Ecologically Sound and Practical Applications for Sustainable Agriculture

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Anna Christine Taylor and John Korstad

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Abstract

Rampant soil erosion of as much as 20 tons per acre per year doesn't merely affect farmers. The nitrogen and phosphorus contained in the soil affect aquatic life and marine ecosystems, creating the dead zones and cultural eutrophication in aquatic ecosystems. Losing topsoil is like losing time—one cannot get it back. Many fear the depletion in topsoil will eventually affect food availability. The authors examine how no-till farming, crossbreeding and domestication of perennial plants, and a purposeful shift toward sustainable intensification and polyculture farming will positively impact future generations. Author Anna Christine Taylor also includes her interviews with professionals who practice sustainable farming or sustainable living. As a millennial, she presents her hope that a focus on

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communication, education, and economic viability will pave the way for the sustainable future.

Keywords

Sustainable agriculture · No-till farming · Polycultures · Soil erosion · Sustainable intensification

> . . .We treat agricultural lands with three million metric tons of pesticides per year; we fix more chemical nitrogen fertilizer, using natural gas via the Haber-Bosch process, than all natural processes combined; we have already lost 20% of the world's top-soil; 20% of agricultural land is now so degraded that it is no longer able to support food production; and species extinctions are three orders of magnitude higher than the geologic baseline. (Dornbos paraphrase of Raven, Persp Sci Christian Faith 64:51–61, 2012)

2.1 Introduction

Dr. David Dornbos, retired global head of Syngenta Seeds' genetic research development and current chair of the Biology Department at Calvin College in Grand Rapids, Michigan, USA, summarizes the sobering prospects agriculture faces worldwide. Water and wind erosion claim 20 tons of soil per acre in 1 year (Mann 2008). Rain washes excess nitrogen and phosphorus fertilizer from fields into bodies of water, triggering algal blooms and starting the eutrophication cascade. As algae and other plant life die, bacteria decompose the organic matter, stripping the water of oxygen and creating zones of hypoxia (Ramos et al. 2018). Researchers estimate that over 400 hypoxic zones exist globally, including the Gulf of Mexico (Paine 2012; Crews et al. 2018). Low oxygen levels have been traced to debilitating genetic mutations in fish, altering the metabolism and immune system, and killing benthic animals such as shrimp and other crustaceans that fishermen rely on for their livelihood (Dasgupta et al. 2015). Monoculture farming causes this ecological discrepancy (Huggins and Reganold 2008). Successful monocultures, fields of only one crop such as corn, offer efficiency, producing a maximum yield for a minimal mechanically driven effort; however, monocultures lack effectiveness. "For example, industrialized food production requires ten kilocalories of fossil fuel energy to produce one kilocalorie of supermarket food, much of which is processed corn and soybean" (Dornbos 2012). Monoculture farming ranks as the top threat to biodiversity, pollution of waterways, and water consumption (Pretty et al. 2018a, b). However, one of the greatest side effects of monoculture farming is soil erosion (Dornbos personal interview 2018; Crews et al. 2018).

Continuous tilling kills weeds but exposes deeper soil to sunlight. Without a root system, the soil has nothing to secure it or shield it from the elements (Huggins and Reganold 2008). Conventional tillage leaves soil exposed for months, leading to excessive erosion (Crews et al. 2018; Dornbos personal interview 2018). The global median rate of soil erosion at 1.52 mm per year outpaces soil genesis at 0.004 mm per year (Dornbos personal interview 2018; Crews et al. 2018).

Today, scientists and farmers strive to remedy and reverse topsoil loss through methods such as no-till farming, crossbreeding and domestication of perennial plants, and a shift toward sustainable intensification and polyculture farming.

2.2 The Need for Topsoil

Soil itself is not lifeless, merely consisting of particles, gravel, and dirt. Soil functions similarly to the human body, requiring essential nutrients, structure, and organic matter. These components in unison give soil the ability to sustain plant, invertebrate, fungal, and microbial life.

Plants require 17 essential elements, macronutrients including C, Mg, N, Ca, O, P, H, K, and S and limited quantities of micronutrients such as Mn, Zn, Cu, Cl, Mo, Fe, Ni, and B to sustain life (Welch and Shuman 1995). Utilizing large quantities of macronutrients, plants synthesize organic molecules such as lipids, carbohydrates, proteins, and nucleic acids (Tully and Ryals 2017). Amino acids, the building blocks of proteins and enzymes, which make up every cell in organisms, contain nitrogen. Phosphorus is a critical element in forming DNA, RNA, and ATP (which provides the energy to power any reaction in living tissue). Phosphorus also makes up the structure of the phospholipid bilayer of cell membranes, which regulate every substance that enters the cell (Tully and Ryals 2017; Stewart personal interview 2016). Positively charged macronutrients, such as phosphorus and nitrogen, ionically bond to negatively charged soil particles; thus, rain and erosion sweep away both soil and the vital nutrients that are essential for plant survival (Dornbos personal interview 2018; Adegboyega 2019).

Less than half of soil consists of pore spaces for water and air. The other half contains a heterogeneous mixture of sand, silt, clay, and soil organic matter (SOM), which consists of organic substrates from decomposing organisms (Crews et al. 2018). For instance, glomalin, a protein secreted by mycorrhizal fungi, binds minuscule clumps of soil particles, which contain organic matter, into aggregates. Repeated tilling of the soil fragments the aggregates, allowing bacteria to consume the released organic matter. Thus, every soil disturbance reinitiates this process and reduces SOM (Crews et al. 2018).

Organisms such as bacteria, fungi, and earthworms benefit soil, recycling wastes back into inorganic nutrients (Reganold et al. 1990). A wealth of microorganisms leads to a great biodiversity of species in the soil and allows for mutualistic relationships between root systems and fungal hyphae (Dornbos personal interview 2018; Reganold et al. 1990). The hyphae's wide horizontal reach allows it to "forage" and capture nutrients such as phosphorus, which benefit the plant, while the fungus benefits from extracting carbohydrates from the root system (Tully and Ryals 2017; Crews et al. 2018).

2.3 No-Till

Using no-till farming methods, farmers essentially leave the soil alone, leaving harvested crop residue atop to decompose into additional nutrients. This layer of organic matter prevents rapid wind and water erosion, protecting the soil beneath and reducing surface runoff, saving water, and preventing downstream pollution from pesticides (Huggins and Reganold 2008). No-till practices retain the SOM within the soil aggregates and reduce the global median rate of soil erosion per year from 1.52 to 0.065 mm. Crews et al. state, "These rates of soil loss are 360 and 16 times the rate of soil formation" (Crews et al. 2018; Montgomery 2007).

No-till farming reduces fuel usage but requires expensive specialized machinery designed to slit open crop residue-covered earth. Stagnant moisture promotes rampant fungal diseases, which can devastate crops (Huggins and Reganold 2008). To prevent weeds and pests from overwhelming crops, farmers apply more than the usual amount of herbicides and pesticides. Unfortunately, these chemicals can build up in the soil and bioaccumulate up the food chain, threatening animal and human health (Huggins and Reganold 2008).

2.4 Crossbreeding and Genetics

Co-founder of the Land Institute, geneticist Wes Jackson dreams of combining low-maintenance perennial plants with food-bearing annual plants through crossbreeding and domestication. Annual plants occupy 80% of global agriculture. With their minuscule root systems and constant need for tillage, annual plants promote rampant soil erosion (Glover et al. 2007).

The massive root systems of perennial plants, often 2 m deep, anchor soil and, thus, provide structure for the soil and for microorganism inhabitants (Glover et al. 2007). The carbon contained in the root systems also adds to SOM and reduces carbon dioxide levels in the air (Crews et al. 2018; Huggins and Reganold 2008).

Annual plants require herbicides and pesticides, whereas some perennials naturally repel pests and diseases (Glover et al. 2010). Some estimate a reduction in cost up to eight times compared to the previous amount of herbicides used for annuals (Glover et al. 2007).

Thus, perennials reduce planting time, herbicide use, tillage, and, therefore, fuel consumption (Glover et al. 2007). Since their root systems and leaves are already established, unlike annuals, perennial plants maximize sunlight during the time annuals are developing underground growth (Glover et al. 2010).

Universities and research centers around the world in Canada, China, Argentina, Sweden, and Australia, including Jackson's Kansas-based Land Institute, research progeny species (Glover et al. 2007, 2010). Using biotechnology, researchers select genotypes that will code for certain phenotypes, physical manifestations of the desired genetic trait (Glover et al. 2007). However, "Of the 13 most widely grown grain and oilseed crops, 10 are capable of hybridization with perennial

relatives. . .When it reaches the reproductive stage. . . the hybrid genetic anomalies frequently manifest as an inability to produce seed" (Glover et al. 2007).

Often, progeny are sterile or only female due to parent chromosomes misaligning during meiosis; thus, researchers backcross the plant, breeding the progeny with their parent to produce a fertile offspring (Glover et al. 2007). Researchers strive toward creating a stable, fertile hybrid high in nutrients such as wheat, maize, rice, pigeon peas, sunflower, flax, and sorghum (Glover et al. 2010).

The Land Institute reached success with Kernza® grain, domesticated perennial intermediate wheatgrass (*Thinopyrum intermedium*) crossed with annual wheat. Its roots reach down to 3.3 m, anchoring the soil. However, the plants' small seeds and lesser grain quality need improvement (The Land Institute 2019).

Genetic manipulation takes time, and changing an annual into a perennial plant will take more than adding a few genes (Glover et al. 2007). However, researchers estimate perennial crops may dominate the market within 20 years (Glover et al. 2010).

2.5 Case Studies Around the World

According to a global analysis of agriculture led by Jules Pretty of England's University of Essex and conservation agriculturist expert John Reganold of Washington State University in the USA, one-third of agriculture employs sustainable practices (Pretty et al. 2018a, b). Sustainable agriculture (redefined by Pretty as "sustainable intensification") strives to reduce pesticide use and erosion while improving caloric qualities, biodiversity, and human health (Pretty et al. 2018a, b).

The focus of sustainable intensification (SI) is efficiency, substitution, and redesign (Pretty et al. 2018a, b). "Efficiency" includes precision farming, which uses satellite-equipped machinery that assesses the soil's need for fertilizer through a combination of information provided from Global Information Systems (GIS) and Global Positioning Systems (GPS) (Pretty et al. 2018a, b; GPS 2018). GIS uses GPS to interpret signals from satellites into a spatial plane, creating a map. Although the two systems sound similar, GPS relays locational information to a vehicle's receiver, while GIS creates maps laden with information that can be used for geographical, economic, political, and agricultural purposes (GPS 2018). Computer software analyzes the information accumulatively, allowing a user access to the data, whether in the tractor, home, or office (Pretty et al. 2018a, b; GPS 2018). Using this geospatial information, farmers apply only the needed amount of fertilizer, insecticides, and any other needed treatments to specific areas and, thus, improve accuracy, cost-effectiveness, environmentally safe methods, and overall farmer understanding (GPS 2018).

"Substitution" consists of planting alternative crops that are genetically resistant to drought or pests. "Redesign" physically alters the environment to reflect the checks and balances of a natural ecosystem. Pretty and fellow researchers champion seven aspects of redesign, "(1) integrated pest management, (2) conservation agriculture, (3) integrated crop and biodiversity, (4) pasture and forage, (5) trees in

agricultural systems, (6) irrigation water management, and (7) intensive small and patch systems" that produce positive effects (Pretty et al. 2018a, b).

Using integrated pest management (IPM), a farmer strategically places a plant, such as *Desmodium* (tick clover), throughout a plot, which acts as a biocontrol, deterring pests and perhaps attracting natural predators of those pests. Placing certain plants in a border around a plot repels other pests. This attracting and repelling strategy is christened "push-pull." Pretty writes, "It is estimated that 132,000 farmers have adopted push-pull in Kenya, Uganda, Tanzania, and Ethiopia" (Pretty et al. 2018b). Farmer Field Schools (FFS) teach practical ways to incorporate agroecology for IPM and provide a network of like-minded people in over 90 countries "with some 19M farmer graduates, 20,000 of whom are running FFS for other farmers as expert trainers" (Pretty et al. 2018a, b).

Farms in Australia, New Zealand, New Guinea, and South America have adopted conservation agriculture, which emphasizes soil coverage and healthy microbe-rich soils. Countries such as New Zeeland, China, India, Nepal, Indonesia, and Vietnam utilize redesign for their pastureland or rice paddies. Although many of these same countries, including Turkey, Pakistan, Sri Lanka, and the Philippines, committed to water management, they have failed to implement it. Farmers in China and East Africa have utilized raised beds and other efficient designs for gardening. In India, the states Kerala and Sikkim committed to only farming organically (Pretty et al. 2018a, b).

Pretty et al. (2018a, b) and other sources document more of these global efforts and success stories for effective sustainable (intensive) farming. We are hopeful and supportive of these ecologically sound and practical applications for sustainable agriculture and look forward to continued growth in these farming reforms.

Anna Christine Taylor's phone interview with Dr. David Dornbos, retired global head of Syngenta Seeds genetic research development, department chair of Calvin College, and professor at Au Sable Institute in Northern Michigan. Taylor took field biology with Dr. Dornbos at Au Sable Institute. (https://www.ausable.org/dave-dornbos)

Taylor: What are the major discrepancies with monoculture farming and how to improve it?

Dornbos: The two biggest problems are soil erosion and biodiversity loss in my opinion. The reliance on chemical fertilizers and pesticides incurs significant greenhouse gas costs but also reduces biodiversity.

Soil erosion [is a major issue] because much of the soil surface is uncovered during a significant part of the calendar year. . . . These soils are exposed to wind and rain all winter long as well as the part of the spring. . . .Soil particles [will] wash into watersheds and cause this eutrophication problem. The minerals that plants need, some of which were applied as fertilizer, [are] attached to those soil particles. You're not just losing the soil; you're also losing your fertility.

The rates that soil forms are a small fraction of one centimeter per year. Soil conservation reduces soil erosion by 75–80%. [However, soil erosion] still happens consistently and soil continues to be lost at an unreplaceable rate even with minimum tillage. So there's still a tenfold difference. . .a tenfold higher loss than soil

regeneration. Obviously, to be fully sustainable, rates of soil genesis need to be equal to the rate of erosion.

Polycultures are the best overall solution, utilizing the developing practices of agroecology, to mitigate soil erosion. Polycultures ensure a more efficient use of solar radiation and water, and they cycle nutrients more efficiently, especially nitrogen. If organized well, polycultures promote diversity of soil microbes which make food plants more efficient, and they can attract insect predators, which, in turn, reduce the reliance on inorganic pesticides.

Think of healthy ecosystems like a forest or a tallgrass prairie—these ecosystems utilize virtually all the available photosynthetically active sunlight year-round. Because corn is a semitropical crop, it ends up getting planted typically in May in temperate areas of North America. Up until the time corn plants canopy the soil surface in June, rays of sunlight or photon energy of light that don't hit any leaves hit the ground or weeds. They go straight from the sun through our atmosphere to the ground. That's lost potential energy. Healthy natural ecosystems have plants that start growing very, very early. Think of the ephemeral plants in the forest understory. Growth begins in February or March. These plants are already utilizing early spring sunlight. A monoculture field typically only has plants growing out there for only three months, and they are only canopying the floor of the field for about a month and a half, so there's a big loss in potential solar energy.

Polyculture systems or forests and prairies have much lower rates of soil loss than they do rates of new soil formation; they've got fully established permanent root systems year-round. Some natural tillage can occur and be okay but very minimal. Hooves of bison or burrowing of mammals are natural forms of tillage.

Now I want to circle back to biodiversity. As we've talked a little bit about polycultures, we've talked about the optimal use of nutrients, light, and water, but [we need to address] pesticides.

I think that when a lot of people think of biodiversity, they are thinking about polycultures—such as apple trees, raspberries, beans, corn, squash, lettuces. There are other biological kingdoms that turn out to be really, really important. Bacterial and fungal species living in the soil help plants grow in mutualistic relationships. There's microbiological diversity in soil that plants rely on, mycorrhizal fungi, for example.

Taylor: Yes!

Dornbos: These crazy fungi will literally penetrate the roots of particular plants, their symbiont, and they derive carbon nutrition from the plant because the plant has plenty of that. A plant can do photosynthesis while the fungus can't. At the same time, the fungal mycelium acts as a very extensive system to get mineral nutrients for the plant. So whether you're talking about fungal or bacterial organisms, roughly 95–98% of these organisms live in the soil. They are often species-specific that can help these crop plants grow much more efficiently.

A monoculture favors only one kind of microbiological symbiote, which means most of the others cannot persist in that place because they never see their host plant for, let's say, 7 years if you're on a 7-year rotation. Imagine in one tablespoon of soil there are like 3 billion bacteria, many different kinds, and they all have different

kinds of relationships with each other and the plants that are growing there. If you're only growing one kind of plant, you're only going to favor a narrow range of those kinds of soil microorganisms.

And the thing is, if you start throwing a bunch of pesticides and nutrients in the soil, who knows what effect that variety of pesticides will have on them? Or if you're applying lots of nitrogen, you're creating these huge pH swings. Imagine going from a pH of 12 to 3 and back to 6 in the weeks following of anhydrous ammonia as a nitrogen fertilizer. Broad pH swings are probably really hard on those microbes, too.

Aboveground, I think about the variety of insects. None of us in our class appreciated mosquitoes all that much, but mosquitoes are important, feeding a whole lot of birds, aquatic macroinvertebrates, and fish.

Taylor: And the dragonflies.

Dornbos: And the dragonflies are also going to eat mosquitoes and some other pests that are on your crop plants. . . . The chipping sparrows, like many of the other sparrows and warbling birds, are little insectivores. They eat half of their body weight in insects every day. If you start thinking about all the other kinds of insects, the parasitic wasps that are out there, dozens and dozens of kinds of parasitic wasps—many with very specific host targets—and dragonflies and whatever other kinds of critters that are floating around out there, these can serve as your pesticides in a biodiverse production system. If you set up a year-round polyculture sensitive to these insects' life cycles, it turns out you will seldom if ever need pesticides. All these other little bugs and bacteria will be doing your bidding for you. I almost never have to apply pesticides in my garden. I don't need to because I never get insect problems. I've got birds and other things hitting about everything except cabbage loopers. Because many different crops grow in my garden, the more devastating specialized insect pests never can build up to troublesome populations.

Taylor: How would you set up polyculture farming? Would you introduce species such as birds and insects or let them naturally come? How would you introduce new species?

Dornbos: Generally, you can simply set up a biodiverse system and let them naturally come and build their own populations once suitable habitat is available to them. I envision extensive localized crop rotations, far fewer cereal grains (which implies far less grain grown for feed and fuel). Imagine vegetable gardens or CSAs on steroids. Forests are naturally laid out in that sort of way, too. At Au Sable, we looked at plant communities with beech trees and oak trees arranged in kind of a mosaic. You typically don't have all beeches in one area and another area with all red oaks and another area of all sugar maples. They are all interspersed, suggesting some sort of relationship. The Native Americans in the story of the "three sisters" crops were clearly creating an environment like that. Do you know the three sisters? Does that ring a bell?

Taylor: No, but it makes me think of the three Fates from Greek and Norse mythology. Shakespeare references them in *A Midsummer Night's Dream*. They are basically the same goddesses that would sit at the tree of life and weave everybody's fate. That's what I thought.

Dornbos: [laughs] Okay, so this is a little different. It was squash, beans, and corn—those were the three sisters. Native Americans, the Iroquois, particularly—and others picked up on it, too—would plant corn and beans in the spring together at the same time. The beans were like pole beans, so they climb, not the typical bush beans you might think of in a garden. The corn grows early, and the beans climb it. The beans are legumes, so they fix nitrogen that the corn uses as they are both growing together, creating a bit of a tangle, but you end up with a strong corn plant because the corn plant has access to the nitrogen that would otherwise limit its growth. When the bean and corn plants were about half mature, that's when the Native Americans would plant squash late June or early or mid-July. Squash typically starts growing later in the year anyway, so you're in the normal life cycle of these plants. The idea is you go ahead and harvest corn and harvest your beans. By the time the beans and corn are dead, the squash grows really effectively in the cold months of the fall. The squash fruits don't grow until August, September, and October. The idea is that in one area you plant an intermix of those three crops that you can optimize the use of sunlight, water, nitrogen, and vertical space because they're climbing on each other.

Imagine a four-dimensional matrix of perennial plants like berry bushes and fruit trees more or less permanently in place with a variety of vegetables and grains rotated over time. With a variety of plant species and minimal use of pesticides and fertilizers, insects and birds and soil microbiota will come naturally and proliferate in the more favorable environment if they are fed year-round. Food animals could certainly be integrated into such a system.

Taylor: How would a polyculture be operated? Spraying nitrogen by hand?

Dornbos: I would think that if engineers would put effort into smaller scale implements for organic and CSA sorts of farms, something close to the scale they do now for big industrialized farming equipment, I think much of what causes us to labor today can be reduced. I am certainly not opposed personally to using technology, but this would need to be re-envisioned to provide alternatives to the industrialized monoculture model we now almost exclusively employ. Even how we grow crops can change by narrowing rows, for example, competition for weeds can be reduced immensely.

Taylor: Do you think that a polyculture system would be possible in that people would be open to polycultures?

Dornbos: Some will, certainly not all. Most in our society take food for granted and many don't want to lift a finger. . . . I would argue some level of work for food follows biblical instruction, creates awareness of and respect for nature, and will produce food of the types consistent with good human health. The success of organic farming and CSAs in many parts of the USA suggests to me that people are open to a different food production system than we currently have. Generationally, as soil, water, and fossil fuel deplete and energy costs limit the production of nitrogen fertilizer and pesticides, agroecologically, savvy systems will grow, I believe. We are on the cusp of a revolution in food systems now, I think and hope.

Taylor: How do we know that no-till is working?

Dornbos: We know no-till works because soil erosion rates have been and are going down. We need to continue these sorts of practices as no soil equals no food. The calculus here is pretty simple. Topsoil does regenerate quickly, and while soil quality can be improved over time, we are speaking of geologic time and not generational time, certainly not the short-term requirements of profit-loss statements. Somehow, we need to financially account for the "loss" of resources that we depend upon and don't seem to value until they are gone. The challenge of cost/benefit in food consumers' minds is problematic when much food of all kinds is inexpensive and available in the local grocery. This apparent largess promotes the perception of low value. Most Americans don't even save for their own retirement, so getting those Americans to take action on soil and biodiversity improvement will take patience, persistence, and time.

Taylor: What is being done in the government now to encourage conservative tillage?

Dornbos: The government does encourage sustainable agriculture but almost exclusively within the context of industrialized monocultures—so-called intensive systems. Of course, this is largely the result of big lobbies (corn growers, beef growers, dairy producers, and big companies). Very, very, very little taxpayer money is devoted via the farm bill, for example, to sustainably intensified food production system development. This should change and needs to change, but I don't see our government having any interest on this topic. This is going to have to be promoted and supported from the grassroots level.

Taylor: What are your thoughts on what a "sustainable future" in farming looks like, or what practices will lead to sustainable farming in different countries and regions of the world?

Dornbos: First, I would hope that we don't continue to export unsustainable food production methods to developing countries.

Second, we need to move away from monocultures. We need to identify more sustainable systems. I fully realize that we cannot move completely from monocultures for feed crops, but there are better alternatives. And, if we as a culture would eat *much* less meat, we would be healthier, and the environment would be healthier. Anything that can be done to increase no-till use and thereby conserve soils should be done. Anything that we can do to increase functional diversity should be done.

Farmers are sort of like serfs in a system; they must largely act at the whim of input suppliers and costs, a public that demands cheap food, and a globalized system that drives cost efficiency. If we are able to internalize the plethora of externalized costs and think in a timeframe of decades and centuries (not monthly balance sheets or daily stock market returns), we would realize that the real costs of producing food in the way we do are extremely expensive, not at all as cheap as it appears. We should value the inputs and products of the process, and the process itself, much more than we do.

Anna Christine Taylor's interview with Nathan Feller and Anna Mueller, Oral Roberts University students who were part of the Zimbabwe Healing Team: the team partnered with a local organization to impact the local economy through wicking

beds, a form of sustainable agriculture (https://oru.edu/news/oru_news/20180726-oru-zimbabwe-healing-team.php).

Taylor: Before this project, how much did you know about sustainable farming?

Feller: I had the pleasure of being exposed to the sustainable farming world before this project took place, but this project taught me a great deal more than I ever could have imagined.

Mueller: I honestly had only heard about sustainable farming in classes like environmental science (EVR 250). I have learned so much about the practical applications of sustainable farming through the research and on-the-ground work of this project. For example, Nathan Pickard taught me much about permaculture during the research phase of this project.

Taylor: For someone who's never heard of wicking beds, how would you explain how they work?

Feller: Essentially, a wicking bed is a closed system that takes advantage of a natural biological process known as capillary action. Water is polar, meaning that one end of the molecule has a positive charge and the other end has a negative charge. This molecular interaction is a fundamental process that enables plants to continually replace the evaporated water molecules from the leaves with water that is in the soil via a long chain of water molecules that flows up the plant. The fineness of a capillary tube will determine its surface tension relative to gravity. The finer the tube, the higher the water will rise. Capillary action or wicking is at the heart of a wicking bed. The bed can be broken down into a few components for simplicity. If you were to cut right down the middle of the bed, you would quickly find that it has two main sections: the water reservoir and the soil. These sections are approximately equal in size and are separated by geotextile fabric so as not to allow the soil into the water reservoir. After selecting an area for the bed, a plastic liner is placed in a 6×6 foot area that is 2 feet deep. An L-shaped tube is placed flush with the bottom of the bed with one end shooting up and out of the bed above the soil layer. This is where the water will be added to the system. A coarse media is then placed over the tube, thus creating the water reservoir. Next, the geotextile fabric will be placed on top of the coarse media and the soil, which is topsoil, compost, and manure mix. Mulch should be placed on top of the soil to reduce evaporation. Initial wetting of the soil should be performed. After this, water should only be placed into the tube, filling the reservoir from the bottom up.

Mueller: The only other thing that I would say is that this system allows for more water retention and conservation and also much greater yields in the beds than a normal garden due to the design.

Taylor: Since one of the Healing Team's goals was to empower the local people and their economy through sustainable farming, how do you foresee the wicking beds impacting the communities' future?

Feller: One of the greatest things about this project is that it was born and bred in Zimbabwe. We had the honor of working with the Foundation for Farming (FFF), which was located a few miles from the community we were working in, and it was FFF that came up with the wicking bed design that we implemented. I believe that

this empowered the local people by showing them a design that was created for their people by their people. We were merely vectors for communication.

Mueller: Our hope is that, like the Latrine project from the previous year's Healing Team, the community members would be inspired to take the initiative to build their own wicking beds. We established a loose system of mentorship with the community leaders where they were required to train three members of the community on how to build a wicking bed during/after we had helped them build their own bed. We also encouraged them to help contribute some funds for others to build beds. If this project takes off as we had hoped (I have not heard about how it is doing now), this project has the potential to greatly increase the crop production and economic success of many members of the community.

Taylor: Did the wicking beds change the community and the culture? If so, how did seeing that change affect you?

Feller: Due to the nature of short-term missions work, I was not able to see the change take place. I have heard that the beds were successful and that families were able to benefit economically from the produce. Hearing about the success brought me immense joy and has shown me how important empowering local people truly is.

Mueller: As Nathan said, it has only been a few months since we launched the pilot, and I have not heard much news about the success in the community of Hatcliffe. For me, it has been amazing to have a part in this project and participate in something that could have a lasting impact on a community.

Taylor: How did you ensure people would plant a diversity of crops in their gardens so they wouldn't saturate the market with one crop? Does everyone pool their revenue and draw from that? How do they organize the process from planting to selling?

Feller: Diversity was a topic that we discussed and strongly recommended; however, it was ultimately up to the individual to choose what they would plant. The economic gain from a type of kale was the most promising for their ROI, and, thus, the majority of the wicking bed owners choose to plant that in their beds. The revenue is on a personal level. Planting and selling are also on a personal level, and it is up to the individual to pick a price and market for the goods that were produced.

Mueller: When talking with the business students on our team, we were mindful of flooding the market, but when it came down to planting the gardens for the community leaders, they all chose between two options because of seedling price, market price, and personal preference. Only time will tell how this impacts the local economy.

As Dr. Korstad mentioned, we did discuss the beginning of a plan to coordinate between the community members a more business-oriented plan to prevent things like flooding the market. As of now, I think this would take a higher level of coordination than we have at the moment, but it could be a development in the future.

We talked about families having many wicking beds—some for their own consumption with a crop rotation model and a few for profit. This would pay for the materials and make excess income within a matter of months. While we were there, they simply planted one bed with the intention of making a profit.

Anna Christine Taylor's Interview with Dr. David Unander, former professor at the Eastern University and current professor at the Au Sable Institute Costa Rica campus. Dr. Unander was also an assistant professor of horticulture at the University of Puerto Rico (https://www.ausable.org/dave-unander).

Taylor: What farming practices are working in Costa Rica? Do they employ polycultures?

Unander: Costa Rica and New Jersey are close to the same land area—and even have two coasts. And there the similarities end! Costa Rica has 9–10 active volcanoes and 100 s of inactive or extinct ones. The geology is mostly igneous, with sedimentary rocks close to the coast (such as youngish coral limestone layers). However, the highest and oldest mountains are uplifts, not volcanic—but they get up above the freeze line, so you even have some tropical alpine ecosystems (a relatively small area) but fairly sizeable cool tropical areas.

[There are lots of] valleys and watersheds, as well as two quite different coasts. A general rule for the tropics is prevailing winds from the East until one is close to the equator. Costa Rica falls between 8 and 11 degrees North, with the ocean on both sides, one of which is like a partially confined, warm bathtub (Caribbean) and the other the largest ocean on Earth, with huge, complicated circulations, affected by cyclic patterns.

There are wet seasons and dry seasons, although the dates of these vary a little with the location. Sometimes winds come from the West, sometimes from the East. Because of the mountains, there's often a rain shadow effect.

To really understand each location, you'd also have to learn the seasonality of the rainfall: does it rain all year consistently, or is there a dry-wet cycle every year? You'd also have to add in what the temperatures are like from elevation. And then consider the soil type and—definitely unlike Pennsylvania, New Jersey, or Oklahoma—effects from volcano emissions, which are acidic, sometimes dramatically so, but also add P, K, and S to the soil as fertilizer.

So, that permits a remarkable diversity of crops grown in Costa Rica, and the dominant crop one sees (or few or no crops at all) can change quickly as one drives around this relatively small country.

Absent would be temperate staples like wheat and barley. I also can't think of ever seeing potatoes, although I'm sure there are places in Costa Rica where they would thrive.

The farming practices vary enormously as does the economic organization. For example, Costa Rica has a long history of agricultural cooperatives, some of which have been very successful, including their international marketing. Other crops are dominated by large corporate plantations and corporate exports and still others by small landholdings with a diversity of plants and animals, plus usually one or two major market products. There's a wide range of scale and practices one encounters. Costa Rica is usually classed as a First World country. That prosperity extends to the level of capital accessible to many farmers and corporations. Their purchases include heavy use of synthetic fertilizers and pesticides, such that the watersheds in the major agricultural areas are heavily contaminated. The use of fertilizers and pesticides is comparable to the USA. At the same time, Costa Ricans are generally literate and

educated, and many are concerned about their environment, so there is an increasing market for plants and animals produced on organic-certified farms. There's a lot of small producers and active farmers markets everywhere.

Bananas, pineapples, sugar, and African oil palm are mostly grown in monoculture plantations, sometimes enormous acreages for export. Roads to the port of Limon are always clogged with 18 wheelers with containers loaded for North America and Europe. Bananas and pineapples eaten in Costa Rica are often grown on small farms, some organic and some not, but most of them grow in more of a polyculture. Some small farmers are successfully competing with Dole, Chiquita, Del Monte, etc., by organic production of bananas and cacao, sold through marketing cooperatives. My Au Sable class visits several successful coops.

Coffee, of course, is extremely important in the Costa Rica economy and is historically the traditional family farm crop. With the exception of a plantation Starbucks recently has opened, coffee seems to be produced on family or small (Crican) corporate farms but marketed through agricultural coops. Quality is strictly adhered to by farmers and by the coops. Due to government regulations, one can't even grow the lower quality but higher-yielding coffee species and qualify it as Costa Rican coffee. This is how they've held their edge in a highly competitive global market.

Ecologically, some farms do shade coffee, which is better for the environment. Many do sun coffee, which produces a higher yield though it is more environmentally degrading. Many use synthetic fertilizers and pest control. Some coffee farms are organic. High-quality coffee requires a particular ecosystem, tropical but cool and wet, yet well drained, so in those fortunate locations, coffee is almost a monoculture, although there's often some acreage for a polyculture of some fruits and vegetables the farmer sells as a sideline. Little family coffee shops/bakeries are also a common sideline in coffee country.

Cattle, pigs, and chickens are really important in Costa Rica. They are a major Central American milk and cheese producer (one source of immigrants in the 1800s came from dairy regions of Europe, like southern Germany, Switzerland, etc.). The area around Vara Blanca looks a little like Wisconsin, with all the Holstein dairy cattle grazing on the rolling hills. The Wisconsin image is broken by the smoking volcanoes looming behind the cows, huge tree ferns, and occasional tapirs that come out of the cloud forest to graze with the cows. Dairy farms range from small family farms (say, 10–20 cows) to huge ranches with hundreds or more. They all are still a major source of eutrophication in the watersheds. Sadly, I learned that was true even for an organic yogurt and ice cream factory we visited: the milk was organic, but so was the waste they just washed downstream.

The northwest coastal plain probably is the closest to Oklahoma you would see, a seasonal dry forest/savanna region. Historically, the agriculture has been, and still is, beef cattle. Costa Rica raises and exports a lot of beef. Dan Janzen, a tropical biologist from U/PA, thinks the cattle and horses the Spanish brought have subtly returned the dry forest toward the ecosystem that was there before humans arrived. The first Indian tribes seem to have hunted all the largest grazing mammals to extinction. Some of the dominant trees that depended on seeds passing through

those animals then became less common. Since the 1500s, pollen records show those trees slowly returning to dominance, which Janzen attributes to horses and cattle eating pods from those particular trees, thus aiding germination! Anyway, that agricultural system has been in place for centuries: the rainforest wasn't really cleared for the cattle; it was always savanna, probably reminiscent to the Spanish of savannas/chaparral in southern Spain where cattle ranches also have existed for centuries. In contrast, the highland dairy cows are in a rainforest and cloud forest that was/are clear-cut for them.

Chickens and pigs are raised on every scale you would see in the USA, from backyards (very common for chickens) to huge factory-like operations. Due to coyotes and other predators, free-range chickens have to be inside some sort of protective enclosure.

Trout is worth mentioning. Apparently, wherever European men went, they sent for their trout sooner or later. The Spanish and other immigrants introduced trout all over Central and South America, where they weren't native. The USA now has a mix of introduced European and native North American trout species. Anyway, small trout farms are a small business common in high mountain areas with cold, clean streams.

There are many tropical and some temperate fruits, often in smallish plantations, occasional larger plantations (such as for mangos or papaya or, at cool elevations, avocados), sometimes a mix of many different kinds. All the tropical staple roots are grown: yuca/cassava, yautia, malanga, sweet potatoes/batatas, and ñame. I think those are all for local consumption or maybe some export to Panama or Nicaragua. Everyone eats them in Central America. A lot of vegetables and small fruit species are grown, again on many different scales of size and organic/not organic. Vara Blanca, where the Au Sable course is based, is famous for its dairy farms and its strawberries. Roadside vendors there sell boxes of strawberries with a local sweet cream dip to eat them with!

There is no single way to characterize Costa Rican agriculture.

Taylor: When you go into a community, what are your first steps? Do you blend the Gospel with creation care? How do you impact the economy through agriculture?

Unander: (1) I stress language learning as essential, wherever one goes. It just can't be a shortcut to be effective at anything personally. Everything else someone does needs to be combined with continuous language learning. It clearly communicates that one honestly values that community.

(2) I'm a fan of being "naturally supernatural," working with what one senses God desires to do at that moment for a particular situation and a particular person. So, yes, it's often very appropriate. It's nice to be able to introduce Jesus into a conversation when it naturally fits the topic. I enjoy it when someone asks me, "Are you some kind of missionary?" and I can say, "No, I'm a biologist."

(3) Sustainability in agriculture has to fit with the farmer feeding his/her family. Any way we help—as outsiders—to make this happen accelerates its acceptance. Plant with Purpose, the Christian service mission that promotes reforestation, learned decades ago, they had to include trees with marketable wood or fruits, to make up for the lost income of planting trees in some sloping land rather than crops.

The most successful agricultural innovations fit the local ecosystem and (usually) existing farming techniques and existing types of foods. World Vision successfully introduced carrots to the Quechua farmers in highland Peru, a region where most of the staple crops in the diet are roots (potatoes, sweet potatoes, cassava, yacón, arracacha, mashua, oca, ulluco, etc.). That added an additional rich vitamin A source to their diet, and basically the agricultural techniques were the same, and also carrots are cooked the same way as most any other root. Carrots also keep better than sweet potatoes (the other good vitamin A source they had); most people immediately like the taste of carrots, so they quickly became a market vegetable to sell as well as eat.

Taylor: What are your thoughts on what a "sustainable future" in farming looks like, and what practices will lead to sustainable farming in different countries and regions of the world?

Unander: See (3) above. Ecologically, the agriculture has to fit a given region's ecology. For example, cattle in Oklahoma fill the niche of buffalo (as still do, of course, native buffalo themselves). The prairie there has always had a large hoofed herbivore, and the grasses actually grow better being clipped by them, at a rational stocking level. The grasses are potentially sustainable versus a feedlot, which depends on bringing in corn or hay grown elsewhere. Sometimes a feedlot makes economic sense in the short run, but the entire capital expense is greater and the environmental impact from large animals crowded in one place.

Ask as many questions of local farmers and gardeners as possible, over time, and among different individuals, and take careful notes; maybe take photos as well (but always ask first!). This can fit very well with the extremely important task of learning or improving skill in the local language that one should always be thinking of. Since I first made a serious commitment to learn Spanish 36 years ago, I still try to "program" some Spanish into every week, so that I keep progressing—reading the Bible in Spanish, listening to local or Internet Spanish radio stations, talking to Spanish neighbors, etc. Almost always, I learn some new words and current pop songs, which people make allusions to, just like people do in English.

I observe that many North American students—Americans and Canadians both, but I think Americans are a little worse—are intimidated by foreign languages. That was me, too! One thing that really helped me one day was suddenly remembering parts of my childhood when my grandfather lived with us for several years. He was an immigrant; in fact, he came as an illegal immigrant, although eventually he became a citizen. He learned English all on his own, beginning from ground zero by trying to talk to English speakers on the construction sites where he worked as a young man, to people riding streetcars with him on the way to work, etc., all around him in Chicago. He became quite fluent, although he never lost a thick foreign accent even after 60 years of speaking English. In spite of his accent, he only rarely mangled English sentence structure in ways that made him unintelligible. No one could ever mistake him for a native English speaker—but so what? He had become part of the community, a nice, hardworking man who just happened to have a foreign accent. There is no shortage of people with accents in any major city of the world in our day.

Perhaps we Americans set our sights too high, unconsciously thinking we either reach native fluency in a second language or it's wasted effort. Back when I was fearfully contemplating learning Spanish (a job offer in agricultural research in Puerto Rico had just come), I suddenly realized one day that, just like my grandfather in English, I'd never fool people that I'm a native Spanish speaker—but so what? The truth is, I'm not! But I've plugged away over the years to keep improving competency. It's such a blessing now to be able to travel and work in completely Spanish-speaking places. Most importantly, it seems perfectly natural now to talk with people about Jesus in Spanish—and pray and worship in Spanish. And it really does communicate, without directly saying so, that one cares about people and their culture, to take the trouble to speak their language.

Except when a farmer has a secret technique that's an "edge" over other farmers, most enjoy taking the role of a teacher to describe their farm to a visitor. Farmers and gardeners are usually proud of being asked what they grow and how and why they do it this way and not that way. They all spend a lot of time alone with their plants, thinking about what's the best use of their time to make a living for one more year. Even on short-term trips in an area, even just a few hours on someone's farm, I try to meander around with a farmer and ask some open-ended questions and just be a listener and writer. With an older farmer, it's often really interesting to ask how farming has changed in their lifetime. So, before trying to do anything much in technical realms, when entering a community, I'd want to learn as much as possible, within whatever time one has (1 day? 1 week? 1 semester? 2 years?), what people in that place believe is the best way to farm and garden and why they think that.

If it's a tropical farm, it will definitely use different approaches for some things than a temperate farm, even though the plant biochemistry is essentially the same. Sometimes farmer traditions are very wise, and sometimes they are quite wrong—just like agricultural extension recommendations can be either in the USA! As outsiders, we may be able to bring a new perspective and solutions to a long-standing problem or, we may be clueless about what to do, but the traditional farmers have a workable, local solution. Or, together, we may discover a new solution neither known there or in the USA.

I hope this is useful!

In Christ,

Dr. U.

Anna Christine Taylor's transcribed phone interview with Nathan Pickard, entrepreneur and founder of the nonprofit company Restoration Collective. Pickard spoke at Oral Roberts University on sustainability, sharing the way he chooses to live and how he strives to impact his community for the better (https://www.restorationcollectivetulsa.org/).

Taylor: I remember your talk about the food forest along the highway, and I just read your articles and watched your video interview. Would you consider your food forest a polyculture?

Pickard: Definitely. The goal is to have different things and diversity in every direction possible, like the root depths—the plants are feeding at different levels. The plant heights and fruiting times are different. You can have spring ephemeral plants

that can provide seed/feed before the trees get their leaves and shade out other plants. One of my goals is putting together a good database of our native plants and the native animals that they support and really trying to get it down to where you can say, "OK we've got this pest problem; what are the predators of that pest so we can have a natural check?"

Taylor: Yes. Biocontrol.

Pickard: Yeah. What habitat does the predator need to survive? What attracts it? Whatever habitat that predator needs, let's plant those plants and create that habitat. It gets pretty complex when you start getting into the polyculture, but it's fun, too. The joy that I get from it is to see how amazing God is. To see his design. It was perfect. He created all this amazing diversity, and it all keeps itself in check and protects itself.

Taylor: Yes, that's really neat. Did you discover this database, or did you put it together?

Pickard: No, unfortunately, I couldn't find anyone who had really done it to a large extent. There was a school; I think in Virginia. It was actually an elementary school, and they had put together the best thing I could find. But then their school system did this major update on their website, and so all that information was lost. I was able to find it on an archive, and I paid one of my employees to transcribe all that information onto a database that we have. The information was so great because it included all the predator-prey relations.

Taylor: Like all the different species?

Pickard: Yeah, and the habitat. So if you have a chigger problem, which we do around here.

Taylor: Ew.

Pickard: Yeah, you can look up the ten things that actually naturally eat chigger, and it's like, "Oh awesome. I want those ten things." But what do those ten things need to thrive and to come to this area? I found the database actually because of the chigger problem!

Taylor: Was that the book you mentioned in your lecture that pushed you to live sustainably?

Picard: No, that was *Pollution and the Death of Man* by Francis Schaeffer. It's written from a theological perspective—why Christians should care about God's creation and stewarding it and be like the biggest environmentalists there are.

Taylor: That was my next question—what inspired you? I remember you talking about living off of things you had grown in your backyard and the different herbs and raising chickens. Was that book the main thing that changed your point of view?

Pickard: Yeah, it's been a lot of things, but that was the best from a theological perspective of why I, as a Christian, should be doing that. That's probably the deepest motivation and change that I had.

Taylor: Was there anything else other than that?

Pickard: I just read all kinds of books. The more you read about everything and think about people and God's creation, I think you just have to end up there, like to really think through my actions and to love my neighbors. Being this huge American consumer is harming my neighbors all over the world, and it's easy to live ignorantly

and consume and consume and consume, but when you're willing actually to see the effects of your choices, then that motives you to change.

Taylor: Could you elaborate on your plan for the school? I remember you worked with the city board, and you wanted to teach children about agriculture, ecosystems, and the species native to Oklahoma?

Pickard: With the school, one of the books I read was *Last Child in the Woods,* and it addresses so many of the problems unique to today that children are facing, like this huge massive attention-deficit disorder. The author really connects back to the fact that children are not out in nature like they used to be and not able to take risks and be out in nature alone. Everything they do is so structured and guided. Their parents are scared to let them be outside by themselves.

Taylor: I think you talked about that at ORU—was that the story you told of kids being scared to go into the woods because it's an unknown? That's what we used to do—everybody would just go play in the woods.

Pickard: Yeah, so I started doing some research, and I found some interesting schools that actually allow that. . . . So I got pretty inspired by that, especially since we live in a low-income area just where kids can't travel out to parks; they don't have the transportation abilities to go see nature. So, how we bring that to them? This school had 20 acres. It was all grass, with no trees at all. It was like a totally blank canvas. We wanted to bring back what was originally here. That's taken a lot of study, so I hope it can be a history lesson for the kids. They'll end up seeing what all this area looked like before.

Taylor: Are they going to incorporate taking care of the trees and berry bushes into the curriculum?

Pickard: That's the goal. So the cool part is they are switching to a public Montessori school, and that adds too much more flexibility for the kids. Conventional education doesn't leave a lot of time in a day. With the Montessori model, if they work hard, kids can finish their work at the beginning of the week, so that they can have all of Friday to do whatever they want. Then they get to do the things that interest them. My goal is to give them 20 acres of interest where they can go out and explore. That was the idea behind the database. We made it so that it's very user-friendly. I think it would be so fun for the kids to say, "I really want to see this type of butterfly" or whatever type of wildlife they want to see. Then they come up with a plan to create the habitat, and then they watch and see if they can find that wildlife.

Taylor: That's very neat. And similar to what my parents let me do because I was homeschooled.

Pickard: So was I.

Taylor: Oh, cool! Yeah, my mom was a teacher for years, and she has her master's in education, so she decided to teach me.

Pickard: Wow.

Taylor: That's what I loved about homeschooling. After we were done with my classes, she would let me go outside and play. I would have tea parties and pretend to make medicines out of plants in my own lab. Being outside in the fresh air helped shape who I am and my interest in ecology and biology.

Pickard: Yup!

Taylor: I really like your idea of incorporating the outdoors with education. That's really cool.

Pickard: Yeah, I'm excited about it.

Taylor: Dr. Korstad actually wanted me to ask what you think of having college students like Anna Mueller, Jake Lanferman, and Nathan Feller intern with you. Do you have any thoughts on that?

Pickard: Yeah, it's been awesome. They went on that mission's trip, and they learned the skills like how to make wicking beds, and it was just so cool to bring that back from Africa. It's like Africa's giving us this gift instead of us thinking we can only give them gifts. Through the students, we built the wicking beds. We filmed the making of it, and I've got a guy who works for Channel 6 News here in town. He'll create a promotional video for it, so we can raise funds to make 12 more of them for the school. That way, every class will have its own wicking bed. The vegetable bed is a part of the Montessori curriculum, and the wicking bed will be right outside their classroom, so they can daily care for that.

I don't have the bandwidth to do all that, so I can't be more excited to have ORU students help. It's so crazy! Because it's really hard to raise funds like grants—all those things take a lot of time. Even a small grant takes so much time to write, so much information. And that's what I have a limit of—time. To be given this gift of time from students has been a huge help.

We're using the wicking beds' video for the Go Fund Me campaign. Hopefully, the parents can take ownership and fund the Go Fund Me for the rest of the materials. The video covers all the information about what's needed for every piece and how to do it. All of that should empower the parents to both fund the materials and then actually be involved in making them for their kids. That's the goal. I love doing stuff that is grassroots, where the people who will be affected take ownership of a project. I've seen the opposite happen. The Tulsa Health Department had all these beds made from a big grant, and there are all these raised beds just sitting there. They had me come speak because they had no involvement. No one cares about these beds. And it's just like, "Well, you kinda started off all wrong."

Taylor: Yes, I can see that. I learned that in my business classes. My professor, Dr. Jeff Paul, would always say, "Get people involved, and then they'll care more because their personal time and effort are at risk."

Pickard: Yup, definitely.

Taylor: Dr. Korstad's second question is: What do you think practical permaculture might look like in different regions of the world, like in the USA or Brazil or Europe or China or Africa?

Pickard: It usually doesn't take going very far back to find the people who practiced it without it being called permaculture, you know? In American history, you go back and find the natives who totally practiced permaculture. I think you can do that in any of these countries. There's been a permaculture leader named Geoff Lawton. He's got a lot of videos of the projects he's done. It's interesting to see the methods he's used in the Jordan and Palestine area where it's almost complete desert. He starts with one tree that can handle the conditions, and that provides enough shade that you can start planting other things and start changing the soil. Then there's

one of my heroes on the permaculture side. He lives on a mountain in Austria. He created all these microclimates using ponds, and he's able to grow lemon trees up on this freezing mountain. It is genius. The principles of permaculture are everywhere.

Taylor: Do you have more thoughts on permaculture?

I think when people see permaculture projects, they think, "That's cute, but how can that feed the world?" I thought that, too, until I read the book *Restoration Agriculture.* The book asks if a 1-acre cornfield is more productive than a polyculture. The author has a large-scale 100-acre polyculture farm. He concludes that if you consider a broader view of calories, a food forest has as many calories per acre as does corn. That was my major inspiration for the food forest. The book throws that assumption on its head, saying, "You can actually feed the world with a food forest. You're building soil and cleaning the air and doing all these things—feeding the world actually healthy calories because that corn isn't."

Taylor: So inflammatory!

Pickard: Yeah, a negative calorie!

Taylor: I remember in your talk you addressed the economic part of sustainability and how you run the accounting part of your organization. Remember talking about your peach tree—how you spend this much on it, and it keeps giving and giving?

Pickard: Yeah, I have a degree in accounting. I started teaching a sustainable personal finance curriculum, which I created that asks the question, "If I consume less, I'll have more time, and if I have more time, what can I start producing for myself?" I think it's the way out of the market system that says, "I need to specialize in one thing and then pay for everything else."

Most people think of saving their money and only getting interest in return. Instead of saving your money, I love thinking about investing it to give multiple different yields, and that is a permaculture principle. For example, I bought the building next door. It's given us some financial returns because we rent out its commercial kitchen to a nonprofit. We took out the parking lot and planted a forest, which provides us food. I could have put that $80,000 into the stock market and gotten some interest off of it, but it's provided so many yields for the community and for us. It's crazy the difference when it comes to investing money. Even for people who don't have a lot to invest, you can buy a fruit tree for $10 instead of spending that at McDonald's. We have probably harvested 1000 pounds of fruit from one of our peach trees, and we paid $5 for it. That kind of return from a financial perspective is incredible—to invest $5 and to get $3000 back in a 5-year period is pretty much unheard of in the stock market. Investing in living things provides a financial return but so much more, like purifying our air and beautifying our surroundings.

Taylor: Thank you so much for taking the time to call! I know you are super, hectic busy. Dr. Korstad suggested interviewing you, and I'm so glad it worked out.

Pickard: You're welcome. Of course!

2.6 Conclusion

Why are people so afraid of sustainability? But, of course. Despite its noble character, sustainability sounds like the agenda of "environmental wackos," convinced that polar bears are more important than people, that sunlight and wind could make more energy than geological resources like coal and gas, and that global warming is more deadly than terrorism or nuclear war. Any proposition with "the environment" in the title reads as "regulations" and "bad press" (Hume 2011). Companies avoid it like a money-sucking leech.

However, Jib Ellison, CEO of Blu Skye sustainable consulting agency, encouraged Wal-Mart executives to be a sustainable company. He defines sustainability and Blu Skye's mission statement, saying:

> Sustainability is the greatest untapped source of competitive business advantage in the twenty-first century. It is the dynamic interplay of convening the right players to develop the right answers but also doing so in such a way that they feel a great sense of ownership that they actually built the trust, wherewithal and the will and the courage and the agreements to actually act in concert to capture the value. (Blu Sky 2020)

Ellison's statement dovetails with his epiphany, his revelation that sustainability could drive a company forward as the main engine, not as a tacked on PR generator aimed to please environmental wackos and to distract a prying public as most CEOs saw it. Focusing on how to do business effectively and efficiently, targeting waste—whether excess water use, cardboard, or plastic—changed the entire perspective and strategy (Humes 2011).

The heart of sustainability is "people, planet, and profit," not only planet, letting the people die and businesses go to waste, as how some environmental wackos put it; not only planet and people, as how some environmentalists put it; and not only profit and people, as how some businesses put it. Sustainability is how Dr. John Korstad puts it—a balanced understanding of doing things that protect all people and don't harm but restore the environment in profitable ways. Economic viability is crucial for people; a healthy environment is crucial for people; healthy bodies are crucial for people. All three parts should work together as one.

Thus, how should we then approach farming sustainability? Like the definition of sustainability itself, the answer is threefold—communication, economic viability, and education.

2.7 Communication

Often when experts in their field expound on their favorite subject, it sounds like this:

> Eru Ilúvatar created Eä through the song of the Ainur, who are the Valar and the Maiar.

When people talk about biology, ecology, agroecosystems, conservative agriculture, chemistry, or sustainability, it's as if they are speaking Quenya, or Mandarin, or Greek. Recently, when I explained to a friend how to remember that corals, hydra, and sea anemone belong to phylum Cnidaria, while sea cucumbers, starfish, sand dollars and sea urchins belong in phylum Echinodermata, in all seriousness, a fellow student turned to me and asked if I were speaking English.

Taking time to explain acronyms, the process and effects of eutrophication, and the effects of soil erosion invites people to understand one's language, to glimpse the inner complexity of one's field, and to share one's intended meaning. I have learned that listening and relating topics to other fields, whether biology, marketing, or industries, I've studied increases the probability that the expert and I will understand each other. Listening and understanding leads one closer to communicating meaning, and, therefore, one step closer to brainstorming a viable solution.

2.8 Economic Viability

Some ideas, like prions, infectious proteins, can be deadly, restructuring neural networks and webs of connections, reducing the brain to a liquid sponge. Such ideas are exemplified in the socialistic "Green New Deal," a deliberate restructuring of the foundation of the economy in the name of sustainability. Sustainability without economic viability is an idealistic prion.

Newly elected socialist Congresswoman Alexandria Ocasio-Cortez proposes that the "Green New Deal" will eliminate cars, planes, coal, and gas and require stripping buildings of their conventional energy generators and installing green ones all over the country. Her deal would cost "$4.6 trillion at minimum" and completely tank our economy (Pruden 2019). Writer Steven Moore observes that renewable energy, such as wind and solar, accounts for only 8%, costing $150 billion of taxpayer's money. He concludes that to implement her plan, taxes "would exceed $2 trillion while displacing some 10 million Americans in high-paying oil and gas industries from their jobs" and goes on to say:

> Initially, the Green New Deal planned to abolish nuclear, and natural gas from the energy mix—which is absurd given that shale gas has contributed to a major reduction in carbon emissions and nuclear plants emit no greenhouse gases whatsoever. Along with hydropower, these are the cleanest forms of energy today.

Ironically, the passenger next to me on a recent plane ride turned out to be a biofuel engineer. When I asked him his thoughts on the Green New Deal, he laughed a long time and told me it would never work.

That's the great thing about America. America does not have a dictator, a collectivist culture, or a rigged legal system. Americans are not denied access to free speech, free or nearly free media, a fair trial, legal recognition of property, or self-defense. If someone spoke out for social equality or just about anything in some totalitarian nations, he'd be in jail or dead. Here, he'd get "likes" on Twitter.

Americans are free to start companies, to engage in joint ventures, and to buy and trade all over the world. Our Founding Fathers constructed a nation where economic, social, and political opportunities are possible. Our economy thrives. Unemployment has plunged, giving companies the room to explore sustainability. In fact, the market inspires entrepreneurship and breakthroughs in technology, even embracing biomass energy in a quest for economic sustainability (Backer 2019). Benjamin Backer, president of the American Conservative Coalition, says:

> Today, for the first time ever, transportation emissions have surpassed electric power emissions in the United States, thanks to a dramatic drop in energy emissions via clean energy innovation through the free market. In conservative Texas, through deregulation, the state is rapidly transitioning to renewables unlike anywhere in the country.

As Dr. Korstad says, businesses will drive sustainability in the market place. Backer confirms it, citing that the USA leads the emission reduction movement. However, webs of government regulations ensnare US companies, who like Bilbo Baggins search for a much-needed sword, to cut the spiderwebs. Even the Harvard Business Review admits the spiderwebs sucked $70 billion from the solar industry. Unfortunately, the highly regulated socialist governments of India and Portugal keep their countries bound like the hapless cocooned dwarves in Mirkwood, which emitted 10 million metric tons of carbon dioxide, while Sweden's free market has led to their idyllic environmentally friendly star status (Backer 2019).

Forcing green energy through socialism would devastate the economy, people's jobs, our military capacity for safety, and our way of life. Zizou Corder paints this reality in her masterpiece, *The Lionboy* trilogy. Everyone's life at the Corporacy is perfect, timely, and controlled. Everyone goes to work. Everyone smiles—fake, *dead* smiles. They don't remember how they got there. They don't remember who they are. They don't know the Corporacy makes its money experimenting on animals and *humans* and selling their discoveries. They are drugged pawns in someone else's game, having given up their voice, controlled by a bloated government.

Fiction mirrors reality as a warning—no toilet paper, food, clean water, or enough medicine. It sounds like the backdrop for an apocalyptic thriller, except it's the reality of Venezuela.

Maybe my friend Tosca Lee, New York Time's best-selling author and queen of psychological thrillers, will write a sequel to *The Line Between*, which offers a cure for the prion infection devastating her fictitious world inflicting madness and death. . .

Or was the prion really green socialism all along?

It's still a free market after all.

2.9 Education

"Show, don't tell," my friend author Daniel Schwabauer continuously reminded me through the process of drafting my first novel. If you show the consequences of something, you never have to say anything. In one of my classes, I presented a case study on plastics polluting the ocean. I played a video clip of a scientist pulling over 200 pieces of plastic out of the stomach of a dead bird, piling the fragments high, flies swarming over the mess of macroplastics and gastric juices. I showed them how plastics never biodegrade or organically break down. My class sat with their mouths open. Students on the front row looked like they were going to vomit. And these were biology students—animal dissections are a way of life. After class, a fellow student approached me. He told me, "I never knew that. I'm going to recycle now!" After showing the presentation to my parents, my mom began filling our recycling bin daily, and my dad donated to an ocean cleanup organization. Even after my own presentation, I think about how every water bottle cap could end up in a sea turtle and a bird. Two bags filled with recyclables, waiting to be taken to the Mr. Murph, sit in my dorm room as I write this.

That is the power of showing.

My high school biology teacher, Dr. Christopher Oglivie, began every single class with the question, "What did you have for breakfast?" After listening to the list of pop-tarts, bananas, orange juice, milk, Frosted Flakes, Nutella, and toast, he would announce, "That is all sugar." Then he would describe in detail the digestive process of those sugar molecules from the mouth all the way through the digestive tract. Listening to his description of the inflammation milk causes in your body, how human enzymes that break down milk degenerate after the human body turns 5 years old, and how broccoli actually has more calcium than milk, I stopped drinking milk, and I was the queen of milk.

Again, the power of showing.

Through Dr. Oglivie, I learned that calories don't matter in the long run. What matters is what you are putting in your body. Was it grown in the ground? On a tree? Will it cause inflammation, like tiny fires burning throughout your body, in your cells?

Next, we would discuss how we could improve our breakfast—add protein, to slow down absorption of sugars to prevent an overload of glucose in the blood so the pancreas won't have to secrete insulin over time; fiber, to help clean out any toxins stored in the gall bladder; water with lemon to give the water molecules carrier proteins to ride on and help hydrate your body.

Education and nutrition dovetail. As my friends Dr. Dornbos and Mr. Pickard agree, corn is empty calories. I think most Americans are sadly misinformed regarding nutrition. Of course, an occasional indulgence, chips, pizza, and soda, is fine. But what chemicals were added to market and sell that snack as one hundred calories? Fruit is great, but it is still natural sugar. Fat isn't all bad. The brain and muscles require protein and healthy fats to build myofilaments and myelinate neuro-connections. The power of showing, not telling, will illuminate the needed changes in any discipline from ocean plastic and nutrition to agriculture.

2.10 Final Thoughts

After researching sustainability, I thought that Jib Ellison's use of appreciative inquiry, focusing on the positives rather than the negatives, was genius. My parents and my professors taught me this principle. Your thoughts and words like seeds create the environment around you. Dr. Jeff Paul, my business professor, once said, "You can think your way down the drain and can think your way up the drain." It depends on you. How you direct your thoughts, your workforce, and your business all influences your success or failure.

Sustainable farming should be approached in this manner. Showing—not telling, demeaning, or commanding—will incite people to change. Communicating between industries that are involved will improve efficiency and cost-effectiveness. Wal-Mart tackled its dairy industry this way, bringing together everyone involved from the farmers to the business executives (Humes 2011). Letting the market drive sustainability through private companies will innovate processes and provide checks and balances, cutting short inefficiency.

Problems can be mountains. I used to look at the mountain of impassable stress blockading the book I wanted to write. My thoughts raged, "What if the story is wrong? What if the whole feel is wrong? What version do I use?" At 2 AM, February 16th, God handed me the idea, the perfect synthesis of everything I'd been trying to write for years. Looking back on my notes that night, I had written out a list of similar crushing questions and ended the page with the words, "Okay, God will send it. It will come." Just when I trusted, the perfect ideas poured down like rain.

Isn't that what life is about? Trusting in Someone other than yourself to come in and pick you up when you can't do it anymore? It's the principle of appreciative inquiry. Instead of looking at the missing pieces of a story, of an industry, of sustainability and saying, "I don't know what fits," why don't we say, "Well, all of this has worked. What else will work?"

References

Adegboyega ER (2019) The impact of soil erosion on agricultural land and productivity in Efon Alaaye, Ekiti state. Int J Agric Policy Res 7(2):32–40

Backer B (2019, February 7) Marrying socialism and climate change: the shortsighted folly of Alexandria Ocasio-Cortez. The Washington Times. https://m.washingtontimes.com/news/2019/feb/7/marrying-socialism-and-climate-change/. Accessed 16 Feb 2019

Blu Sky (2020) https://blusky.me/. Accessed 25 Apr 2020

Crews T, Carton W, Olsson L (2018) Is the future of agriculture perennial? Imperatives and opportunities to reinvent agriculture by shifting from annual monocultures to perennial polycultures. Globa Sustain 1(11):1–18

Dasgupta S, Huang IJ, McElroy AE (2015) Hypoxia enhances the toxicity of Corexit EC9500A and chemically dispersed southern Louisiana sweet crude oil (MC-242) to Sheepshead minnow (*Cyprinodon variegatus)* larvae. PLoS One 10(6):e0128939

Dornbos D (2012) How should Christians promote sustainable agriculture in agrarian systems? A normative evaluation. Persp Sci Christ Faith 64:51–61

Dornbos D (2018) Personal interview

Glover J, Reganold J, Cox C (2007) Future farming: a return to roots. Large scale agriculture would become more sustainable if major crop plants lived for years and built deep root systems. Sci Am 297(2):82–89

Glover J, Reganold J, Bell L, Borevitz J, Brummer E, Buckler E, Cox C, Cox T, Crews T, Culman S, DeHaan L, Eriksson D, Gill B, Holland J, Hu F, Hulke B, Ibrahim A, Jackson W, Jones S, Murray S, Paterson A, Ploschuk E, Sacks E, Snapp S, Tao D, Van Tassel D, Wade L, Wyse D, Xu Y (2010) Increased food and ecosystem security via perennial grains. Science 328 (5986):1638–1639

GPS: National Coordination Office for Space-Based Positioning, Navigation, and Timing (2018). https://www.gps.gov/applications/agriculture/. Accessed 7 Jan 2019

Huggins D, Reganold J (2008) No-till: the quiet revolution. Sci Am 299(1):70–77

Humes E (2011) Force of nature. Harper Collins, New York, pp 14–23, 87, 160–180

Mann C (2008) Our good earth. Natl Geogr Sep 2008:84–107

Montgomery DR (2007) Soil erosion and agricultural sustainability. PNAS 104(33):13268–13272

Paine V (2012) What causes ocean "dead zones?" https://www.scientificamerican.com/article/ocean-dead-zones/. Accessed 2019 June 11

Pretty J, Benton T, Bharucha Z, Dicks L, Flora C, Godfray C, Goulson D, Hartley S, Lampkin N, Morris C, Pierzynski G, Prasad V, Reganold J, Rockström SP, Thorne P, Wratten S (2018a) Global assessment of agricultural system redesign for sustainable intensification. Nat Sustain 1:441–446

Pretty J, Benton T, Bharucha Z, Dicks L, Flora C, Godfray C, Goulson D, Hartley S, Lampkin N, Morris C, Pierzynski G, Prasad V, Reganold J, Rockström SP, Thorne P, Wratten S (2018b) Global assessment of agricultural system redesign for sustainable intensification: supplementary information. Nat Sustain 1:441–446

Pruden W (2019) Second thoughts in the Unicorn Caucus. Jewish World Review. http://www.jewishworldreview.com/cols/pruden021219.php3. Accessed 16 Feb 2019

Ramos TB, Darouich H, Gonçalves M, Brito D, Castelo Branco M, Marins J, Fernades M, Pires F, Morals M, Neves R (2018) An integrated analysis of the eutrophication process in the Enxoé reservoir within the DPSIR framework. Water 10(11):1576

Reganold J, Robert P, Parr J (1990) Sustainable agriculture: traditional conservation minded methods combined the modern technology can reduce farmers' dependence on possible dangerous chemicals. The rewards are both environmental and financial. Sci Am 262(6):112–114

Stewart R (2016) Personal interview

The Land Institute (2019) Kernza® Grain: toward a perennial agriculture. https://landinstitute.org/our-work/perennial-crops/kernza/. Accessed 7 Jan 2019

Tully K, Ryals R (2017) Nutrient cycling in agroecosystems: balancing food and environmental objectives. Agroecol Sustain Food Sys 41(7):761–798

Welch R, Shuman L (1995) Micronutrient nutrition of plants. Crit Rev Plant Sci 14(1):49–82