Promoting Restorative Landscape Use:

Birds and the Need for Ecologically-Sustainable Agricultural Business

Interdisciplinary Studies Research Project

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If agriculture is to remain productive, it must preserve the land, and the fertility and ecological health of the land; the land, that is, must be used well. A further requirement, therefore, is that if the land is to be used well, the people who use it must know it well, must have time to use it well, and must be able to afford to use it well. Nothing that has happened in the agricultural revolution of the last fifty years has disproved or invalidated these requirements, though everything that has happened has ignored or defied them.

Wendell Berry, *What Are People For?*

ABSTRACT

Intense ecological crises are mounting worldwide due to extractive consumption practices and a ballooning global population. Degradation of land, evident in many forms, is an intersectional crisis and must be approached theoretically as well as practically. This project views human agricultural practices as direct change agents on landscape health, and how birds may be seen as a proxy for ecological health due to their sensitivity to habitat change. These themes are explored from the disciplinary perspectives of biology and business, utilizing experiential agroecological research in Arusha, Tanzania as a case study. **Agriculture worldwide conforms to a generally exploitative model fueled by business practices, and produces systems of unstable food production, diminished resilience, and reduced ecosystem health. Combatting this systemic degradation with ecologically sustainable alternatives will promote food security, enable adaptability in a changing climate, and allow for improved livelihoods for farmers.** The project concludes with recommendations for generalizable agricultural practices, specific interventions with a local non-governmental organization, and avenues of action for the general public.

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INTRODUCTION

The cool morning air sits in the valley, misty in the predawn light. Faint birdsong begins to drift from the boughs of a few trees scattered across the hillsides. As the day brightens and the sun rises behind Mount Meru before bursting forth in warm rays, the airborne water evaporates, slowly fading away. Cars, trucks, and motorcycles begin to use the main regional highway, and farmers get to work hoeing their fields to remove weeds. The wind picks up, swirling the exhaust fumes across the valley and lifting the dusty soil into great clouds billowing into the air. The wind moans as it moves through masses of bushes covering the landscape with small white flowers. It is a very dry August morning in Ngaramtoni.

The presence of the dust in the air, the exhaust fumes and paved scar on the land, the invasive weeds covering the ground (*Parthenium hysterophorus*) and even the ability to see the valley itself due to deforestation, are all evidence of humanity's impacts on this region of northern Tanzania. These primarily negative impacts have unfortunate ecological consequences and have thrust change upon the lifestyles of people throughout the region as they must adapt to an altered landscape. Agriculture, is taking a particularly large toll on the land, reducing the biodiversity of the region, destabilizing soils, and diminishing fertility. Farmers use the land in the same ways year after year, with little time for regeneration time. Agriculture worldwide conforms to a generally exploitative model fueled by business practices, and produces systems of unstable food production, diminished resilience, and reduced ecosystem health. Combatting this systemic degradation with ecologically sustainable alternatives will promote food security, enable adaptability in a changing climate, and allow for improved livelihoods for farmers.

BACKGROUND

Description of Land Degradation

Land degradation takes many forms, including the loss of soil fertility, erosion, an imbalance of species, pollution, deforestation, overgrazing, and invasive species, among others (Stocking 2001). "Land degradation is defined as the temporary or permanent decline in the productive capacity of the land, and the diminution of the productive potential, including its major land uses… its farming systems… and its value as an economic resource" (Stocking 2001). This diminishment of ecosystem functioning through human influence is a pressing problem as it promotes food insecurity, reduces the stability of systems of resilience in times of change, and places people throughout the world in a place of having to move from traditional livelihoods to more industrialized ones. These challenges are not only heightened by a rising global population, but also the changing preferences of this population. As material affluence increases worldwide, consumers demand more goods and services, which take an increased toll on the environment. Food production systems are at the base of this complex of issues. Agriculture is the largest polluter of land globally, though not often perceived as such by the public because of its non-point-source nature (Conway and Pretty 2013). Additionally, because of its critically important place in providing for the daily needs of every living human being, agriculture remains a constant element of human society. This constancy alone should motivate us toward change, as the land continues to be degraded further with each day that passes under this agricultural schema, and experiences irretrievable losses of stability and biodiversity.

Additionally, land degradation impacts human communities, leading to economic losses among small-scale farmers in the majority world. No matter the specific ecological crisis facing the farmer, the weakened economic state can lead them to attempt cultivating marginal lands with degraded soils, exacerbating the issue through a positive feedback cycle. This interconnectedness of ecosystems works against the farmer when the system begins to diminish in effectiveness (Dass et al. 2011).

This degradation, when seen from a Christian perspective, is indicative of a lack of stewardship theology whereby spiritual matters are divorced deeply from material matters. This limited theological scope causes higher value to be placed on the idea of "salvation of souls" than on care for all created things, the stewardship of which is the earliest recorded activity that God mandates to humankind (Genesis 2:15).

Agriculture

Agriculture has been practiced worldwide since the known dawn of human civilization in the Fertile Crescent approximately 10,000 years ago (Ryszkowski 2002). The scope of this project is not intended to cover the total development of agriculture across history. However, since the development of armaments in World War II, much of the same technology that was put towards the production of armaments was transferred to the creation of farm implements, including the development of chemical fertilizers and pesticides (Conway and Pretty 2013). The practices of using machines such as tractors and tillers to break up the ground, storing grain in metal silos, transporting by truck and train over long distances, and having large facilities for processing are all indicative of an industrial complex surrounding food (Pollan 2006), and are an historically more recent development. Not only is this system energy-intensive, but it also separates people from

the food that they are eating, thereby divorcing them from a compelling personal reason to care for and value the land. As Micahel Pollan, known expert on food writing and journalism, states in his book *The Omnivore's Dilemma*:

> What is perhaps most troubling, and sad, about industrial eating is how thoroughly it obscures all these relationships and connections. To go from the chicken (*Gallus gallus*) to the Chicken McNugget is to leave this world in a journey of forgetting that could hardly be more costly, not only in terms of the animal's pain but in our pleasure, too. But forgetting, or not knowing in the first place, is what the industrial food chain is all about, the principal reason it is so opaque, for if we could see what lies on the far side of the increasingly high walls of our industrial agriculture, we would surely change the way we eat (Pollan 2006).

This system is a far cry from the vision that many people today have of agriculture, of a family farmer lovingly caring for a small plot of land and cultivating by hand. This misconception is a further demonstration of the obscured relationships with the origins of food.

The intentional obfuscation is happening not only in the United States but also around the world, as industrial food systems displace decentralized, local food networks. This change is manifested in linguistic shifts in East Africa, as now in Swahili there are two terms for chickens and their eggs. A recently-developed word, *kisasa*, refers to the chickens that are raised in cages and solely for food production. In contrast, *kienyeji* refers to the chickens that live outdoors on farms and are generally self-sufficient, laying smaller and more flavorful eggs. This distinction makes its way into the marketplace as

well, with the *mayai ya kienyeji* (farm eggs) commanding a higher price than the mass-produced eggs, *mayai ya kisasa* (Lyon, *personal observation*). Certainly, these distinct terms would not have existed before an industrialized food system began to develop in East Africa.

Agricultural practices focused on the total volume of production are inherently unstable and resist natural processes. Working against the natural system of nutrient cycling, a progression of nutrients which retains soil fertility, and instead treating the soil with petroleum-based fertilizers is not only energy-intensive, but also expensive for the farmer. These inputs rely on the economic and infrastructural realities of existing and functioning fertilizer factories and the farmer maintaining the economic capacity to purchase these inputs annually. Seeking to diminish crop pests through the use of pesticides is a false hope, leading instead to repeated applications of poison that kill other species, both beneficial and detrimental to the crop. Additionally, to plant one single crop invites disaster: pests or diseases that affect that crop have no natural barriers to their population expansion, leading to huge boom cycles that can be devastating for farmers' fields (Nel and Loubser 2004). Alternative pest management strategies can be as simple as planting multiple species of crops close to one another or in the same field, such that the concentrations of pests that affect any one crop are diminished. Undoubtedly, this approach necessitates time and intentionality that is not largely associated with a pure-production perspective and may entail minor crop loss; however, it is a highly stable system, in contrast to using chemical inputs and machinery-heavy methods (Nel and Loubser 2004).

Although a critic may assert that the description above purports agriculture is a simple binary—growing food exploitatively or working in tandem with the natural world—it actually takes several forms, as a wide variety of practices can be used on the same land or by the same farmer. However, the extremes can both teach a dedicated learner valuable lessons. The poisoning, erosion, salinization, and nonnative species invasion that occur as a result of traditional industrialized agriculture are all warning signs against the allure of pure production quantity. On the other end of the spectrum, the ecologically-sensitive cropping practices such as permaculture that result in improved soil health, soil retention, completely natural pest management, and places for native species to live can testify to the hope that is found in tapping into natural processes that have sustained natural landscape and agricultural spaces for millennia. Supporting these practices is an act of restoration in a landscape of degradation.

Birdlife

Birds play an important role in every human society. Whether birds appear in a society's folklore (storks bringing infants, swallows or robins signaling the start of spring), art (feather boas in Las Vegas, ceremonial headdresses, or owls in France's Chauvet cave paintings), religion (doves for peace, peacocks at southeast Asian temples, quetzals in Aztec civilization for god Quetzalcoatl), or entertainment (cockfighting, birdwatching, birds as pets), there are a multitude of ways in which they affect the culture of the region in which people interact with them. On the other hand, many societies rely heavily on birds, both domesticated and wild species, for food. Thus, the trade of birds, for meat, eggs, and feathers takes on economic significance. While these aspects of bird and human interaction are each of their own unique importance, they are not in and of

themselves within the scope of this publication. They do, however, affect how people see the birds around them.

The significant effects of birds on the agricultural landscape can be observed in multiple studies. For example, in 2004, Jherime Kellermann and a team of scientists from Humboldt State University studied avian predation of insects in coffee fields in the Blue Mountains of Jamaica. Through excluding birds from specific pairs of coffee bushes in the field, they assessed the impacts of migrating birds on control of the coffee berry borer, a significant pest of these fields. Kellermann discovered that the fields without birds had significantly higher borer infestation than the areas that the birds could access. Mapping these data onto an economic framework, the team estimated gains of $44-$105 USD per hectare of crop fields. Later that year, another Jamaican study indicated that insect-eating birds in coffee fields provided pest-reduction services of up to $310 per hectare per year (Johnson et al. 2008). Considering that $310 is the bulk of a yearly wage for many people living in the Majority World, the effect of birds on the landscape could equate to direct livelihood improvement for people in agricultural communities (Johnson et al. 2008).

These ecological interactions with birds acting as pest mangers transcend biomes. Birds provide the same service on apple orchards in the Netherlands, as Great Tits (*Parus major*) similarly reduced the detrimental effects of insect pests on apple production. This resulted in a higher yield of apples by approximately 3.1 kg per tree (Mols and Visser 2002). As these two studies show, birds' assistance in cultivating high-value crops, such as coffee and apples, is a strong impetus to further investigate how birds affect pest management in other places and on other crops.

Definition of Terms

Agriculture is the intentional cultivation of plant and animal species for human use (Denham et al. 2016). Various forms of agriculture have been employed throughout history, including monoculture, polyculture, shifting agriculture, silviculture, and aquaculture. Each of these terms references separate agricultural paradigms with their own distinctive practices and features.

Agroecology sees human-created agricultural systems in the context of the broader ecological function of the location where the food production is taking place (Mendez et al. 2016).

Agroforestry is "the introduction, or deliberate retention, of trees on farms through either spatial or temporal arrangements" (Tropical Agroforestry 2004). However, Leakey (1996) defined agroforestry as "a dynamic, ecologically based, natural resource management system that, through the integration of trees in farm and rangeland, diversifies and sustains production for increased social, economic and environmental benefits." This latter definition, though some might object that it is significantly older, provides a more concrete descriptive framework for what agroforestry should look like in practice, and is the one to which this project will adhere.

Birdlife, a term growing in popularity, is the umbrella term for the avian communities that exist in a certain region. Prominent bird-conservation NGO BirdLife International has used this term to develop their own branding as an organization that cares for birds of all types around the world.

Degradation, specifically of landscapes, "is defined as the temporary or permanent decline in the productive capacity of the land, and the diminution of the productive potential, including its major land uses… its farming systems… and its value as an economic resource" (Stocking 2001).

Ecology is the study of the interactions between an organism and its biological and physical environment (Krohne 2016). Related is population ecology: the study of the interactions between a group of individuals of a given species and the environment (Krohne 2016). The disciplinary values of quantitative analysis, macro-level phenomena observation, and seeking to elucidate connections between seemingly-disparate actors in an ecosystems are all deeply held frameworks and approaches in ecology.

Ecosystem services are natural processes that contribute tangible benefits to humans such as flood control, filtering pollutants, and pest control (Krohne 2016), or more simply, the aspect of the earth that benefit humans (Şekercioğlu 2010). Ecosystems are all the biotic and abiotic components of a community (Krohne 2016).

Entrepreneurship is the process of "creat[ing] something new, something different; [to] change or transmute values," particularly in a business context (Drucker 1985).

Ethnoornithology is the comparative study of the knowledge of birds held by human communities throughout the world (Tidemann and Gosler 2010).

Integrated pest management is defined as "as a set of techniques that aim at maintaining pathogen, pest and weed populations at levels below those that cause economic loss (Dix, et al. 1998).

Ornithology is a subdiscipline of zoology concerned with the study of birds, in every aspect of their nomenclature, physiology, behavior, and role in ecosystems.

Profit is the difference in value received for a resource greater than the production cost of that material (Bowers 2016). Thus, profitability is the capacity of an organization to maintain profits.

INTERDISCIPLINARY FRAMEWORK:

For this interdisciplinary research project, a mixed-methods approach was employed, including the disciplines of biology and business. As these disciplines consider both the environmental and microeconomic realities of the study, respectively, they were deemed most appropriate for addressing the issue of land degradation and most faithful to classroom theory. This text thus acts as a translator for people from the environmental and scientific realms as well as the business world, enabling comprehension of how their own interests relate to the topic of land degradation. Additionally, this interdisciplinary framework is a means through which both the environmental changes and human livelihoods can be integrated into one complete whole, taking it from two of the value systems that are most prevalent in the landscape. In order to illustrate how interdisciplinary studies functions, the following is an extended metaphor.

IDS Metaphor

Just as multiple complex processes result in an energizing cup of coffee, so too do various disciplines compose something new: an interdisciplinary study that gives an energizing perspective to a particular problem. Intentionality, concurrency, and curiosity

are three foundational traits of the interdisciplinary mindset and approach that are also found in the coffee-making process. Planting, harvesting, roasting, grinding, and brewing coffee are all component processes to the final cup of coffee that so many people enjoy. If you one of these processes is omitted, the coffee is irreversibly changed. Similarly, with interdisciplinary thought and action, each discipline offers a unique service to the end pursuit: a re-energized approach to a problem. With the various techniques, traditions, and perspectives of the discipline, the study itself is *robusta*, drawing deeply from the histories of those approaches to make the study yet more complete. The integrated whole at the end is a single study, just as the result of planting, harvesting, roasting, grinding, and brewing is a single cup of coffee. The study and what it reveals can be enjoyed by many, not only those personally involved in one of the component disciplines. Similarly, coffee can be appreciated by many people who know nothing about the hard work and ancient techniques that compose the delicious liquid in their cup. A coffee farmer could certainly enjoy the fruits of his or her labor as well, but the effect is not limited. There is a driving intention with every part of the research process, yet the end result can still be brewed in different ways, with varying roasts. Similarly, there will be many ways that people enjoy interdisciplinary advances, not limited to any constrained structure of thought or technique.

Biological Theory

From a biological point of view, agricultural business is deeply integrated with the natural systems that we see to be taking place constantly in the natural world. Ecosystem processes such as nutrient cycling, production/consumption, and the sustainability of a finite, closed, balanced system are the tenets of the work. These

essential components of the natural world provide valuable alternative models for viable food systems. An example of this is the theory of agroecology, promoted by David Holmgren, in which ecological systems must be the model for agricultural systems, and that the two are not inherently separated but unified. This theory contends that the functions of the broader ecosystem will have an impact on the agricultural system, thus making them a single system with multiple parts (Mendez et al. 2016). Also, the interconnectedness of the two provides distinct value to the production of food. For example, biodiversity can act as a web of protection from the population of any one species expanding out of balance. This "web of protection" concept is especially important in the development of the applied approach of integrated pest management.

Integrated pest management (IPM) relies on natural systems as well as human interventions to approach the problem of agricultural pests in fields. It means that natural predators are used as a means of pest control, and that pesticides or other human-based interventions may be applied as necessary to the context. This approach allows for the continued safety of the crop, as pest species are managed or diminished in prevalence by the predatory species. As long as the pest species that is targeted in the intervention is diminished, the farmer is willing to let the predator of that species continue to exist in the field.

The classic IPM example that has been employed with great effectiveness across time is that of ladybird beetles and aphids. Aphids (belonging to the taxonomic superfamily Aphidoidea) are small, soft-bodied insects that have sucking mouthparts with which they consume plant juices for food. Though one aphid by itself has hardly any effect on the plant, when living in the thousands on a single plant these insects can

impede the growth of the entire plant or can reduce its agricultural productivity. Ladybird beetles (commonly known as ladybugs) are known predators of aphids, consuming anywhere between 115 and 180 in a single day (Rasheed et al. 2018). The intervention that some organic farmers have used on their plants to reduce aphid infestations has been to purchase ladybird beetles by the thousands from specialty growers and release them throughout their field. As the ladybird beetles act naturally and consume their prey, the farmer reaps the benefit of healthier plants and improved productivity. As long as the aphids are abundant, the ladybird beetles will continue to consume them (Rasheed et al. 2018). This utilization of a natural enemy of the crop pest (through predation) is a main tenet of IPM.

Not every insect species has such a clearly specialized enemy species (an assumption that Méndez et al. 2016 calls "the naïve Newtonian assumption that interactions are generally linear and occur effectively in reduced dimensionality"), yet similar interventions can be employed to improve the effectiveness of the farm. As the farmer is no longer using pesticides to kill insects on her crops, the field retains other aspects of its vitality, such as soil nutrient health and microbial diversity. IPM thus not only affects the problem at hand, but also allows for the rest of the farm to flourish.

This concept of one agricultural practice allowing for the flourishing of others is a reflection of agroecology. As such, interconnectedness is a direct representation of the importance of ecosystem processes that occur naturally. As one species predates another, the overall abundance of the prey species is diminished. This allows the location's species richness to improve as opportunities arise for other species to gain from resources that the prey species uses.

Ornithology is another important aspect of the biological framework. Ornithology is the branch of zoology concerned with the study of birds in their physiology, natural history (that is, habits and habitat interactions), and in their cultural value. Not only are the birds themselves of biological importance, but the study of birds requires the study of other aspects of ecology. Many species of birds are highly dependent upon vegetation, so the study of plant science, ecological succession, and landscape ecology are helpful for conceptualizing bird population dynamics and lifestyles. Additionally, each bird fills an ecological niche. Many passerine bird species make a dietary shift to insects during the breeding season to feed their young a high-protein diet for early growth. For this reason, the abundance of insects varies with the presence of birds.

Ecological succession is the flow of species from one stage of ecosystem development to the next. Two types of succession exist, but generally only one is relevant here. *Primary succession* is the first movement of species onto a previously barren land area. An example of this is the development of plant life on the barren rock of a newly-formed volcanic island. Starting with lichens and the ensuing development of small amounts of soil, the land is able to support more species over time. The light and friable soil supports a few grasses. As the grasses grow, they push their roots deeper into the rock, forming tiny cracks and beginning to split it apart. Once the grasses have formed, some small bushes and scrubby plants can move in. These provide shade for other species of plants, protecting them from harsh sunlight. Consequently, trees are able to move onto the land, joined by the species of birds and animals that the trees can support.

Secondary succession, on the other hand, describes an ecological succession wherein species move onto area that has been disturbed by human or natural conditions.

An example of this is the regeneration of mature trees on land that originally had been forest but was later converted to agricultural fields. In this case, there is a movement of species that involves grasses and perennial weeds, then brush and bushes, followed by coniferous trees and finally hardwood deciduous trees. Secondary succession has a deep effect on birdlife. Many species of birds have specific affinities for grassland, brush/scrubland, young forest and meadows, or more mature forest. As the ecosystem progresses through changes over time, the land becomes favorable for different species of birds, and determines whether or not they will be found there. Thus, secondary succession is a changed composition of species in the landscape over time, and is the relevant succession type for this study, as it describes ecosystem responses to anthropogenic disturbance.

Business Theory

Business is a crucially-important part of human societal functioning and decision-making. From entrepreneurial projects to established corporations, business takes many forms. No matter the appearance of the business, however, a few tenets remain the same in every firm. The most prominent tenet, value creation, drives the monetary and financial success of a business, enabling people to be employed and for a business to expand over time. Value creation is the step in the process where the business acts as a middleman, transforming a raw product into something more valuable. As structures of transformation, the business practices utilized can have a massive impact on how the end product operates. Additionally, as a crucially-necessary step between raw material and consumer product, business always has a space for itself, a niche whereby it will always exist. The act of value-creation is also an exercise in creativity, where those who engage

in business are extending the ability to make connections and solve problems towards the end of creating something to which other people are willing to ascribe value.

Jeroen Kraaijenbrink of the University of Twente in the Netherlands and author of *The Strategy Handbook*, published in 2015, has written on the topic of value creation. He writes in a working paper titled "A Value-Oriented View of Strategy" the following:

> Firms create value… Economists and sociologists have acknowledged and theorized this role of firms for over more than two centuries… Firms also create values. Through their focus on the production of products and services and through their marketing and competitive activities, firms promote capitalist and other values within and outside of their boundaries (Kraaijenbrink, n.d.).

Kraaijenbrink addresses the dual nature—value creation and values-creation—of systems whereby business transforms materials from lower to higher value, and offers services that are valuable to the client. The creation and transformation of value is just as important for the consumer as it is for the producer, as each willingly takes part in the transaction. Value creation is also essential to the continued success of the venture, as Todd Zenger of Harvard Business School writes: "Value creation in all realms, from product development to strategy, involves recombining a large number of existing elements… Companies that enjoy sustained success are typically founded on a coherent theory of value creation" (Zenger 2013). Zenger goes on to describe how companies that have lost their commitment to a specific form of value creation are unable to sustain profits, and unless the company returns to a focus on the original market positioning, it will not be able to maintain profitability nor survive.

Antonio Argandoña is the CaixaBank Chair of Corporate Social Responsibility and Corporate Governance at the IESE Business School in the University of Navarra in Pamplona, Spain. A highly-respected academic and professional in the field of business and economics who was born in January 1943, Dr. Argandoña was awarded the University of Navarra Gold Medal in 2016, among other honors. His authorship includes the paper "Stakeholder Theory and Value Creation," published as a working paper by the IESE Business School in May 2011. In this paper, Dr. Argandoña integrates the concept of stakeholder theory with value creation, bur relies on the originator of stakeholder theory, R. Edward Freeman, for the definition: "all of those groups and individuals that can affect, or are affected by, the accomplishment of organizational purpose."

Furthermore, Dr. Argandoña describes value creation by saying "In neoclassical theory, economic value is created when the price that consumers pay for goods and services is greater than the cost of producing them." While succinct and intuitive to many, this definition is helpful for framing exactly what happens when value is created. Dr. Argandoña then connects this neoclassical framework to stakeholder theory, saying, "so far we have been referring to economic value, but there are other ways of understanding what that "value" actually consists of. What can a stakeholder be seeking when he starts an occasional transaction or a lasting relationship with a company?" By then proposing different scenarios, Dr. Argandoña assists the reader in understanding how the stakeholder benefits from the company functioning to create value.

These definitions are worthwhile as we consider the effect of business on a community. Not only are the business owners and customers affected by the actions of the business, but all stakeholders are affected once the value is created. It is a central role,

as without the creation of value the business is not acting in a way that is profitable. There is nothing from which the business can glean revenue, and eventually profit, if value is not created in the first place and realized by both the initial producer, the business and the consumer – in short, all stakeholders.

Peter Drucker is considered by many to be the undisputed father of all modern management theory, and wrote the seminal work on entrepreneurship, *Innovation and Entrepreneurship,* in 1985. In that text, he describes entrepreneurship not only as a concept but as a discipline which can be practiced (Drucker, 1985). Though some might say that this is a dated source with little to offer the modern reader, on this point Drucker remains relevant. Early in the first chapter of this book, the well-versed expert describes the essential qualities of entrepreneurs: "They create something new, something different; they change or transmute values" (Drucker, 1985). This transmutation of value in the creation of something new is essential to value-creation, another core business theory already described above. These theories provide a way of understanding the human drivers of landscape use that so deeply affect ecological function.

Integration and Borrowed Terms

As observed, agriculture affects landscapes considerably, and one of modern agriculture's main drivers, business, plays an important role in shaping the agricultural landscape. Some terms in the business sphere are directly borrowed from the discipline of biology. Currently, though often misused, "ecosystem" and "ecology" are very popular terms. They are in vogue due to the increasing recognition that organisms very frequently interact with others of their kind and of different species, and because of the craze in the United States and much of the Western world to embrace sustainability in

business practices. Just as the organisms in a God-made system are communicating with one another, so too do electronic devices communicate and connect with each other; thus, various product lines from the same company are beginning to be called "ecosystems." In the 2016 book *Peace Through Entrepreneurship,* author Steven R. Koltai includes a chapter titled "It Takes an Ecosystem." This chapter gives account of the Meltwater Entrepreneurial School of Technology (MEST), located west of Accra, Ghana, in which aspiring value-creators have access to a suite of resources that are described as a "self-contained entrepreneurship ecosystem" (Koltai 2016). Koltai, an expert in entrepreneurship promotion and a former State Department official, goes on to assert that "MEST is a great example of the ecosystem approach to entrepreneurship promotion (although a somewhat closed ecosystem serving only those admitted to its nurturing embrace). Entrepreneurs thrive in healthy ecosystems." This appropriation of an ecological term is further developed in Koltai's work, as he creates a framework with six fundamental pillars of a successful ecosystem: 1) identify, 2) train, 3) connect and sustain, 4) fund, 5) enable through public policy, and 6) celebrate (Koltai 2016). These pillars, a framework for thoughtfully develop entrepreneurs, demonstrate the lengths to which businesspeople are committed to ecological terms in their work.

To fully enter in to the interstitial space between biology and business, practicalities must be sought. One way of doing this is through a case study, grounding the theory in lived experiences and perspectives shared by those who experience the intersection of these fields. The following is a case study elucidating agroecological connections in East Africa.

CASE STUDY:

Tanzanian Agriculture and Birdlife

Across much of sub-Saharan Africa, subsistence farmers are the primary workforce, the keepers of the land, the ones on whom nearly all human life on the continent relies. They are the heroes of the families who rely on them, and they are more vulnerable than ever to a changing world: to both globalization and changing climate. They are underappreciated by the ones who are to come after them, and they are aging. These women and men (primarily women) grow the staple foods eaten by nearly a billion people, and many are reliant upon the earth itself for their livelihoods. In most cases too, the systems which they inhabit are rain-fed, without the infrastructure of irrigation. In the places where irrigation is also a norm, there remain challenges with water scarcity as rivers and lakes are overused and aquifers deplete. For these women and men, much of life is focused on the highly important tasks of feeding themselves, their families, and the rest of the continent with their grains, legumes, fruits, vegetables, and livestock.

The economic impact of these people is enormous, as they participate in consumptive practices alongside the rest of society. To have the ability to buy products in the market, a crop surplus is necessary: not only do they have the responsibility to feed themselves and their dependents, but also to have some excess with which they can have economic gain. It is not only their own purchasing power, however, that defines their participation in the macroeconomy—they are also creators of value in the form of raw agricultural products. This has been a very stable occupation throughout history. With current changes in climate, however, even those places which have classically been the

bastions of stability are experiencing some massive challenges. Erratic rains (both droughts and floods on unprecedented scales), irruptions of crop pests, changing temperatures, the spread of disease, invasive species, and interactions with wildlife are all challenges that these farmers face, among many others such as soil depletion of nutrients, erosion, and increasing urbanization and brain drain of the youth. As these challenges mount, the livelihoods of many people are put at risk. Their farm-based business, family microeconomics, and participation in the macroeconomy are all endangered by these challenges.

One of the most challenging aspects of this shift is the difference in the species composition of much of the world's landmass. As agricultural systems subsume land that was formerly biodiverse grassland or forest, species diversity declines. This diversity is one of the strongholds, if not the very foundation, of all ecological health. Much of the world's systems are dependent upon this health, with ecosystem services such as pest management, soil retention, water clarification/cleanliness, and air filtration and oxygenation occurring at their height in these systems when they are intact. With the advent of modern monoculture agriculture, there is a big shift in the way that the landscape functions, as monocultures sterilize the landscape, reducing the diversity to the one species of crop that is planted. This greatly reduces the range of species that are able to live on that land down to those which can depend on the crop plants for all of their needs of food, shelter, places for reproduction, and necessary space to establish a territory.

Additionally, with a loss of biodiversity, and specifically the loss of specific predators, the conditions become ripe for a multitude of challenges: erosion of topsoil

after tilling, infestations of crop pests such as insects and some species of birds, the outbreak of diseases such as rusts and blights. This places in a precarious position the fields of people who are already reliant on rainfall patterns and other weather conditions to survive. As the situation escalates, pressure becomes even more intense, and people and places are then at yet greater risk. And this is not to mention the species that have no ability to survive on the crop plants for food, shelter, and their other lifestyle requirements. For these organisms, the sterilization of the landscape through monoculture becomes a death knell: they are required to flee from habitat that previously supported them, or attempt to live in subpar conditions, which place stress on every aspect of their natural history and reduce their reproductive success. The effects are so great that many species have gone extinct or are currently teetering on the brink.

Agroecology

Agroecology sees these two systems—agricultural productivity and ecosystem function—not to be two separate phenomena independent of one another, but rather as one integrated whole. Agroecologists recognize that human flourishing is dependent on the health of the environment, and that an integration of multiple species on one plot of land (polyculture) can stabilize many of the problems that industrial agriculture creates. By helping to maintain the balance of natural systems of interaction, the quality of life of people who rely on the land is also maintained and viable habitats are provided to more species of plants, animals, and birds. In a changing world, this stability can be the difference between life and death, between crop yields or crop failure, between flourishing life and survival, not only for the people who are present in that locale, but

also the increasing urbanites (many of whom in recent memory migrated from rural areas themselves) who eat the fruits of their labor.

Tanzania finds itself in the middle of this conundrum. With a burgeoning population of both humans and livestock, people are increasingly hard-pressed to live the lives that previous generations did. Corn (maize) farming is primary in the Tanzanian landscape because corn is the most commonly eaten staple crop in the nation, accounting for 70% of cereal crop consumption and 20% of all agricultural GDP, according to the Tanzanian government (URT 2013). Most maize farmers are part of rain-fed systems, which results in high amounts of variation in their production quantity. Additionally, most are organic farmers who, whether for economic reasons or environmental ones, do not use fertilizers, pesticides, or herbicides in the growing of their maize. For these people, the effect of the ecosystem on their lives is that much more pronounced: nothing is being buffered by human action or technology. When corn borers break out in the field, there can be total destruction. When granivorous bird species eat their corn or fungal growths attack it, the organisms around the farmers are eating them out of house and home, chewing through the profits that they have worked towards daily. For this reason, any biological protection which Tanzanian farmers can gain from the ecosystem around them can be a literal lifesaver, or, more commonly, it is something that can simply affect the amount of production in their fields. Seeking ways of strengthening these self-sustaining systems is an important move, as they work in tandem with the farmers in their labor. Their businesses can flourish alongside the native species around them.

Birdlife is an important part of this equation. Tanzania is one of the most biodiverse regions of the word in terms of birdlife, with many ecological niches being

exploited by the avian life and species migrating from as far away as Siberia to overwinter in the Tanzanian landscape. Each of the over 1,100 species of birds in Tanzania has a subtly different impact on the lives of farmers, and the interactions that they do have with farmers in many ways affect farmers' treatment of birdlife and determine whether their population thrives or dives. Each of the over 1,300 species (Stevenson and Fanshawe 2004) has a subtly different impact on the lives of farmers, and the interactions that they do have with farmers can determine how the farmers treat them, whether their population thrives or dives. Each of these bird species has cultural value too, to a greater or lesser extent. Some of these species were used for food in the past and play a part in Tanzanian cuisine. Indeed, to lose these species means not only losing a vital player in ecosystem function, but also to further the unraveling of Tanzanian culture already begun by colonialism.

ECHO East Africa

In the early 1970s, Educational Concerns for Haiti Organizations (ECHO) was founded by a businessman from Indiana after a trip to that Caribbean nation. He desired to help connect and provide resources for organizations that worked in Haiti, with ECHO continuing to work in Haiti until 1981. Under the leadership of a new Executive Director in that year, the vision grew, and ECHO began to work almost exclusively in the field of international agricultural development, working with partner organizations to strengthen their work. It soon developed into a hub of sharing for the best practices, tools, and technologies among many international development organizations. Today it continues in that capacity, while its large headquarters, in Fort Meyers, Florida, USA operates an

extensive agricultural research trial farm to display best practices of tropical agricultural techniques to over 10,000 visitors per year (ECHOnet 2018).

ECHO International's East Africa Regional Impact Center was founded in 2012 and for the last six years has been establishing itself as a regional resource in the agricultural communities, both with local farmers and NGO partners. One of the capacities that ECHO East Africa operates is a tree nursery, which produces both native and exotic trees to sell locally. However, in recent years the sales from the nursery have been lower than was hoped, and thus the impact of ECHO in the local community has diminished.

The vision statement of ECHO International is "Honoring God by empowering the undernourished with sustainable hunger solutions." Its mission statement is "Following Jesus by reducing hunger and improving lives worldwide through partnerships that equip people with agricultural resources and skills." The agricultural resources and skills can vary as widely as appropriate technologies for farmers, workshops that communicate new ways of composting, to having international symposia which bring together NGO stakeholders to learn from one another. Connectivity and a spirit of sharing are important to ECHO, as catalyzed on ECHOcommunity, an online source for agricultural publications and other resources, all of which are available for free to development workers and ECHO employees. Additionally, a monthly publication called ECHO Development Notes disseminates the latest findings to ECHO stakeholders and development workers worldwide, reaching over 3,500 people monthly.

Currently, "ECHO's primary functions are providing agricultural information to overseas workers, distributing seeds for promising food plants, and offering training

opportunities at the Florida farm," according to its website (ECHOnet, n.d.). The main competitive advantages of ECHO are the longevity of its work in the agricultural field and solid reputation for fiscal responsibility. Due to the latter, it is often supported as a charity in the U.S. and seen very well by charity-rating institutions, which may offer it access to capital that other organizations do not have. In East Africa, the Regional Impact Center's friendly team is a main competitive advantage, as well as the spirit of collaboration that defines the organization worldwide. Looking at the East Africa tree nursery in particular, ECHO offers six species of Tanzania's twelve most threatened plants, which means that they offer access to a biological resource that is not often offered by other organizations.

Factors Considered in Project Design

Seasonality

Ecosystems are dynamic. In this dynamism, seasonal changes are especially pronounced. Bird species from Europe migrate to Tanzania and elsewhere in South and East Africa every September through December. These migrations change the species makeup that can be seen in the fields in the study area. With new species of birds arriving back in the region, insect predation would be altered. The season during which data was collected was limited to only August, a month that is very stable for population fluctuation, as only resident species are present. This minimized any temporal shift in data that would not reflect baseline conditions.

Limitations of Researcher

As a newcomer to the East African agroecology scene, I was severely limited by my lack of local knowledge. Many of the factors that make northern Tanzania unique and which are normal to people living there were and remain foreign to any outside observer. In order to account for this, colleagues who are well-versed in Tanzanian tree identification were sought for advice on particularly hard-to-identify tree species, and any birds that I did not know were noted in the data sheets as "Unknown A," "Unknown B" and so on. In this way, diversity could still be understood without knowing exactly which species were missed. Over time, as knowledge grew, these notes were not as commonly made. During the interview portion of the work, Tanzanian college students accompanied my farm visits and would translate the oral interviews by noting responses on a data sheet. This overcame a level of limitation that otherwise would have hindered my work and could have led to misleading results (Morales and Perfecto 2000).

Avian Activity Levels

Avian activity levels are very dynamic, with most passerine (perching) birds being primarily diurnal (active during the day) or crepuscular (active at dawn and dusk). This affects the range of birds that can be seen, as non-moving or non-vocalizing birds are quite hard to notice. To account for the changes in bird activity that can occur over the course of a day, all avian studies were initiated within twenty minutes of 9:20 a.m. Avian specialists might correctly contend that the peak activity of many bird species is in fact much earlier in the morning. However, in deciding the time for initiating these point-count surveys, we also had to account for the availability of researchers after the start of the workday at 8 a.m. and for travel time to the research site. Thus, the start time was a

balance of human activity and bird activity to maximize possible exposure to the diversity of species present in the fields.

Harvest Cycle

Seasons were also considered for the maize crop, as the pest prevalence in the plants varies by the season. Young shoots have a very different pest load than mature, ready-for-harvest stalks, and the former would not be a representative picture of the effects of insects throughout the year. To this end, data was collected at the very end of the growing season, immediately before harvest. The qualitative nature of this data collection allowed for a descriptive "snapshot" of the pest load throughout the year, as the plant continues to show the effects of any pest damage from throughout the growing season. An important factor in this process was also that any grain-feeding insects would be present on the plants, not only those that feed on the vegetative matter.

Materials

A variety of tools were used, both for the comfort and diminished health risk of the researcher and for the accurate collection of data. The following is an itemized list of these materials that were used on a daily basis during the data collection phase from August 1 through 31.

1. 8 x 40 binoculars (Eagle Optics Shrike)
2. Backpack (North Face)
3. Bird identification guide (*Birds of East Africa* by Terry Stevenson and John Fanshawe)
4. Buff

5. Clipboard
6. Compass
7. Data sheet
8. Graphite pencil
9. Hiking boots
10. Insect identification guide (*Pocket Guide: Insects of East Africa* by Dino J. Martins)
11. Laptop computer (Lenovo)
12. Lightweight, breathable spandex shirt (Columbia)
13. Lightweight pants
14. Sunscreen
15. Stopwatch
16. Tall socks
17. Tree identification guide (*Field Guide to the Common Trees and Shrubs of East Africa* by Najma Dharani)
18. Water bottle

Methods

Field Selection Variables

In order to interface with the community of Ngaramtoni (subvillage of Seuri) in a productive manner, we first sought permission from the village elder, or *mwenyekiti*. This government official gave us the explicit go-ahead to survey farm fields and certified this in writing (see Appendix I). Each field was confined to the ecological zone found on the

foothills of Mount Meru defined by the Potential Vegetation Map for Africa as Afromontane Dry Transitional Forest (Kindt et al. 2015)

All surveyed fields were limited to maize (*Zea mays*) as the primary crop. The maize had to be a standing crop for the field to be surveyed. This standardized bird and insect presence that would be affected by whether or not the crop was present. A single road, roughly north-south in orientation, was used as a rough transect, with eligible fields surveyed on either side of the road. See Appendix IV for a map.

Avian Surveys

Each avian study was conducted by point-count survey, which is standard in this type of ornithological field work. This was an unlimited point-count, which takes into account all of the birds in visible range within 360° of view from the point. Though some might argue that this would be an unrepresentative way of approaching a survey of a very specific area (the farm field itself), all of the fields that we surveyed were less than an acre in size. Such a small field size would lend itself to very limited activity within the study area, as some of the fields had bird activity around the perimeter during the study time but not inside of the field. Given the topography and spatial layout of the trees at the border, this was the most appropriate study method contextualized for the study site.

The timing of the start of the first point count was 9:20 am ± 20 minutes. This was in an effort to balance the earliest human capacity to travel to the farm with the highest behavioral activity of the local bird species, which are consistently more active during morning hours than during midday or afternoon.

Farmer Surveys

Each farmer whose farm experienced a biodiversity assessment of birds and trees was also interviewed orally regarding cropping practices and general demographic information. The interviews were conducted the same day as the biodiversity assessment, usually in the morning. The survey tool itself was a data sheet which directed what information was collected from the interview. Tanzanian university students assisted in the oral administration of the survey, in an effort to ensure accuracy of comprehending respondents' answers. Additionally, these valuable assistants acted as cultural brokers, allowing for the farmers to feel more comfortable during the survey process. Generally, the survey took between 30 and 45 minutes to complete, depending on the extent of the farmer's response. See Appendices II and III for the survey forms used.

Data Analysis

All data, once collected on paper data sheets, were entered into an Excel data workbook for basic analysis. This allowed for easy calculation of the range of species found as well as to find the Shannon Index, a diversity calculation that finds the likelihood that a given species is going to be found among a group of species.

Results

Ecological Connections

a) Birds

Bird species richness ranged from 4 to 13 species, averaging 10.8 species per farm. Thirty-eight species total were seen during the survey period. Species observed included granivores (Red-Eyed Dove Streptopelia semitorquata), nectivores (Scarlet-

Chested Sunbird Chalcomitra senegalensis), insectivores (White-Fronted Bee-Eater Merops bullockoides), passerine carnivores (Common Fiscal Lanius collaris) and large raptorial carnivores/scavengers (Augur Buzzard Buteo augur). The Shannon index for all sites averaged 1.83.

b) Trees

Tree species richness ranged from 1 to 20 species, averaging 9.83 species per farm. 48 tree species were seen across all survey sites. The most common species observed was the introduced *Grevellia robusta* with 543 unique counts, seconded by native *Croton megalocarpus*, recorded 49 times. 61% of all trees recorded during the study were the introduced *Grevellia robusta.* The Shannon index for all sites averaged 1.54.

c) Crops

Primary arthropod pests were aphids, earwigs, and corn borers. The most frequently observed arthropods were fruitflies or other members of the order Diptera, found in every maize field surveyed. Next were earwigs and aphids, each of which were found in 75% of maize fields, followed by caterpillars or other chewing larvae in 50% of the fields. Additionally, fungus, phosphorus deficiency (evidenced by russet leaf coloration), and moles were found to be affecting the fields. In two instances, Baglafecht Weavers (*Ploceus baglafecht)* were seen to be predating the corn crop itself within the field of vision of the point-count surveyor.

d) Farmer interviews

Farmers interviewed (n=12) ranged in age from 29 to 65 years old, with an average age of 44.25 years. Every farmer grew maize (*Zea mays*) intercropped with beans

(*Phaseolus vulgaris*). 41.6% (n=5) intercropped with pigeon pea (*Cajanus cajan*) in the field, too. On the smallholder farms, 25% also reported growing sunflowers and 8.5% (n=1) reported growing pumpkin greens, bananas, and lablab (respectively, *Cucurbita maxima*, *Musa acuminata x balbisiana*, and *Lablab purpureus*). 91.6% (n=11) did not practice crop rotation of any type—they intercropped beans and maize in the same plot season after season. The farmers interviewed cultivated a total of 19.1 acres of land, ranging from 0.3 acres to 4 acres, and averaging 1.6 acres per farmer. 88.5% (n=10) of farmers responded that they had planted the trees surrounding their field.

Social and Business Insights

The interviews with farmers reveals that the average age of the farmer is 44.25 years. Given the demographic distribution of the nation of Tanzania misplaces the farmers is very elderly age. The us, the main innovation in the agricultural sphere may have to come from younger people, who are more willing to shift agricultural practices to meet modern circumstances and challenges. From a business point of view, the intercropping maize with beans enables farmers to bring different types of products to market, which could help to mitigate financial instability. However, as both maize and beans are high-volume low value crops, from a business point of view this diversification's stabilizing factor may be minimal. Each of the farmers is utilizing knowledge end land area to create value. Each farmer can thus be considered an entrepreneur, starting her own farm enterprise. Many of the farmers seemed to hold strongly to their traditional cropping practices, using phrasing like "we always do it this way."

Discussion of Case Study

Ecological Importance

Though *Grevellia robusta* is well-established in the region, it was a surprise to discover that 61% of all tree cover in and around crop fields was due to this nonnative species. As the branches of this tree are covered in leaves and generally grow very upright, there are limited opportunities for insectivorous birds to use them as hunting perches. Many of these birds, such as the white-throated bee-eater, are highly efficient at catching flying insects, so to have them near the field would be only a benefit to the farmer. Additionally, as *G. robusta* is not a tree that bears seeds that are widely eaten by native wildlife, this tree is diminished in its biological productivity capacity. During the very beginning of the rainy season, however, this tree does produce masses of flowers that are consumed by native sunbird species (*Chalcomitra spp.*).

Social Importance

ECHO East Africa is well known and respected in the community of Ngaramtoni. Utilizing this social capital to promote the sale of native tree species introduction of conservation agriculture techniques is an important competitive advantage. Community members for respect ECHO and are more likely to adopt their practices than those of other NGOs. Additionally, what is considered an appropriate farming technique in the community may be affected by peer pressure found within tight community bonds. Utilizing these social factors as a means towards promoting flourishing livelihoods is one redemptive application of this case study.

Financial Importance

The consistent use of high-volume low value crops among smallholder farmers predisposes them towards financial instability. There is little diversification of products going to market; furthermore, all harvest of cereal grains happens at the same time of year. The supply and demand fluctuations force farmers to sell their crops at the time when the price is lowest. A low cost investment in native tree seedlings that will provide high-value timber in the future could be one way that these firms augment their income in a diversified way. Many seedlings at echoes tree nursery are available for sale for merely 500 Tanzanian shillings, with the most expensive rare trees engrafted fruit trees costing 5000 Tanzanian shillings (USD $0.23 - $2.30).

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RECOMMENDATIONS

Permaculture and Sustainable Agricultural Integration

Alternative agricultural paradigms are crucial to the continued production that meets the world's food needs because currently accepted agricultural approaches cannot be sustained in perpetuity. These may be contextualized for regional needs, depending on the factors affecting the site and the type of agriculture used.

Begun in Australia in the 1970s (Holmgren 2011), permaculture is modeled according to ecological principles. Permaculture encourages nutrient cycling and long-term integration of plants into landscape. Additionally, many species of plants and animals can live on the same piece of land, employing the same diversity security system that is necessary for continued production. Employing and adapting these principles worldwide will allow for the continued response and adaptation to the changing climate. Permaculture systems can take many different forms such as utilizing rice patties as places for growing fish, integrating apple orchards with crop production, and even sustainable fisheries.

Permaculture is based on 12 principles: 1) observe and interact, 2) catch and store energy, 3) obtain a yield, 4) apply self-regulation and accept feedback, 5) use and value renewable resources and services, 6) produce no waste, 7) design from patterns and details, 8) integrate rather than segregate, 9) use slow in small solutions, 10) use and value diversity, 11) use edges and value the marginal, 12) creatively use and respond to change (Holmgren 2011) . If the world is going to continue meeting the needs of a growing population, permaculture is one approach to integrating sustainable agriculture

current systems; however, it will require a significant effort. Being modelled on ecosystem interconnectedness, permaculture embraces the resiliency that ecosystems have, while focusing on growing products useful to humankind. It bridges the gap between ecosystems and industrialized agriculture, maximizing the benefits of both. These interventions may not be effective if those agencies which promote transformation are not enabling other people and organizations to benefit from their services. Marketing techniques and strategic positioning in the marketplace can be the differentiating factors which promote the mission of the organization.

Options for ECHO

Marketing Approaches

Main areas of improvement include signage at headquarters, improved social media, tree sales at local markets, improved collaboration with the Arusha Housing Authority which has bought trees in the past, and carbon offsetting programs with safari and tour companies for ECHO's native tree nursery. Primarily, ECHO may focus on brand awareness, improved pricing, and continued dedication to social media. For continued financial viability, this organization must press into the niche market of native and vulnerable trees while allowing other sellers to continue producing more exotic species. Not only does this strengthen ECHO and its market placement as a tree nursery, but it also strengthens ECHO's witness to valuing conservation agriculture.

Most-Beneficial Tree List

Due to ECHO's presence in the community and its established tree nursery, ECHO is well-positioned to provide particularly beneficial trees to local farmers. Which

tree species are provided, however, can have a massive difference on the landscape ecology of the Arusha region. In the past, over 90% of trees that sold were exotics; however, a move to more native species would be advantageous to the farmers in this region. As the ecological assessment above indicated, 61% of the trees found in and around fields in the area are fast-growing exotic trees. The trees that are most beneficial for distribution to farmers are the long-lived tree species native to the Afromontane Dry Transitional Forest vegetation zone, as they provide high-value timber, are suited to current soil conditions, and supply habitat for the birds of the area. These include *Markhamia lutea* and *Rauvolfia caffra.* Through pressing into these species which set ECHO apart from other area tree nurseries and communicating to farms which species may be best suited for their farm and its needs, ECHO both finds a market for its seedlings and tangibly promotes the mission for which it stands: honoring God through sustainable hunger solutions and improving the livelihoods of people worldwide.

Possibilities for Consumers

Much of this project has focused solely on the lives and functions of the producers of a good or service: farmers with their raw agricultural products or ECHO with its conservation-agriculture knowledge. Yet allowing an opportunity for consumers to take part in the process of land restoration is imperative, as consumers drive the profitability of any entrepreneurial venture.

In any situation in which there is the opportunity to buy sustainably-produced foods, consumers are able to improve their impact on the land through shifting their consumption practices. This is where the impetus for change originates, anyway—it is

people living by their convictions and the market adjusting to accommodate them and gain value from their preferences.

IMPLICATIONS

Future Agroecological Prevalence

In the future, Agricola G will become a much more prevalent concept. With on knowing how to produce food well and in the way that does not destroy the land. Whether that concept is permaculture, urban gardening, aquaculture, or any other alternative agricultural paradigm, these concepts will have a vast importance to food systems and the global economy. Much more research is needed to find the exact combination of factors that will best balance ecosystem health with productivity for human consumption. However, the principles of agroecology are compelling and offer hope for some sustained change.

Strengthened System Resilience

Not only will food production come to the forefront of global attention, but also resilient systems that can withstand the impact of climate change Will be of increasing importance. Many farmers are already receiving deleterious effects to their crop yields due to more erratic weather conditions and changing climactic patterns. The resilience of systems, whether financial, ecological, or even social, will rely upon an understanding of the protection that comes with biodiversity. Whether or not land degradation is approached for healing through restorative agricultural practices remains to be seen.

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APPENDIX I: Permission to Research from Village Official

K.K Mwenyekiti wa Kitongoji cha Seuri

MWENYEKITI WA KITONGOJI CHA SEURI
TAREHE 26/7/2017
SAHIHI
KATA VA OLTRUMET

ECHO

EAST AFRICA IMPACT CENTER
P.O. Box 15205, Arusha – Tanzania
Simu: +255754480184
24 Julai, 2017

KWA: Ofisi ya Mwenyekiti
Kitongoji cha ~~Ekenywa~~ Seuri
Ngaramtoni – ARUSHA

Ndugu Mwenyekiti,

Kuh: Mtajwa Sean Lyon Kufanya Uchunguzi wa Kilimo katika Kijiji Chetu

Rejea hapo juu, tunapenda kumkaribisha Sean Lyon, ambaye anafanya kazi ya kujitolea kwa ECHO kuchunguza viumbe hai katika mashamba ya wanakijiji wanaomruhusu. Ataangalia aina na idadi za ndege, na wadudu waharibifu, na wadudu rafiki na aina za miti katika mashamba.

Atafanya chini yangu, Mkurugenzi wa ECHO Afrika Mashariki. Uchunguzi wake utatusaidia kufikiria mambo yanayosababisha matatizo au mafanikio katika mazingira tofauti za mashamba. Atatumia wakati kwa makini kutumia muda katika mashamba, kukusanya idadi na inatarajiwa kuchukua masaa kadhaa kwa kila shamba. Lengo la kazi hii ni kugundua mahusiano kati ya aina mbalimbali za mti karibu na shamba, aina gani za ndege zilizopo, na uharibifu wa wadudu ni kiasi gani kwa mazao. Itasaidia ECHO kufanya mapendekezo jinsi ya kuboresha matunzo ya ardhi na mashamba. Mkulima akiwa na wasiwasi kuhusu uwepo kwa Sean, anaweza kuwasiliana name, kwenye simu +255 0754 480 184 kwa majibu ya maswali yoyote.

Natanguliza shukrani kwa kumkubali Sean Lyon na kumtia moyo awe na amani katika jamii yenu.

Wako katika kujenga taifa.

Erwin Kinsey

Erwin Kinsey, Mkurugenzi
ECHO
Arusha, Tanzania

APPENDIX II: Survey Form in Swahili

Namba ya dodoso:____ Dodoso la Agroekologia kwa Mkulima

Tarehe: Eneo:

Jina na Umri wa Mkulima Anayohojiwa:

1. Ni lini ardhi hii ilibadilishwa kutoka msitu na kuwa shamba la kuzalisha mazao? _____
2. Ni mwaka gani ulianza kulima shamba hili? _____
3. Shamba hili lina ekari ngapi ?_____
4. Ni mazao gani ya msingi ambayo unapanda shambani kwako?

   ☐ Mahindi ☐ Maharagwe ☐ Mbaazi ☐ Ngwara ☐ Migomba ☐ Viazi vitamu ☐ Alizeti

   ☐ Mazao mengine_____ ☐ Mazao mengine_____

5. Je! Unazungusha mazao? ☐ Ndio ☐ Hapana Mzunguko inakuaje?

   _____

6. Je! Viumbe hai gani vinashambulia mazao yako?

   _____

7. Je, unanyunyiza dawa katika mazao yako?

   ☐ Ndiyo ☐ Hapana Aina gani ya dawa ?_____

8. Katika kaya yako umetumia magunia mangapi ya mazao katika mwaka jana? Na uliuza magunia mangapi?

   ___kg ☐ Mahindi ___kg ☐ Maharagwe ___kg ☐ Mbaazi ___kg ☐ Ngwara

   ___kg ☐ Viazi vitamu ___kg ☐ Mazao mengine_____ ___kg ☐ Mazao mengine_____

9. Je! Tangu uanze kulima, umeona aina au idadi ya ndege zimeongezeka au kupungua katika shamba lako hapa? ☐ Namba wengi zaidi ☐ Namba wachache zaidi ☐ Aina wengi zaidi ☐ Aina wachache zaidi

   _____

10. Je! Ulipanda miti yoyote karibu au ndani ya shamba lako?

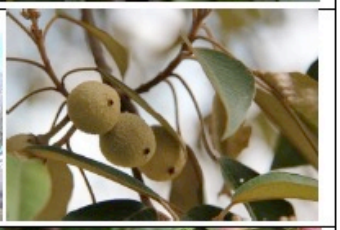
    ☐ Ndiyo ☐ Hapana Ikiwa ndiyo, kwa ulichagua aina hizo za miti?

11. Ni moja kati ya miti ifuatayo ambayo ungechagua na kupanda kwenye shamba lako?

12. Ikiwa siyo miti hii, ungetaka mti gani?

☐ Grevilea ☐ Mkaratusi ☐ Mhoba ☐ Jakaranda ☐ Wattle ☐ Michongoma
☐ Mparachichi ☐ Mwembe ☐ Mtipisi ☐ Mti mwingine ya matunda_____

Namba ya dodoso:____ Dodoso la Agroekologia kwa Mkulima

□ (A) Olyabiyabi/ Mfurufuru	 
□ (B) Mringaringa	 
□ (C)Olmargoit/Mlalai	 
□ (D) Olsanuwesi/Mfuruanga	 
□ (E)Loliondo	 

APPENDIX III: Survey Form in English

Survey # ____ Tanzanian Agroecology Farmer Survey 2017

Date:

Location:

Name and Age of Farmer Interviewed:

1. When was this field farmed for the first time? _____
2. What year did you start farming this field? _____
3. How large is this field, in acres? _____
4. What are the primary crops that you are growing here?

   ☐ Maize ☐ Beans ☐ Pigeon Pea ☐ Lablab ☐ Bananas ☐ Sweet potatoes
   ☐Sunflowers ☐ Other crop(s) _____

5. Do you practice crop rotation? ☐ Yes☐ No What are the crops you rotate?

   _____

6. What are the main pests/problems in your fields?

   _____

7. Do you spray your crops with pesticides?
   ☐ Yes ☐ No If yes, what types of pesticides or herbicides?

   _____

8. How many kilos of crop did this field produce last growing season? _____
9. Since you started farming, have you seen species or numbers of birds increasing or decreasing around your farm? ☐ More species ☐ Fewer species ☐ Higher numbers ☐ Lower numbers

   _____

Sources for tree ID photos:

Croton macrostachyus: http://www.westafricanplants.senckenberg.de/images/pictures/euph_croton_macrostachyus_rvbli_2_3460_50d9fa.jpg, http://www.westafricanplants.senckenberg.de/images/pictures/euph_croton_macrostachyus_rvbli_3_3460_38ab62.jpg

Cordia africana: http://www.zimbabweflora.co.zw/speciesdata/images/14/148190-6.jpg, http://www.zimbabweflora.co.zw/speciesdata/images/14/148190-8.jpg

Croton megalocarpus: http://larmat.uonbi.ac.ke/sites/default/files/cavs/agriculture/larmat/images/croton_megalocarpus._0.JPG, http://www.zimbabweflora.co.zw/speciesdata/images/16/165160-4.jpg

Albizia spp: https://www.plant-world-seeds.com/images/seed_images/ALBIZIA_JULLIBRISSIN/size3_500x500/ALBIZIA%20JULIBRISSIN1.JPG, https://maxpull-gdvuch3veo.netdna-ssl.com/wp-content/uploads/2013/05/albizia-silk-tree.jpg

Olea capensis: https://upload.wikimedia.org/wikipedia/commons/2/21/Olea_capensis_capensis_tree_in_flower_cape_town.JPG, https://upload.wikimedia.org/wikipedia/commons/thumb/2/28/X_Ironwood_Tree_Olea_capensis_FoliageDetail_1.jpg/1280px-X_Ironwood_Tree_Olea_capensis_FoliageDetail_1.jpg

10. Did you plant any of the trees around your field? ☐ Yes ☐ No
    If yes, which species and why did you choose them?

    _____

Survey # ____ Tanzanian Agroecology Farmer Survey 2017

Which one of these trees would you pick to plant on your farm? If none, which tree would you want?

☐ (A) Croton macrostachycus

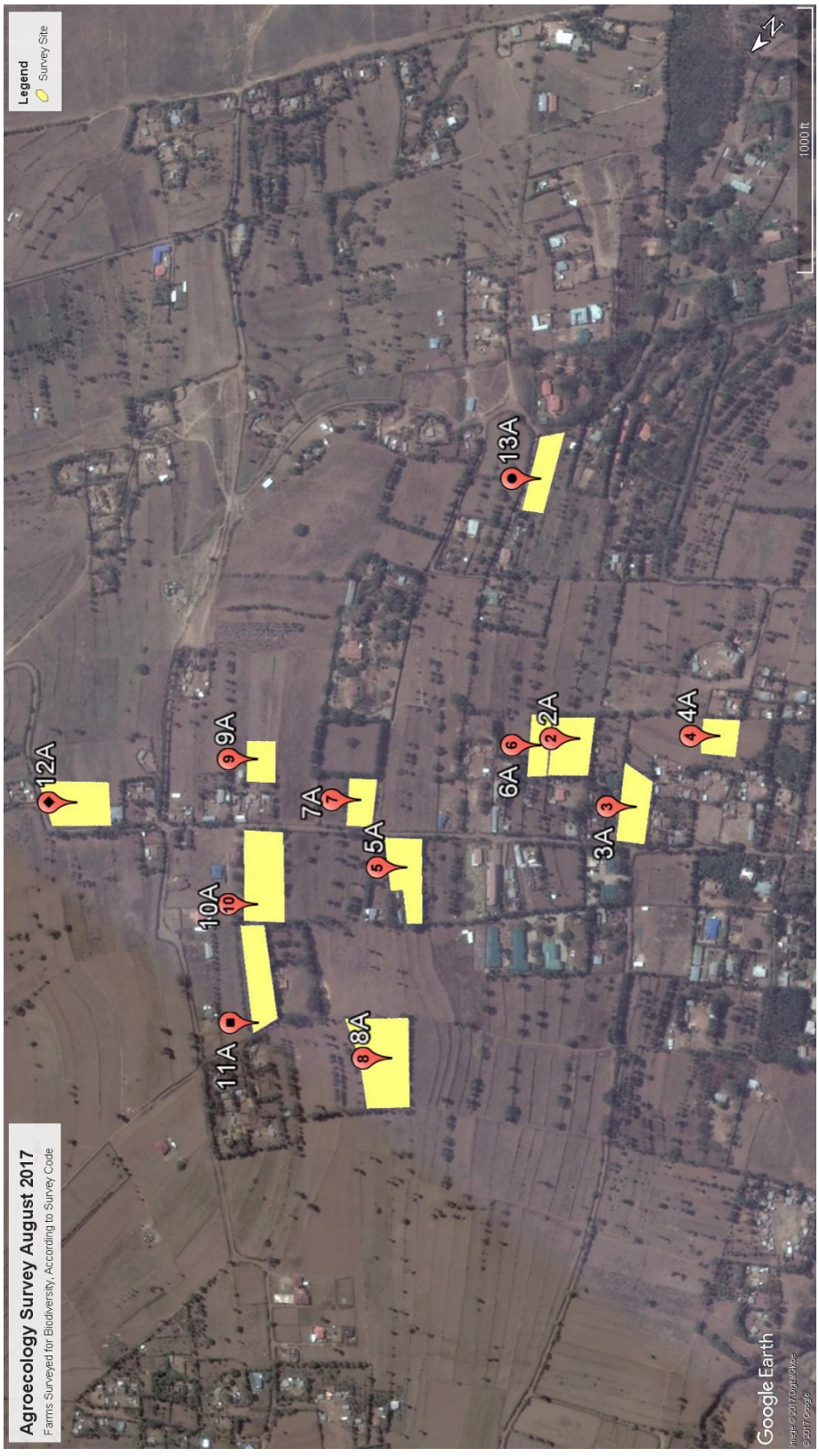

☐ (B) Cordia africana


☐ (C)Croton megalocarpus


☐ (D) Albizia spp.


☐ (E)Olea capensis


APPENDIX IV: Map of Survey Sites (Subvillage Seuri, Ngaramtoni, Arusha, Tanzania)



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