Alternatives to Agrilogistics: Designing for Ecological Thinking

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Sustainable HCI (SHCI) researchers have historically looked to small and urban farmers to help situate and extend notions of sustainability within economic, social, and political frameworks. In the face of climate change and the Anthropocene, however, we ask how designing *like* the alternative farming practices of small and urban farmers might open up new, ecological approaches to agricultural technology. We conducted ethnographic field work with small farmers and their community in Indiana and show how they are challenging "agrilogistics," defined by philosopher Timothy Morton as a strict separation of nature and culture in food production, a separation, he argues, which underlies the substantial agricultural contributions to climate change. Our ethnography led us to suggest new possibilities for design of agricultural technology that support ecological thinking and caring for more-than-human actors through visceral imaginaries, posthuman storytelling, and engaging curiosity, possibilities which may offer ways to disentangle agricultural technology from agrilogistic paradigms.

CCS Concepts: • **Human-centered computing** → Human Computer Interaction (HCI) • **HCI theory, concepts and models**

KEYWORDS: Agrilogistics, sustainability, agriculture, small and urban farming, agtech, social computing

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1 INTRODUCTION

Agriculture is one of the earliest technological traditions, blending the study of the natural world with human technologies to pattern and harness nature into reliable food sources. However, in the face of climate change, there has been rising concern about the sustainability of current global and industrial agricultural models which are caught in a climate change fueled paradox. On the one

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hand, agriculture contributes to climate change: *"From farm to plate, our food system is responsible for a staggering 44 to 57 percent of anthropogenic greenhouse gas emissions"* [91:12]. This includes the deforestation and land used for agriculture, packaging, transport and retail of food, and emissions from agriculture combined. While on the other hand, intensified agriculture is vulnerable to the impacts of climate change, which directly affects growing conditions. According to research done by the United Nations, *"the impacts of climate change are reducing the capacity of natural resources (biodiversity, soil and water) to sustain the food demand of the world's increasing population"* [70:3]. There are many contributing factors to the ways in which climate change is entangled in agricultural practices, such as government subsidies to agriculture, globalization, the green revolution and other engineered methods of agricultural intensification. These are parts of a larger trend of economic consolidation and industrialization in agriculture [14,51]. The result has contributed heavily to what many are calling the Anthropocene, which refers to the geological age where, *"humans act as a main determinant of the environment of the planet"* [16:209].

In this paper, following the lead of ecological posthuman philosophy, we foreground matters of agricultural ontology—where ontology is defined as a branch of metaphysics concerned with the nature or essence of being or existence [25]. In other words, we are interested in how humans have constructed a kind of "agricultural reality." Throughout the course of this paper we discover there might be a plurality of agricultural realities, or ontologies, some designed/defined by industrial agriculture and others generated by small and urban farmers. In the following, we seek to clarify these ontological positions for the sustainable HCI [SHCI] community, whilst also imagining avenues for how technology can support sustainable agricultural ontologies, or realities. To observe alternative and sustainable agricultural ontologies, we turn our concern towards how small farmers are thinking and working in ways that innovatively begin to disentangle agriculture from climate change and the Anthropocene and ask how we might design like them in the conceptualization of agricultural technologies. This contributes to a growing body of SHCI research into small farms, urban farms, and urban gardeners [17,38,43,57,60,64,66,85,94]; the role of HCI during the Anthropocene [6,9,54,55,59,92]; and attempts to decenter the human in design, in pursuit of alternatives to "human-centered design" [1,48,54,87].

As a way to begin to observe differing agricultural realities, or ontologies, we use the concept of "agrilogistics" coined by ecological philosopher Timothy Morton [69] as a framework to compare our ethnography against. Agrilogistics, according to Timothy Morton, is a rigid way of thinking about the difference between nature and culture that stems from agricultural practices. He argues that in the agrilogistic model, all beings outside of the agricultural project become "pests" to be managed and even eradicated. According to Morton, this agrilogistic project developed in hopes of systematically addressing hunger by protecting food sources from plague and pest, but while it has done much to feed ever growing human populations, it has also contributed to the Anthropocene by ignoring ecological conditions and limits. The broad question Morton's work addresses is how we might continue to feed the human population while pulling back from the practices and agricultural ontologies (namely the stark human/non-human divide which he argues undergirds the agricultural project) which has led to the unintended and ironic consequence of contributing to the Anthropocene and climate change, which challenge food security and Earth's ecological well-being.

Although researchers and practitioners do not yet have perfect answers to the question of sustainable food production at scale, much attention in Sustainable HCI [SHCI] has turned to small farmers, urban farmers, eco-farmers, and the local farming communities to expand notions of sustainability, and we follow suit. By examining ways in which small farmers with alternative values like sustainability, conservation, community building and local food systems positions themselves in relation to the values and practices captured by Morton's concept of agrilogistics, we join other HCI/Social Computing researchers who are interested in supporting sustainable food systems [17,42,43,74], community values of small/urban farmers and gardeners [64–66,89,94], and human/non-human symbiotic encounters [57]. By positioning Morton's theory in the context of small farmers, we begin to explore not only a more complex picture of farming in the the Midwest, but of the multiple ontologies held by small farmers, placing abstract philosophical constructs in relation to grounded analysis and possible application [62,86]. In this paper, we use findings and experiences from an ethnographic study of small and urban farmers in a Indiana in the US in late winter of 2019 through spring of 2020, and analyze our experiences through the lens of 3 axioms that Morton argues underpin Agrilogistics. We sought to understand how farming tools, techniques and strategies held by small farmers might expose us to different agricultural ontologies which offer both expanded and ecologically sensitive world-views and pragmatic methods and tools which could support climate change resilient agricultural models. In order to see the shifts in ontologies between 'agrilogistics' and small farm agricultural ontologies, we describe our ethnographical encounters with small farmers in comparison to Morton's agrilogistic axioms, finding nuance in how small farmers either adhere to them or subvert them. Based on our analysis, we distill several principles we see at play in small farmer's approaches to implementing and conceptualizing social computing technologies which can be further used to dissolve nature/culture divides and widen the ecological scope of agricultural projects: (1) visceral imaginaries and the power of touch, (2) post-human collaborative histories and storytelling (3) designing for curiosity, not survivalism.

2 BACKGROUND

Much social computing research on industrial agriculture focuses on ubiquitous sensors, artificial intelligence, and automated systems. Although we recognize their extraordinary contributions to ensuring the global food supply, we are also concerned that without reflecting on how these technologies engage in larger ecologies, this research project may contribute to agrilogistic ontologies. An alternative thread in social computing research sees farming as part of a complex sustainability problem space that bridges social, economic and political issues. In the following, we situate our work by explaining the trajectory of agricultural intensification, and we discuss the history of sustainable HCI and its focus both on ontological design and small farmers and sustainable food systems. We then track the emergence of posthuman lenses in design which examine small farming and other more-than-human intersections and suggest that by using agrilogistics as an antagonistic ontological position, we are able to articulate what small farmers offer in terms of an alternative ontology for agriculture.

2.1 Agricultural Intensification

In the last one hundred years, agricultural production underwent a revolution in pursuit of productivity and efficiency. This trend is being continued via computational agriculture, in which sensors and algorithms allow more accurate modeling and forecasting, growing, and harvesting of food [32,68,96]. This general model is referred to as intensified agriculture. According to Laura Lengnick, author of Resilient Agriculture [51], much of the agricultural land in the US was settled by the 1920s and therefore, increased global demands on the agricultural market were solved not through increasing the volume of land being farmed, but through intensifying agriculture — or "produc[ing] more on less land with less labor" [51:14]. This pattern of agricultural intensification seems necessary given the continued growth of the world's population and productivity challenges related to climate change. Intensification is also part of trends of agricultural consolidation and industrialization where efficiency and cost cutting is achieved through automation [51].

As mentioned in the introduction, contemporary agricultural production is entangled with the problem of climate change. The homogenized and globalized supply chains and agricultural practices mean that food supply both contributes to heavily to climate change while simultaneously rendering food supply chains vulnerable to climate change related effects like extreme heat and less predictable weather. In Indiana, where we conducted research with small farmers, climate scientists researching the impacts of climate change on agriculture admit, "today, Indiana farms are more specialized and larger than in the past, making them more vulnerable to climate-related risk" [12:3]. Farms will be more susceptible to climate change related impacts like heavier rain incidents in spring which lead to less reliable spring planting schedules, and hotter summers leading to animal heat exhaustion, lower corn yields, increased weed and pest problems, and increased CO_2 emissions from faster decomposition of soil [12]. This pattern reflects a tension inherent in agrilogistic modes of producing food, where 'violent' attempts to straighten ecologies through agriculture now face the compounded ramifications of those attempts – something Morton claims is inherently 'weirdly looped.' In other words, the current mode of agriculture has, in a way, doubled back on itself and is now facing consequences from its initial success [69]. Like a gift that becomes a curse, there appears to be an inherent incompatibility between agrilogistics and agricultural intensification and ecological thinking. If food security and survival are our goals, agricultural ontologies that value regenerative practices and the complex interplay of human and non-human life must be supported by agricultural technologies.

2.2 Sustainable Agriculture and the Anthropocene in Social Computing and HCI

Small Farming and SHCI in Social Computing

Our research advocates for sustainable agricultural practices, situating it within an established agenda of Sustainable HCI [SHCI] research. SHCI began as a way of thinking about the longer-term implications of product design and consumption, but has since diversified to engage with economics, infrastructures and policies, including the area of small farming and sustainable food systems. Blevis first advocated for re-thinking sustainability from the perspective of production and consumption cycles—introducing the concept of disposal and re-use cycles as a way to think of the entire lifespan of a digital object [10]. DiSalvo et al. and Dourish expanded this perspective to stress the structural roles of policy, economics, and other social factors [26,29]. Ontological commitments have long been a part of the sustainability agenda in SHCI as many early works were motivated by the ecological philosophy of Fry and Williams who suggest that design is ontological and world building [30,95]. Fry argues that to design unsustainably is to de-future, or erase the possibility of being in the future. We continue this ontological interrogation through using Morton as a lens for examining posthuman positions in our ethnographic findings.

Following calls to think more systemically about sustainability, some SHCI researchers turned to sustainable food, gardening and small farming to explore intersections of policy, economics and culture. Various studies warn of how small and subsistence food producers will be challenged by climate change [43], stress the importance of small, local food systems for sustainability [11,17], explore the alternative values of small urban famers [42,73], and empower small farmers in India through information sharing [76]. Small farms, urban farms, and community gardens also continue to be sites of inquiry for sustainable HCI research because small and urban farmers think about and practice agriculture in a way that is often in opposition to intensified agriculture, valuing sustainability, ecological thinking, social justice and community organizing. The urgency of addressing sustainable and small food systems has recently been re-stressed nearly a decade after initial calls [11,43] as researchers call for farming within limits and sustainable and post-human ways of thinking about climate resilient food systems [3,27,28,72].

Small farm research within the HCI community has exposed that small farmers have community-oriented values that often focus on sustainable and regenerative agricultural practices. HCI research has uncovered small farmer values, showing how small farmers and urban gardeners are often less interested in technologies for ubiquitous computing, automation or scale, and more interested in technologies that support community and sustainability. Some HCI research has explored how farmers and gardeners value skill sharing, sharing of community space, cooperation [39,85,94]. Others have shown how HCI practitioners might design to support small-scale farming values of community inclusion and provisioning [42,73], the values of small farmer family units[53]. Starkly alternative values are explored by research into how IT might support permaculture (grassroots sustainable agriculture) communities who value local control of food supply, environmental stewardship, sociocultural equality, regeneration, and active resistance to inequality in the food system [71]. Other research within the HCI community highlights how small farmers integrate politics into their practice by highlighting community-oriented, grass-roots efforts to address food scarcity, food security and food democracy [64,78,79,89]. These studies include infrastructuring local food democracy [79] supporting and understanding grassroots online organizing of a small-scale food production community in Australia and Germany [64,83] or observing how small farmers operate in a loose heterogeneous political networks described as Tiny Publics capable advocating and organizing around amorphous ideas about sustainability that can therefore be broadly defined and pluralistic and grassroots [89]. It is clear that small farming is not neutral, it is imbued with values, politics and alternative visions for ways of being in relation to each other and nature.

Ultimately, Small farms differ from conventional agriculture as much in kind as they do in size; they are not "dumbed down" versions of large farms, and technological approaches that effectively serve the latter appear to have little appeal to the former. In our research, we show the values of small farmers in the Midwest, contrast them to agrilogistics, and show how these alterative values of production of food and care of the land show useful avenues for how IT can support small farmers through futures with climate change. While former research has hinted at the alternative agricultural ontologies of small farmers, by using the comparative lens of agrilogistics, we clarify the differences and explore how they might disentangle agriculture from climate change. And in this research, instead of thinking of how we might design for small farmers, we actually begin to imagine how we might design like small farmers and their social practices. Inspired by the tactics suggested by Håkansson & Sengers, who conducted research into sustainable HCI alongside simple living families and suggest SHCI might design not for but like their simple-living interlocuters [33], we look to small farmers in the Midwest who we might design like to support sustainable agricultural practices. Extending the scale beyond a family, to a community, we were also inspired by how small farmers form a sustainable social practice community. According to Strengers and Maller, thinking of social practice moves sustainability agendas beyond individual behavior change to radical community-scale change [77,90]. Using the comparative lens of agrilogistsis, we both highlight the values and posthuman insights of small farmers and ask how technologies might be inspired by and support their alternative sustainable ontologies.

Plant Voices, Histories, and Devotion – Posthuman Leanings

HCI and social computing research around small farming and urban gardening has explored more experimental directions that give voice and history to plants and highlight devotion and care of plants. Two projects materialize imagined communication with plants, one through a RFID enhanced watering pail that when brought close to plants, 'speaks' with the plants voice about the plant's preferred environment and history [40], and another uses speculative design to imagine human-plant communication through a system based on light signals [88]. Another design draws attention to qualities of farm and garden work through digitally augmented hand tools that accentuate the kind of devotional nature of gardening [47]. Researchers in the area of smart cities and IoT have also developed connected seed libraries, where seeds at the libraries are connected to stories from the small farmers who supplied the seeds, exploring the possibility of seeds to contain not only a source of food, but community stories [37]. We see these projects as ways of materializing and incorporating the voices and histories of plants through social computing technologies. In our research we affirm the importance and potential of giving voice and history to more-than-humans, while expanding this impulse into expressing the co-constitutive qualities of our interactions with more-than-human seed and land histories and futures.

Posthuman SHCI and Agriculture

Another recent strand of SHCI research takes on an ecologically posthuman agenda, calling for the decentering of the human in design as a strategy to counter the prevailing forces of the Anthropocene era. Post-anthropocentric and posthuman research agendas have been deeply investigated by feminist STS scholars such as Haraway, who advocates for human-non-human relations and naturecultures [34,35], Braidotti who discusses posthumanism's relation to technology, climate change, and bio-politics [13], and Puig de la Bellacasa, who suggests feminist care ethics as a lens for posthumanism and tending to living processes of soil [80,81]. Posthumanism and the Anthropocene sparked a paradigm shift in SHCI research, with implications for social computing research as scholars call for post-anthropocentric approaches to design which 'decenter the human' [54], include more than human actors in their methods [18], designing for cohabitation [87], collaborative survival [55], permaculture and care [60], symbiotic encounters with nature [57], use design to understand naturecultures [56], and making future ecological concerns tangible [9]. Specifically, the grounds for posthuman social computing in agricultural spaces are quite rich, as demonstrated by recent observations of how humans and non-humans are symbiotically linked in agricultural practices [58] and how, borrowing inspiration from permaculture, we might design social computing applications and systems with nature [60]. It is important to note that much of this literature is founded on feminist care ethics, techno-feminism and situated, embodied understandings of human/non-human intersections, while Morton remains more sweeping and high-level and has been critiqued by some for having Eurocentric and androcentric views [62,86]. Our research contributes to this growing research agenda by using the concept of agrilogistics but showing it as part of a mesh of multiple agricultural ontologies. We share a belief with Morton that it is critical for agricultural ontologies to acknowledge climate change and we believe studying small farmers can help us clarify and support posthuman agricultural ontologies and disentangle agriculture from worsening climate change.

The posthumanist agenda in SHCI has leveraged various theoretical framings to-date, leaning largely on feminist new materialist frameworks [34,35,93]. While these writings address climate change tacitly, arguing for naturecultures, symbiotic encounters, and polyphonic acts of noticing, our contribution lies in empirically testing a new framework (Agrilogistics) which offers a more direct language to explain and disentangle agriculture's ontological and material connections to climate change. We argue that this framing allows us to demonstrate how small farmers are breaking away from extractionist and intensified modes of agriculture through subtle posthuman ontological orientations which we, as CSCW and social computing researchers, can observe, be inspired by, and support. Additionally, attempts at decentering and considering the non-human in SHCI are nascent, and as designers seek ways to extend timescales [9], explore naturecultures [56,59,87], utilize embodied knowledge [9,55], and notice differently [7,55,57], this paper adds to a growing body of work which seeks to understand and design mediations between the human and more-than-human which capture our complex, messy, existential entanglements. To this end, in this paper we also offer strategies for co-constitutive, posthuman design practices inspired by small farm communities, their agricultural tools, practices and ways of framing agricultural ontologies.

2.3 Agrilogistics in Three Axioms

In Dark Ecology, ecological scholar Timothy Morton coined the term agrilogistics as an ontological way of being in the world that stems from agriculture.

> *"The term names a specific logistics of agriculture [...]. Logistics, because it is a technical, planned, and perfectly logical approach to built space. Logistics, because it proceeds without stepping back and rethinking the logic. A viral logistics, eventually requiring steam engines and industry to feed its proliferation. Agrilogistics: an agricultural program so successful that it now dominates agricultural techniques planetwide" [69:42]*

And, while Morton claims agrilogistics is "toxic," it has been successful because it "promises to eliminate fear, anxiety and contradiction—social, physical, and ontological—by establishing a thin rigid boundaries between human and nonhuman worlds" [69:43]. The result of this type of farming and its separation of human and nonhumans has led to the Anthropocene, as mentioned in the introduction, but also creates challenges to analysis due to its ubiquity:

> "*the humanistic analytical tools we currently possess are not capable of functioning at a scale appropriate to agrilogistics because they are themselves comprised products of agrilogistics. The nature-culture split we persist in using is the result of a nature-agriculture split . . . This split is a product of agrilogistic subroutines, establishing the necessarily violent and arbitrary difference between itself and what it conquers or delimits" [69:43].*

Morton argues that three philosophical axioms are the foundation of agrilogistics:

1. **The law of noncontradiction is inviolable**. Agrilogistics asserts strict boundaries between human and non-human entities which he calls 'noncontradiction'. This law creates an 'excluded middle' that ignores the entities that live in a liminal zone between the inside and outside boundary of the agrilogistic project, enforcing strong binary thinking. For example; a plant can be a weed or a commodity, it is either inside the agricultural program, or outside and something to be eliminated.
2. **Existing means being constantly present**. The second agrilogistic axiom suggests that the objects of agriculture (soil, sun, pollinators) are eternally available and unchanging—what Morton refers to as being "without conditions". This conception implies that agricultural conditions are stable, dependable, and limitless for human use, cultivation

and consumption (e.g., next year, the field will still be available for value extraction in essentially the same ways as it was this year and last year).

3. **Existing is always better than any quality of existing**. The final axiom is a "quantity over quality" idea, suggesting that sustaining more human lives is more important than contributing to quality of life. According to Morton, agrilogistics asserts that *"more people is better than happier people"* [69:53]. An example: the genetic modification of certain crops to make them easier to harvest, at the expense of their taste and nutritional benefit.

In summary, agrilogistics (axiom 1) radically separates humans from non-humans, excluding any overlap between them; (axiom 2) it then reduces non-humans to eternally unchanging identities that are not subject to growth, development, decay, or death as a category (e.g., while an individual bee will die, bees as an agricultural resource do not); and (axiom 3) the food system is for minimal sustenance of human life, but contributing to good life—meaningful labor, the pleasures of taste, etc.—is out of its scope. We use Morton's axioms tactically, that is, to look for opportunities to resist agrilogistics—by asserting the continuities and interdependencies between the human and the non-human; attending to the capacities for change—growth, adaptation, decay—of all aspects of agriculture; and foregrounding quality over quantity in connection with food, sustenance, agricultural labor, and dining. As we look at small farmers through the lens of agrilogistics, we seek alternative ontologies for farming, for although we find that small farmers do have different ways of thinking of agriculture, they still 'define the edges' of their agricultural project. In this way, we observe the nuance possible in these axioms, and also observe a kind of widening of the scope of the agricultural project to include far more actors. Widening agricultural scope maybe be one of the ways that we dismantle agrilogistics, according to Morton, who refers to agrilogistic 'temporality' (or the scale at which it imagines its impacts) as a narrow tube. *"Operating within a very narrow temporality tube has been hostile to lifeforms, some of which are humans themselves. It's time to widen the tube,"* [69:120] Morton suggest. Paying attention to how small farmers achieve a wider agricultural scope through their tools and practices, we join other sustainable HCI scholars in seeking to identify, to support, and examine ways to expand thinking beyond the lean, or narrow, agrilogistic paradigm.

RESEARCH METHODOLOGY

The present study is part of a broader research program exploring bottom-up innovation, creative industries, and entrepreneurial life in global contexts since 2011. It operates on the assumption that small and urban farmers' practice can be read as a form of bottom-up innovation, applied to the domain of sustainable food production. This work draws from ethnographic fieldwork done with small and urban farmers and conservation experts around the Indianapolis, IN area, where we conducted site visits and interviews in the winter and spring of 2019-2020. By examining small and urban farmers' practices, methods and tools in relation to Morton's three agrilogistic axioms, we offer a critical and empirical contribution to HCI research on posthuman approaches to sustainable food production. Through ethnography, we test Morton's theory as well as show how agriculture is by no means a universal paradigm, but a series of agricultural ontologies operating in parallel, vying for alternative versions of food production and food economies.

Sites

The American Midwest is known as an agricultural epicenter of the United States and as such, is a hub of not only large-scale farming of monocrops and animal farming (predominantly soybeans, corn, wheat and pigs) but also is home to an active community of small farmers, urban farmers and urban gardeners. By visiting farms in both rural and urban settings, interviewing members of soil and water conservation districts and sustainability departments at Indiana University-Purdue University Indianapolis (IUPUI) we began to form a comprehensive picture of ways in which farmers are thinking of sustainable farming, ag tech, urban production farming, farming for educational purposes, soil and water health, food democracy and seeds and farming's intersections with climate change.

Data Collection

We collected data from a constellation of sources which reflected the Indianapolis small and urban farming community. For part of our data collection, we adapted and conducted ethnographic walking probes [46,52] on eight small and urban farms surrounding Indianapolis. Each farm employed different goals and strategies for their farming such as cooperative farming, small-scale production farming, or farming for community education. All of these farms considered themselves small farmers and worked on low-acreage and at a local scale. In these farm visits, we sought to learn about alternative farming practices, tools and values that differed from those found on industrial farms. We did this to unearth possible ways to design that resembled the small farmers values and supported sustainable farming practices through social computing tools and systems. As academic researchers, we felt meeting the farmers at their farms and letting them show and tell us about their work in their words allowed us to move past preestablished notions of farming and challenged our assumptions about the stereotypical life of a farmer. Each farm walking probe lasted between 1-2 hours and was guided by our interlocutors. At each farm we would walk the grounds, ask questions, look at tools, smell the animals and the hay, hear about the histories of the farm and the surrounding land and take photos and fieldnotes while discussing day-to-day farming practices with our farmer interlocutors.

In addition to visiting farms, using a snowball method, we also interviewed total of 20 subject matter experts including agricultural economist, local and American farm bureau representatives, land-grant university agriculture extension personnel, USDA/NASS researchers, farming activist, etc. We also met members of the small farming community who are either small farmers themselves or work closely with the small farmers such as members of farming extensions, seed savers (who garden and farm), soil and water conservation experts, and a sustainability director at IUPUI who oversees a university farm. By interviewing the small farmers and their community, we hoped to understand both small farmers' practices and how their community supported their needs and augmented their practices, drawing a fuller picture of the intersections between institutions, policies, and actual small farmers. We interviewed each group of these SMEs for between 1 and 1.5 hours, transcribed the interviews and took notes. Finally, we attended the Indiana Small Farm conference and the Circle City Seed Swap to attend events, mingle with small farmers, and learn about how these farmers function as a community. At each event, we took notes and photos and captured reflections on the events after they were over. All names have been anonymized to protect our interlocutors' privacy.

Interpretive Procedures

The research team conducted data analysis of interviews through a procedure known as *explication de texte* [75], or close reading, an analytical method originating in the humanities [4]. Close reading differs from more strictly empirical methodologies, such as content analysis, in foregrounding the hermeneutic aspect of interpretation; that is, the interpretation does not seek to represent the contents of the interviews, but to use them as a springboard towards new modes of thought. While remaining grounded in textual evidence, close reading accommodates the purposes of the interpreter as well as their skilled incorporation of external theoretical perspectives (in this case, Morton as well as feminist posthumanism), in service of constructing new understandings, of generating new openings, and of proposing new ways of seeing or understanding a phenomenon. The approach focuses on themes, including their contents and also the particular ways in which they are expressed (e.g., their diction, turns of phrase, use of metaphor). In such an analysis, themes are understood both to be what a text or discourse is about [15], and also what provides the text its organizational unity and connection to more general human concerns beyond the immediate subject itself [49]. This constructive and generative methodology is appropriate because this research is not intended narrowly as a report on certain agricultural practices, but rather an integral part of our effort is to engage in design futuring, as it might be informed by such practices.

We also used this approach to interpret our experiences, which we captured in notes and photographs. We included these artifacts within the thematic analysis, coding them alongside other textual readings, allowing them to bring nuance and verification to the *explication de texte*. The research team has used this particular analytical methodology in prior work on maker culture, bottom-up innovation, and sustainable farming in Asia [5,56,58]. Two of the five researchers involved in the analysis have doctoral training in the humanities and are experienced with this analytical practice; the other three are design ethnographers who are also experienced at critical interpretation. Broadly, the *explication de texte* proceeded as follows: initially, the analyst seeks to build a literacy with the main contents of the texts. This literacy, which might be characterized as knowledge that any other reader would also share, gradually develops into a sensitivity for the particular data set. Developing it, we examined our interlocutors' use of diction, metaphor, narrative structures, allusive resonances, and connotation, etc. This phase followed an iterative and dialogic process, alternating between reading alone and reading together, and between reading theory and analyzing textual data. To do this, we created a shared Figma where quotes from theory about agriculture sat alongside quotes from our participants. Using this collaborative resource, the concept of agrilogistics and Morton's work in Dark Ecology emerged as a helpful framework to articulate the alternative, ecological and climate-sensitive values and goals of the small farmers and their community who we spent time with.

4 DISENTANGLING AGRICULTURE FROM AGRILOGISTICS

In what follows, we analyze our ethnographic engagement along the three agrilogistic axioms Morton put forward. The analysis will show that small and urban farmers and conservationists, through their tools, methods, and ways of approaching agriculture, ontologically refute these axioms in action.

4.1 From Pests to Helpers: The Included Middle

In this section, we discuss how conservation experts help disseminate and illustrate information about soil health and soil microbiomes which is then instrumentalized through small farm tools and praxis. This way of reconceptualizing soil is a move from pest to helper as farmers start to see the ecological advantages of lively soil full of roots and microbes. These findings refute the first axiom addressed by Timothy Morton, which states 'non-contradiction is inviolable.' This is the idea that there is a rigid boundary which logically excludes undomesticated lifeforms (such as bugs, weeds, and fungus) from those domesticated life forms which are part of the agricultural project (humans, ploughs, animals). This logical exclusion often turns into actual violence and death (e.g., pesticides and herbicides). Morton draws attention to how those boundaries are actually quite blurry. Instead of seeing all non-human and non-cultivated entities (weeds, wetlands, or bugs) as pests, he argues that with the right mindset, one might begin to see them as ecologically necessary. These pests or non-traditional helpers are what Morton calls the excluded middle, alluding to a logical fallacy by the same name in which one is presented with a false choice between two options. The middle is excluded when there is, "black and white, yes and no, with nothing in between" [69:87]. While some farming practices have relied on technologies like tilling fields and large monocrops, practices that don't consider the value of biodiversity or soil microbiomes, in the following we show that conservationists' communicate principles of soil health and work with small farmers to contribute towards a soil-health revolution, including soil as a key member of the health and success of farming endeavors.

In order to exclude the middle, one must make a concerted effort, as one must catalogue and also police which beings belong, and which do not belong in the agricultural project. We found that small and urban farmers do that work differently than conventional farmers who adhere to a more agrilogistic paradigm. The small farmers we visited frequently mentioned how tools and practices of 'big ag' assert stark divisions, while small farmers tended to have more flexible boundaries, viewing soil health and microbiology, seeds and root structures, and ecological cycles of death/composting as contributing to their farms. Small farmers and their allies we interviewed and observed were well aware of the tendencies of large farms to 'exclude the middle' – for example, when discussing hybrid corn growing, a GIS expert who does conservation programs with the Indiana State Department of Agriculture (ISDA), Todd Laughlin, explained,

> *"If you're someone whose business is to grow seed corn or something, or maybe you're in the game of like making hybrids then you're going to till more because you don't want weeds at all, you don't want anything competing, they have to treat this field differently because it's almost like doing an experiment."*

Conditions have to be perfect to reduce threat of any cross pollination or contamination for the product to be successful, leading to the forcible expulsion of any possible "contaminants."

A significant focal point of small and urban farmer collaboration with non-humans is soil health. John Brewer of the Marion County Soil and Water Conservation District (SWCD) runs programs to teach urban small farmers how to use cover crops and practice no-till farming. He teaches that the benefits of planting cover crops and practicing no-till farming are remarkable on soil health and carbon sequestration. Cover crops develop soil quality and nutrients, making planting more productive. For example, Brewer told us about a farmer that he consulted with whose soil was compact. He explained that, *"she started using cover crops and she said [they] turned [her soil] into like potting soil."* Using cover crops had significant results. He continued, *"They planted [all their land] that year and after that, they only had to use like half their beds to produce like everything they needed."* Instead of tilling and fertilizing as in conventional agriculture, the farmers planted what might otherwise be seen (and excluded) as weeds, which, far from crowding the food-growing plants, allowed them to flourish. An added benefit of cover crops is that they sequester carbon, so that fewer fields lie barren, and more organic matter is trapped in the soil at any given time. The cover crops thus benefit the farmer (through enhanced productivity), the soil, and address climate change.

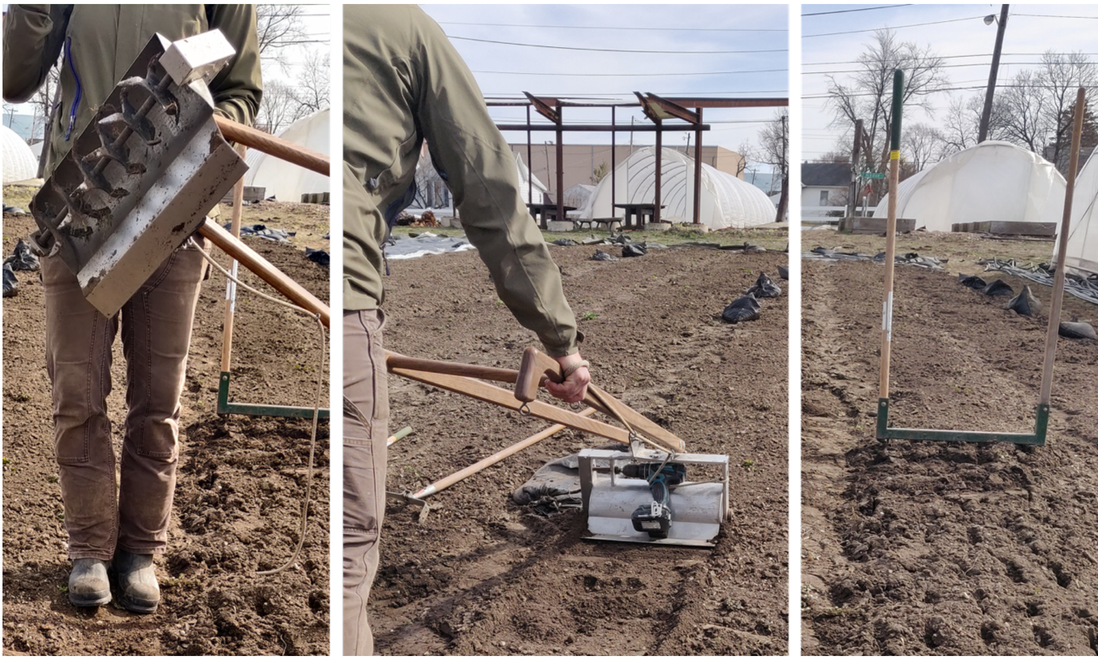

Figure 1: Tools at the City Farm. From left to right: The blades of the drill-driven tiller, the drill-tiller in use, and the broad fork, sunk into the earth

Understanding the benefits of cover crops is one thing; persuading farmers to plant them is another. Small farming is a stressful profession where there is a fine line between productivity and profit. Farmers at City Farm, a small urban production farm mentioned they 'push' their beds so hard that they don't have time to plant cover crops. Another strategy the conservationists advocate for alongside cover crops is low or no-tell farming. Tilling soil on a yearly basis disrupts the root structures and microbiomes of the soil that hold it in place and promote organic decay and nutrient content. Soil and water conservationists have developed visuals and live demos so that people can see the benefits of low or no-till farming for themselves. One of the most impactful examples they showed us were pictures, side by side, of two pits dug into two different fields. One pit was from a traditionally tilled farm, and the other from a no-till farm in operation for 20 years. The pits showed a cross-section of the soil underneath the surface. As one soil conservationist described,

> *"Sometimes they'll [do the two-pit digging for] a guy that just started no-tilling a field versus one that he's had like 20 years, and when you get to standing in each one and it's just like; how much farther the good looking soil profile goes down, like you can see like the layer compaction, earthworms in there, grubs, not to mention nodules for different nutrients and stuff on all the roots it's insane."*

The impact of this description was dually reinforced by a video they shared on Instagram of a demonstration that they do to show the benefits of soil with root structures. They pour water through a chunk of soil that resembles a no-till farm and a chunk of soil that resembles a frequently tilled farm: the water runs straight through and then carries away the tilled soil in a muddy washout, while water is absorbed or filtered by the soil of the healthy no-till dirt.

No-till farming is not just a concept; it is also a material practice that happens in the physical world, and as such, it has significant implications for the tools that farmers use. When we visited City Farm, we discovered that while they don't plant cover crops, they still made efforts to maintain as much of the soil health as possible by using hand tools that minimally disrupt the underlying soil microbiome. The farmers weeded with broom handles with loops of wire fastened to the ends to be able to reach unwanted weeds without having to bend over while disturbing the minimum amount of soil. Farmers used broad forks instead of tills to prep beds for planting. Broad forks have big tongs spaced far apart which farmers sink into the earth by stepping on them and then wiggling the broad fork back and for to gently break up soil compaction without turning over the earth. This ensures microbial colonies can stay in place and aren't exposed to sun or weather. Another tool these farmers used was a 'driller' which uses a makita drill to drive a set of short metal blades which 'fluff' the top several inches of soil—enough to plant seeds, but not to disturb the microbes. These tools were specifically designed to enhance soil health and work with soil as technology for plant health and wellbeing. The farmers actively imagine the microbiomes of the soil when designing and using these tools. When observed closely, these tools show a detail and attention to caring for soil, which relates the devotional garden tools developed by Jenkins [47].

Improving soil health via cover crops can have cascading effects. Part of Todd Laughlin's GIS work with ISDA is assisting in programs to return Indiana farmlands to wetlands. To boost productivity, he suggested farmers have sometimes used, "marginal land" which encroaches on wetlands. Laughlin explained that Indiana used to be home to considerably more wetlands – according to research done by the US Department of the Interior, Indiana used to be comprised of around 24% wetlands which has been reduced to 3-4% [21]. Wetlands, however, are critical for water filtration as water runs through multiple watersheds across Indiana. The hope that as farmlands become more productive through cover crop and no-till farming, farmers can move away from farming these marginal lands as farmland becomes more resilient and productive. New policies pay farmers to pull drainage systems out of their fields (formed by underground ceramic tiles) and return them to wetlands. The program will pay farmers for up to 25 years in the hopes that once the wetlands are established, the farmers will see their value and continue to keep the wetlands after the payment period ends. In this, we see an exchange where marginal tiles with artificial drainage system are removed from the agricultural project, and re-emergent wetlands, like cover crops, are neither inside nor outside of the agricultural project but rather sit somewhere in between. Here, the design strategy of un-making can also be glossed as a challenge to agrilogistics' first axiom.

Cover crops are useful mainly in how they support the health and wellbeing of the other plants and the soil by "always keeping roots in the soil," (see also [57]). To prepare beds for planting harvestable food, farmers must employ a 'kill strategy' for their cover crops. We were especially struck by the physical effort of manifesting this kill strategy shown in a slide from Marion Country Soil and Water Conservation District soil conservation expert Kevin Allison's presentation about cover crops from the 2020 Indiana Small Farm Conference. In his slide, cereal rye towers over a friend of Allison's who is helping him to crimp (or breaking and bending over) the cover crop of tall cereal rye by hand (figure 2) at Allison's own farm.

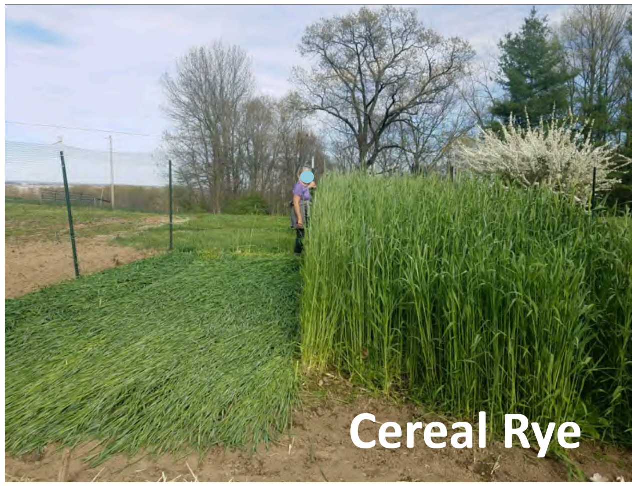

Figure 2: Kevin Allison's field with cereal rye being crimped by hand. This photo was from a presentation given about cover crops for the Indiana Small Farm Conference in 2020 © Kevin Allison

This photo offered a striking example of how farming, while supported by science, is also still a manual manipulation of and reliance on other living things, resulting in tangible outcomes. This strategic use of growth and then death is ecological in its own right, acknowledging that growing can be valuable even if it doesn't produce a commodity. "Unproductive" plants, through their lives and death, maintain a metabolic ecosystem, which better nourishes the actual commodity plants better than the leaner ontology of the agrilogistic paradigm.

Small farmers are not exempt from excluding certain beings from their agricultural project. When we visited City Farm, a small urban farm which produces crops (mainly greens) for the local farmers market on about an acre and a half of urban land, the farmer leading our tour discussed a kind of fungus that had been plaguing their plants. To keep the fungus away from healthy plants, the farmers had to pull up the infected plants and dispose of them far, far away to keep the contamination away. This example shows that small farmers also do the work of identifying and policing the boundaries of their agricultural projects. But even so, within small and urban farms, we witnessed a 'widening' of the aperture of thinking about indirect, ecological partnerships between farmer goals and the larger ecologies they were enmeshed in. As other HCI research has noted [57,60], small, urban farmers often seek ways to recognize and to cooperate with nonhumans, extending care and cultivation of these now-included excluded middle-beings into technologies and practices.

4.2 Seeds as Posthuman Technology

Morton's first axiom focuses on the separation of the human from the non-human, and the exclusion of anything in the middle, which allows the human to unilaterally manage and regulate the non-human. We saw that while all farmers engage in some form of this, in an agrilogistic view, the scope of beings that are "in" the agricultural project is much narrower than that of small and urban farmers. This section deals with Morton's second axiom, which asserts that non-human entities do not have conditions, that is, that they are static entities, by and large undifferentiated, and always standing in reserve. Morton illustrates this axiom by considering the connection between seeds and bees. In the summer of 2014, 42% of the bee population died. Meanwhile, industrial giant Monsanto produced seeds and pesticides that weakened the intestinal lining of bees, even as bees were being pushed north into new habitats due to climate change. Morton argues that there is refusal by agrilogistics to wonder if improving the conditions of bees could help them thrive: *"There is a general anthropocentric doubt that bees have conditions at all"* [69:49]. In this section, we argue that this axiom is refuted by the practices of seed savers who care deeply about the conditions of seeds though seed cultivation, archiving, and keeping seed histories alive.

We work through Morton's second axiom first by expanding our conception of "technology" to include seeds, a move we were inspired to make by a conversation John Brewer, a soil conservation specialist for Marion County SWCD. After explaining what we (and our research participants) mean by "seeds as technology," we consider different variations of the idea, including Monsanto's genetically engineered seeds, conventional hybridization, and heirloom seeds. Embedded in all variants are two key ideas: one is that of unlocking/realizing the potential of a seed, and the other is the ways that seeds store not only genetic material but also histories, culture and knowledge. Where the variants differ is in the extent to which they are subject to Morton's second axiom, that is, the extent to which they are treated as "without condition"—and the implications of that treatment, both for farming and for sustainable HCI. In the following section, we show that seed savers, who are themselves small farmers, care deeply about the condition of seeds, either preserving them in their 'original condition' as heirlooms, or working collaboratively with seeds, climates and growing conditions to cultivate unique and special produce.

The idea of seeds as technologies came up in our interview with Brewer, when he brought up that he was going to be giving a talk about Science Technology Engineering and Math (STEM) tools he uses in his work to help with soil and water conservation efforts and he responded,

> *"I'm just going to bring a seed and some cover crop roots to show how effective cover crops can be at helping with soil and water conservation and I'm just going to say like, You don't have to have a computer, this is my technology, I'm just like, "I'm using this to grow this, and this grows into like a biological animal just churning soil health and nutrients and water quality."*

Brewer's statement reminded us that many people today use the word "technology" as a shorthand for "computing" or "information technology," but that the concept of "technology" goes back to the ancient world, with close associations to agriculture. The Oxford English Dictionary defines technology as *"a discourse or treatise on an art or arts; the scientific study of the practical or industrial arts,"* which captures two ideas that are central to this section: first, that technology is knowledge about a practical or industrial art or craft, and second, that this knowledge is manifest in a medium—a discourse or a treatise. Or, as we will show, a collection of seeds. The care and cultivation of seeds can be accomplished in ways that do, or do not, attend to conditions, such as climate, local history and tradition, and biodiversity.

Curiosity piqued, we went to the Circle City Seed Swap, an event organized by Females Farming Forward, a self-proclaimed, *"diverse group of Indiana-based female farmers united to support one another and raise awareness of our varied agricultural pursuits."* The public invite, sent out via diverse social media outlets touted the event as, *"working to protect and preserve biodiversity of seeds giving power to local food systems, educational and community resource building, and protects pollinators and cultural history as well as agricultural heritage."* As we walked around the seed swap, we saw a kind of representation of the circle of life of the food system. There were representatives from seed libraries, where seeds are literally stored at the public library as a way to distribute seeds to the community to address food scarcity; there were small farmers bringing little packets of seeds they had saved from their farm; two booths were dedicated to heirloom seed saving; one booth was dedicated to educate people about native seeds and seeds for pollinators, where seed pods were dried on branches that the facilitator just had stashed in brown paper bags.

Females Farming Forward had their own booth where we stopped to learn more about the goals of the seed swap, which were to bring attention to the existence of a local seed culture and local seed knowledge, to swap seeds, and to bring awareness to larger issues around the need for local seed adaptation and biodiversity as strategies to combat climate change and preserve local food heritage and culture. The table had small manila envelopes of seeds which were hand labeled that contained cotton, corn, tomatoes (figure 3). Seeing the envelopes there, we suddenly became aware of our own tacit assumptions: we had forgotten that cotton or corn (widely imagined as some of the historical and mass-produced monocrops of agriculture) started as a seed pod that could be disseminated at a local, boutique scale. This realization prompted several questions: What had happened to this knowledge? What is lost when local knowledge of seed propagation is replaced with mass industrialization of seeds to the point that ordinary citizens forget that it could be any other way? What is the difference between seed saving vs. buying a seed from a catalogue? How do these two different methods of seed production vary and what do they represent?

While visiting the seed swap, we encountered two local heirloom bean and seed collectors, a man named Russ Crow who collects and preserves linages of heirloom beans, and 'Tomato Jim' who collects and maintains heirloom tomatoes and peppers. Seated at tables right beside each other, the septuagenarians each had hundreds of tiny plastic baggies of heirloom seeds. We asked Tomato Jim what constituted an 'heirloom' variety of a plant. He explained that heirlooms just mean a plant that is old — a variety of a plant that has been around for at least 50 years. Secondly, he told us, an heirloom plant must be open-pollinated, meaning that if one collects seeds from the plant and plants them the next year, those seeds will "grow true", meaning the seeds will reproduce the plant exactly as it was the year before. It turns out, and a huge impetus of this event, is to advocate for food sovereignty over control of local economies of open pollinated seeds. In Free Seeds and Food Sovereignty, ecologically oriented anthropologists Campbell and Veteto discuss the ways in which *"biological and legal strategies—hybridization and patenting—forced farmers into the purchase of seeds as an annual input"* [14:448] starting in the mid-20th century. In contrast, hybrid seeds, say, for corn, could produce higher yields, and thereby farmers began to rely on these seeds instead of saving seeds. This kind of intensification became more lucrative as seed companies began to patent seed technologies, which in turn attracted oil and petroleum companies, who *"could bundle sale of seeds with other requisite inputs such as proprietary glyphosate herbicide* [36]" [14:448]. In short, Farmers have turned away from seed saving due to intensification of agriculture, and events like the seed swap seek to reverse these trends.

The two heirloom vendors' tables were also covered with vast collections of beans and seeds, which we learned were tied to a history of the plants themselves, including a lineage of bean and seed collectors who they had been mentored by an inherited knowledge and seeds from. At Russ Crow's booth, bean categories such as "Bush - Dry" and "Pole - Snap" contained little-known sub-varieties such as: "fowler", "falcon" and "bird-egg blue". Every single variety of tomato or pepper at Tomato Jim's tables were labeled with a name as well as a short history and description of the variety, demonstrating how intimately Tomato Jim knew each variety and the type of care and knowing he expected seed swappers to take away with whatever variety they poached from his table (figure 3).

Figure 3: Images of seed swap. Left to right and top to bottom, images from Tomato Jim's booth, Russ Crow's booth, a native seeds educator's booth, and the Females Farming Forward booth.

Both told similar stories as to how they came to collect and cultivate heirloom plants: both worked with a mentor and then inherited that mentor's bean collection. Tomato Jim inherited his collection from a friend and mentor, Gary Millwood, who was trying to collect all of the heirloom tomatoes and peppers in Kentucky. Russ Crow inherited a large portion of his heirloom bean collection from John Withee, who is the founder of the worldwide Seed Savers Exchange. Russ told the story of how John Withee began seed saving by starting a grassroots campaign of flyers in grocery stores to find a bean he remembered from his childhood. Russ explained that Whote realized the risk of losing heirloom varieties to more commercially available seeds and started Seed Savers Exchange to preserve heritage varieties and garden biodiversity. However, on his website, Russ Crow suggests that, "beans were not only bred to nourish the body, but also bred for their beauty to feed the spirit. Indeed they do" [19]. Diversity in plant life, care and keeping of plants and their varieties not only appeals to a strictly utilitarian plan of survival, it also is part of a larger plan to enjoy the beauty of growing living things.

Seed saving isn't just an act of preserving heritage and biodiversity, according to Ben Cohen, an active small farmer and seed saver who gave a talk about saving seeds at the Indiana Small Farms Conference; seed saving is an age-old tradition that allows the farmer to actively cultivate and reproduce plants using seeds from the most delicious and hardy plants effectively co-creating and realizing the potentials of a plant through saving the seeds year over year. He likes to work with chefs to help cultivate specialty varieties by collaborating with the chef's palate. Such an approach shows the efforts farmers and communities make to notice the conditions of plants as they care and keep them year over year. In addition, the process of seed saving allows plants to adjust to local ecologies: as Cohen put it in his talk, buying seeds from a catalogue is like "pushing reset" every year, erasing any synergies that the plant varieties may have gained with the local soil and climate. And finally, Cohen mentioned that cultivating seeds acknowledges a need for constant attunement between plants and their local ecosystems as climate change shifts weather patterns and severity and shifts warmer growing regions gradually more northward. Ultimately, having genetic diversity and locally attuned plants increases the possibility of continued success of planting.

In this section, we have introduced the idea of seeds as technologies, and alluded to three variations on the idea. One is industrial agriculture's mass production of seeds as part of a broader industrial strategy of selling a complete monocrop solution, from genetically engineered seeds to carefully matched pesticides, fertilizers, and farm equipment. Another is almost the opposite: the heirloom approach, which a sort of living historic preservation project to ensure that vegetables grown next year are the same as those grown last year and, indeed, decades ago. Finally, there is an approach that sits in between, in which certain seeds are given preference year over year for bringing out desirable qualities—of taste, of local ecological fit, etc.

To appropriate a phrase from Cohen, each of these three approaches aims to "realize the potential of the plant," but what that potential actually refers to differs in each case. In the industrial case, it is easy to see all parts of the system as homogenized and managed, in Morton's language, "without conditions," because it is their lack of condition that allows them to work at scale, in field after field. The potential of the plant that industrial applications bring forward arguably is their conditionlessness. Heirloom seeds, in contrast, preserve history: this is "the same" bean that my family ate in my childhood; here they are valuable because they have been kept in an 'original condition' – where instead of the conditionlessness of engineered homogeneity it is the 'original condition' of historic preservation. However, we argue that the original condition requires love, labor and acknowledges the seed as a living history to be preserved. Finally, the preferential cultivation of seeds intentionally brings forward desired potentials, and indeed is a practice that goes back to the ancient world, an approach that depends on the seeds having conditions, so that one can pick and choose among them and decide which to reproduce into the future.

4.3 Metabolic Quality

Morton's first axiom of agrilogistics entailed a radical (and in effect violent) separation of the human and the non-human, and his second axiom asserted that non-humans lacked conditions and are viewed as an eternal 'given'. In the third and final axiom, Morton argues that while agrilogistics might sustain a large quantity of human life, it is less concerned by the quality of that life. Morton writes, *"No matter whether I am hungrier or sicker or more oppressed, underlying these phenomena my brethren and I constantly regenerate, which is to say we refuse to allow for death"* [69:51]. This extension of agriculture without concomitant extension of quality of life is exemplified by Campbell and Veteto who analyze the crops offered by commercial seed producers. They explain,

> *"During the later half of the 20th century, nutrient content of commercial crop varieties decreased as varietal research focused on uniformity suitable to mechanical harvest, good response to chemical fertilizers, resistance to agrochemical applications, and long shelf-life after long-distance travel [22]. These foci illustrate corporate prioritization of technological*

> *processing over nutritional values, human and environmental health, and availability of food to insecure populations" [14:449].*

Focusing on this third axiom, in this section, we refute this axiom by offering examples of how small farmers use agriculture to mend quality of life. They do so via two broad strategies: challenging the separation between humans and non-humans, particularly by foregrounding the metabolic links between humans and nonhumans; and also by emphasizing quality food and agriculture's role in contributing to good-feeling communities. Finally, we argue that curiosity and ingenuity small farmers employ while working on small farming techniques breaks through walls of "survivalism", showing agriculture can be used as a space of meaning-making and empowerment, perhaps providing fertile grounds for countering apocalyptic visions of climate change.

Small farmers build quality of life through posthuman communities that are deeply aware of the metabolic interactions between plants, bugs, animals and humans. According to David Goodman, a metabolic model of agro-food networks, "involve a two-step process: on the land, where agricultural nature and its harvest are co-produced and coevolve with social labor, and at the table, where these co-productions are metabolized corporeally and symbolically as food" [31:17]. Goodman here integrates metabolic processes (which might be described in terms of the chemical and biological processes of nutrition) with economic activities (physical and social labor) and sociocultural practices (the symbol of the table); here, and in doing so he establishes the link between quantity and quality of life—the full belly as the outcome of meaningful work.

The joy of feeding others was a theme emphasized in our visit to Cindy Feldman, a small rural farmer who raises sheep and chickens and has a mid-sized personal garden. She explained how part of her rationale for becoming a farmer was to feed people "good food," and she actually fed us an amazing vegetable beef soup made with carrots from her garden. To extend her offerings of good food into her local community, she partnered with three other women-run farms to open a community food co-op. Similarly, Ally Moore, a grower who runs City Farm mentioned one of the highlights of her job as a small urban farmer was building relationships with the people who have bought produce from her over the years. Sharing the products of their labor is part of the joy and community found in these small farms. Both affirm Goodman's unifying the metabolic, economic, and sociocultural dimensions of agriculture within human experience.

Amy Bennet offered a different vision of how food production can contribute to communities. Born and raised in Ethiopia and immigrating to the US in 1973, Bennet is a trained chemist who has a passion for teaching science to youth. Her desire to teach science led her to her work with a diverse array of youth, many from disadvantaged backgrounds, at her farm in Indianapolis. She attributes the farm to a student suggestion: when Bennet couldn't figure out how to get kids to care about the scientific method, she asked them what they wanted to learn about,

> *And the girl just raised her hand and said, can we plant flowers? A little girl in fourth grade and name is Jessica, she started the program pretty much. So, what had happened was, as a scientist I was like: so here is the scientific theory that's already filled in because the question was they did not like science. So how am I going to make them like it? I already had all the [study] design written and everything . . . then, right at that moment, I'm [thought] I'm going to erase everything from the scientific theory thing I filled out. They need to fill it in—what is their question?*

After realizing that to care about science, these children needed to be able to ask their own questions, Bennet founded the Farming Hands Center, which allows local children and teenagers to come be a part of a stable, caring community through farming. The farm allows students to apply science in hands-on ways, building hypotheses around plant behaviors, crafting strategies for addressing problems and getting observable feedback. Bennet described how excited the kids were to diagnose health issues in plants and alleviate them, claiming they "get so happy" when they figured out a way to get rid of insect eggs on their plants by introducing another insect that eats those eggs. STEM education is a big area of focus at the Center, and part of the value of STEM for these kids is it shifts them out of survivalism and into a more agentic mode of thinking though asking and answering their own questions. According to Bennet,

> *"These are students that have to learn to survive. Survival means, 'do what I say don't ask questions' so they don't know how to ask any questions. They don't know how to give opinions. So, that's where the scientific theory comes: perfect. [We ask,] "What is your question? How do you want to do it?'' And they will just simply look at us. Then . . . you give them a little bit, you might have to say, 'what about this?' . . . then they get it, then maybe they get it a little more . . . it's a kind of breaking in."*

Ultimately, small farmers are not only challenging agrilogistic farming methods, tools, and technologies, but they are also creating alternative value structures. Discussing what she calls, "pricy bargains" or things that cost much less than they should, Jennifer Dover, director of IUPUI Sustainability (a department dedicated to sustainability, food security and a university farm) acknowledges how, *"sometimes we talk a lot about efficiency, but ultimately sometimes efficiency becomes a race to the bottom, right? So like commercial ag is a product of efficiency, right? . . . That was the most efficient way to grow food"* suggesting that there actually is an unaccounted for cost to 'efficient' production in agriculture. Small farms are, due to scale, less able to operate with tractors and other tools of efficiency. Urban farms like City Farm, in Indianapolis, grow a huge variety of crops to be competitive at farmers markets; there is no way to achieve the economies of scale that large farms can. These small farms become efficient in fundamentally different ways, through density in crop-planting (more crops in less space), applied ecology (e.g., extending seasons through high tunnels that keep things warm, through careful application of fertilizer, though cover crops, and compost—which, unlike large farms, small farms can afford to apply at scale). These alternative scales can accommodate different value structures, avoiding fossil fuels, fine tuning fertilizer and water applications, growing diverse arrays of plants etc. As mentioned before, these farmers' size and location to community also allow them to create new spaces for provisioning like co-ops, create intimate relationships with those who are eating the food they grow, or supporting community education and healing through teaching STEM via farming.

5 DISCUSSION

In the present research, we used ethnographic work with small and urban farmers in juxtaposition with the three agrilogistic philosophical axioms Timothy Morton argues underpin agrilogistics to show how these farmers are dismantling systems of agriculture and ensuant ways of thinking (nature/culture binaries, quantity over quality) than have led to the Anthropocene and climate change. We showed how small farmers care for their soil and the communities of fungus, worms, and root systems it supports, suggesting alternatives to the law of non-contradiction. We then showed how farmers cultivate seeds, passing down collections of heirlooms that represent not only local histories, but also creating climate-resilient biodiversity infrastructures, calling into question the axiom of 'constant presence' which assumes that non-humans don't have conditions, they just 'exist'. And finally, we showed how urban farmers and sustainability experts are pushing back on value structures and seeking ways to enhance quality of life of their communities through agriculture, undercutting the agrilogistic axiom that quantity of life is always better than quality of life.

Ultimately, our research engages small, urban, and non-traditional farmers in hopes of obtaining glimpses of alternatives to practices of food production that are destructive to the planet such as those Morton characterizes as agrilogistic. Through positioning our small farm agricultural ontologies as alternatives to an agrilogistic ontology, we suggest that sustainability is a set of practices that stem from a way of thinking and that small farmers are creatively re-thinking agriculture—their practical methods for addressing climate change are undergirded by posthuman thinking and inclusion of more-than-human actors. We contribute to Social Computing and HCI research which look for opportunities for technologies to support values of small farmers, urban farmers, and community gardeners in grass roots community building, food security networking, and sustainable farming practices. The work contributes to the design of future social computing in agriculture by demonstrating the uptakes of alternatives to agrilogistic thinking to show the mutually constitutive relationships among non-human, human, nature, and technology.

In the following we discuss methods small farmers are employing which demonstrate post-agrilogistic ontologies through building empathy and intimacy with more than humans. We show how small farmers and their communities use visceral imaginaries, posthuman storytelling and curiosity as approaches for agricultural adaptation to climate change, and suggest ways that social computing researchers and technology designers interested in sustainability might support or emulate these approaches.

5.1 Touching Imaginaries

Farming at a small scale is an embodied affair. We saw it in Kevin Allison's 'in the field' photograph of crimping 6-foot-tall cereal rye by hand or the description of the youth gardeners at the Farming Hands Center's joy of discovering that deploying certain bugs in their garden could get rid of harmful eggs from a different bug. While there is a hard and fast science to agriculture, it is also so incredibly intuitive and immediately tangible – you place seeds in the ground, they grow, etc. This tangible, hands-on scientific, active knowledge permeates agriculture and has been co-opted to explain and help build imaginaries around soil health by conservationists. The principles underpinning this move offer strategies for posthuman, sustainable HCI research as well.

We saw a kind of communication design being accomplished by the Marion County SWCD and ISDA specialists in their pit digs and live soil quality demonstrations. Through these material enactments, farmers (and the public) gain visceral imaginaries of the secret life of their soil which helps farmers (and anyone really) quickly grasp how caring for soil will help their crops, but also, implants a teeming world of life (which due to its underground nature, is usually not visible to the naked eye) into their imaginations. Digging a pit might not seem like a design intervention, but we attest that we were transported by the description of the pit that had been dug into the soil of a no-till farm. We imagined the wriggling worms and grubs, the fungus communities nestling between root structures which are laden with nutrient rich nodules. Once the logic of how these other beings mesh with and support farming practices is in place, tilling a field seems violent. Suddenly, tilled dirt seemed as though it might be lonely or unwell: unsupported by roots, bugs, or microbes, drying out under the hot sun, washing away in the rain. It happens fast, radicalization via the pit dig, and perhaps one can never unsee or unhear the possibilities of the lively soil. These images were reinforced by the soil quality test where water was run through healthy soil with established root structures and unhealthy soil that was barren of life. As water collected into the healthy soil like a sponge, the unhealthy soil was quickly washed away. Such communication strategies and tools remind us of other HCI exemplars seeking to relate to other species or ecologies in tangible ways [9,55]. The small farmer touches dirt daily, but these imaginaries help them envision happy soil far below their feet and into the future. These imaginaries of soil require a commitment by the farmer to longer timeframes of cultivation and consideration. Data about soil must move beyond measures of the soil in its current state, which is a common, commercial application of soil data [68], toward long-term accumulations. Soil health is cumulative, so how might designs incentivize accumulations through visceral imaginaries that map to soil? As SHCI and social computing researchers develop embodied and novel posthuman approaches to mediating and understanding the world that decenter the human and draw attention to more-than-humans [7,9,55–57,61,87], design that reflects long-term accumulations and viscerally imagines in order to include non-humans is critical.

While soil health is easily measured through sensors or algorithms, we discovered that tangible imaginaries and touch encourage deeper care-filled connections for the 'excluded middle' of soil in agriculture and inspire longer intervals of care and cultivation than the initially obvious 'yearly' rhythm of the harvest and the seasons. Soil has emerged as a critical stakeholder, valued by small farmers and their community—adding more-than-human concerns to a canon of values already established by social computing researchers such as community engagement, food provisioning, and local and sustainable food systems [71,73,78] (to name a few). As soil health is an established way to combat the effects of climate change, taking the abstract notions of soil 'data' and translating them into tangible, visceral imaginaries and understandings might be critical for encouraging more farmers to adopt posthuman agricultural ontologies. This reconceptualization of data can be seen as a larger project within HCI to make data's ambiguity visceral and embodied. Researchers such as D'Ignazio and Klein's offer the concept data visceralization [20] to argue that data should move to more embodied understandings while other researchers suggest data can be messy, plural, entangled and embodied [2,9,24,44,63]. At the simplest level, data might be tied to ways of cultivating deeper understanding of soil health like visual images of happy root structures, bustling microbes or more macro views of the progress of a soil's subterranean thriving. At another level, this insight reminds technologists of the value of touch, embodied knowledge and tangible information to small farmers. Ultimately, we might encourage farmers to think of the soil as less a thing to manage, and more an entity to cultivate toward mutual thriving.

While data might help farmers see the world differently, views of the world shape technologies and the Marion County SWCD and ISDA specialists are inserting new data about soil into farmer's understanding of the world, creating a mythos of the soil microbe which was translated into the design of tools at City Farm. In the case of the broadfork, farmers imagine the tongs reaching deep into the earth and aerating the soil, moving it enough to decompress the soil but not turning it over or damaging microbial communities. Similarly, the tool created to fluff the top few inches of soil to prepare it for planting was specifically designed with the imaginary of how it would touch the soil in ways that would keep microbial life intact – reaching only a few inches deep, disturbing as little of the established soil groups as possible. Informed by the conservationists, small farmers designed tools to touch soil gently and not disturb the microbiome. Throughout these examples, we see that the development and use of a tool are tied not only to literal functional needs (e.g., turning soil), but also to visceral imaginaries – imaginaries that not only precede the design of the tool but that also accompany its use. As mentioned by many other HCI and CSCW scholars who study small farms, small farming is a loose community of actors who share values [38,60,73,78], practices [42,64,66] and politics [89] we extend this notion of small farm communities, seeing them as ecologically aware, fed by knowledge from conservationists which then permeates imaginaries and manifests in tool construction. The community forms a posthuman sustainable social practice [90] based in ecologically posthuman, visceral imaginaries.

There is a connection between touch, tangibility and posthuman thinking (which other researchers have picked up on as well and we have explored in prior work [8,9,45,63,82] which is vital for shifting behavior towards climate-resilient agricultural practices. While an Agrilogistic paradigm sees, in some ways, a human as 'above' the earth, there is a two-way intimacy proposed by tangible interfaces and touch in posthuman design strategies. Feminist and ecological Science and Technology Studies (STS) scholar Puig de la Bellacasa exposes this intimacy when she asks: *"is knowledge-as-touch less susceptible to be masked behind a "nowhere"? We can see without being seen, but can we touch without being touched?"* [82:97]. Digging a hole into the earth to foster visceral images of the liveliness of soil is a way of touching the earth to understand it. In turn, it touched us back but in visceral imaginary way – we now have a new semi-tangible understanding of the way that dirt works. This understanding, cultivated into the community by conservationists, shifts tools and practices and ultimately asks farmers to adhere to longer-term thinking and experiment with different ideas about economics. Investing in soil over time through either cover crops or tools is, according to conservationists, an investment in a more productive farm. Supporting and disseminating ecological, visceral imaginaries are a critical move in breaking a loop of agrilogistic farming in part because they are economically viable alternatives.

5.2 Posthuman Storytelling

Interestingly, when given visceral details or imaginaries of the lively nature of dirt, farmers were able to build scenarios for those microbes, imagining their lifeworlds and how to best work with them in a kind of tool-mediated partnership. In terms of story or world building, as ecologies are brought to life in people's imaginaries, a map of possibilities begins to expand across space and time. For example, in visiting the Marion County SWCD experts, we discussed how the Midwest used to be predominantly wetlands and how much land has been transformed by agriculture, while acknowledging that wetlands critically factor into water filtration and ecological well-being. Thinking of these longer, geological time scales helped us collectively start to see a picture of land use over time, and a kind of narrative emerged. As conservationists we spoke with mentioned, existing policies attempt to reclaim land for wetlands, but part of the challenge of these policies is getting participation. Storytelling and use of the visceral imaginaries and land-histories could potentially help farmers see their placement in a lineage of past and future land quality, expanding the scope of agricultural ontology.

Stories for conservation, reclamation and collaboration with more than humans – all projects necessary to begin to address climate change and sustainability – arguably take on a posthuman quality, in order to break with nature/culture binarism. They require that we see ourselves not divorced from some 'pristine' imaginary of nature. Instead, we are actually quite involved in co-production and care of ecologies. We do so not only as responsible caretakers for the land, but more fundamentally in learning to identify with the land, as a reader identifies with a literary protagonist. Seeing a healthy farm as a narrative's protagonist partly anthropomorphizes it; that is, audiences can relate to a farm (or the land, an ecology, or the Earth itself) as a character-like entity with a past and future, needs and capabilities, actions and desires—and yet the farm in such a narrative never literally becomes humanoid. As with ancient mythology (e.g., Poseidon as the god of the sea), natural phenomena are given names and stories in which they are always human and not-human at the same time. The post-human character of these literary entities provides them the capacity to change and to grow, that is, to have conditions, while preserving their salient features, such as how they need, absorb, and filter water, or how they sustain microbiological life.

Into such a storied soil go seeds, and we have already seen that seed (hi)stories are as complex and diverse as that of the soil in which they come to life. All seeds for farming are in some way artificially produced and are a collaboration between farmers and plants. In the case of heirloom seeds, their histories are preserved along with their genetics as they are carefully passed down from mentor to student. Here storytelling is a collaboration between the seed collectors, who act as storytellers of the seeds, which like books, contain the coded biological histories of plants inside their covers. Interestingly, this history must be grown to be kept—the seeds must become plants to produce a new generation of seeds—a continued collaboration. While we, as humans, often think of our histories as passed down through language, this example demonstrates that histories are inscribed in insects, plants, or DNA, that is as living bodies in the world.

In another seed saving tradition, one espoused by seed saver Ben Cohen, farmers cultivate plants by choosing the seeds from the best plants for a variety of reasons, from being resilient to climate to being delicious to chefs. This activity is analogous to that of literary criticism—of experts identifying what is best and seeking to preserve that across generations. The analogy may seem fanciful, yet the English word "culture"—and its etymological history—has been used to describe the arts and biology alike (e.g., we "cultivate" literary taste as well as cell cultures). In fact, Morton, quoting Derrida in Of Grammatology, suggests culture is inextricable from agricultural cultivation, *"The furrow of agriculture, we remind ourselves, opens nature to culture (cultivation). And one also knows that writing is born with agriculture which happens only with sedentarization."* [23:287] Nature, culture, agriculture: the terms are linked historically and philosophically" [69:82]. These collaborations between farmers, climate, artisans, and their communities show that human history/culture/tradition is inextricable from human collaborations with plants.

We came to view the seed as a kind of biological history book as well as near future cyberpunk novel that both challenges the idea that 'plants just happen' (the axiom of constant presence) and also the notion that humans are at odds with nature – or that 'nature' isn't part of culture [34]. Through our research, we came to understand that seeds are technologies not only for terraforming soil, as suggested by cover crops, but for serving as a medium of cultural preservation of the joint history of humans and plants, as well as critical protagonists in how agriculture can be resilient to climate change, as it is critical to preserve biodiversity and cultivate locally resilient seed strains. Seeds house both histories and futures simultaneously in a single package. As the wind distributes seeds, spreading life across the land, so these histories also spread imaginaries over space and time, as seeds are passed down through families or mentors. We argue that one role for future HCI research is to contribute to the cultivation, storage, performance, and dissemination of the biological matter, histories, and imaginaries that constitute these posthuman narratives.

This impulse to give voice and histories to plants [37,40] or speculatively bridge the plant-human language barrier [88] has begun to emerge in HCI and CSCW research, and we commend and extend these efforts. Seed savers are positioned by Hetlinger et al. as "guardians" who look over seeds [37]. We also see seed savers a kind of guardian, a historian who guards the mythologies of the long-entangled human/plant co-evolution which is important to future survival with climate change. A critical position in posthumanism is a de-linearization of history and futures [50] and we see this as well with seeds. As many non-SHCI authors have stressed, open pollinated and local seeds are a source of freedom and power for communities by disentangling them from seed monopolies and moving back towards local self-reliance [14,41] as well as being vital for survival in climate changed futures. A posthuman approach to seeing the conditions of seeds as intertwined the history and fate of peoples moves beyond strategies to know about plants or talk with them [40,88] to strategies to mobilize and respect plants and seeds as co-conspirators in future survival. To move from a human-centered or agrilogistic approach to thinking of the intersection of seeds and technologies toward a posthuman centered approach, we argue that in addition to of thinking of seeds as objects to be utilized, we must see them as containing collaborative histories and futures – another varied refrain on collaborative survival [55]. Liu et al.'s concept of collaborative survival focuses on foraging—a subject 'outside' of the bounds of 'culture'. Seeds and farming reflect a closer and more blurry territory, somewhere between pure 'nature' and pure 'culture'. Here nature has been tamed and we must now remember how to respect it as vital, alive and a collaborator. While seeds have been used as technologies of intensification, and technology employed to help intensify seed management, production and distribution, we ask IT might also support posthuman histories of seeds that acknowledge cultural heritage, place, and twining interactions of cultivators, break down the human/non-human binary, and germinate climate-aware and biodiverse futures for agriculture. Any posthuman future must grapple with the past. Radical models of innovation might offer novelty not through 'newness' but through how they reclaim community, place and power. How might technologies be designed to highlight how humans are intimately linked to the histories of cultivation and futures potentials of the conditions of seeds, breaking from or providing alternatives for intensified models of seed production and monocrop agriculture? How might seed economies of scale and de-conditioning of seeds be challenged by views of seeds as deeply storied and co-constitutive with human histories and futures? We see this as shifting from information technologies that tells us about plants to information that tells us about our becoming with plants offering informational hubris and hope.

5.3 Beyond Survival: Curiosity

Technologies that utilize visceral imaginaries and embrace posthuman storytelling offer playful openings of new possibilities. By using touch and narrative experiences to explore the vibrantly lively worlds of soil and gaining understanding of more-than-humans through visceral imaginaries, instead of asking 'how can the world not die' we are asking 'how can we design tools or methods to help the world be more vibrantly alive'? By asking questions like 'where did that bean from my childhood disappear to' seed saving has been transformed into a kind of living history of the intersections between peoples, the locations, their cultures and their plants—which shifts questions from ones like, 'how did we kill the world', to, 'what are the ways we have shaped and been shaped back by plants for a long time and how can we continue to celebrate our histories passed down and encapsulated in seeds?' –for example.

In the words of Amy Bennet, mentioned above, asking questions helps the youth that she works with get out of a survivalist mentality. The kids she works with lead difficult, even traumatic lives (she mentions many of them have witnessed violence or don't have a stable place to store or cook the food they grow together). According to Bennet, such traumas have placed the children into a kind of mental freeze—an attitude of just doing whatever it takes to survive. In the application of the scientific method to farming, the kids, perhaps for the first time in some of their lives, are being allowed the space to be curious. This mentality permeates the Farming Hands

Center from its very inception where she allowed a little girl to suggest a scientific area of focus: growing flowers. Curiosity framed in the scientific method where the youth can ask a question, create a hypothesis, and test it, gives them agency to wonder if other things might be affected by systematic questioning and trials. In this way, curiosity builds agency, unfreezes survivalism, and orients children toward learning and discovery. We saw other examples of a curiosity and imagination-driven agricultural inquiry throughout our research as well: when farmers at City Farm wanted tools to not disrupt the soil microbiomes, they crafted such tools themselves. When Cindy Feldman farms to bring people good food, she not only feeds the guests in her home, she collaborates with other local farmers to create a local food co-op that sells locally produced food and products to her community.

These examples showcase the care that comes through farming, care for more-than-humans and humans simultaneously. The acknowledgement of a metabolic system requires such care ethics to emerge. While Morton suggests all agriculture is agrilogistic, we found through ethnographic research, on the ground and closer to a non-stereotypical array of farmers who are women and serve marginalized communities, radically different agriculture paradigms emerge where care is paramount and less-overtly efficient models emerge. Returning to curiosity, curiosity is a kind of care that also has ethics. Asking questions takes time. By allowing questions to be asked, a process is subject to revision, to slowing down and to messiness. The models of agriculture promoted by intensification seek always to streamline, automate, expand and become more efficient, which, outwardly might seem advantageous. But in a metabolic agricultural system, especially one that is undergoing climate change, the agility and curiosity of small farmers might be more successful in the long run as their practice of questioning, testing and listening, lends itself to on-the-ground solutioning and innovation. In this way, we see that grassroots technological innovation is well positioned to revolutionize agriculture.

Prior CSCW and social computing research has focused on the ways small and urban farmers reach out to their communities and help reshape values as well [71,78,79,89]. Most notably, the concept of tiny publics [89], or loose, pluralistic, political orientations in small farm communities, was reflected in our findings. We saw the full array of interlocking pieces at events such as the seed swap and small farm conference. Much of the work that small farmers do is run as a non-profit or as charity like the Farming Hands Center. Farmers who operate as production farmers are under stress to be financially viable. Small farming can be self-exploitative [67,84]. So while understanding metabolic relationships with the land and food and stabilizing food systems through local food economies is another way that small farmers stand in contrast to agrilogistic paradigms and offer resilient strategies against climate change we ask how IT can support these grassroots efforts which in turn, support their own communities. We believe our research suggests that designing for these small, local food growers and their communities, with attention paid to posthuman, metabolic values, we are positioning these farmers to be competitive and viable alternatives in climate changing futures. Prior HCI research has shown, and we reflect, that community is one of the cornerstones of local farming and conservation movements. To avoid the ‘freeze’ of survivalism, social computing technologies for sustainable agriculture should also support playful and explorations by small farmers and their communities which allow them to ‘ask their own questions’ and be curious – social computing systems ready for appropriation or prototyping or open-ended discovery. Tackling climate change requires the inclusion of more-than-humans in community thinking and pluralistic exploration of alternatives.

6 CONCLUSION

We began this work with the conundrum of how interconnected large-scale, industrial and intensified agriculture is with climate change and how susceptible it is to the impacts of climate change. We have offered insights, through analyzing small farming practices using Timothy Morton's agrilogistics framework, to understand the ways in which small farmers are employing posthuman strategies that have the potential to disentangle agriculture from its imbrications with climate change. By contrasting ethnographic findings with Morton's concept of agrilogistics, we moved from a high-level philosophical framework, which has many insights, and which has also been critiqued for its limitations, to the level of the embodied and lived practices of an array of small famers and their community. Through this we began to complicate Morton's claims and clarify ways in which small farming communities cultivate and implement alternative agricultural ontologies in ways that are partial, iterative, loosely collaborative (grassroots), and exploratory. We move from Morton's 'big picture' to nuanced accountings and strategies for designing technologies in posthuman ways. This approach scoped our thinking by tying us to Morton's framework and explicit focus on posthumanism and agricultural ontologies, but simultaneously, it gave us the structure to thoroughly reflect on these two things. We discussed how small farmers have practical methods for addressing how agriculture contributes to and is vulnerable to climate change such as soil restoration, seed saving, and curiosity, and these practical approaches, when observed through posthuman and agrilogistic lenses, show alternative ways of understanding more than humans through embodied knowledge, tangible imaginaries and expanded histories and futures which intimately include more-than-humans. In other words, the pragmatic solutions of small farmers are scaffolded on tacitly different ontologies of agriculture than that of agrilogistics. Ultimately, we would like to suggest that solutions to climate change are action-oriented, and these actions need to consider subtly shifted ontologies, geared towards seeing non-humans as dear and important collaborators in climate changed futures. The design of social computing systems in sustainable agriculture must attend to these subtleties and support posthuman farming practices through the inclusion and integration of the lives and care of more than humans to build subsistence in order to begin to combat the effects of climate change.

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