrotechnology or crop development. The legal battles are just too much.

Now, that was a hypothetical scenario. But it does illustrate my main point here quite well: the objection effect as produced by the AIA restricts agricultural innovation. This is creating an innovation bottle-neck effect, where there are only two current technologies that are used to transform plants, and both patents for them are held by the private sector.¹⁸ The description above illustrates why there aren't more. The objection effect doesn't just apply to agrotechnology or plant transformation technology, it also applies to the patented crops themselves. The restriction of genetic patented materials results in a minimization of biodiversity. In the 21st century, partially due to patent objections, the available pool of genetic material is slowly becoming more and more constrained, and genetic diversity is lost. This loss of genetic diversity could lead to

¹⁸ Schimmelpfennig, David. "Agricultural Patents: Are they Developing Bad Habits?" *Choices: The Magazine of Food, Farm and Resource Issues* 19, no. 1. American Agricultural Economic Association. (Mar 1, 2004): 19-23

crops becoming more susceptible to drought and pests, as the “resistant” strains slowly prove to be less and less resistant. In addition, these patents force farmers to depend on seed banks, and seed providers, instead of harvesting and growing seeds from the leftover harvest, for fear of accidental patent infringement. This keeps the farmers reliant on companies like PepsiCo and Brayer, who sell the seeds at an upcharge.

I could go on to explain how the objection effect, and by extension the AIA, arguably contradicts Article VIII of the Constitution, but honestly this blog is already long and confusing enough, so I will leave you with one last way that patents negatively affect farmers: companies can sue farmers for patent infringement if their patented crop ends up in the famers field.

It is very hard to control where all organic matter ends up. Many plants are spread by seed carriers or the wind, allowing them to travel far and wide. When some of these seeds happen to land in a farmer’s field, and propagate with their existing crop, the company can sue them. In one such case, *Bowman v. Monsanto*, the company Monsanto sued an Indiana farmer over the propagation of their seeds. This case appeared in the Supreme Court in 2013, and the court sided with Monsanto.¹⁹ This creates an unsettling legal precedent, allowing companies to sue famers for patented crops in their fields, regardless of the amount. Monsanto has personally stated that it will not sue anyone who has less than 1% of the total crops in the field be Monsanto crops, but that is not backed up by legal enforcement, so it basically means nothing.

¹⁹ "Bowman V. Monsanto." *IIC - International Review of Intellectual Property and Competition Law* 44, no. 6 (Sep, 2013): 721-723. doi:10.1007/s40319-013-0083-9.

Overall, agricultural patents are, at minimum, an overwhelming inconvenience to farmers, and at maximum, could starve us all by reducing biodiversity and restricting the genetic material (the DNA) of crops.

So, as I draw to the end of this laundry list of problems with conventional agricultural practices, I would like to offer some hope. Both issues I talked about today are solvable. Both the agricultural patent and the plow (and previously discussed horriblenesses), could soon emerge as ancient relics of a by-gone age, or be unrecognizably transformed by the future.

Next week, let's talk about how.

P.S: One more thing about patent law because I simply couldn't resist and also found it very cool to think about: patents in the U.S can't apply to living things. You couldn't go out and patent a tree, or a plant. Most agricultural patents are able to be patented because lab work in some way was used, and therefore the argument is that these new crops would have never occurred in nature, so they can be patented. However, some farmers and seed suppliers, mainly of organic seed companies, use selective breeding to create new plants. Selective breeding is when farmers or plant developers take two plants that both show the characteristic they like, such as two tall plants, and breed the two tallest plants together, to hopefully get tall offspring. They keep doing this over and over, and eventually end up with a seed that will almost definitely grow into a tall plant. Replace the word "tall" with drought resistant, pest resistance, or whatever type of plant you want to make. This process takes a long time, but some organic seed banks do it to develop seeds that are hardier without being classified as genetically modified. So, as a

result of this, there seems to be a much larger possibility for expansion in the organic seed market than the non-organic seed market. Just some food for thought. Pun intended.

Putting My Money Where My Mouth is: Introducing Syntropy (10/2/2020):

For the last two weeks, I have been working through some of the problems with conventional agriculture. Perhaps you have been thinking:

“This girl said that she would offer me a way to enjoy my salad guilt-free, and she not only failed to live up to that, but she’s also actually made me more stressed out by listing a bunch of problems I can’t solve. This blog is dumb. Where’s the syntropy part??”

I hear you, good people yelling at me through the screen, and have no fear: today’s the day we put the “syntropy” in “a year in syntropy.” Based on your intense fist-pumping celebration (which I can only assume everyone is doing), you probably couldn’t be more stoked to dive right in and start discussing microbial plant root interactions, but before we get too far into it, allow me to explain the basics.

The Basics:

Syntropic agriculture is a type of sustainable agriculture based on five main tenets.

1. Ground cover

Syntropic agriculture promotes the idea that no bare soil should exist anywhere on a farm. This includes the spaces between rows, as well as the rows themselves. It entails planting “cover crops” or “ground crops” to support healthy seed and soil development. Basically, every syntropic grower's fervent hope is that the average passerby would look at the farm, see a forest, complete with leaf litter, different grass

types, and greenness not restricted to rows. Remember that plants also need certain nutrients to grow, so the implementation and use of nitrogen-fixing plants, and plants that provide other nutrients, would also fall under ground cover in the syntropic method.

2. Maximize photosynthesis

To maximize photosynthesis, crops must be selected carefully to avoid competition. Light is a valuable commodity, and plants must be carefully planned out to optimize growth patterns.

3. Stratification

This is, in my opinion, the most confusing tenet. Stratification deals with the basic principle that limited space=limited plant growth. When planting crops together, farmers have to understand the amount of space taken up by each plant. Stratification divides all plants into 5 main categories, or “strata”: emergent, high, medium, low, and ground cover. Emergent plants require the most sunlight and need to be in constant sun to thrive. They are also typically tall plants, such as corn or eucalyptus, but there are always exceptions. Currently, syntropic farmers think that emergent plants should take up about 20% of the space available to them, resulting in them getting enough sun without competition from other emergent plants and allowing the sun to nourish the other plants. Plants under the designation “high” need a lot of sunlight to survive, but less sunlight than emergent plants. Plants with the designation high should take up about 40% of their available space. Plants with the designation medium require a medium amount of light and take up around 60% of their available space.

Guess what amount of light plants with the designation low need?

Ding-Ding-Ding! Yep, it's a low level of light! A million dollars to you. "Low" plants need low levels of light and should take up about 80% of their available space. Ground cover plants should take up 100% of the space available, as alluded to in the ground cover principle. The designation of a plant as emergent, high, medium, or low is fairly subjective and often occurs based on a farmer's personal experience. Plant designation can change based on average climate, and plant designation is determined largely by trial and error. However, one helpful way to determine a plant's strata is to observe under what conditions it grows in nature. Currently, this principle is still in development and happens in flux. The basic principle is to avoid competition between crops while providing each crop with the optimal environment for it to grow. These percentages are the current "best guess" for a general guideline in how to plant syntropically.

4. Developing Natural Succession

In nature, forests grow on their own. This occurs because of natural succession- the idea that as one plant dies, another is ready to replace it. In agriculture, this tenet involves planting everything one patch of land would need to produce crops for 100 years. That sounds like wayyy too many plants, but practically, this often looks like simple crop rotation. For example, if a farmer is interested in harvesting both corn and sunflowers, seeds of both species would be planted simultaneously, but the corn would naturally germinate and grow before the sunflowers. Once the corn was harvested, the sunflowers would germinate and grow. That's the basic method. Take that idea, multiple it by about 100 times, and you have developed natural succession.

5. Active Management

Management is perhaps the most important tenet. This is how syntropic agriculture can be used as a successful business plan and provide ample food resources to the community. If done correctly, syntropic farms can exist and thrive for years without human intervention. However, these farms will not be able to produce the same annual crops twice. In an unmanaged syntropic farm, once an annual crop is either harvested or cut down, it will likely not return. It will provide the springboard for the new crop instead. By retrofitting the farms for certain crops, i.e., planting new crops of annuals each year, but allowing the rest of the crops to grow as planted, a farmer who chooses to sell annual crops would have increased economic security and increased environmental health.

Over the next few months, I will explain each tenet in detail, elucidating both **why** it works scientifically and **how** it works practically. Once each tenet is addressed, I will also explain how to plan a syntropic row from the ground up (does that count as a pun? If so, pun intended!). I want to take you from here:

“I have no idea what “syntropic” is, but I guess learning about new ways to grow food is kinda cool.”

To here:

“I would survive in an apocalyptic wasteland because I fully understand how to grow and manage my own food.”

And guess what? That process has already started! Moving forward, please expect lots of diagrams. Well, a fair number of diagrams. They won't be overwhelming or anything.

Cover Crops: The Most Complicated Blanket in the World (10/9/2020):

I love plants. Anybody who has read this blog should suspect that by now, but I thought I would clarify for the uninitiated so I don't scare them off with my unbridled enthusiasm for the wonderful practice that is using a cover crop. Ground cover is the first tenet of syntropic agriculture, and it typically covers two main sources of cover: organic ground cover, often abbreviated as OGC, and cover crops. The key difference between OGC and cover crops is that cover crops are planted in the ground, while OGC is not. Think about OGC as a mulch or bed of leaves, and cover crops as a bed of wildflowers. See the difference?

Both OGC and cover crops work together to help the soil fertility on farms, but for the majority of this blog post I will be focusing on cover crops, because quite frankly, cover crops are way more interesting than OGC. Also, I spent many, many, hours spreading mulch this summer, and if I have to think about it anymore than absolutely necessary, I may throw up.

Organic Ground Cover:

OGC is fantastic, primarily for the protectionist element that it brings to an area. When you lay down a thick blanket of leaves or woodchips, or other types of ground cover, the soil is being protected. OGC traps water, helps prevent wind erosion and wildlife interference, and attracts decomposers (things that eat dead things), all of which support soil fertility and crop production.²⁰ The best part about OGC is that once it's on

²⁰ Zhang, Yichuan, Lifang Qiao, Chaoping Chen, and Jian Zhou. "Water Absorption Features of Organic Ground Cover under Artificial Rainfall." *Alexandria Engineering Journal*, January 1, 2020. doi:10.1016/j.aej.2020.08.010

the ground, you are done with it! No additional labor required. The worst part about OGC is that it sits on top of the soil rather than mixing with it, so the effects can be limited. Nevertheless, OGC are a simple, easy technique to improve soil. Now for the complicated stuff.

Cover Crops:

YAY! I could not be more excited to write this blog post. Cover crops are confusing, contradictory, and an absolute joy to figure out. Because it can be so confusing, I am going to structure this section on cover crops in two sections. First, I am going to explain why cover crops are used by farmers in the United States. Second, I am going to explain how cover crops are used by farmers in the United States, and the barriers that stand in the way.

1. Why Cover Crops?

Technically, the answer to this question is simple: farmers use cover crops because it improves the quality of the soil. But that's pretty much the reason for everything that farmers do, because good soil leads to a good crop, so let's get a little more specific.

Cover crops support and improve irrigation practices by increasing the absorption of water into the soil.²¹ How does this happen? In soil, there are two types of pores, called macropores and micropores. Macropores are the space in between the soil particles, and micropores are the spaces within the soil particles. I like to think about soil as a house. In

²¹ Bryant, Corey, Martin Locke, Larry Krutz, Bobby Golden, Robert Steinriede, G. Spencer, Trent Irby, and Daniel Reynolds. "Furrow-Irrigation Application Efficiency in Mid-Southern USA Conservation Tillage Systems." *Agronomy Journal*. 113, no. 1 (2021): 397-406. DOI: <https://doi.org/10.1002/agj2.20468.2021>.

the house, there are hallways (macropores) and air vents (micropores). In this house, Ms. Water Particle just got home from work in the clouds, and needs to rest in the bedroom. It would be far easier for Ms. Water Particle to go through the hallways to get to her bed than it would be for her to go through the air vents. In the same way, water finds it much easier to navigate through soil through macropores as opposed to micropores. Cover crops increase the presence of macropores in the soil through the decay of their roots. As the roots decay, they leave behind macropores, increasing the ease of water flow through the soil, and therefore also improving irrigation practices.²² This can also improve “free water” in the soil, which in turn encourages microbial growth in a damp environment.

In addition to supporting irrigation by encouraging the development of macropores, cover crops result in more hydraulic roughness in a field.²³ I love the term hydraulic roughness because it sounds really intense and hardcore, but it’s actually very simple. Hydraulic roughness is the amount of friction water experiences when passing over land. The more hydraulic roughness, the more friction. More friction means that water takes longer to move over the surface, and more time spent on the surface of soil means more absorbance into the soil. Picture trying to spread butter on the outer crust of a lovely French baguette. Your knife may slip around the hard outer crust, and the butter will rest on top, not sink into the bread. This is a bit like how water flows over hard

²² Bryant, Corey, Martin Locke, Larry Krutz, Bobby Golden, Robert Steinriede, G. Spencer, Trent Irby, and Daniel Reynolds. "Furrow-Irrigation Application Efficiency in Mid-Southern USA Conservation Tillage Systems." *Agronomy Journal* 113, no. 1 (2021): 397-406. DOI: <https://doi.org/10.1002/agj2.20468.2021>.

²³ Bryant, Corey, Martin Locke, Larry Krutz, Bobby Golden, Robert Steinriede, G. Spencer, Trent Irby, and Daniel Reynolds. "Furrow-Irrigation Application Efficiency in Mid-Southern USA Conservation Tillage Systems." *Agronomy Journal*. 113, no. 1 (2021): 397-406. DOI: <https://doi.org/10.1002/agj2.20468.2021>.

packed soil surfaces with a low hydraulic roughness. It is more likely to run over and off the surface without getting absorbed, just like butter on bread crust. Now picture ripping apart the baguette and spreading butter on the soft, rough, pliable inner surface of bread. This is like soil with cover crops and therefore a high hydraulic roughness. Just as the pockets of warm fluffy bread capture and hold butter, the friction of the soil captures and hold water, affording it a greater opportunity to absorb.

Cover crops give a lot to the soil. They help support the soil fertility, and help water absorption. So why, then, do only a marginal number of farmers use them?²⁴ Let's take a closer look at how farmers use cover crops, and the barriers surrounding cover crop use in the United States.

2. How do farmers use cover crops? And why don't more farmers use them?

When in use, farmers will plant cover crops in a rotation with harvestable crops as a way to restore the soil. This is sometimes call "crop rotation", but I don't like to use that terminology because it implies that the crops being rotated are harvestable crops, which cover crops generally are not. Cover crops are most often planted over winter in fields that would be otherwise unused, in hopes of increasing crop yield (the amount of profitable crop harvested) in the spring.²⁵ However, the planting of cover crops costs both time and money, something that is in short supply for most farmers. Now, you

²⁴ Singh, Gurbir, Thilakarathne, Ashani D. G. M., Karl W. J. Williard, Jon E. Schoonover, Rachel L. Cook, Karla L. Gage, and Randy McElroy. "Tillage and Legume Non-Legume Cover Cropping Effects on Corn-soybean Production." *Agronomy Journal* 112, no. 4 (2020): 2636-2648. doi:10.1002/agj2.20221. <https://doi-org.holycross.idm.oclc.org/10.1002/agj2.20221>.

²⁵ Singh, Gurbir, Thilakarathne, Ashani D. G. M., Karl W. J. Williard, Jon E. Schoonover, Rachel L. Cook, Karla L. Gage, and Randy McElroy. "Tillage and Legume Non-Legume Cover Cropping Effects on Corn-soybean Production." *Agronomy Journal* 112, no. 4 (2020): 2636-2648. doi:10.1002/agj2.20221. <https://doi-org.holycross.idm.oclc.org/10.1002/agj2.20221>.

might say “If cover crops increase soil quality, and therefore crop yield, then wouldn’t that make up for the extra seed costs?”

And I would say yes...in theory. You see, the fun thing about cover crops is that the effectiveness varies extensively by plant and region, so in order to maximize the benefit of a cover crops, a farmer has to pick the right one.²⁶ If a farmer picks the wrong cover crop, it may actually cause negative interactions with the soil, and decrease soil fertility. One small choice could ruin, or severely decrease a harvest. Would you like to hear something even more fun? There is very limited data about what cover crops provide the best benefit for specific regions and crops, so not only do farmers have to make what could be an incredibly costly decision, they have to make it blind.²⁷ They could make a best guess after reading a few studies, but these would be generalizations. Generalizations are the enemy of productive farming. Each aspect is so specific—the region, the climate, the crops planted, the previous land use—everything affects how cover crops impact the soil. In order to make cover crops a viable option for farmers, we have to gather more information about how they function. This costs money, which always seems to be in limited supply. Especially if you are working toward sustainability and not profit.

²⁶ Ruis, Sabrina J., Humberto Blanco-Canqui, Roger W. Elmore, Christopher Proctor, Katja Koehler-Cole, Richard B. Ferguson, Charles A. Francis, and Charles A. Shapiro. "Impacts of Cover Crop Planting Dates on Soils After Four Years." *Agronomy Journal* 112, no. 3 (2020): 1649-1665. doi:10.1002/agj2.20143. <https://doi-org.holycross.idm.oclc.org/10.1002/agj2.20143>.

²⁷ Singh, Gurbir, Thilakarathne, Ashani D. G. M., Karl W. J. Williard, Jon E. Schoonover, Rachel L. Cook, Karla L. Gage, and Randy McElroy. "Tillage and Legume Non-Legume Cover Cropping Effects on Corn–soybean Production." *Agronomy Journal* 112, no. 4 (2020): 2636-2648. doi:10.1002/agj2.20221. <https://doi-org.holycross.idm.oclc.org/10.1002/agj2.20221>.

I must confess, after writing that last paragraph I feel a little like a 13-year-old who just waved a lollypop in a child's face and then ripped it away. "Do you want this amazing thing that has the potential to revolutionizes our farming system? Well, that's a huge bummer for you, because it can't translate to wide-spread use. Sorry!"

It is, however, a welcome reminder that many farmers do wish to incorporate sustainable practices into their business. They merely lack the resources and support to do so, both from pure academic and informational standpoint, and from a governmental standpoint. We are failing our farmers, not the other way around.

To recap: Cover crops=good! The fact that famers can't reliably use them=bad! 😞.

Maximizing Photosynthesis: Here Comes the Sun (with help from beetles, not the Beetles) (10/23/2020):

Leave no stone unturned! Or sun unused, as the case may be with syntropics. The second tenet, maximizing photosynthesis, is perhaps the simplest. Don't make the mistake, however, of believing that because it is simple, it is unimportant.

Photosynthesis is the most important biochemical process in the world. And yes, that is a hill I will die on. Photosynthesis is what makes this planet livable; it vents oxygen into the air as a byproduct, removes toxic carbon dioxide, and is the bedrock of our food systems. In short, photosynthesis is magic. Luckily for us, it is the type of magic that can be understood and explained. In this upcoming section, I will take you on a journey though photosynthesis, and then explain how this tenet works in agricultural practice.

For some reason, in all my years of learning science I have always been taught photosynthesis in October. This has led to me thinking about photosynthesis as a

haunted house of sorts. Photosynthesis begins with a tiny particle of light hitting a leaf. Or as I like to think about it, a very excited kid entering a haunted house. The kid has a ton of energy when entering the haunted house, and may put up a brave front. However, as soon as it is time to enter the haunted house, the kid loses his bravery, and becomes scared and apprehensive. He becomes, in essence, a different person (or at least a different haunted house costumer). The same thing happens when light hits a leaf. Just as the haunted house scares the kid into a different person, the leaf transforms the light particle into a chemical particle. But how does this process happen?

All light particles have energy...kind of like a kid waving his hands in the air in excitement. Kids can't run into the outside walls of the haunted house and get in though; they need to find a door. Light does too. On a leaf, this door is called a reaction center, and they are equipped with special, microscopic parts of plants called an antenna system. Just like a scary banner proclaiming a haunted house would draw in kids, an antenna system captures light, and draws it into the reaction center of the leaf. The reaction part of the leaf is the same as an entrance room in a haunted house. When the light particle hits the leaf, this energy excites other particles in the leaf, very tiny particles called electrons. Imagine the hand-waving kid running into the haunted house, and then suddenly stopping in terror, only to have an ax wielding actor run at him. Viewed from a photosynthetic point of view, that actor has absorbed the kid's energy. Or in a leaf sense, the electron has observed the energy of the light particle. Now, the electron (or ax wielding murderer) has all the energy. Where does she go from here? To other rooms of course! All who enter the haunted house must be scared. These customers the ax-wielder is scaring are not light particles, however. That kid got scared in room one and left. No,

these customers are the hardier teenagers, who stuck it out past the entrance and are milling in rooms on one side of a hallway. Or, in a leaf, these are hydrogen atoms, hanging out on one side of the internal barrier near the reaction center. The ax-wielder moves from room to room, looking from someone to scare, and these teenagers flee across the hallway, to rooms on the other side. In a leaf, that ax-wielder becomes an electron, moving through a series of reactions in the electron transport chain. As the electron moves from station to internal station in the leaf, the energy it carries is used to move electrons from one side of the barrier to the other. Just as the teens prefer to be on the less scary side of the hallway, and are forced into the other side by our lovely ax-murder, the hydrogen atoms prefer to be outside the barrier, and are forced inside by the energy of the electron.

As the ax-wielder comes to the end of the hallway, she is exhausted. The hallway is pretty long, and she has been sprinting after way-ward teens all night. What she needs, is a ride. Then, how lucky! At the last room, a designated ax-wielder picker-upper is here to sweep her up and away to her next engagement. Similar to the ax-wielder picker-upper at the end of the hallway, the electrons have an electron acceptor that they go to after the end of the electron transport chain. But what happens to the teenagers (or hydrogen atoms)? They are still trapped on the other side of the hallway, and are desperate for a way out. They search and search, and at long last find a door. It will not open. Becoming gradually more and more frantic, the teens bang on the inside of the door, their voices hoarse and strained, the hands bruising as they push with desperate force. It will not open. Tears, snot, blood from broken fingernails as they claw at the unmoving barrier in front of them; the smell of despair is tangible. It will not ope...opps,

jk. It opened. The owners of the haunted house were waiting until a crowd of people were walking by, hoping to pique the interest of other customers by demonstrating just how scary the haunted house truly is. The teens pour through the door, streaming out into the night. The owners' scheme has worked. Other people, seeing the terror, know that this is a good haunted house, and get in line. By waiting until other customers were nearby before opening the door, the owners have made more money.

In photosynthesis, the “door to the outside” is called a hydrogen pump. The hydrogen atoms, just like the scared teens, really want to be back outside the barrier they were forced across. The hydrogen pump provides a way out, and just like the owners harness the teens to make more money, the cell harnesses the energy of the hydrogen atoms streaming through the pump to make energy in the form of ATP, by forcing an additional phosphate onto a molecule that only has two phosphates. A phosphate is a group of atoms. ATP is a common form of energy currency in cells, much like cash is in society. Plant cells then use ATP (along with other things like carbon dioxide) to make food for themselves. And in the process, food for humans! But it all comes from one little particle of light.

That is precisely why farmers are so concerned with plants getting the right amount of light—too little light, and the plant will die, just as a haunted house would with no customers. In syntropy, this means that plants must be selected very carefully. If plants had to compete with others for light, it will be harder for them to grow, just as a haunted house would find it harder to attract customers if there was another haunted

house in the area.²⁸ In order to avoid that, syntropic managers must always think about the light requirements of different plants, and must avoid planting together plants that would compete. In practice, this sounds simple, but it often involved complication planning and preparation. This is also part of the tenet “stratification”, which will be discussed next week. In the meantime, I hope that you all look at plants a little differently, after having learned of the complexities it takes to make energy from sunlight. After all, if you had a haunted house inside you, I’d bet you’d be super uncomfortable. And they do this complicated process every single time light shines on a leaf. So please, say “thank you” to a plant today.

Stratification: Oh God, What IS This? (10/30/2020):

Stratification I find to be the most confusing tenet of syntropic agriculture. For one thing, it’s still being fine-tuned by the creator of syntropic agriculture, Ernest Gosh. The actual inventor of the agricultural system that we are talking about isn’t completely sure how it works. For another thing, this tenet of syntropics deals with plant niches, which are still not fully understood.²⁹ So yeah, this should be a super fun section, full of exact scientific knowledge with nothing left up in the air. But as it says in the header, “let’s grow together” so I will do my very best to tell you everything I know, and we can learn the rest as a team.

²⁸ Hautier, Y., Niklaus, P.A. and Hector, A., 2009. Competition for light causes plant biodiversity loss after eutrophication. *Science*, 324(5927), pp.636-638.

²⁹ Silvertown, Jonathan. "Plant Coexistence and the Niche." *Trends in Ecology & Evolution* 19, no. 11 (2004): 605-611. doi:<https://doi.org/10.1016/j.tree.2004.09.003>. <http://www.sciencedirect.com/science/article/pii/S0169534704002630>.

When we grow, both as plants and as people, we must be aware of the level of competition in our lives. Now, for people, sometimes competition can be a good thing: it pushes us to do better, become motivated, put in our best effort, etc. But for plants (and most other creatures on Earth) intense competition can be a detriment. Plants are not competing the same way humans do, for first place in a swim meet, or the department bonus at the end of the year. Plants, when they compete, are competing for their lives. In every environment, there are finite amounts of resources. There is finite sunlight (confused about how this could be true? Think about taking a walk through a sunny field as compared to a walk in a shady forest), water, and soil nutrients. When plants have to compete for these resources, it stunts the growth and development of plants. As you can imagine, when you are trying to grow mass amounts of food for a human population, plant competition could be seriously detrimental. In syntropic farms, it is the manager's job to figure out how to plant a variety of plants without making them compete for resources.

The key framework that manager's and farmers use to avoid competition between plants is called stratification. Stratification, the third tenet of syntropic agriculture, focuses primarily on sunlight as a resource. Before I start to talk about stratification (I'm getting there! I promise) I want to briefly address why sunlight is the main consideration for syntropic farmers. Why not soil nutrients? Why not water?

Plant species have an amazing ability to pull nutrients from the soil through their roots. As I have talked about previously, one of the main goals of syntropics is to nurture and support healthy soil. The best part about this? Plants do it on their own. The coolest

part about this? We don't really know how!³⁰ The current best guess is the plants do this through root exudates, which is basically root juice. Plants give off this root juice through their (you guessed it) roots, and it somehow influences the healthy microbes around them to help stop harmful microbes from growing. How this information gets communicated to the microbial networks, scientists are currently not sure.³¹ Philosophers also don't know. I asked one to make sure I covered my bases. Despite not understanding how, scientists are in wide agreement that plants, left alone, will largely make the soil that is best for them and their specific nutrient needs.³²³³ There is some evidence that biological pest controls, such as fungi that kill bugs, can impact the microbes in the soil. But they do so in a positive way! In one recent study, scientists found that introducing one specific fungus species *Metarhizium*, not only helps with pest control, but also increased the number of plant-growth bacteria in the soil.³⁴ One specific

³⁰ Jacoby, Richard, Manuela Peukert, Antonella Succurro, Anna Koprivova, and Stanislav Kopriva. "The Role of Soil Microorganisms in Plant Mineral Nutrition-Current Knowledge and Future Directions." *Frontiers in Plant Science* 8, (2017): 1617. doi:10.3389/fpls.2017.01617. <https://pubmed.ncbi.nlm.nih.gov/28974956> <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5610682/>.

³¹ Jacoby, Richard, Manuela Peukert, Antonella Succurro, Anna Koprivova, and Stanislav Kopriva. "The Role of Soil Microorganisms in Plant Mineral Nutrition-Current Knowledge and Future Directions." *Frontiers in Plant Science* 8, (2017): 1617. doi:10.3389/fpls.2017.01617. <https://pubmed.ncbi.nlm.nih.gov/28974956> <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5610682/>.

³² Lei, Haiying, Ake Liu, Qinwen Hou, Qingsong Zhao, Jia Guo, and Zhijun Wang. "Diversity Patterns of Soil Microbial Communities in the Sophora Flavescens Rhizosphere in Response to Continuous Monocropping." *BMC Microbiology* 20, no. 1 (2020): 272. doi:10.1186/s12866-020-01956-8. <https://pubmed.ncbi.nlm.nih.gov/32867674> <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7457492/>.

³³ Cavalieri, Andrea, Frederik Bak, Adriana Garcia-Lemos, Jacob Weiner, Mette Haubjerg Nicolaisen, and Ole Nybroe. "Effects of Intra- and Interspecific Plant Density on Rhizosphere Bacterial Communities." *Frontiers in Microbiology* 11, (2020): 1045. doi:10.3389/fmicb.2020.01045. <https://pubmed.ncbi.nlm.nih.gov/32528445> <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7264394/>.

³⁴ Barelli, Larissa, Alison S. Waller, Scott W. Behie, and Michael J. Bidochka. "Plant Microbiome Analysis After *Metarhizium* Amendment Reveals Increases in Abundance of Plant Growth-Promoting Organisms and Maintenance of Disease-Suppressive Soil." *PloS One* 15, no. 4 (2020): e0231150. doi:10.1371/journal.pone.0231150. <https://pubmed.ncbi.nlm.nih.gov/32275687> <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7147777/>.

one that increased was a type of nitrogen fixing bacteria, which is very important for plants.

Essentially, this means that if farmers are fostering a positive soil environment, which they can do by following the tenets of syntropic agriculture, then they really don't have to worry all that much about competition for soil nutrients. Farmers also control the amount of water plants receive through irrigation techniques, so plants shouldn't have to compete for water. I suppose plants could still be drowned by water if there is a huge rainstorm or flood, but acts of nature are largely beyond the control of any one farmer or farm. I say "largely" because I don't know everything that exists and if some weather-warping witch runs a small farm in Nebraska, I certainly don't want to offend her. You're valid, witch. But generally speaking, syntropic farmers shouldn't worry about soil nutrients or water. That only leaves one thing that plants could compete over: sunlight.

And now, at long last, we are at stratification. Stratification is a system used by syntropic farmers to make sure that every crop planted gets the right amount of light for that crop. Some crops need a lot more light than others, and a large part of the challenge in arranging syntropic rows is making sure that every crop has adequate light. Stratification basically ignores all other differences plants have, and separates plants into five different categories, or strata, based only on sunlight needs.

1. Emergent plants, which need constant or near constant sunlight
2. High plants, which need a lot of sunlight, but less sun than emergent
3. Medium plants, which need occasional sunlight

4. Low plants, which only need some sunlight, or scattered sunlight
5. Ground cover plants, which need the least amount of sunlight

Now, emergent plants are also normally quite tall, because they are reaching up towards the sun. Practically, this means that you can't plant an emergent plant next to a high plant, because the emergent plant will block out all of the sun for the high plant. However, you could plant an emergent plant with a low plant, because the sunlight filtering through the emergent plant would be enough for the low plant. In this scenario, the emergent would actually shield the low plant from getting too much sun, so they work together really well. The same relationship works for high plants and medium plants.

So how do we know which plants are which? The answer to this question, as with so many other questions, can be found by studying the natural environment. For example, you will often find blueberry bushes growing at the edge of forests. This would imply that blueberries seem to thrive in medium to low light conditions, because the tall trees of the forest would block out some light. Blueberries then, are likely a medium-low plant, and would not do well in the baking sun. Classifying plants as emergent, high, medium, low or ground cover is way more complicated than I would like, as the light needs of the same plant could change based on the environment it is in. For example, in Australia, raspberries are a low-level plant, but Australia gets more powerful UV rays than New England.³⁵³⁶ In New England, raspberry plants grow best in a median level of

³⁵ *Pers. Comm.* Neil Hawes. October 20th, 2019.

³⁶ "From Australia to Brazil: Sun Worshippers Beware." *Bulletin of the World Health Organization* 87, no. 8 (2009): 574-575.
doi:10.2471/blt.09.030809. <https://pubmed.ncbi.nlm.nih.gov/19705004> <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2733274/>.

light. Also, there is no database for this system of strata classification because syntropics is a relatively new way of farming. To me, the difficulty in placing plants into strata is one of the highest barriers to implementing syntropic agriculture. To properly identify a plant's strata, one must have an intimate knowledge of not only the conditions a crop prefers, but the conditions it prefers in the environment that it is in. That's a tall order. I do not fit the bill, and I think I would be hard-pressed to find anybody who does.

But we will move on from that slightly depressing thought, and go instead to a happy, rosy world in which we do have all of the correct information about our crops' strata. How do we know how much of each type of strata to plant? I like to think about the strata as a broken five-tiered fountain. The rain that falls is the sunlight, flowing down through each of the five strata. The tier that catches the rain first has to, by default, be the smallest, because the water would overflow and then move down to the next tier, just like sunlight would do. The tallest tier represents emergent strata. The number of emergent strata that you plant has to be small enough to allow light to go down to the rest of the plants, just as the small top tier of the fountain fills up and then overflows. The next tier would be the high strata plants, the next the medium strata, then the low strata, and finally ground cover plants, which would be the bottom of the fountain, absorbing all of the water that made it down the other four tiers. Just as the size of fountain tiers needs to allow water to trickle down and fill the rest of the fountain, plant strata need to be in a ratio that allows sunlight to trickle down and support each crop.

The exact percentage ratios may change, but Ernest Goshe, the creator of syntropy, recommends that you start with 20% emergent, 40% high, 60% medium, 80% low, and 100% ground cover. This adds up to more than 100%, but it's designed to. The

percentages are not in relation to each, but rather the overall amount of space that it is possible for the crops to be planted in. For example, if you were planting an emergent crop, and had 100 acres to do so, you should actually only plant 20 acres of the emergent crop, which is 20% of the “available” space. In syntropic agriculture, different crops are planted in and around each other--remember the initial idea that syntropic farms should look like forests, not farmland. The 80 acres that is not being planted with emergent crops may seem like an empty space, but keep in mind that the emergent crops will be spread out among the farm, and other crops planted around them.

On the other side of the spectrum, ground cover should take up all the space available to it, and should be planted at a ratio of 100%. Ground cover is essential to the workings of a syntropic farm (for a remind why, see the blog post “Ground Cover: The Most Complicated Blanket in the World), and it also does not block out sunlight for any other crop below it. It receives as much sunlight as possible, kind of like the pool at the bottom of the fountain. The other strata, high, medium, and low, operate in the same way as emergent does, with varying levels of planting depending on the strata. It could also be the case that these strata-planting ratios need to change given the specific environment the syntropic farm is in. Right now, all of the recognized syntropic farms are in tropical climates, namely Brazil and Australia, but as the method spreads to more temperate zones, it may need to change. Stratification is complex and still in development, but I have given you all I currently understand about it. If I understand more later, I promise you’ll be the first to know.

Natural Succession: The First Day of Your New Favorite Class, Forest 101

(11/9/2020):

Fun fact: I almost skipped this blog post by accident because I forgot about this tenet and then spent about an hour writing the blog for next week instead. Whoops.

And despite what my fun fact may imply about natural succession, it is actually a really interesting topic. It starts with one of my favorite subjects in the world: forests. Forests are pretty amazing. They self-develop over hundreds of years, and can last for millions more. Natural succession, as used in syntropic agriculture, is an attempt to recreate the development patterns of forests in order to create healthy conditions for crops. This is a pretty tall order: forests (and the plants inside them) are incredibly complex ecosystems, even more so because we still don't fully understand how plants work. In order to copy forests, we first have to understand them. And with that in mind, I'd like to formally invite you to...

Forest 101

Welcome class! I'm so glad you all could make it to this bonus seminar on forest development and succession. This field has gotten heated over the past years, so prepare for The Drama™. But before we get to the gossip, let's get on the same page about development. All forests first developed over bare rock. There was no soil or no other plants, just...rock. So how did plants manage to get a foothold in bare rock? Through the use of pioneer species, plant species that are especially good at developing with little to no soil requirements. To picture this happening in real time, we are going to mentally travel to Hawaii, where volcanic rock offers us a playing field for development. First, the wind and elements must break down the rock enough for pioneer species to get a foothold among them. Common pioneer species include lichen and mosses, which often grow on bare rock and have next to no soil requirements. In addition to lichen and moss,

weedy-yet sturdy-vascular plants, such as ferns also appear, taking advantage of the open space. By the way, when I say “sturdy” here, I am referring to the fact that these plants need very little soil to survive, and I don’t mean to imply that these initial plants last a long time. They don’t. Over time, the lichen, moss, and weedy plants die off, creating a layer of biological material over the bare rock, which eventually develops into a rudimentary soil. Then, slightly less sturdy (i.e. needs more soil) plant species will be able to grow there, and then these plants die off, become soil, and the next round of plants come in. This is called succession—when one species of type of plant dies off and creates a fertile environment for the next plant to grow. Over hundreds of years (our best guess is around 350-600 years, but we don’t know for sure) a full forest develops.³⁷³⁸ I cannot, however, yet explain what happens at the “end” of the successional chain. That is part of The Drama™ I mentioned earlier, and we have to get through one more thing before we talk about it.

Development over bare rock is a specific kind of succession called primary succession. Another kind of succession, secondary succession, is also possible, and much more likely to happen today. Secondary succession occurs after a disturbance to a forest, such as a wildfire, tornado, or human interference. I find it useful to think about

³⁷Bonnell, Tyler R., Rafael Reyna-Hurtado, and Colin A. Chapman. "Post-Logging Recovery Time is Longer than Expected in an East African Tropical Forest." *Forest Ecology and Management* 261, no. 4 (2011): 855-864.
doi:<https://doi.org/10.1016/j.foreco.2010.12.016>. <http://www.sciencedirect.com/science/article/pii/S037811271000719X>.

³⁸ Liebsch, Dieter, Marcia C. M. Marques, and Renato Goldenberg. "How Long does the Atlantic Rain Forest Take to Recover After a Disturbance? Changes in Species Composition and Ecological Features during Secondary Succession." *Biological Conservation* 141, no. 6 (2008): 1717-1725.
doi:<https://doi.org/10.1016/j.biocon.2008.04.013>. <http://www.sciencedirect.com/science/article/pii/S0006320708001456>.

the development of forests as if they were houses. In primary succession, a house is built on a craggy bluff overlooking the water from scratch. In secondary succession, a house is built on an abandoned city lot after the previous house was razed down by a mob celebrating the Philadelphia Eagles Superbowl victory. I don't know when we jumped from Hawaii to Pennsylvania, but we're here now. Our PA house is emblematic of secondary succession because we are not starting completely from scratch. The foundation is still there, and maybe the sewage and drainage pipe system escaped the crowd. Similarly, in secondary succession, the soil and foundations of a forest are still there, but the forest itself, trees, flowers, ferns, moss, etc., are all gone. As there is fairly limited bare rock left, this is the type of succession we see most often now. The initial disturbance of a forest could be fire (California forests are about to undergo secondary succession in a big way), a violent tornado or wind storm, or one of the most common kinds of disturbance to our forest today: human interference. Human agricultural interference is particularly prevalent, as acres of forests were and are being cut down for farmland. Because what we are trying to do here is model succession, and my guess is that most syntropic farmers will be working on reclaimed farm land that was previously used for conventional agriculture, the majority of syntropic farms will be trying to model secondary succession.

Secondary succession pretty much works in the same way as primary succession, but instead of super hardy plants and lichen that don't need soil, pioneer species in secondary succession, are fast growing species able to spread and colonize an area very easily. A common example of a pioneer species are ferns, which appear in forests around

the world after disturbances.^{39,40} And then basically the same thing happens, except it take less long because the soil was already there and didn't have to be built up over generations of dead plants. Still though, this process takes a long time (think 180-200 years) and there is a heated debate in Ecology about what happens at the "end-point" of natural succession.⁴¹ That's right folks, we've finally reached The Drama™.

The Drama™ started about 150 years ago, when a Finish botanist named Ragnar Hult came up with the idea that each forest has a climax, of a final stage of vegetation, in which it enters an equilibrium. This proved to be very controversial, and was largely substituted for the idea of potential natural vegetation, or PNV, in 1965.⁴² The key reason for the disagreement is that PNV presents the "end state" of a forest not as a steady state system, where the ratios of various plants, animals, and decomposers don't change, but as a more fluid system that naturally goes through changes over time. Basically, PNV is a hypothetical vegetation state that would occur if humans completely stopped influencing an area and allowed it to fully develop. Since than, this idea has been debated, argued, refined, developed, and I'm sure caused a few screaming matches. There are papers that argue that PNV is impossible to model on the basis that the

³⁹ Brock, James M. R., George L. W. Perry, William G. Lee, Luitgard Schwendenmann, and Bruce R. Burns. "Pioneer Tree Ferns Influence Community Assembly in Northern New Zealand Forests." *New Zealand Journal of Ecology* 42, no. 1 (2018): 18-30. <https://www.jstor.org/stable/26538092>.

⁴⁰ Dalling, J. W. and S. P. Hubbell. "Seed Size, Growth Rate and Gap Microsite Conditions as Determinants of Recruitment Success for Pioneer Species." *Journal of Ecology* 90, no. 3 (2002): 557-568. <http://www.jstor.org/stable/3072239>.

⁴¹ Chiarucci, Alessandro, Miguel B. Araújo, Guillaume Decocq, Carl Beierkuhnlein, and José María Fernández-Palacios. "The Concept of Potential Natural Vegetation: An Epitaph?" *Journal of Vegetation Science* 21, no. 6 (2010): 1172-1178. doi:10.1111/j.1654-1103.2010.01218.x. <https://doi.org/10.1111/j.1654-1103.2010.01218.x>.

⁴² Chiarucci, Alessandro, Miguel B. Araújo, Guillaume Decocq, Carl Beierkuhnlein, and José María Fernández-Palacios. "The Concept of Potential Natural Vegetation: An Epitaph?" *Journal of Vegetation Science* 21, no. 6 (2010): 1172-1178. doi:10.1111/j.1654-1103.2010.01218.x. <https://doi.org/10.1111/j.1654-1103.2010.01218.x>.

methodology (PNV traditionally is worked without considering human impact) is unsound and therefore useless to use.⁴³ There are papers that argue the opposite, that PNV modeling can be used as a considerable advancement in forest reconstruction.⁴⁴ There are papers that argue PNV should not be used at all.⁴⁵ There are papers that argue to abandon PNV would be to abandon years of positive scientific development.⁴⁶ There are papers which show forests following the direction of PNV models.⁴⁷ There are papers which demonstrate that even old-growth forests never reach an “end point”, throwing the entire concept of PNV into disarray.⁴⁸ These heated debates (mostly found in the introduction and discussion sections of these papers, if you want to read for yourself. They get a bit academically catty, which can be quite fun) are made worse by the fact that we STILL DON'T UNDERSTAND HOW PLANTS PARTITION

⁴³ Chiarucci, Alessandro, Miguel B. Araújo, Guillaume Decocq, Carl Beierkuhnlein, and José María Fernández-Palacios. "The Concept of Potential Natural Vegetation: An Epitaph?" *Journal of Vegetation Science* 21, no. 6 (2010): 1172-1178. doi:10.1111/j.1654-1103.2010.01218.x. <https://doi.org/10.1111/j.1654-1103.2010.01218.x>.

⁴⁴ Hickler, Thomas, Katrin Vohland, Jane Feehan, Paul A. Miller, Benjamin Smith, Luis Costa, Thomas Giesecke, et al. "Projecting the Future Distribution of European Potential Natural Vegetation Zones with a Generalized, Tree Species-Based Dynamic Vegetation Model." *Global Ecology and Biogeography* 21, no. 1 (2012): 50-63. doi:10.1111/j.1466-8238.2010.00613.x. <https://doi.org/10.1111/j.1466-8238.2010.00613.x>

⁴⁵ Zerbe, Stefan. "Potential Natural Vegetation: Validity and Applicability in Landscape Planning and Nature Conservation." *Applied Vegetation Science* 1, no. 2 (1998): 165-172. doi:10.2307/1478945. <https://doi.org/10.2307/1478945>.

⁴⁶ Loidi, Javier and Federico Fernández-González. "Potential Natural Vegetation: Reburying Or Reborning?" *Journal of Vegetation Science* 23, no. 3 (2012): 596-604. doi:10.1111/j.1654-1103.2012.01387.x. <https://doi.org/10.1111/j.1654-1103.2012.01387.x>.

⁴⁷ Prach, Karel, Lubomír Tichý, Kamila Lencová, Martin Adámek, Tomáš Koutecký, Jiří Sádlo, Alena Bartošová, et al. "Does Succession Run Towards Potential Natural Vegetation? an Analysis Across Seres." *Journal of Vegetation Science* 27, no. 3 (2016): 515-523. doi:10.1111/jvs.12383. <https://doi.org/10.1111/jvs.12383>.

⁴⁸ Brzeziecki, Bogdan, Kerry Woods, Leszek Bolibok, Jacek Zajaczkowski, Stanisław Drozdowski, Kamil Bielak, and Henryk Żybura. "Over 80 Years without Major Disturbance, Late-Successional Białowieża Woodlands Exhibit Complex Dynamism, with Coherent Compositional Shifts Towards True Old-Growth Conditions." *Journal of Ecology* 108, no. 3 (2020): 1138-1154. doi:10.1111/1365-2745.13367. <https://doi.org/10.1111/1365-2745.13367>.

RESOURCES. Sorry for yelling, I just find it very exciting and baffling and curious. Basically, those who study vegetative science are still trying to accurately model and understand the shape of natural succession, and much like participants in spin-the-bottle at the first boy-girl 13th birthday party of the year, every scientist has a dream about what *could* happen.

So, if the world of ecological science doesn't agree on a model or outline of restoration, how can syntropic farmers use the concept to their advantage? By simplifying it a whole lot and crossing their fingers. One of the big upsides to developing syntropic farming is that you don't need to understand *why* the natural world works the way it does (although I am trying to), you just need to be able to recognize patterns and take advantage of them. In this case, it is clear that succession is successful, PNV model or otherwise, and part of this success is based on the death and biomass contribution of previous plants. Syntropic farms are designed to grow as forests grow. A farm taking 600 years to develop fully, however, is highly impractical. Instead, syntropic farms try to plant 100 years' worth of plants at the same time. On the surface, this seems highly impractical. I can hear you muttering to yourself:

“100 years of plants at once? That's madness! Wasn't she just talking about limiting competition last week?”

Yes. Yes, I was. The key to this concept is that some crops develop faster than other crops. For example, corn is an emergent, fast growing crop. Sunflowers are also an emergent species, and grow slightly less quickly, around double the time it takes for corn to grow. This means that if I were to plant corn and sunflower seeds at the same time, the corn would germinate and grow before the sunflower seed germinated. This ensures

If a stratum is left out, a syntropic farmer will likely find that another plant, perhaps a less advantageous one, will take advantage of the space, and spring up in the middle of the row. Again, organizing a syntropic farm this way takes time and effort. It can also lead to problems. For example, if I am a corn farmer, I need to be able to harvest corn year after year. This system set up so that corn can only be harvested once, before another emergent takes its place. The solution to this problem lies in the fifth and last tenet, active management. We will talk about that two weeks from now, (I'm reserving Friday the 13th for a scary syntropic story) but in the meantime, if you are taking a walk through the woods, look around! And think about what came before.

Active Management: How Does This Make Money? (12/2/2020):

Here we are. The last tenet of syntropy. Active Management is, in a way, the most intuitive tenet of syntropy. It is also one of the hardest. After all, wanting to make a profit in a business is a very intuitive thought — learning how to make that happen can take substantially longer. Active management is a big part of what separates syntropic agriculture from more conventional restoration practices. Unlike most restoration practices, a syntropic farm has to both restore the land and profit off the land. So how do they do this? What does it look like? The answer, as always, is more complex than one might think.

A lot of it, as always, comes down to careful planning. Syntropic farmers must develop a 3-D syntropic plan that covers all of the strata for more than 50 years. Of

course, this chart, like the one we discussed “here” is only 2-D. In order to make a farm real, you need to add a dimension or two.

Farmers, when building their syntropic farms, have to think in a 3-D model of what that farm will look like in 20, or 50, or 100 years. They need to take into account harvesting plants and the safety and health of workers. Planting a pricker-filled raspberry bush right beneath an apple tree for an example? No good. Workers would get hurt picking apples, and also all of the raspberries would be crushed. That’s not good business practice. It’s also just not good morally — we are all trying to be good people here, are we not?

Practice considerations such as these are very important when farmers plan out their farms. Long-term timber crops, such as Australia red cedar, should be planted not right at the beginning, but around two years into the life of a syntropic farm. These trees are very fragile as seeds, as they typically need a better quality soil, making it a better plan to plant them late, when you can be assured of the health of the soil. But because of that, a farmer would need to reserve space for the Australian red cedar, and not allow other plants to creep in. This means that a farmer must be aware of all the growing properties of their plants, and know which ones are “creepers” and like to spread out into space.

As you can imagine, this is a huge roadblock to farmers entering the syntropic field. It is hard to plan out a farm when so much of the planning is based on specific, inaccessible knowledge. Most syntropic farmers I have spoken with (and it’s only four, so I am not claiming that this is a representative sample by any means) have only gotten into syntropics after years of conventional farming. As with any job, experience and

knowledge build up over time, and the experience and knowledge of conventional farming made it much easier for them to transition? to syntropic farming. As one syntropic farmer said to me last year, it would be a “hell of a job” for someone new to growing to begin syntropic style.

That is why active management can be so difficult. It is not the most conceptually difficult task (again, it is fairly intuitive to say that a business should make money) but it requires a huge base of knowledge that is not quickly acquired.

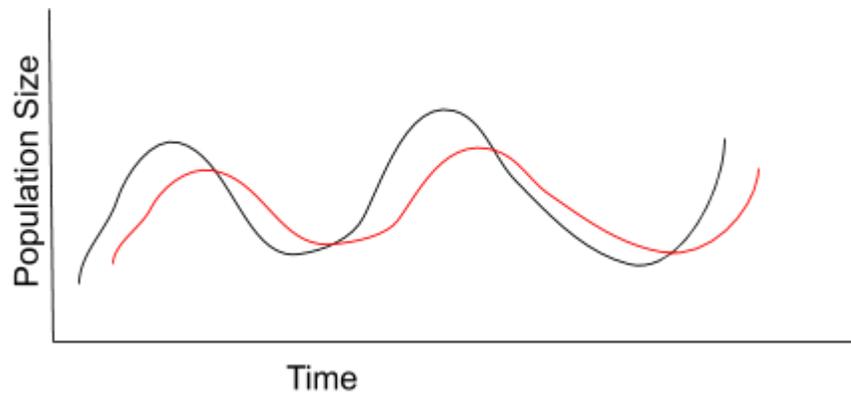
I want to emphasize this point: It is extremely hard to plan a syntropic farm. I also want to emphasize this point: We can make it much easier. Information can be easily and quickly sent and received in this day and age. I can easily picture a database of plant information specifically geared towards syntropic growers. I am going to discuss this possibility more later in the year when I talk specifically about ways to overcome barriers to syntropic growing in the United States, but I wanted to include it here because planning the syntropic farm is a large part of active management.

But let us say that we have successfully planned and planted our syntropic farm, a big part of actively managing the space. How do syntropic farmers tackle problems, such as pests, without the use of pesticides or other additional material? If all the plants are designed to grow and then die after harvest to support the other crops, how do syntropic farmers make enough money?

Let’s start with a typical farm problem that one may deal with: pests. The key to understanding a syntropic response to all of these things is to change the viewpoint in which we see them. Although animals and bugs are often viewed as unwanted on

conventional farms, there can be no healthy ecosystem without bugs and animals, and so, in line with our view of growing a forest, not a farm, syntropic farmers expect the infestations. Instead of looking at the pests as though they are completely unwelcome, syntropic farmers instead think about what the pest is telling them. Is this a natural pest? Is it due to a deficiency in the plant? Are these pests targeting a whole crop or just a few select individual plants? Do pest problems happen at a certain time of year? These are just some of the many questions that syntropic farmers may ask when they see a pest infestation. The answers to all of these questions inform the level of management required by the farmer. If the pest is a natural predator of the plant, it may actually be a blessing in disguise. Some syntropic farmers chose to do nothing about this type of natural infestation, believing that a natural predator will soon also come into the system, and eat the pest causing the problem.

It is true that most ecologists agree that the population dynamics of predators and prey are connected in some way. The most common explanation for how these populations are connected is a series of equations called the Lotka–Volterra equations. Essentially, this is a pair of complicated math equations that just end up saying that the population size of predators and prey track each other, and the predator's population is just a little bit behind the prey population. It kind of looks like this (please excuse my awful diagram (I'm not even going to be so bold as to call it a graph):



The red is the predator and the black is the prey. As you can see, the two populations track each other. The predator, however, lags behind the prey, changing just half a step behind them. This makes sense, as predators eat prey, so let's say that, at point A on the graph, the prey population has peaked, but the predator population hasn't, it is still experiencing growth. As the prey population began to decline, the predator population peaked, and then declined after the prey population.

If you are a syntropic farmer who chooses to do nothing when pests come knocking, this curve means good news for you. Soon after the explosion of pests you should, according to Lotka and Volterra, have some new visitors all too happy to eat up the annoying pests.

But of course, it's not that easy. Population dynamics are always in flux and can change based on the density of the population, or it can change based on other factors, such as the presence of alternative prey sources nearby. Many ecologists are still trying to find a perfect way to map population dynamics, and as they get more specific, they get more intense.

The truth is that we still don't know exactly how population dynamics work, and there has been recent evidence that structured spaces, such as a farm, develop different

community dynamics than an unstructured space, such as a natural forest. This could mean that predator and prey dynamics are very different on a syntropic farm. It could also mean that they don't functionally change at all. So if you are a farmer, and you choose to wait for predators to come and eat your pests, know that it might work really well! It also may not work so well.

Luckily, there are other ways to control pests, other than the "wait and see" method. A recent development in pest control has been the development of Integrated Pest Management or IPM. IPM is a practice designed with the overall health of the surrounding ecosystem in mind, and it ends up employing many of the principles of syntropic already. It places a heavy emphasis on the health and quality of soil, as well as planning and planting your crops properly to help minimize pests.

A common use of IPM involves the deployment of biological pest controls, aka, things that eat the pests. Biological pest control is the release of predators into the environment to eat the pests. It is essentially like the "wait and see" method, but instead of wait-and-seeing, you are cutting out the wait and just seeing if the predators work. Spoiler alert! They generally do. In fact, the use of biological pest controls is actually much more effective on organic crops than conventional crops. Organic crops, just like syntropic crops, never have pesticides sprayed upon them, making them a great resource for pest predators. Now, organic crops aren't exactly the same thing as syntropic crops, as organic crops are still planted in a monoculture. The use of monocropping does not encourage organic pest control, so it is relatively safe to assume that syntropic farms would have the same benefits of IPM. In addition, the use of intercropping has been

shown to reduce pest levels overall, so syntropic farms should have fewer pests to manage anyway.

It can be extremely difficult to decide which biological control species to let into an area. There are countless examples throughout history of an exotic animal being released into an area and then devastating the local wildlife. Obviously, farmers would like to avoid that if possible. The choice of the right biological pest control is going to depend on the environment of the farm, the type of pest, and the time of year that the pest occurs. It would do no good to have a predator that preys upon the eggs of a pest if the pest is currently an adult. Luckily, there have been advancements in studying the movement of pests in order to help farmers out with the timing of their biological pest control. In fact, we can now predict when migrating pests will arrive with a high degree of accuracy using weather radars, which is incredibly cool. Basically, these huge radars track atmospheric dispersion, which is the movement of tiny particles throughout the atmosphere. They can use these data, along with “echos” to determine where pests are. An echo in atmospheric data is a specific type of pattern that indicates something in the atmosphere. There are rain echos, clear-air echos, bow echos... basically, there are shapes in data from the atmosphere, and these shapes tell us something about what is happening with the weather. Or in this case, with bugs!

Biological pest control is a good tool for a syntropic farmer to have in their toolbox, although there is much more to learn about the effectiveness of this strategy in syntropic farms. Part of the challenge of active management is that, like all of syntropy, it is still being developed. Running a farm is hard, and requires a lot of day to day minutiae. Hopefully, a syntropic farm minimizes some of this; no weeding needs to be

done, because there shouldn't be any weeds, and the amount of time spent on irrigation should also be lessened as the soil quality will be able to retain more water than a conventional farm. The construction of a new row is normally the most labor-intensive part, aside from harvesting, and the development of ground cover and biomass fosters good independent plant growth.

But there is no syntropic farm if it doesn't make money. It doesn't matter how good you are at planning, pest management, irrigation strategies, or the cultivation of biomass if your business doesn't support itself. Syntropic farmers are in an interesting position when it comes to making money. On one hand, they are very well protected from crop failures and market fluctuations. The sheer amount and variety of crops mean that syntropic farmers will usually have at least one crop to sell, unlike mono-crop farmers who have a chance of oversaturating the market and then undervaluing their crop. However, syntropic farmers are also at a disadvantage. Once one crop in the system is harvested, it's gone. The farm moves forward, and new strata emerge. This may be great for the overall ecosystem, but it is kind of a bummer for farmers who were hoping to replant high-value crops year after year. The good news? They can!

Syntropic farmers embrace a component of active management called retrofitting, which is when an existing row is altered, or "retrofitted" to house a repeat or high-value crop. It is still recommended for farmers to avoid growing the exact same crop in the exact same space, but because these farmers are adding to a row, and not ripping up the ground, it is still within the realm of syntropy. Simply put, a retrofit would look something like this: A farmer harvests their emergent corn crop and sells it for a good profit — perhaps better than expected. Looking at the amount of time left in the

season, Farmer (an everyman character — or should I say an everyfarmer character?) decides that they can get one more corn crop in. The row plans have been set for a long time, but Farmer notices that the next crop in the emergent strata are very good at seed banking (staying in the soil until the conditions are optimal for growth). This means that if Farmer plants right now, the corn plants will outcompete the next crop in the strata, so the corn will grow instead, and the next crop seed will remain dormant in the soil. Farmer ends up with two rounds of corn harvest instead of one, and they have not compromised the health of the syntropic system. Now, depending on what environment Farmer is working in, this type of retrofit may look different. In Australia, where there is a year-round growing season, Farmer may be able to retrofit all year long. In a New England environment, this type of retrofit needs to be done in conjunction with the seasons. Farmer would have to plan their retrofit to take advantage of the specific growing time and environmental conditions that they are working in.

In some cases, this type of retrofitting can be done to specialize in a certain crop. Let's stick with the example of corn for now. If Farmer decides to specialize in corn, they can plan a corn retrofit around every 90 days. If Farmer wants to be more extreme about it, they can not even plant any other emergent species, and just retrofit corn repeatedly as the only emergent. This practice is not recommended because repeatedly planting the same crop causes problems with soil health, but the robustness of a syntropic system allows syntropic farmers to get away with it a little more than conventional farmers. Some syntropic farmers are experimenting with the development of grain crops as a specialized retrofit. Grain crops naturally grow in monocrop-like

systems, so integrating them into a syntropic farm can be difficult. Again, this is a developing field of syntropy, so it may take some time to perfect.

In the end, actively managing a syntropic farm is a lot like running any other business. You have to make sure that you are checking in on your product regularly while supporting the essential aspects of your business (i.e soil health), and reducing unexpected costs (i.e. pests eating all your corn). It is slightly more complicated than a conventional business because of the intense focus put upon restoring the environment and natural resources for sustainability, but as more and more products and ideas come into play, the easier it will become. A few years of challenge for a lifetime of sustainable food production. I don't think I'm being too harsh when I say that it seems like a pretty good trade-off to me.

Syntropic Agriculture: Putting It All Together aka A Planting Guide (12/4/2020):

Okay folks, here it is. The ultimate (and also the worst; it's the only one) guide to building and planning a syntropic farm. I should note that this can always be scaled down or up to the space you have. Got a window box? That's perfectly fine. Got 100 acres of beautiful farmland you just don't know what to do with? This is for you too.

This process can largely be divided into two steps: designing a row, and physically building a row. Designing a row is a complex, four-dimensional puzzle, highly dependent on personal goals. Which makes it both fun, and sometimes challenging. Again, you have to think about your row in your mind, kind of like you are Beth Harmon in *The Queens Gambit*, except instead of playing chess on the ceiling you are growing different combinations of plants together and seeing what works best. Still,

even the best ceiling-forest can get a bit lost in the weeds, so syntropic practice recommends that each row have a driving force behind it. The construction of each row must be planned around a central plant, crop, or idea, i.e. a “heart”. Thinking about your row having a heart seems to be a mere aesthetic choice for syntropic practice, but humans have a long history of associating the human heart with love.⁴⁹ And we tend to take of the things that we love. This unconventional practice may actually help motivate a syntropic farmer to put in the hard work, even if they do not realize it.

This “heart” could be almost anything: a specific crop or plant, such as an avocado, a more complex idea such as a strawberry rhubarb pie, or even a concept such as pollination. It is really just a good way to focus your thoughts throughout the planning of a syntropic row. Once you decided what the heart of the row will be, the process of designing and physically building a row can start. For instance, if a farmer has decided that their “heart” crop is avocado they may plot out the conceptual plan for their row in using a simple chart

⁴⁹ Yalom, Marilyn, “How Did the Human Heart Become Associated with Love? And How Did It Turn into the Shape We Know Today?” ideas.ted.com. Hachette Book Group, April 16, 2020. <https://ideas.ted.com/how-did-the-human-heart-become-associated-with-love-and-how-did-it-turn-into-the-shape-we-know-today/>.

	45-90 Days	90-120D	120-180D	180-365D	2-5Y	5-20Y	20-40Y
Emergent						Avocado	
High							
Medium							
Low							
Ground Cover							

The above chart is a great planning and conceptual tool for this. It also allows the farmer to prioritize different plants, and to see ahead of time where there may be conflicts. We have talked a lot about planning: this chart is the best planner I have found for syntropic rows. You can also adjust this chart to meet your own needs. For example, I know a syntropic farmer who adds another row for legumes because legumes tend to behave differently from other plants.⁵⁰⁵¹ The center of the above row is avocados. Now, the farmer knows that for the best quality avocados, there can be no other plants that are emergent strata in the 5-to-20-year mark and take up the same space as an avocado tree.

⁵⁰ Peoples, M. B., J. Brockwell, D. F. Herridge, I. J. Rochester, B. J. R. Alves, S. Urquiaga, R. M. Boddey et al. "The contributions of nitrogen-fixing crop legumes to the productivity of agricultural systems." *Symbiosis* 48, no. 1-3 (2009): 1-17.

⁵¹ Olde Venterink, H. Legumes have a higher root phosphatase activity than other forbs, particularly under low inorganic P and N supply. *Plant Soil* **347**, 137–146 (2011). <https://doi.org/10.1007/s11104-011-0834-7>

Developing a syntropic row can get overwhelming. Picking a heart allows you to work out from a center point. Many farmers do this by first ignoring strata (counterintuitive, I know) and filling in “support plants”, or plants that they know work well with avocado.

	45-90 Days	90-120D	120-180D	180-365D	2-5Y	5-20Y	20-40Y
Emergent						Avocado	Red Cedar
High					Banana		
Medium							
Low							
Ground Cover	Clover						

In the case of this row plan, I know that avocado need a lot of water in the soil. I also know that banana store a lot of water and release it gradually into the soil.⁵² At this stage, you could also add a successional plant for avocado, such as red cedar. You would also want to add a ground cover plant to cover your bases early on (pun intended!).

After you add the main support plants, you can go ahead and start filling in the rest of the chart. It is always a good idea to add a mix of crops that you believe will be profitable, i.e., raspberries, and that you believe will serve as good biomass for the row,

⁵² Sampangi-Ramaiah, Megha H., Kundapura V. Ravishankar, Shivashankar K. Seetharamaiah, Tapas K. Roy, Laxman R. Hunashikatti, Ajitha Rekha, and Pandurangaiah Shilpa. "Barrier against water loss: relationship between epicuticular wax composition, gene expression and leaf water retention capacity in banana." *Functional Plant Biology* 43, no. 6 (2016): 492-501.

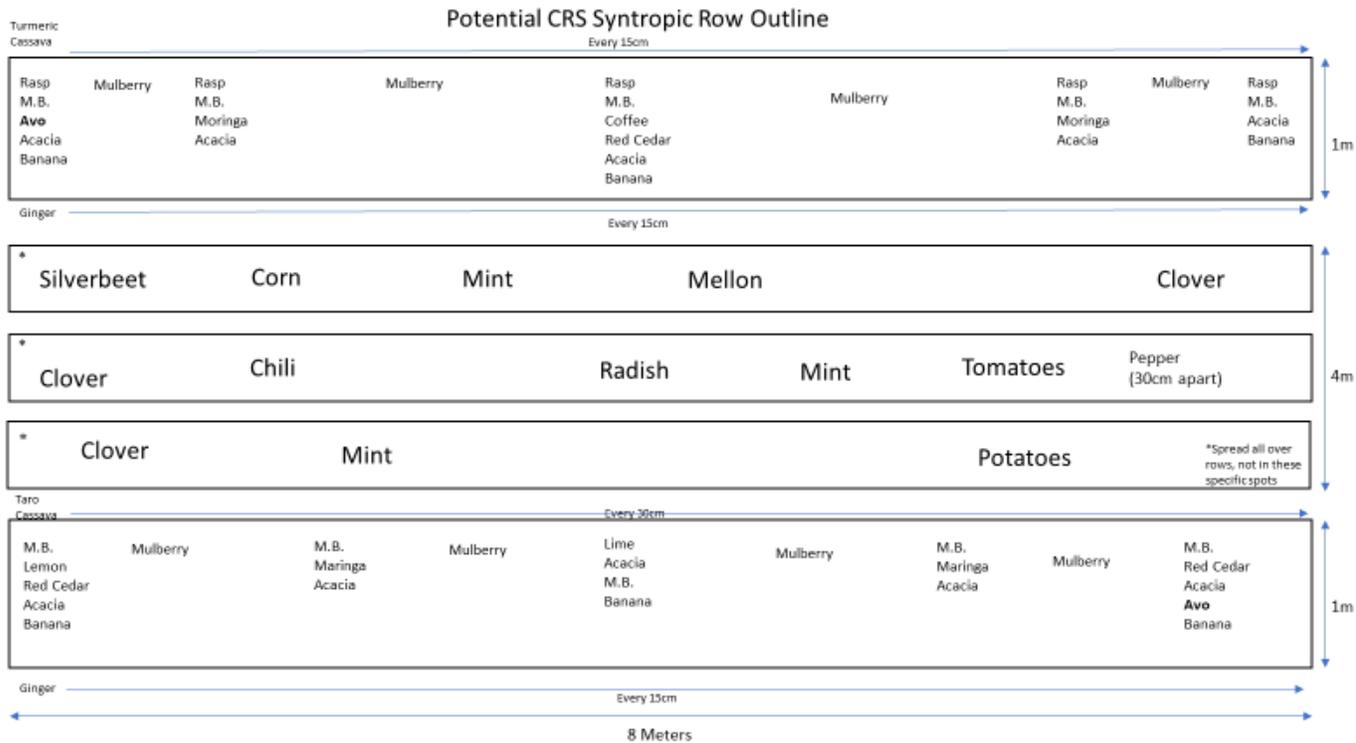
i.e., corn and mint. With that in mind, this is freestyle time! Add what plants fit that you enjoy. I would recommend avoiding very prickly plants like roses, but it is really up to you.

	45-90 Days	90-120D	120-180D	180-365D	2-5Y	5-20Y	20-40Y
Emergent	Corn			Moringa	Acacia	Avocado	Red Cedar
High	Radish	Potato		Cassava	Banana		
Medium	Silverbeet		Raspberry			Lime	
Low	Mint			Ginger Taro	Coffee		
Ground Cover	Clover						

Despite all the potential gaps being filled, this row is actually not done yet. In order to ensure that the row will function optimally, we got to add a few redundancies. In this case, redundancies mean that more than one plant should exist at each stratum. At first, it may seem like the crops would compete with one another, but if they occupy different physical space, this competition shouldn't take place. For example, potatoes and peppers will not compete because they have different growing patterns, despite being in the same stratum. As I keep saying, we don't know that much about plant niches so adding redundancies helps us mimic nature, the overall goal of syntropy.

	45-90 Days	90-120D	120-180D	180-365D	2-5Y	5-20Y	20-40Y
Emergent	Corn			Moringa	Acacia	Avocado	Red Cedar
High	Radish Tomato	Potato Pepper		Cassava	Banana		
Medium	Silverbeet		Raspberry Chili			Lemon Lime	
Low	Mint Ginger	Melon		Ginger Turmeric Taro	Mulberry Coffee		
Ground Cover	Clover						

With the initial chart filled out, the next step in designing a row is to plan out where to plant the crops. There are many different considerations when planning the physical elements of a row, including ease of harvest, worker safety, and biomass placement. The most common syntropic row design is two tree lines, and then three to four rows of plants in between them. But again, syntropy is designed to be unique to each farmer and situation. Syntropic rows could be grown in any number of ways. If you are just starting a small plot or home garden, I would encourage you to experiment! If you are trying to grow crops for profit, it is typical to use rows because it makes it easier to use farming equipment. In a typical syntropic row, the tree crops would be planted on the outside of the row. Among these tree crops would be the majority of the other profitable crops in the low and medium strata. This is because the shade from the tree crops will be instrumental later in providing shade for these strata. We want to take advantage of what is provided by the environment. The middle of the row would have emergent strata, to take advantage of the full sun, and bio mass crops, because adding biomass from the middle of the system is easier than trying to add it from the outside.



I made this row plan thinking about a larger background garden that would have to be harvested by hand. This allows for a level of flexibility in designing the width and breadth of the row that would be unavailable otherwise, if the rows were designed for largescale harvests that use machinery. Where crops are planted in the row is based on the individual planting needs of the crop. For example, a low strata crop that can be planted every 30 centimeters would likely be planted in the tree line, because the trees would provide the shade necessary for a low strata plant, and there would be space between the trees to harvest the plant. If a crop with those characteristics had been planted in the middle of the row, it would likely have less shade, and be harder to harvest. Alternatively, the middle rows are good for planting emergent crops such as corn, and crops planted for biomass, such as panic grass.

Most of this placement is just common sense. For example, raspberries are only planted along the outside edge of one row. This is because raspberries produce spikes along the stems, and if they were to be planted throughout the system, it would be unpleasant to harvest other crops, and to harvest biomass. Besides safety and harvest considerations such as that, much of the specifics of the row come from the plants themselves. Avocadoes, the main crop harvested out of this system, need to be planted six to eight meters apart. This is the measurement the row is based on, as a result, it is eight meters long and six meters wide. This allows the maximum number of avocado trees per row to be planted. All the other crops can be placed around the parameters. Again, this is determined by the main crop, idea, or concept decided upon at the beginning of the process of designing a row. Our redundancies also help us out a bit when we are planting. The inclusion of these redundancies guarantees that something will come up in that space and allows the farmer to avoid bare ground and gaps within the system.

Once the plan for a row is done, the planting can begin. Planting a syntropic row can be time consuming and labor intensive. The steps, although not very fun, are laid out in full here:

1. Gather enough biomass to cover the entire top of the row with biomass up to a depth of two feet. Lay this next to the row.
2. Hoe up the row and rake the loose dirt into a loose pile in the middle of the row. At this point, go through and pull out loose green matter in the dirt, such as small stems of grass that were uprooting during hoeing. These can be added to the biomass line next to the row.

3. Line the outside of the row with some type of timber. This could be banana plants, or more traditional timber such as oak or cedar. The row should now be a mound of dirt lined with logs of some kind.
4. Shape the dirt into a rough “M” shape, such that there is a shallow trough in the center of the row.
5. Cover all exposed earth with the biomass that was put aside earlier.
6. Plant all crops through biomass layer, making sure to cover all bare earth around the plant but leaving the crop itself uncovered to maximize photosynthesis. The only crop that needs to be planted later is red cedar, which requires higher quality soil to grow. Red cedar should be added into the system about two years after the system is established.
7. Water everything well at least once a day for the first week, and then water based on plant and soil needs.

If set up properly, syntropic farms needs substantially less water than a conventional agricultural setup because covering up any bare ground and the use of water-retaining plant stems such as banana help to keep the soil moist. However, some measure of irrigation will still be required in the early stages of a syntropic farm setup because young crops are still vulnerable to drying out. As the system grows, the amount of water it requires as impute decreases. A one- or two-year-old system will likely require no water.⁵³

⁵³ *Pers. Comm.* Neil Haws. October 13, 2019.

And ta-da! You now have your very own syntropic row! Or home garden, or window box, or great way to get your children to rake the yard by telling them the leaves are great biomass for their new garden. Whatever you chose to do, I hope that this guide helps in some way. I encourage you to adapt this to your own situation, and as long as you follow the five tenets of syntropy it should go well.

CHAPTER 2: SYNTROPIC AGRICULTURE IS MULTI-SIDED

I Failed. AKA: Why This Blog Exists (11/14/2020):

Over the summer, I failed. Now, in general, I fail a lot. I fail at art, and school, and personal goals. I find it a point of pride to fail often and regularly. It means I can learn something. It means I was pushing myself. It means that I have something to do next. I usually have no problem with it.

But, as someone trying to develop a thesis around syntropy, having my backyard syntropic row fail just hit a little bit harder than a normal failure. I thought I would have to completely change my thesis, or develop a completely differently plot outline. This backyard row, created with terrible gardening equipment, in ground that had never been worked, by an extremely new gardener—I can see how it was kind of doomed to fail. So, in honor of Friday the 13th, I will be taking you on the story of my failure. It just felt appropriate.

My failure, like many failures around the world today, started with a global pandemic sending me off my college campus and to my childhood home. This happened March 11th, right after I submitted my thesis proposal to the school. The next few days were, as one may imagine, a bit hectic. I packed up my dorm room, said goodbye to friends, somehow found the time to go to class (who holds class the day after the world ends?) and mourned in confusing solidarity with others whose own plans had rapidly changed. In between all of this, I found the time to go to a small, out of the way 3x9 meter plot right on the line where fields change to forest on the upper campus. Located behind the main practice fields, the plot was in reach of a hose (good), fairly close to the

greenhouse (really good), and already had soil tests done on it regularly by the college (truly excellent). I had spent the last few weeks carefully and systematically making a plan for a syntropic row. Before March 11th, I was excited to plant. I had picked out native, pollinator plants to fit the environment and landscape of the land nearby the plot. The school already keeps beehives in the same location, so I pictured myself on a hazy spring morning, leisurely watering my blooming syntropic row as bees buzzed happily in the background. I cleared my plot with the head of groundskeeping, and got money from the school fund to buy seeds of various kinds. I was planning to plant in early May, and come back throughout the summer to monitor and water my row.

Nope.

Instead, less than a week after I finalized my plans, I was staring at the dead grass of my backyard. Well, I thought, I still need a plot for next year. I am in the same general region as the plot planned before. Could I plant it by my house? I decided to try. In mid-May, later than I had planned but still very much in the time scale to plant spring plants, I got to work. Instead of planting seedlings, as I had anticipated, the lack of greenhouse access now meant I had to direct seed all of my plants. Direct seeding is riskier than planting seedlings, so I knew I had to be careful. Ordinarily, I would have been able to perform a soil test, to test the levels of nutrients and better inform my plant choices. I was not able to do so. I had to assume that the soil, as other plants were growing in the same location, contained all the necessary nutrients for my row to grow.

Prepping the row was a special kind of fun. And by special kind of fun, I mean it wasn't fun at all. It was quite horrible, actually. The ground I was planting had not been touched for over 20 years, and the best tool I had to break it up was a 15-year-old ice

slammer (a metal wedge on the end of a long wooden handle) we use to clear our brick steps in winter. I forged ahead, prepping the ground for planting and hauling up dead leaves and other debris from the forest to use as ground cover before my initial plants grew in. I planted the seeds carefully, following my initial plan. I gave the ground a good bit of water, and I waited. And I waited. And I waited. And nothing happened. Of all the seeds I planted, definitely 100+, maybe 5 or 6 struggling plants managed to break through soil and reach the direct sunlight.

Two, three months pass. I began to think I may have to accept that my row was less of a row and more of a patch of dirt covered in leaves that ferns were slowly starting to take over. I can't say why exactly it failed. I have some guesses, ranging from the fact that my house is in a valley and as a result receives very limited sunlight, to the intense cold snap that randomly occurred within 72 hours of planting my seeds. If I had to put money on it (and thank god I don't) I would guess the cold snap. To be honest though, it didn't matter to me in the moment why the row had failed. I just knew that it did. And because I have seen thriving syntropic farms, I knew that the problem wasn't the concept of syntropy—it was me. Something I had done had messed it up. Planted too early, wasn't prepared with enough equipment like warming tarps and drip tape, watering too much, watering too little...the litany of mistakes I could have or did make is endless. Normally, when I fail, I can for see some chance in the future to succeed in the same field. In the haze of quarantine and listless summer months, I couldn't see a second chance to succeed at this.

Despite having worked on a couple of farms, I am not a farmer by trade. I'm not a fan of weeding, trellising makes me nervous, and if I ever have to mulch a flower field

ever again, I'm going to drown myself. Given this, I don't really know why I expected my plot to succeed. Green thumb, I am not. I fully accepted my failure, and reached out to my advisor and explained the situation. After approval from the head of the Honors Department, I began to work on a new format for the thesis project, one that definitely couldn't freeze and die in the cold ground.

After developing my new thesis plan, I felt rejuvenated. I wanted to figure out why exactly my row failed. I went to the root of all agricultural problems: the soil. Using federally produced data and soil information from a 2006 survey, I looked up the specific soil attributes of my backyard. Instead of what I was hoping for, which was that nothing could ever grow there ever and I was a fool for even trying, I found that my house was sitting on soil designated as "Farmland of local importance".⁵⁴ In Merrimack county in New Hampshire, where my house is located, this means that it is not excessively sloped, rocky, or wet, and has less than 40% shallow soil.⁵⁵ Basically, it's not impossible to grow things, as it would be in a marsh for instance, but it is not especially easy to grow things there either. After learning this, I do feel a bit better about my failure of a row; at least I'm not in "prime farmland" aka "any idiot could grow almost anything here". While looking this up, I also learned that the soil around my house consists of "Paxton fine sandy loam, 8 to 15 percent slopes, very stony".⁵⁶ Huh.

⁵⁴ Natural Resources Conservation Service (NRCS) New Hampshire, United States Department of Agriculture (USDA). April 13th, 2006. Merrimack Belknap Soil Survey Update. Agricultural Evaluation Worksheet. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_015053.pdf. November 13th, 2020.

⁵⁵ Natural Resources Conservation Service (NRCS) New Hampshire, United States Department of Agriculture (USDA). March 18th, 2013. Merrimack Belknap Soil Survey Update. Soil Data Directory. https://prod.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1083451.pdf. November 13th, 2020.

⁵⁶ Natural Resources Conservation Service (NRCS) New Hampshire, United States Department of Agriculture (USDA). April 13th, 2006. Merrimack Belknap Soil Survey Update. Agricultural Evaluation Worksheet. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_015053.pdf. November 13th, 2020.

Well, the “very stony” part of this description is absolutely accurate and I can tell you that first hand. “Paxton fine sandy loam” is a soil designation for soils that are deep, well drained, moderately permeable, and moderately to strongly acidic. Now, I initially planned this row for behind my school, so I am largely not worried about the deepness or well-drained soil, as both of these soil characteristics can make it easier for plants to grow. I am slightly worried, however, about the acidity of the soil behind my house. That may have made a difference in how my plants were supposed to grow.

I designed the row using local MA plants that I knew grew in the area around my school. Could it be that the soil around my house was too different from the soil around my school? I didn’t think so, because they are in the same U.S. agricultural hardiness zone, but I wanted to check anyway. The soil around my school did end up looking different at first. In the area where I was to plant, the soil was not Paxton fine sandy loam soil, but a Charlton-Hollis-Rock outcrop complex, 3 to 8 percent slopes.⁵⁷ This means that there are two types of soil where I was going to plant initially, Charlton soils, and Hollis soils. The “complex” is how the soil is mixed together. I thought that I had a new clue as to why my row failed. The soil types I planted in were different from the soil types I planned to plant in—and I am not sophisticated enough to undertake soil engineering in my backyard. Not yet, anyway.

⁵⁷ Natural Resources Conservation Service (NRCS), United States Department of Agriculture (USDA). July 31, 2019. Web Soil Survey. <https://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx>. November 13, 2020.

After looking into more, I discovered that both components of the soil, Charlton soil and Hollis soil, actually also had pretty high acidity.⁵⁸ So, it probably wasn't the soil acidity that made all my plants die. That doesn't mean it wasn't the soil though. Soil is highly specific, as I have briefly mentioned before, and the soil properties can change based on the types of plants within it. As I talked about in my blog post on stratification, the plants that I seeded should have developed a healthy relationship with the soil, so as long as the basic characteristics of the soil are compatible with the plants. Which they are. Given that, I am still a little bit confused as to why my row didn't grow the way it should have. I'm back to my initial idea of the cold snap killing all of my seeds, and back to wishing I had invested in some warming tarps. Oh well.

I didn't get exactly what I wanted. I failed a major component of my thesis and had to regroup entirely. It hurt then, and quite frankly it still hurts a little bit now. I don't know if I will ever succeed at growing a syntropic row of my own. But I know that when I failed, I got a whole lot of new ferns and a blog. And at least I don't have to mulch anything over Thanksgiving Break.

So What Do Farmers Need? An Interview with Work Song Farm (2/22/2021):

As I have mentioned before in the blog, many times farmers of all types wish to be more sustainable, but lack the resources to overcome the barriers to sustainability. Regrettably, I did not have time during this thesis process to conduct an appropriate statistical survey of farmers, but I have had the opportunity over the course of my general life and research to speak to several farmers about these barriers. As can be seen

⁵⁸ Natural Resources Conservation Service (NRCS), United States Department of Agriculture (USDA). May, 2016. Natural Cooperative Soil Survey. Charlton Series/Hollis Series. https://soilseries.sc.egov.usda.gov/OSD_Docs/C/CHARLTON.html. November 13, 2020.

in the interview printed below, the number one impediment farmers face to implementing sustainable change is time and money. These two factors are mentioned time and time again when speaking to farmers about these issues, whether the farmer lives in Australia or the United States, works in conventional or organic agriculture, or works in a big or small farm.

In order to fully understand what farmers need to overcome this access barrier, it is important to speak with them directly. The interview I have chosen to share with you all comes from a farm in Hopkinton, New Hampshire. Work Song Farm is a small, organic, family run farm who provides year-round fresh produce to their customer base. Full disclosure, I used to work for this farm, and it was a great summer filled with fantastic people, both my co-workers and my bosses.

Brief side note before we dive in: keen readers will remember me complaining about mulching a few blogs back—And yes, it is fantastic to be so validated in this interview.

With immense thanks to Dan and Abby at Work Song for their thoughtful answers, here is the interview. Questions are in bolded italics.

Why did you decide to be an organic farm as opposed to a conventional farm?

Well, first we have to define what we mean by “organic.” There’s organic, the grass-roots movement to steer agriculture back to the natural system it has been for millennia (except for the brief period, post World War II, of industrialized agriculture, now known as “conventional”). Then there’s Organic, as certified by the USDA, with all its rules and records and bureaucracy.

We participate in both: the former because it is consistent with our personal ideals and our theories of how best to grow food. We feel it’s better to try to work within natural systems than to try to outsmart or obliterate them. The latter, the USDA version,

because it's a marketing tool—a shorthand way to tell our customers we farm a certain way.

We will always maintain our farm organically, though we may decide to drop Organic Certification at some point. We are so close to our customers we really don't need that label to build trust.

What government organizations do you work with? Do you think this process could be streamlined at all?

We work with quite a few. The USDA NRCS has conservation programs that we have participated in: to build high tunnels, set up irrigation systems, use cover crops, and the like. The NH Dept of Agriculture is the agency that certifies our organic status. They also license our scales, permits to spray pesticides (even organic ones) and put out farm maps for consumers to find farms in their area. There's the UNH Cooperative Extension, which is mainly a resource to connect farmers with the knowledge and research that comes through the University. There's also the County Conservation Districts, which are sort of the county level outreach for NRCS.

I'm not sure if these agencies coordinate formally, but I have witnessed some collaboration between them, like a workshop hosted by Cooperative Extension with speakers from NRCS or NHDAMF. Sorry for all these acronyms. They're hard to write out, but easy to Google.

I'm sure there's room for improvement streamlining all these agencies, but good luck trying to do so. It could be a bureaucratic quagmire.

What barriers do you face when thinking about becoming more sustainable?

The two biggies are always time and money. As a small farm we're always strapped for both, which often leads us to skimp on the sustainability practices we'd like to use, in

order to pursue the weekly paycheck or the family down time. Resources and sustainability are a bit like chickens and eggs; one is dependent on the other. Solar panels are a good analogy. In the long run, they save money as well as being more environmentally friendly, but they require an initial investment that is likely out of reach for those of lesser means.

Are there any long-term goals you have for the farm?

It would be great to be more energy self-sufficient. Solar panels would be great, and we're trying to figure out how to capture heat from compost piles to use in our greenhouses.

We'd also like to emphasize more winter growing/marketing, possibly ease up in the summer months, in order to even out the work load throughout the year. That would be a form of sustainability in itself. Related to this, we'd also like to rely less on seasonal employees, and find one or two permanent helpers who can really invest themselves in the success of the farm, and maybe even spin off enterprises from it—maybe add some livestock, preserve crops (frozen strawberries), or some other venture that would add value to the farm's products.

Also I want to build the barn-of-my-dreams, and, of course, work less and make more money.

What changes do you think should be made to the organic guidelines? Should these guidelines change based on the size of the farm?

I don't pay much attention to the organic rules, other than those that affect us directly. I know there's been a lot of controversy lately about the allowance of CAFOs and hydroponics and such in Certified Organic agriculture. Without doing much research, we definitely fall on the side that opposes things like that. We even joined an organization called the Real Organic Project, which attempts to distinguish farms that

grow in soil and let their livestock onto pasture from the big agribusinesses that have lobbied the USDA to accept their practices as organic. But we joined more out of curiosity than any real political commitment. We prefer to keep things simple: know and listen to our customers, and vice versa. We operate at such a local level (we sell 95% of our product within 5 miles of the farm) that engaging in national discussions is low on our priority list. Maybe some day.

What is one farming practice that you wish you could implement on your farm, but lack the time/money/equipment for it to happen?

We use a lot of mulch—specifically tree leaves in various states of decomposition—as part of our soil health strategy. Natural mulch keeps the soil covered, conserving water and nutrients, smothering weeds, minimizing tillage, providing food and habitat for soil organisms, and adds carbon (organic matter) to the soil. Spreading all this mulch by hand is laborious and time-consuming. I would love to have a tool to chop and spread the mulch more easily.

What is one thing you wish more people understood about running a family farm?

We're actually really fortunate to have in our area so many customers who are supportive, appreciative, and forgiving. Perhaps the biggest misconception is that farming is a simple life, and the rhythms of nature are like a current that carry the farmers gently from one task to another. It is much more complex and chaotic than that. While there are moments to zone out with some repetitive activity, like weeding, most of the time it's a fast-paced, stop on a dime and switch directions sort of life.

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This is just one interview with one small farm. However, the barriers faced by Work Song Farm are universal-lack of time, money, technology, and some difficulty with bureaucracy. What this tells me is that for the United States to feasibly switch to

syntropic agriculture, or any kind of sustainable agriculture, we need more support for our farmers. And we need to listen to them.

We will be back to our programing next week to discuss the differences between syntropic agriculture and other types of sustainable agriculture. In the meantime, think about supporting some local farmers if you can.

Cage Match: Syntropic VS... (3/6/2021):

Hello, all, it has been a minute since I have had the opportunity to regale you with thoughts and facts about agriculture, and in the past few months my sanity has slipped even further away from me. Luckily, losing my sense of sanity puts me in fantastic company these days, and besides, the absolutely absurdity of the current USA agricultural system seems to require a partially *un*-sane mind to navigate anyway. But before we get into the cause of my brain smoothie (TARIFFS), I would like to do a little compare/contrast with the various types of sustainable/non-conventional agriculture that are currently in use.

One of the difficulties in discussing sustainable agriculture is that many ideas overlap with one another. For instance, two different sustainable methods, i.e. “permaculture” versus “syntropic agriculture” may actually include a lot of the same ideas, thoughts, and practices, but because sustainable agriculture is still very much a developing field, the same concepts get presented very differently. This can make it hard to pinpoint the actual differences and similarities in types of sustainable or non-conventional agricultural systems This guide is meant to compare and contrast syntropic agriculture with three other common “sustainable” agriculture methods: organic,

permaculture, and restorative agriculture. These are not the only kinds of sustainable agriculture by any means, but rather a representative sample of the most common kinds of sustainable agriculture.

Syntropic Agriculture Vs. Organic agriculture

These two agricultural systems are vastly different. As Dan Kilrain pointed out in his interview, the word “organic” often had two different meanings for people. There is the “organic” practice of working with the land and nature as had been done pre-conventional agriculture. This lowercase “organic” practice often involves working within the natural earth systems to grow food, as opposed to trying to fight or remove natural systems from agriculture. This idea of a lowercase “organic” practice has no formal rules or guidelines to it, and it’s a pretty nebulous concept. So, I am going to be focusing on the more common kind of organic farming, uppercase Organic farming. This uppercase “Organic” farming is a certification a farmer can receive from the USDA, and has strict rules and regulations for growers to follow before their work can be considered Organic. If you are interested in reading the full rules and regulations for Organic growers in the United States, they can be found [here](#). An important note is that the “Organic” label is often used as shorthand for consumers. It allows consumers to easily tell whether or not the product has been made or harvested with the help of synthetic or inorganic materials. For farmers, however, the rules are much more complex than just the limitation of materials. Since these rules are very long, I am going to boil them down to a few main points:

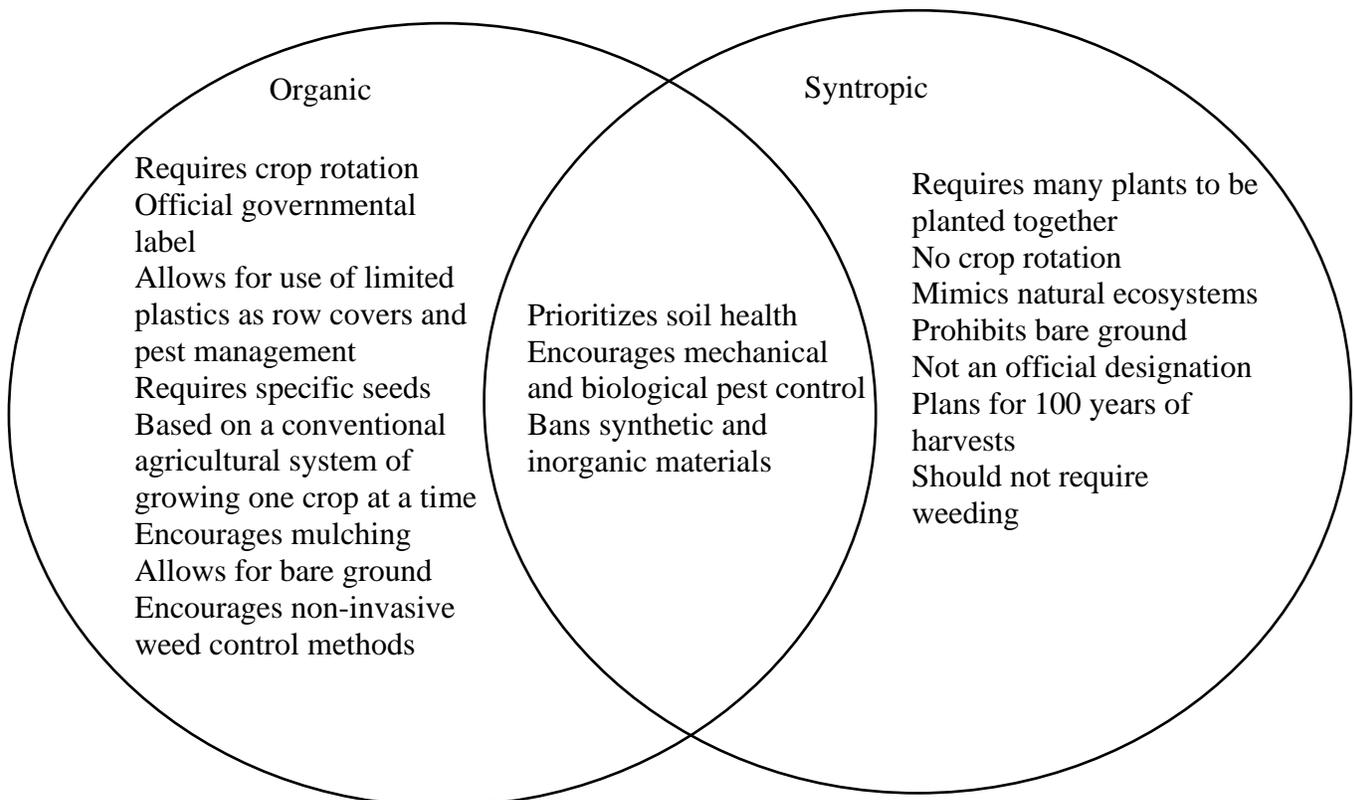
1. Producers of Organic produce must maintain or improve soil quality. This is a big one for the USDA, and most of their regulations come back to this. The

tilling and cultivation practices producers use take this into account, the weeding practices take this into account, the pest management practices take this into account, and the mulching practices take this into account.

2. Organic produce must come from certified Organic seeds. Basically, this means that producers or farmers who are Organic can only get their seeds from a seed supplier that has been previously certified as Organic. This rule can cause problems for small Organic farms, because these suppliers don't always have the best strains or kind of produce that is ideal, and because it ends up being kind of a chicken and egg situation at times. You need to grow Organic produce to get certified Organic seeds, but without certified Organic seeds you cannot grow certified Organic produce.
3. Organic farmers and producers must implement some type of crop rotation that, going back to point number one, protects the soil health.
4. Organic farmers cannot use inorganic or synthetic materials on their land for three years before certification, and while their certification is in effect.

There's also a lot of rules about Organic meat and poultry. That's not really my purview but I wanted to mention it for the sake of being thorough.

Okay, so now that we have established a basic understanding of Organic agriculture, it's time to do my very favorite thing in the world: a Venn diagram.



As you can see from the warm and friendly Venn diagram, the methods overlap in a few important ways. They both make soil health a priority, and they mostly do not depend on pesticides for pest control. The key difference is that an Organic producer is allowed and welcome to produce in the conventional way with one crop per field, and then use field rotation to keep the soil healthy. Because syntropic agriculture is almost the exact opposite of that, I can definitely foresee that a syntropic farm would likely be initially denied an Organic certification from the government, simply because the regulations do require crop rotation practices. Overall, though, these two ideas of more sustainable farming are pretty compatible. There are some substantial differences, but the intended outcomes of both methods are the same. Healthy soil, and healthy food management.

Syntropic Agriculture Vs. Permaculture

Oh boy! From the jump, I can tell you that these two sustainable agriculture methods are fairly similar. Permaculture has been around for a little bit longer, it has more frequency of use in the substantiable agriculture lexicon, and overall, it's a pretty well-known method. "Permaculture" comes from a combination of the words "permanent" and "agriculture". Actually, when I first learned about sustainable agriculture and designed my first rows, it was with help from a permaculture book from the 1980s, so this method does carry a special place in my heart. That being said, it's basically just a less specific and less long-term way of doing syntropics. I would never say that without backing it up, so let's get into it.

The permaculture method exists less as a set of explanations for how to grow food well, and more as a set of ethical principles and design principles. Bill Mollison, the founder, for lack of a better word, has since said that permaculture is "a design of systems with which we can live."⁵⁹ Mollison views the idea of permaculture less as a farming style and more as a life philosophy. This is wonderful, but not an overwhelmingly helpful way of teaching others the practical skills it takes to practice permaculture. As a result of this ambiguity, David Holmgren expanded on this idea of design to come up with 12 ethics of permaculture. All of these rules do follow from Mollison's initial concepting of permaculture and they act as a more practical guide to implementing permaculture. Holmgren's 12 rules are as follows⁶⁰:

1. Observe and interact

⁵⁹ Mollison, Bill, and David Holmgren. *Permaculture*. Lesmurdie Progress Association, 1978.

⁶⁰ Holmgren, David. *Essence of permaculture*. Melliodora Publishing, 2020.

Use careful observation and interaction to copy natural systems

2. Catch and store energy

Take advantage of surplus energy and resource when possible

3. Obtain a yield

Aim for rewards that encourage growth and implementation of the system

4. Apply self-regulation and accept feedback

Be careful not to overextend resources, and plant with a mind for the future

5. Use and value renewable resources and services

Use renewable sources whenever possible

6. Produce no waste

Instead of recycling or reusing, strive to use waste-free methods so there is nothing to recycle or reuse in the first place

7. Design from patterns to details

Start with a big idea, and then slowly clarify as you refine the design

8. Integrate rather than separate

Aim to create an integrated plant system where each plant contributes to the health of other plants

9. Use small and slow solutions

The “quick fix” often has hidden consequences; the slow way is often more effective. Ex: A mechanical weed puller may be faster, but more likely to miss weeds that chokes out plants later

10. Use and value diversity

Plant a lot of different plant species

11. Use edges and value the marginal

Don’t neglect the edges of a permaculture system, instead use them to grow plants that naturally grow there

12. Creatively use and response to change

Don’t get locked into doing things a certain way, instead remain flexible and look for growth opportunities.

If these don’t seem too specific, it’s because they’re not. Holmgren expands on each of these ideas to explain the philosophies behind them, but he also doesn’t include any specific instructions as syntropic teachings would. Others on the internet have used these 12 guidelines to promote permaculture to others, but sadly these websites also do not include additional instruction.⁶¹⁶²⁶³

Again, these are the guidelines that Holmgren came up with based on Mollison’s general philosophy. Mollison himself would explain permaculture as a system of design

⁶¹ Barth, Brian. "Permaculture: You’ve Heard of it, but what the Heck is it?" Modern Farmer., last modified April 19, accessed March 2, 2021, <https://modernfarmer.com/2016/04/permaculture/>.

⁶² Telford, Richard and Holmgren, David. "Permaculture Design Principles." Permaculture Principles., accessed March 2, 2021, <https://permacultureprinciples.com/principles/>.

⁶³ Waddington, Elizabeth. "The 12 Principles of Permaculture: A Way Forward." Ethical., last modified April 23, <https://ethical.net/ethical/permaculture-principles/>.

principles that allow you to reconnect with and take back your own food supply. Think about Mollison's vision of permaculture as a backyard garden designed to use and save every bit of water possible. Mollison has a thing about big agriculture, he actually thinks it should be banned⁶⁴, so this rigidity to conventional systems tends to be reflected in his work. As a result, the guiding principles he laid out focus much more on general advice rather than specific instruction. His later informational talks and pamphlets did include more direct instructions, broken up by the type of land one was looking to farm.⁶⁵ For example, if one is planning to build a backyard garden on a steep slope, Mollison would recommend terraces or steps be carved into the slope, in order to save as much rainwater as possible. All his advice is an application of the general principles he puts forth, and much of it is based on conserving rain. If you're interested, you can read more of that advice [here](#).

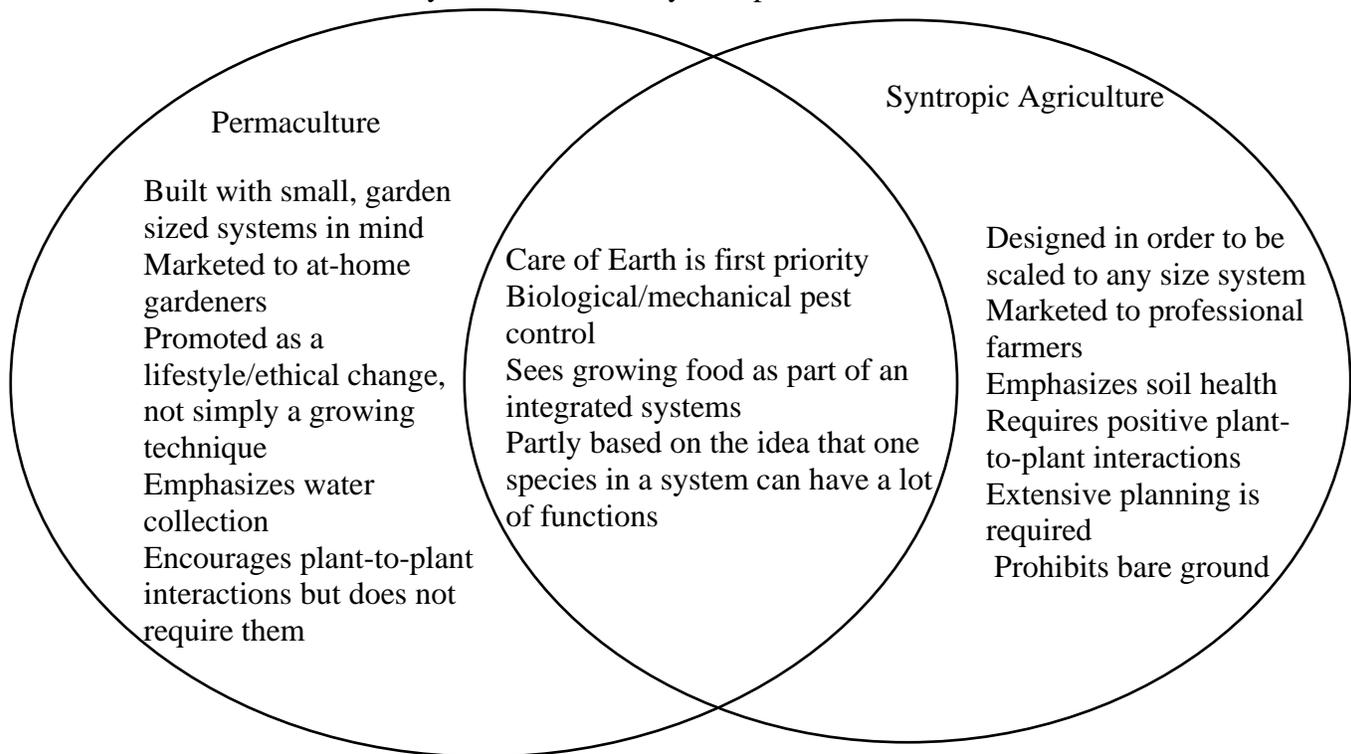
Mollison's guidelines to permaculture are simple: Care for the earth, and care for the people. Within that simple statement is a whole host of implications. Caring for the earth requires working with nature to use and utilize current systems-many of Mollison's designs use recycled or recollected rainwater. Mollison also advocates for closed loop systems, which basically means no added nutrients or fertilizers should be used.⁶⁶ This is the same as syntropic agriculture, which also uses no additional fertilizers or nutrients, it is just presented and framed in a different way. As can be seen in the Venn diagram

⁶⁴ Mollison, Bill, and David Holmgren. *Permaculture*. Lesmurdie Progress Association, 1978.

⁶⁵ Mollison, Bill, Reny Mia Slay, Jean-Luc Girard, and Jean-Luc Girard. *Introduction to permaculture*. Tyalgum, Australia: Tagari Publications, 1991.

⁶⁶ Mollison, Bill. "Permaculture: a designer's manual." *Permaculture: a designer's manual*. (1988).

below, many of the ideas of permaculture and syntropic agriculture overlap, and the main difference in the two systems is scalability, and presentation.



Permaculture and syntropic agriculture are compatible with each, and I can easily see how a permaculture garden could fulfill syntropic requirements, and almost every syntropic farm would fulfill the permaculture ideal. Outside of potential scale, which is one of the main differences between the two systems, I like to think about permaculture and syntropic agriculture as squares and rectangles. Just as every square is a rectangle, but not every rectangle is a square, every true syntropic farm is a permaculture, but not every permaculture is syntropic in nature.

Syntropic Agriculture Vs. Regenerative/restorative agriculture

Regenerative/restorative agriculture (or RR aggy, as I have affectionally nicknamed it) has a few different definitions, depending on where you look. It is usually

an umbrella term or industry shorthand for management practices that focus on carbon sequestration within the soil. Sometimes “carbon farming”, or the growing of plants specifically to capture carbon, is also included under the banner of RR aggy, but again, it depends on whom in the industry you ask (or what blog you read!). Looking at how the term RR aggy is used in the scientific community, it seems clear that the term does not have a consistent definition.⁶⁷ A recent publication in 2020 proposed the following definition for RR aggy as

“an approach to farming that uses soil conservation as the entry point to regenerate and contribute to multiple provisioning, regulating and supporting services, with the objective that this will enhance not only the environmental, but also the social and economic dimensions of sustainable food production.”⁶⁸

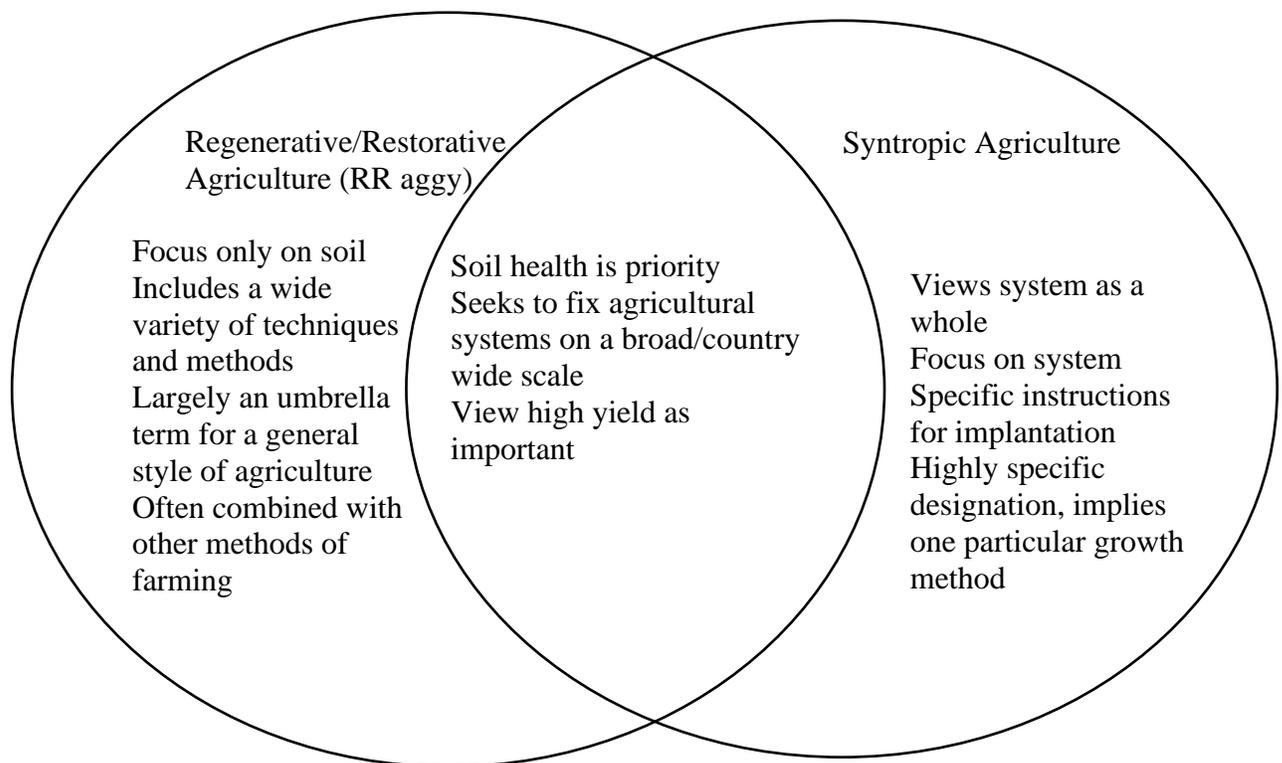
Woah. That’s quite a mouthful, but what it boils down to is this: people who practice RR aggy look at agriculture from SOIL perspective. By thinking about what most benefits the soil, RR aggy growers believe that other problems with conventional agriculture would also be solved. As far as I can tell, one of the primary goals of RR aggy is to solve the many problems of conventional agriculture, but this is expected to occur naturally after only focusing on the soil health. The objective of a RR aggy grower would also be healthy soil, and through the achievement of that objective, the other problems would cease. The diminishment of other agriculture problems is a goal, but one that a RR aggy grower would be indirectly working towards.

⁶⁷ Schreefel, Loekie, R. P. O. Schulte, I. J. M. de Boer, A. Pas Schrijver, and H. H. E. van Zanten. "Regenerative agriculture—the soil is the base." *Global Food Security* 26 (2020): 100404.

⁶⁸ Schreefel, Loekie, R. P. O. Schulte, I. J. M. de Boer, A. Pas Schrijver, and H. H. E. van Zanten. "Regenerative agriculture—the soil is the base." *Global Food Security* 26 (2020): 100404.

Now, as to what practices are used in RR aggy style, it really runs the gambit. Basically, anything that helps the soil could be considered a RR aggy practice, included mulching, no-till, crop rotation, and many other methods. Even permaculture has been mentioned as a RR aggy method.⁶⁹

This lack of consensus from the agriculture and scientific community about what RR aggy actually is has led to uncertainty about how best to implement or incorporate RR aggy into conventional agriculture systems.⁷⁰



Although there are clear differences in RR aggy and syntropic agriculture, they are not incompatible visions of sustainable agriculture. RR aggy has a more restrictive

⁶⁹ Shepard, Mark. Restoration Agriculture: Real-World Permaculture for Farmers Acers U.S.A, 2014.

⁷⁰ Schreefel, Loekie, R. P. O. Schulte, I. J. M. de Boer, A. Pas Schrijver, and H. H. E. van Zanten. "Regenerative agriculture—the soil is the base." *Global Food Security* 26 (2020): 100404.

way of viewing the health of a system, as they only focus on soil, while syntropic agriculture has a gestalt view of farming. This difference does not make them incompatible, in fact, a RR aggy grower would mostly likely embrace syntropic agriculture because of the positive impact it has on soils. Overall, I would say that the differences between RR aggy and syntropic agriculture are a cause of difference of focus--RR aggy focuses on soil, and syntropic agriculture focuses on the system as a whole.

Sustainable agriculture is a large field with a lot of vaguely defined terms. It is challenging to get a consistent definition without literature reviews and analysis by researchers in the field, and too often this confusion leads to problems with implementation. I hope that for you, this mini guide to different kinds of substantiable agriculture was helpful.

The Final Stop on the Syntropic Journey... (3/18/2021):

...And we have arrived at our destination: the economic side of agriculture. I am going to go through the confusing town of agricultural economics street by street, starting with the main roads of the agriculture economy, then move onto the “under construction” section of town, or the current day state of the agricultural economy, and then attempt to project the changes that would occur to this town if syntropic agriculture would be implemented in the United States. So, let’s take a tour of this town together. Up ahead on Main Street to our right is a grey building housing the tariff office.

The Tariff Office:

As we move to the front of the unassuming building, we see a huge sign that reads “TARRIFFS ARE POLITICAL”. And this is true. Tariffs are basically taxes on foreign agricultural products that are designed to protect American farmers. Or, if you’re in France, designed to protect French farmers. Agriculture is a global business, and different countries sell agricultural products either to each other or to companies that are in other countries. Sometimes, foreign countries can sell their products for less than what American companies can sell their products for, because labor costs differ from country to country. Obviously, companies want the best deal possible, so they are more likely to go with the foreign, cheaper option. But this may put American farmers out of business. So to protect American farmers, the United States government adds taxes to the cheaper, foreign goods, which make them more expensive, and less appealing to companies. It is basically a way to ensure that American farmers aren’t heinously outcompeted by foreign farmers.

However, tariffs are often retaliatory. If we open up the door to the Tariff Office, we will see representative from all different countries glaring at each other, waiting for an increase. If the United States chooses to increase tariffs on products coming from China, for example, China will very likely increase tariffs on products coming from the United States. This can be damaging to farmers, who now will likely not be able to sell their products in China. In fact, this exact thing happened under the Trump Administration. In 2018, the Trump administration enacted a series of tariffs against several trade partners, China included. Although these initial tariffs were primary on non-agricultural products such as steel, China responded by enacting a series of retaliatory tariffs on a variety on American products, including nuts, fruit, and soybeans.

As we walk father into the Tariff office, we can see the results of this. Both the United States representative and the Chinese representative are glaring daggers at each other, and waiting poised to make changes. Behind the United States representative is a pile of burning cash, which represents the 15.6 billion dollars lost in trade because of these retaliatory tariffs.⁷¹ Oh yes, tariffs of this kind often result in the loss of a lot of money for the country. The rest of the world's representatives are monitoring this exchange, ready to jump in and offer tariff deals that best suit their country.

As we go further into the building and begin to come out the other side, a growing roar can be heard. Leaving though the back of the Tariff Office, the cause becomes visible. At the back of the Tariff Office is a hastily constructed shack with the words "Market Facilitation Program" scrawled on it. Ahh, here is the governmental response to the tariffs restricting the farmers income. The Market Facilitation Program, set up by the Trump administration to help support farmers, gives direct cash payments to farmers. The shack has a proud sign that says "Over 14 billion paid to farmers in 2019!"⁷² Wow, that is quite an achievement! And an awful lot of money to pay out because of trade disruptions and tariffs. In fact, money from the Market Facilitation Program and other governmental programs accounted for about 40% of national farm

⁷¹Carter, Colin and Steinbach, Sandro. "The Impact of Retaliatory Tariffs on Agricultural and Food Trade." Cato Institute., last modified December 9th, accessed March 10th, 2021, <https://www.cato.org/research-briefs-economic-policy/impact-retaliatory-tariffs-agricultural-food-trade>.

⁷² U.S Government Accountability Office. "USDA Market Facilitation Program: Information on Payments for 2019." GOA.gov., last modified September 14th, accessed March 10th, 2021, <https://www.gao.gov/products/gao-20-700r>.

income, and some believe that farmers are now too dependent on the government for income.⁷³

Pushing through the crowd around the shack, we emerge on a side street, leading away from the heart of town. The tariff office we leave behind, with the understanding that the Biden administration may choose to change the current tariff rate, and tear down the shack perched at the back door.⁷⁴ Walking along the cobblestone path, we move off the Main streets, and out to the developments on the edge of town.

Construction Zone, aka some things going on today in the United States agricultural market:

As we approach the developments, it's clear that some interesting things are being built. Now that we have ventured through the main street in the town and have an idea of the lay of the international agricultural economy, this Construction Zone is the domestic agricultural market, so construction here is based on the domestic market value of agriculture. Looking around at the buildings that are being built, at first glance we see that one building in particular is going up very quickly, almost becoming a skyscraper before our very eyes. Yelling out to a worker, we learn that the building represents the price of agriculture commodities. As the building gets taller, the price of agricultural commodities increases. An agricultural commodity is essentially any crop that is produced in the United States. The rapid pace of construction on the building indicates

⁷³ Chinn, Menzie and Plumley, Bill. "What is the Toll of Trade Wars on U.S. Agriculture?" PBS.org., last modified January 16th, accessed March 10th, 2021, <https://www.pbs.org/newshour/economy/making-sense/what-is-the-toll-of-trade-wars-on-u-s-agriculture>.

⁷⁴ Hillberry, Russell. "Trade Policy Outlook: What should we Expect from a Biden Administration?" Purdue University, Agricultural Economics., last modified December 9th, accessed March 10th, 2021, <https://ag.purdue.edu/commercialag/home/paer-article/trade-policy-outlook-what-should-we-expect-from-a-biden-administration/>.

that the price of agricultural commodities is rapidly increasing. This increase is likely due to Covid related supply chain delays.

Around the rapid construction of the agricultural commodities tower, other, smaller condos are being steadily built. One in particular is emblazed with the letters FARMLAND REIT, and as we pass by the construction workers, we can't help but overhear that a lot of them have already been bought by billionaires, such as Bill Gates and Jeff Bezos.⁷⁵ Let's take a closer look at what this means. I call out party to a halt in front of the FARMLAND REIT, and as we gaze up at the luxury condos, I spin a small tale:

“REIT stands for Real Estate Investment Trust, which are basically companies that people can buy stock in that own some type of income producing real estate. Farmland REITs are trusts that own farmland. If people want to buy stock in farmlands, and not just a specific farm, they will often buy into a farmland REIT. Recently, billionaires such as Bill Gates have begun to buy mass amounts of stock in farmland REITs, inspiring the building of these condos to represent that investment.⁷⁶ Of course, the only people who know exactly why this spending spree has occurred are the buyers themselves, but experts generally guess that it is because farmland is a tax-efficient, safe investment.⁷⁷ No doubt, this spree also has to do with the sky-rocketing agricultural

⁷⁵ Schwartz, Harrison. "As Billionaires Buy Farmland, Individual Investors Buy Farmland Partners." Seeking Alpha., last modified March 9th, accessed March 10th, 2021, https://seekingalpha.com/article/4412396-farmland-partners-trading-near-nav-but-billionaire-buying-sprees-may-extend-the-rally?utm_source=from.flipboard.com&utm_medium=referral.

⁷⁶ Schwartz, Harrison. "As Billionaires Buy Farmland, Individual Investors Buy Farmland Partners." Seeking Alpha., last modified March 9th, accessed March 10th, 2021, https://seekingalpha.com/article/4412396-farmland-partners-trading-near-nav-but-billionaire-buying-sprees-may-extend-the-rally?utm_source=from.flipboard.com&utm_medium=referral.

⁷⁷ Schwartz, Harrison. "As Billionaires Buy Farmland, Individual Investors Buy Farmland Partners." Seeking Alpha., last modified March 9th, accessed March 10th,

commodities building going up next door, which improves the values of the FARMLAND REIT building being built next door.”

I end my mini schpiel, and we all stare up and around at the buildings for a while, taking in the rapid changes and the pace of progress. Eventually, the shouts of construction workers become too much, and we move past the builders, and out further into the great abyss around this town. This is the future, and what will be built here is anyone’s guess. I cannot predict how the agricultural market in the United States will grow and shift with time; the next big changes may result from investors in the private sector, or from the governmental actions of the Biden administration.

But if we switch our large-scale conventional agriculture to syntropic agriculture, what would happen? How would the town change, and what future building plans would erupt?

The Future

The future is murky, of course, and the following will be speculation about how the market might change if syntropy is implemented country wide. For starters, that Market Facilitation Program that I mentioned earlier? May need some changes. When growing on a syntropic farm, farmers often have many different crops to take to the market, instead of mass amounts of just one. This would likely result in less governmental funding being needed, as even if one product has tariff enacted upon it, farmers would still be able to sell alternate products to recoup some of their lost income.

2021, https://seekingalpha.com/article/4412396-farmland-partners-trading-near-nav-but-billionaire-buying-spree-may-extend-the-rally?utm_source=from.flipboard.com&utm_medium=referral.

In addition, the United States may be able to get rid of the tariffs it currently has enacted against other countries, because the US farmers, with more efficient soil and general crop production, may be able to better compete in a global marketplace.

The production of staple crops such as rice and corn depend on the management style of the farmers themselves, but there is no reason to suspect that the yields of these staple crops would decrease, especially if the farmers decided to do a 90-day retrofit on their rows. See [here](#) for more information about retrofitting and farm management. It is also possible that commodity prices would fall slightly, as more produce options would be available from more farmers. Specialty crops, such as fruit and nuts, may decrease in price as farmers expand their syntropic system. If it has not been abundantly clear already in this blog post, I am not an expert on agricultural economics, and so these amateur predictions are just that—predictions.

What I am sure about is that adopting syntropic agriculture would come with a whole host of changes, not just economically, but also socially, politically, and perhaps even morally in this country. The ripple effects of adopting this style are incredibly hard to predict, and could result in any number of unforeseen changes. But even though the thought of the unknown is scary, it is clear the current agricultural system has [significant problems](#) as outlined above, ones that will not be solved with tariffs and direct cash payments to conventional farms.

CONCLUSION

While on this blog-writing thesis adventure that has occupied my mind this last year, I have often thought about the future, and the possibilities that could emerge from a simple sharing of information. I didn't market my blog anywhere, or promote it through social media, but I did gain ten followers over the course of the year, readers who would be alerted each time I posted a blog post. Ten people doesn't seem like much, but if ten people came into my room right now and watched me type this out, I would be overwhelmed. That is ten more people with an exposure to soil science, agricultural information, and hopefully a new sense of where food comes from. Writing the blog was an education in itself. I have never done a long-form project piecemeal like this, and it was very rewarding. Breaking this thesis up into weekly installments allowed to comfortably track my progress and stay focused. It prevented the thesis from becoming overwhelming and it allowed to more deeply understand each aspect of syntropic agriculture. I learned something every week from my research—so many of the journal articles and papers I read opened my eyes to new information.

It's hard to pick a favorite moment or fact that I learned, but one that really stuck out to me was how little we understand about resource partitioning in forests. I had learned in ecology that there were gaps in our understand of tree communication, but to read for myself how little we truly know was shocking. It emphasized how much more there is to learn in the field of botany and ecology. It also made me realize the hubris of scientists who believe they understand exactly how trees contribute to forest community dynamics. They, in fact, do not know anything of the sort.

Looking toward the future of agriculture in the United States, I am filled with a mixture of hope and apprehension. Hope, because sustainable agriculture practices of all kinds are becoming more mainstream, partially fueled by the rise of social media and sustainability marketing. People are starting to think critically about their food production. Critical thinking, however, can take some time to lead to real change. My apprehension stems from two main areas: agriculture is often political, and many people do not believe in climate change. As the United States government goes through significant policy changes every 4 to 8 years, it is extremely difficult to predict how the political sphere could impact agriculture. As governments changes, so does tariff implementation, market policy, and environmental guidelines. Change to any one of these sectors could drastically impact growing practices and market practices.

However, these changes would impact both syntropic agriculture and conventional agriculture, so beyond costs for the individual farmer, there is no specific guidelines as of now that would prevent someone from syntropic farming. Political changes will continue to impact the agricultural market regardless of how sustainable it is. Although political changes will affect the agriculture market, hence the reason for my apprehension, they likely will not prevent syntropic agriculture from expanding.

Much more concerning to me is the simple fact that many people either do not understand, or are willfully ignorant of the impending climate crisis. I worry that people will not feel the appropriate urgency in altering food production, resulting in a slow adaptation of sustainable farming. We have the potential to grow more than enough food for the planet. The likelihood we live up to that potential seems low. However, I am not without hope, as countries around the world, including the United States, have developed

sustainable practices and there are dedicated researchers, scientists, and citizens determined to expanded their reach. In order for us to keep growing the amount and quality of food we currently do in the United States, there must be changes to our agriculture system. It is my dear hope that development of syntropic agriculture is one of these changes.

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