Symbiotic Encounters: HCI and Sustainable Agriculture

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ABSTRACT

Recent sustainable HCI research has advocated "working with nature" as a potentially efficacious alternative to human efforts to control it: yet it is less clear how to do so. We contribute to the theoretical aspect of this research by presenting an ethnographic study on alternative farming practices, in which the farm is not so much a system but an assemblage characterized by multiple systems or rationalities always evolving and changing. In them, relationships among species alternate between mutually beneficial in one moment (or season), and harmful in the next. If HCI is to participate in and to support working with nature, we believe that it will have to situate itself within such assemblages and temporalities. In this work, we look into nontraditional users (e.g., nonhumans) and emerging forms of uses (e.g., interactions between human and other species) to help open a design space for technological interventions. We offer three ethnographic accounts in which farmers—and ourselves as researchers—learn to notice, respond, and engage in symbiotic encounters with companion species and the living soil itself.

CCS CONCEPTS

• **Social and professional topics** → Sustainability; • **Human-centered computing** → Empirical studies in interaction design.

KEYWORDS

Sustainable HCI, farming, posthumanism, Anthropocene, assemblages, noticing differently, companion species

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1 INTRODUCTION

We are living in an age of substantial environmental crises: climate change, water pollution, soil depletion, biodiversity loss, and food crisis, just to name a few. In sustainable HCI, there are several ongoing threads aiming to address environmental concerns: one develops theories and methods to support sustainable interaction design practices [9, 10, 16, 63, 73–76, 83, 84], another focuses on human-food interaction, including farming, cooking, consumption, distribution, and disposal [11, 33, 39, 47, 57, 67, 82]. Many have argued that building a more resilient future requires a broader shift of perspective than monitoring and regulating individual behaviors [1, 14, 23, 24, 56, 71]. In response, some propose considering the macro sociotechnical context within which individual behaviors are situated [14, 24, 60, 71]; others call attention to collective activism and community engagement in supporting sustainable food practices [16, 57, 82]. And a relatively new thread draws from concepts in posthumanism to incorporate the perspective of nonhuman others, such as animals, plants, and fungi [46, 51, 54, 80].

Nonanthropocentric HCI scholars argue that human-centered design approaches are not sustainable, and in fact they are catastrophic. For example, in the pursuit of labor efficiency and greater yields, industrial farming has developed high dependency on fertilizers and pesticides. Without adequately taking the capacity and adaptability of the environment into consideration, these practices have resulted in the production of drug-resistant pests and virulent diseases. To address the problems caused by human domination, HCI and design researchers have proposed de-centering humans in design [22, 26, 54, 80]. By de-centering humans, they do not mean to negate humans; on the contrary, it refers to placing

humans in the ecology along with other species, a realization that humans are neither detached from nor in control of worldmaking. In other words, nonanthropocentric HCI reorients our attention from a human-centered agenda to a multispecies worldview [86].

As researchers who identify with this non-anthropocentric research agenda in HCI and design, we also recognize how far we are as a field from achieving our collective potential in this area. Today, several theories have been explored and applied in HCI-natureculture [50, 55, 72, 80], posthumanism [13, 38, 44, 89], global assemblages [17, 18, 53]—but that as a community we've only just begun to unpack how this will translate into in HCI theories, methodologies, and findings.

We contribute to this developing nonanthropocentric HCI agenda through our ethnographic work on farms in Taiwan. These produce food sustainably in part by building on symbiotic encounters between humans and non-humans, including insects, weeds, snails, and food waste. Guiding the study itself and our presentation of it here are a set of theories from posthumanism and multi-species thinking, in particular, Donna Haraway's notion of "companion species" [35, 36] and Anna Tsing's practice of "noticing differently" [85]. We apply these theoretical resources to support our interpretation of our ethnographic data. These theories help us to construct a perspective that enables us to provide images of human/non-human collaboration, exemplifying how humans and natural environments can cooperate for mutually beneficial ends. In doing so, we consider our contribution to be two-fold. First, we respond to the call of de-centering humans in sustainable HCI by making posthuman concepts more tractable, grounded on our ethnography. Second, we analyze our ethnographic encounters with a layer of abstraction concerning how these concepts and our empirical study might bring new, nonanthropocentric perspectives to different research interests in HCI, including potential roles for technology to support symbolic encounters, as well as ways that HCI methodologies might themselves be influenced by this work.

2 BACKGROUND

We position this work broadly within the domain of sustainable HCI, and more narrowly within a body of recent research pushing beyond human-centered approaches to HCI.

2.1 Sustainable HCI

According to U.N.'s 2017 annual report, approximately 821 million people are living in hunger, comprising 11% of the global population [64]. Food crisis is a complicated issue merging together problems of climate change, urbanization, and various forms of pollution and resource depletion [65]. Recognizing the complexity of building a sustainable food culture, Choi and Blevis [16] call for transdisciplinary collaboration and argue that building a resilient future requires "an iterative and evolutionary process involving interactions amongst people, place, and technology." We find this framework helpful because it breaks down an intricate issue into three domains to make it more workable.

Farming research in HCI has explored different sociotechnical environments where sustainable food practices take place. Work in urban agriculture focuses on encouraging community engagement, collective activism, and citizen science [16, 39, 40, 67, 68, 82]. For example, Odom's [67, 68] work on urban community gardens reveals the members' resistance in implementing technologies in their gardening practices but are widely interested in bringing visibility to urban agriculture sites through web campaigns and workshops. Steup et al.'s [82] study shows that small-scale farmers collectively act as a "tiny public" to shift food sovereignty away from large supermarket chains to local food producers and policies. Other researchers have looked into farming in rural areas or developing regions where the cultural-material constructions are distinctive to the ones in urban spaces. This line of research tends to address challenges in technology accessibility and adaption [31, 61, 69, 81, 88]. For example, a recent study in rural Kenya by Oduor at al. [69] suggests that rural farmers are interested in accessing farming information that increase yields (e.g., soil fertility, distribution of irrigation water, and sales opportunities); however, they are less tech savvy and require more knowledge in order to utilize ICT technologies.

We are inspired by the current corpus of farming research in HCI because they fuse cultural, political, economic, and technical concerns to construct a broader understanding of sustainable food practices. However, if we go back to Choi and Blevis's framework [16], we see that people and technology are often at the center of analysis. Instead, the notion of place is often loosely described in terms of its cultural-material constructions. What is often backgrounded is how nonhuman stakeholders—insects, pests, wild plants, bacteria, microorganisms, and other critters—come into play. Although nonhuman stakeholders comprise the major landscape of the farmlands, they remain relatively passive and static in participating and shaping food cultures.

There are a few exceptions. For instance, in the spirit of creating sustainable global food systems, Raghavan et al. [74] turn to agroecology: an farming method that leverages ecological principles (e.g., the flow of natural resources, the rhythm of growth) to produce high yields

while reducing negative environmental impacts. Similarly, Liu et al. [56] propose using the permaculture philosophy of working with nature to replace the traditional control model in industrial farming and sometimes in the agenda of sustainable HCI. This line of research has made explicit that the natural environment—its rhythm, capability, limit, and agency—bear potential in shaping sustainable food culture. In the present work, we seek to surface the multispecies world in the farms. Specifically, we are interested in unpacking the interactions between human and nonhuman stakeholders.

2.2 Strange Companions and Symbiotic Encounters

HCI researchers have in recent years directed attention to the concept of Anthropocene [20] to understand and account for the impact of humanity on the planet. Specifically, several research proposals have advocated for the decentering of the human in technological design because human exceptionality is problematic, and both human and non-human shape complex socio-technical entanglements [21, 22, 26, 45]. For example, Smith et al. leverage key concepts in the Anthropocene—naturecultures, hybrids, and decentering the human in design—to develop design strategies that refigure human-animal relations to support cohabitation and presumably even redefine cohabitation [80]. The posthumanist concept of "collaborative survival" was the jumping off point for Liu et al. to design a set of wearable tools for mushroom foraging, and in the process, explore what post-anthropocentric design could mean [54]. Light et al. challenge the prevailing "bovine design" model that compromises the needs of other species in service of human superiority. They call for the turn to the more-than-human world because it is "… the least we might do as we strive for the grace to accompany fellow-species towards their own (and perhaps our) extinction." [51]. How might HCI research and design reconfigure itself to design for humans and nonhumans in a relational perspective?

As a response to these challenges, we have taken up two alternative analytical sensibilities from anthropology and posthumanist scholarship: Anna Tsing's "noticing differently" and Donna Haraway's "companion species" [35, 85]. To introduce her understanding of "noticing differently," cultural anthropologist Anna Tsing recounted her own experience learning polyphony, a style of music combining two or more individual melodies together. She recalls, "when I first learned polyphony, it was a revelation in listening; I was forced to pick out separate, simultaneous melodies and to listen for the moments of harmony and dissonance they created together" [85, p.24]. "Noticing differently" refers to the ability to acknowledge and simultaneously step in and out of multiple simultaneous frames of references. We can attend to a single thread or a relationship. Sometimes those relationships are temporary but effective nonetheless. As we will show, noticing differently can mean perceiving the potential of a temporary relationship and developing—or, more literally, cultivating—it. We view these as symbiotic encounters, building on Tsing, who writes:

> Twenty-first century research on organisms ranging from bacteria to insects to mammals has shown that symbiosis is a near-requirement for life […] our bodies contain more bacterial cells than human ones. […] Life, put simply, is symbiosis 'all the way down.' As Donna Haraway suggests, recognizing the importance of symbiotic makings is just the beginning of 'staying with the trouble.' Symbiotic relations must be constantly renewed and negotiated within life's entanglements [86, p.M5].

The farmers we studied are engaged in this work of renewing and negotiating within the entanglements that constitute their farm plots, in some cases even referencing contemporary theories of the Anthropocene.

A related concept is that of companion species, offered by Donna Haraway [34, 35]. This concept emphasized moments when species meet, "species interdependence is the name of the worlding game on earth, and that game must be one of response and respect. That is the play of companion species learning to pay attention. Not much is excluded from the needed play, not technologies, commerce, organisms, landscapes, peoples, practices" [35, p.19]. Accordingly, companion species is about interspecies relationality, calling our attention to the present when "myriad unfinished configurations of places, times, matters, meanings" take place [36]. The call for the cultivation and sustainment of the companionship between human and non-human go beyond the domesticated and include all non-human actors, including plants, molds, bacteria, and even those that pose a threat to humans.

3 RESEARCH LOCATION AND METHODOLOGY

We have been researching bottom-up innovation, creative industries, and entrepreneurial life in Taiwan since 2011. The present work draws from and is informed by our long-term fieldwork, documented in [5, 7, 29, 30, 53, 56]. In the context of this paper, we foreground the ethnographic field research we conducted between June 2017 and August 2018 in two farming villages in rural Taiwan.

Sites. Pinglin district and Yilan counties are known in Taiwan as hubs of agricultural experimentation. Many farmers in the two sites engage in eco-friendly farming,

small-scale farming, organic farming, and AgTech farming. Common among them is the commitment to explore and practice alternative farming activities to unsustainable industrial agriculture, with a particular focus on reducing the use of pesticides in farming and integrating more harmonious between land, people, environment, and resources. We provide some background on each below to situate our findings.

Pinglin, a rural town in Taiwan, is located in the mountainous area in the south of Taipei City. Here, 80% of its residents are involved with tea-related activities on a daily basis, including growing, processing, managing, and trading [42]. Tea trees are prone to pest attack, so conventional tea cultivation relies heavily on pesticides and fertilizers to ensure the beauty and juiciness of tea leaves, and the quantity of tea that can be harvested in any given season; however, because of Pinglin's unique geological location, local tea farmers work closely with government administrations (e.g., Agriculture department in New Taipei City government, tea research and extension station under Executive Yuan), research institutions (e.g., National Taiwan University Graduate Institute of Building Planning), and non-profit organizations (e.g., Tse-Xin Organic Agriculture Foundation) to experiment with different ways of cultivation [15, 28, 91, 94]. While less than 1% of farms in Taiwan are certified organic, 6% of these in Pinglin are [15].

The second site is Shengou Village (深溝村) in the rural Yuanshan township of Taiwan's Yilan County. In recent years, Yuanshan township has seen a surge of new generation of farmers, many of whom are young (20s-40s), former city dwellers and professionals (e.g., lawyers, engineers, biologists, cultural anthropologists, media producers, designers, and architects) with advanced degrees. Shengou Village is especially known for "小農群聚" (small farmer collectives) who express a desire for a different kind of human-land relationship: they practice and experiment with alternative farming techniques and principles to address ever-increasing deleterious environmental impacts [4].

Data Collection. Our data included fieldnotes, photos, audio recordings, and artifact collections from farmlands which included flyers, catalogs, and booklets farmers created to promote their products, community-building activities and events among others. Interviews were conducted in Mandarin Chinese, and the English quotes in this paper were all translated by the authors. Two of the authors are native of Taiwan and native speakers of Chinese; the other, born in the US, has conversational competence in Mandarin. Our interlocutors include farmers, residents of farmlands we visited, agricultural policy makers in Taiwan, and more. Since Taiwanese farmers engage in activities and practices both off line in person and online virtually (e.g., announcing events, exchanging how-to tips, and documenting and sharing farming activities in forums and social media such as Facebook), it was necessary to engage with subjects in their own terms, so we also employed a set of digital ethnographic approaches[12, 41, 59, 62] to examine how experimental agricultural activities and interaction unfolds virtually and how farmers interface with others outside of the farming communities, including other farmers and consumers. We developed a customized scraper tool to automate the collection of posts and comment threads from Facebook, with individual items numbering in the tens of thousands.

Interpretive Procedures. The research team conducted data analysis through a procedure known as *explication de texte* [70], or close reading, an analytical method originating in the humanities [3]. Two of the three researchers involved in the analysis have doctoral training in the humanities and are experienced with this analytical practice; the third is a design ethnographer who is 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's 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—mutually informing one another until a picture emerged that seemed to fit with participant discourses and activities, our inquiry goals, theoretical resources, and our own experiences.

4 EXPERIMENTS IN SYMBIOTIC ENCOUNTERS

In the following sections, we offer three accounts from our ethnographic work focusing on symbiotic encounters. As is common in critical intellectual traditions, we move from relatively descriptive accounts of our object of inquiry (to establish a basis of mutual understanding) towards increasingly interpretative ones (to develop our original contribution). Thus, each of our vignettes is initially descriptive, while more interpretative claims are offered later, particularly in the Discussion.

4.1 Oriental Beauty and the Frog King's Beast

The fieldwork took us to organic tea farms in Pinglin in the summer of 2017. Tea farmer Chen Lu-He (陳陸合), a Pinglin native, spent much of his career at Panasonic before retiring and returning to his hometown to take up farming. Chen was financially stable at this phase of his

life, so he wanted to experiment with ways that he can give back. Chen is known for being a pioneer in organic farming in Pinglin, nicknamed the "frog king" for his dedication to preserving local environment and wildlife [93]. We visited Chen's Green Light tea farm, which sits on top of the mountains overlooking Beishi River, one of the water sources of the Feitsui Dam that a quarter of the total population in Taiwan relies on.

Previous research [15, 78, 79, 92] has shown that Taiwan's world-famous oriental beauty (東方美人茶) and honey scented tea (蜜香茶) are the a result of tea farmers having an effective relationship with non-human actors (in this case, bugs) in tea cultivation. In fact, oriental beauty and honey scented tea become popular because of a distinctive fruity and sweet-like-honey aroma during brewing. These aromas are triggered by Jacobiasca Formosana (小綠葉蟬), a small leaf hopper that feeds on tea buds and leaves. Chen showed us how to recognize the "infected" leaves (Figure 1):

> This leaf has been stung by the leafhoppers, that is why it's yellow and stunted... if you don't use spray pesticide you will see these leafhoppers in the tea farm.

Figure 1: The yellow and stunted foliage in the back is infected by leafhoppers; the ones rolled up are the nests of the tea tortrix; and those with burning dots have been attacked by stink bugs. Photo taken by the authors.

The leafhoppers are extremely small, measuring just 0.1-inch-long, making it hard to be detected through naked eyes. Farmers in Taiwan often call them (in the Taiwanese dialect) ian-a (蜒仔) or fuchenzi (浮塵子, written as "floating dust" in Chinese) to illustrate their diminutive size and prevalence during summer and autumn when their population peak [87]. Chen pulled out his phone to show us a close-up of this insect. He also showed us the needle-like proboscis of the leafhoppers, which penetrates the tissues of the tea leaves for its juice. The insect-bitten tea leaves produce two kinds of chemicals: one is the so-called ian-a smell (蜒仔味), which attracts spiders that eat the leafhoppers; meanwhile the plant produces another chemical repair the damage to its leaves, causing a chemical change in the leaf that results in the natural honey scent during tea brewing.

Recent biochemical studies indicate that the damage done by the leafhopper activates a defensive response and significantly increases a fragrant compound, which contributes to the sweet note of the tea [25, 78]. It is worth noting that the quality and quantity of tea depends heavily on the leafhoppers—the damage has to be done in the right amount and at the right time, because tea leaves of different ages react differently to the same bite, and too much damage increases the bitterness of the tea [79].

Cultivating oriental beauty and honey scented tea thus involves an intricate interaction between farmer and the non-human world, where leafhoppers are key actors. While leafhoppers cause physical damage to the foliage and reduce the yield of the season, they also contribute to the production of the distinct honey aroma, making the tea a highly sought-after commodity. They also attract the spiders that prevent their overpopulation—solving two difficult and unrelated problems at once.

Organic tea farmers in Pingling actively facilitate an alternative engagement with the natural environment by relinquishing control, including the use of both fertilizers and pesticides. In her exploration of permaculture movement as an alter-biopolitical intervention, Maria Puig de la Bellacasa describes permaculture ethics as the engagement with

> the consequences of living in naturecultures, recognizing the interdependency of all forms of life—humans and their technologies, animals, plants, microorganisms, elemental resources such as air and water, as well as the soil we feed on. It thus decentres human ethical subjectivity by not considering humans as masters nor even as protectors of, but as part of earth's living beings. [72, p.152]

In the case of tea farmers and leafhoppers in Taiwanese tea farms, by decentering the needs of the human (i.e., maintaining bugs-free tea farms), a different relationship between the non-human and human emerges, one that is based on appreciation, affection, and responsibility as opposed to interspecies conflict and competition.

A skeptical reader might consider Chen's tea farm as yet another example of control—one that is carefully arranged to attract leafhoppers to consume the foliage, triggering the defensive mechanism in the leaves to release a unique honey scented aroma and elevate the value of the tea. A recent agriculture research project attempted to generate the unique honey aroma and mass produce oriental beauty by injecting tea leaves with identical chemical compounds

that are original produced by the leafhoppers [78]. In this counter scenario, humans replicate and take full control of the production of honey aroma mechanism in a lab setting, taking the leafhoppers and spiders out of the equation completely. The difference between the two models is clear: while one focuses on instrumentality, requiring less time, and thus ensuring greater and more reliable availability of the honey scented teas, the other is about cultivation and sustainable collective caring, an aspect of permaculture we shall turn to in the next section. It is a feature—not a bug [sic]—that humans derive immediate benefit as well as the non-human participants.

4.2 The Weed Hacker

Moving back to Shengou Village in Yialn, we worked with Chen Xing-Yan (陳 幸 延), a 30-year old engineer-turned-farmer who settled in the village four years ago. Xing-Yan is the founder of Open Hack Farm, a group of farmers and technologists dedicated to leveraging open source and LASS (location aware sensor systems) to innovate on agricultural productivity in a sustainable way. For example, he developed "Farmer's Helper," a chat bot to help farmers obtain information about the weather and suitable crops to grow in a given season. The chat bot also offers alerts on extreme weather conditions (e.g., thunderstorm) and possible pest attack. The Facebook group for Open Hack Farm has 1400+ members, and similar AgTech groups in Taiwan such as Smart Agri, AgriHarvest, Data-driving Farming, and Agricultural Technology Research Institute have combined followers measuring over 75,000.

Sitting by the ditch of a country side road, Xing-Yan's field appeared to us more like a wasteland than a farmland: hundreds of crops, flower, trees, and weeds all jammed together in a 0.24 acres space, and it was hard for us to distinguish the wild from the cultivated. Xing-Yan's field creates a sharp contrast to the ones surrounding his: those feature rows of crops, demarcated walkways, wooden scaffolds that support the climbing plants, and screens covering the crops that are vulnerable to pests. One might easily mistake Xing-Yan's field as an abandoned land with little sign of human attention. Xing-Yan nicknamed his garden 草草瞭事 (cao cao liao shi), which sounds like the Chinese idiom 草草了事 (literally doing things hastily and carelessly). The play on the words is significant: Xing-Yan did not use the character 了 for "do" or "act" originally used in the idiom; instead, he substituted in the character 瞭 that sounds like (and almost rhymes with) "understand," but suggests appreciation—notions of intention and care, the exact opposite of what the idiom connotes. Indeed, by working alongside Xing-Yan during our multiple visits to Shengou Village, we came to understand Xing-Yan's unique farming practice, including how he understands what constitutes "harmful" plants in his field and how he responds through special practices of weeding and composting.

We joined his weeding routine in a hot and humid summer afternoon in 2018. Weeding to Xing-Yan is not about removing all the non-crop plants from his field, only the ones in the Poaceae and Cyperaceae families in plant taxonomy, because they reproduce in a fast pace and can easily dominate the farmland. Plants in the Poaceae family are easily recognized because of their prickly leaves. Xing-Yan explains,

> these plants produce thousands of seeds in a single plant, making it extremely difficult to remove [...] I prioritize the Poaceae family when I weed. And of course, it is not enough to be selective in weeding, you also need to refine the soil to make it suitable for more advanced plants to grow, so they can compete against the Poaceae family.

He made a comparison between his and surrounding fields:

> If you compare my field to the ones next to mine, you can see all the weeds in those are the prickly kinds [...] I've already done several rounds of weeding, so there are not so many Poaceae plants in my field. Although it's pretty messy right now and needs more work to clean it up, the remaining weeds are the ones with broad leaves, even ferns.

These weeds, in Xing-Yan's eyes, are companions to the crops he is growing (the word he uses is 共伴, literally "to accompany" or "to be a companion"). The practice of "companion planting" in agriculture traditionally refers to the planting of different crops in proximity for a variety of different reasons, including maximizing the space, pest control, pollination among others. Native Americans, for example, planted corn, beans, and squash together, referring to them as the "three sisters," because they complement and enhance each other [49]. Companion planting is a common strategy in polyculture (defined as the use of multiple crops in the same space) and permaculture (an agricultural philosophy that aims to leverage patterns seen in the ecosystem) as a way to cultivate and maintain biodiversity. Here, Xing-Yan extends that logic to weeds, instead of planting other crops in his field to increase yield, he regards weeds as "companion crops" ("共伴") to his rice because they cover the soil to maintain its moisture, offer shelter to the critters in his field, help compete against the invasive weeds, and provide sugar glucose through photosynthesis to feed the microorganisms in the soil. It

might not, on first glance, be much to look at, but as [86] argues, "Co-species survival requires arts of imagination as much as scientific specifications."

Another time we returned to find Xing-Yan weeding and composting. Xing-Yan insisted on using his own hands rather than machines to ensure that the roots of these plants are clear and the damage done to the soil is minimized. He compressed the weeds he removed from the field into many bundles. Two days later we returned to Xing-Yan's field to observe and participate in his composting practice. In the front of the field sits a large area covered by black tarps. Xing-Yan had placed wood planks, tree branches, and farming tools on top of the tarps to prevent them from being blown away by the wind. The weed bundles he removed from the field a few days ago—most of them were now brittle due to the burning sun—also sat on top of the tarps (Figure 2). Underneath the tarps was a large pile of compost soil—black, moist, fine, and abundance of living lives such as ants, earthworms, and centipedes. The soil was made from weeds that Xing-Yan removed from his field before: the ones belong to the Poaceae and Cyperaceae family. We transported some of the old compost soil to a plastic bin for storage. The plastic bin was divided into two separate storage spaces, measuring approximately 30 inches wide and 60 inches long each. Xing-Yan then plowed the leftover compost with the rake to let it breathe; the weeds that we collected two days ago were then added to the pile, creating a fluffy texture.

Figure 2: The haphazard appearance of Xing-Yan's farm belies its sophisticated arrangement of recycling and care. Photo taken by the authors.

Xing-Yan told us that water is an essential ingredient in facilitating the composting process but not the most important. He headed toward a blue bucket resting at end of the compost by the ditch. The liquid inside the bucket was dark, and it immediately filled the air with a nasty, rotten odor when cover was removed. Xing-Yan poured a scoop of the dark liquid to the weeds on the compost pile. Sensing our puzzlement about the liquid, Xing-Yan told us it included

> all kinds of fermented fluids... I just dump everything expired into the bucket... it doesn't really matter... I also put some rice and bread in the liquid because it needs flour... I mean they need vitamins.

The "they" Xing-Yan referred to are microorganisms in the rotting liquid, and the "vitamim" is the nutrient which they feed on. Characteristic of all of Xing-Yan's practice is a dialectic between apparent haphazardness and a sophisticated arrangement of care. His farm looks messy to the eye, and yet its weed management is superior to that of its neighbors. Even its name is based on an idiomatic expression for carelessness, with a pun that inverts its meaning. Harmful and even threatening weeds are bundled with care, then layered with fermented expired foods, which become vitamins that nourish his crops and heal his soil.

4.3 Toppling the Scales

Tucked away in Shengou village (深溝村), the Yilan-based Land Dyke Family Farm is an experimental farming collective founded in 2012 by social activist Shawn Wu. The name Land Dyke was coined by American eco-feminists in the 1970s at the height of returning-to-the-land movement [52]. Its Chinese name is "Tulake" (土拉客). The name in Mandarin Chinese means "using land to greet people," but when pronounced in Taiwanese dialect, it shares the same sound as the words for farm trucks. Unlike the separatist ideal celebrated by early lesbian farmers in the US fighting against patriarchy, the six feminist queer farmers take inspiration from its principles of collective cooperation in order to create a more community-based agriculture. They learned how to grow vegetables from 73-year-old Zhu Mei-chiao, a female veteran vegetable farmer and decided to live and work together in Shengou village with rice cultivation as the primary crop and fruit and vegetables as supplement. Like other small-scale friendly farmers ("友善小農" or "youshan xiaonong") in Yuanshan township, Land Dyke is committed to eco-friendly farming and follows the sustainability principles established by the "Yilan Eco-friendly Smallholder Farmers' Alliance": it forbids pesticides, chemical fertilizers, and harming lives if they do not harm the crops, and the use of imported supplies [43]. In practice, Land Dyke insists that after the grains have been harvested and dried, they will not be treated with chemical preservatives. They also hand-collect golden treasure snails (福壽螺 or 金寶螺), a major pest of rice agriculture in Taiwan and across Asia, as opposed to killing them with pesticides.

On July 20th, 2018, Land Dyke released a long post on their blog and Facebook page documenting their ongoing struggles with scales—tiny insects that suck sap from the

citrus trees and then secret honeydew, a sticky and sugary substance, onto the leaves and branches. Ant colonies are attracted by the honeydew and feast on it, further damaging the trees. The honeydew also attracts a sooty mold that grows on the leaves of the affected plants, interfering the photosynthesis process [2, 87].

The two farmers tell the story of their eventual and heart-breaking decision to go against their eco-farming principles and use pesticides in order to save the citrus crops. They witnessed the gradual decline of the affected citrus trees over a period of four months in the spring of 2018, first with falling twigs and branches, followed by the development of sooty mold covering all over the plants (Figure 3). They tell of their anguished decision to use pesticides in an attempt to save the orchard. But the use of chemical pesticides proved to be too little too late: after Land Dyke applied chemical pesticides in the citrus orchard in July, the scale infestation continued, and they caused further damage when the wasps who used to reside in the orchard abandoned it the day after the chemical spray. They did eventually save the trees; however, they later disclosed on a blog that the harvested citrus fruits had 0.01ppm of pesticide residue, leaving it up to consumers to determine if they wanted to purchase them [48].

Figure 3: Healthy (left) vs. scale-infested citrus trees in Land Dyke's orchard (Image credit: Land Dyke).

NaiNai and GuaGua (the two Land Dyke farmers who cared for the orchard) first noticed the presence of scale insects in March when the citrus trees started to bloom. Scale insects feed on the sap of citrus trees and secrete honeydew, which accumulate on the foliage, fruits, and branches. When the insect infestation is severe, it can wipe out the entire orchard. Between March and June, NaiNai, GuoGuo, and other members of Land Dyke had done what they could with all the non-chemical control methods, such as wiping and washing affected leaves with lukewarm water and soap, flushing the infected part of the orchid with water, physically destroying ant nests on the trees, and spraying the infested plants with neem oil (an organic and biodegradable broad-spectrum pesticide). Nothing seemed to work, and the scale insects gained more ground, in part because of the unusually high temperature in the region, the delay of the monsoon season, and the low quantity of ladybugs, the scale insects' natural predators (and thus beneficial insects to the citrus tree) were not enough in quantity to combat scale insects.

After four months of battle and struggle, the farmers made the painful decision to use non-natural pesticides for scale eradication. NaiNai motivated their decision thus: included

> We can no longer bear to watch these fruit trees die… we love them, we lack the strength and the courage to watch them die. [43]

At the same time, they were also concerned about their livelihood and felt responsible for their neighbors':

> It usually takes 6 years of nurturing before fruit trees can start having stable yield… we did not have enough capital to survive 6 years with no income. Further, if we don't act now, what happens when scale infestation spreads to the nearby orchards, affecting our neighboring farmers' livelihood?

They were stricken with guilt for not acting sooner; at the same time, they wondered about the timing when natural measures stop working and chemical pesticides need to take over:

> If we could have made the decision earlier, could we have only had to spray once and reduce the harms that chemical compounds have posted to the land to its minimum?

She continued, reflecting on the challenges of practicing eco-farming:

> Does eco-friendly farming only mean the eradication of all chemical fertilizers pesticides? To me, there is no standard definition to eco-friendly farming. [Instead,] it is all based on the trust the consumers have on the farmers and the goodwill the farmers invest in the land.

In describing the condition of the Anthropocene, Swanson and her colleagues relates it to the "suffering from the hills of another species" for humans and nonhumans alike [86]. The Land Dyke account shows the vulnerability of their encounter where the fate of one species change the entire ecosystem with no clear "winners" because "entanglement with others makes life possible, but when one relationship goes awry, the repercussions ripple" [86, p.M5]. The Land Dyke example does not have a magical twist nor a happy ending, reminding us that being Eco-Friendly sometimes simply

fails. But there is a silver lining, because in its failure, it can clarify tradeoffs and support future decision making.

5 DISCUSSION

HCI researchers focusing on climate change, sustainability, and the Anthropocene are seeking paradigms and models by which humans can better harmonize with nature. They have introduced a rich vocabulary from posthumanism—collaborative survival, natureculture, companion species, noticing differently, etc.—to decenter humans from our thinking; and they have begun to identify and propose new designs that reflect posthumanist values. Yet the scope of the problem is almost incomprehensibly large, and the role of HCI in it remains nebulous.

We have offered three accounts of ethnographic encounters which, we believe, exemplify contemporary efforts with affinities for posthumanist thinking. Part of their attraction to us is their connection to the land—soil, bugs, secretions, fermentation—and to the posthumanist theory. Many of the connections were surprising. For example, tea farmers depended on a pest whose crop destruction can, under the right circumstances, elevate the crops to a gourmet status. Or Xing-Yan's ability to see weeds as companion crops, leading to a conceptual and physical recomposition of his farm plot and his practices. We also showed failure—the scales who destroyed the orchard and the environmentalist farmers who tragically acted too late—and how it nonetheless produced useful knowledge.

What our ethnographic work has not yet shown is a role for technology or for a research community that focuses on the human side of technology—from its innovation through to its end users and their consequences. Although we do not (nor is it our intention to) offer concrete answers as to how technology might address issues in both environmental sustainability and food crisis, we recognize HCI's long-standing commitment to understanding use and users as foundational to technology design, and we position this study as doing so in two ways. First, our ethnography helps HCI researchers understand emerging sustainable farming practices, including who is engaging with them and what technologies/approaches they are using. Second, unpacking our ethnography with a theoretical lens has helped us look to non-human "users" and the interactions between human and other species, which then helps to define a space of possibility for technological interventions. In the discussion section, we reflect on what we've seen in relation to HCI research and practice.

5.1 The Earth as Lab

HCI, like many other fields, tends to define "the lab" and "in the wild" as if they are opposites, sites that produce different kinds of knowledge, that demand different sorts of methods, and so forth [77]. Yet "the wild" was one of humanity's earliest labs; experiments in food production—and the origins of the scientific method itself—go back to ancient times. The farm functions well as a lab for many reasons. Its spatial organization accommodates different kinds of experiments simply by dividing it into sub-plots. Its cycles—day and night, alternations of dry and rainy stretches, seasonal, annual, and beyond—accommodate replication and variation (e.g., crop rotation). Natural processes such as decomposition and the effects of animal and vegetable life happen on their own, often rapidly. What IT developers today call a "minimum viable prototype"—a rapid effort to concretize and test an idea with the intention to learn and iterate—finds analogues throughout the sites and stories we heard. Experiments in soil optimization, seed hybridization, and creative recycling go back millennia, and they come with considerable knowledge and a technical vocabulary that are as worn as an old almanac.

Perhaps the most obvious question is how emerging technologies map onto this. Obviously, sensors, AI, and IoT are already finding applications in AgTech. Industrial farming and cutting-edge IT research and development are already collaborating. Yet all over the world there are also smaller collectives like the ones we've studied, inventing and testing practices that blend new technologies, biological and agricultural knowledge, and agricultural philosophy (e.g., that of permaculture). As with other forms of bottom-up innovation, or long-tail innovation, much of it won't succeed, let alone be transformative. Yet as many of our interlocutors over the years have pointed out, even one Facebook or Google out of a million other efforts is a notable payoff.

A role for HCI, then, is to use its resources to increase participation in these forms of innovation. It can accomplish this in several straightforward ways. One is the development of tools and toolkits that encourage participation; the success of the maker movement was in part based on the availability of digital fabrication tools that were reasonably affordable, easy to learn, and efficacious. How can technologies help more people learn to see and to act on the potential of symbiotic encounters? Automated camera traps have given scientists and the general public non-invasive yet scientifically important glimpses into the behaviors of some of the world's most elusive and endangered species, such as snow leopards and jaguars. What could technologies such as sensors, micro-robotics, and cameras help the public learn to see about the soil? How might HCI facilitate the public's motivation and ability to rehabilitate soil? Given the rise of urban farming and the ongoing availability of small garden

plots in suburban and rural settings, the possibility of popular garden labs and experiments in precision farming seems like an achievable goal.

Another HCI contribution could be technologies that aid in the dissemination of methods and results. Again, the maker movement, DIY and repair movements, ham radio, craft e-commerce platforms, and amateur animation and video platforms like Newgrounds and YouTube all provide models that offer technologies that both disseminate the most promising ideas and onboard new participants and help them grow their skills.

5.2 Intimacy with the Biosphere

We have outlined how this work might join the ongoing research threads in HCI in developing tools and technologies to support amateur farming and environmental sustainability. However, we believe that HCI has something more profound to offer than technological intervention. In the following section, we reflect on our own transformations as design researchers. In all three of our ethnographic engagements, the farmers expressed a care for the land that was emotionally charged. In this paper, we shared Land Dyke's narrative about the near destruction of their orchard—a costly and painful threat that they could have easily prevented with pesticides, made worse by the fact that they eventually did use pesticides but at the cost of contaminating their crops. The story is told in a tragic style, and the anguish of the teller, as much as events in the orchard, propels the narrative forward. It might be tempting to dismiss this as some kind of romanticized, touchy-feely nostalgia for the land. Instead, we interpret it as a reflection of their intimacy with the biosphere, which also entails a deep understanding of the effects of pesticides and other forms of toxicity. This intimacy is based in identifying with the other lifeforms inhabiting the same ecosystem, at times competitors, at times companions, and at other times unconcerned with one another.

We know this because we underwent such a transformation ourselves. Our embodied understanding of the earth—bacteria, bugs, worms, secretions, rot, fermentation—changed as we worked it. Prior to this research, we saw worms and bugs as disgusting pests, dirt as something to vacuum up and remove. But our time spent shoulder to shoulder with a farmer and former software engineer trying to heal the soil has changed how we see the soil, how it sustains itself, and how it sustains life—including our own. We now notice differently, both in the ordinary sense that we notice different things, but also in Tsing's more specific sense of the word: we see the soil now as an assemblage of different processes, structures, meanings unfolding dynamically over time. In certain moments, the interests of humans (as farmers, as consumers of food) and the interests of aphids or spiders or bacteria align; it's good for all of us, and this good outweighs (in the best case) or at least partly offsets (in the worst case) the subsequent misalignments. The ability to see that way is theorized in Tsing's work, but it just might be how farmers have seen all along. How technology will aid that vision, and how that vision will place demands on technology, remains to be seen.

HCI research has long championed users [32], even represented them [19]. It has expanded the notion of user satisfaction into the thriving research and practice domain of user experience [37, 58]. It has advocated for empathy for users [90], developed methodologies to achieve it [6], and proposed moving from a user centered approach to consider a wider range of stakeholders [8, 27]. Posthumanist HCI is advocating a non-human-centered approach to computing, one that views nonhumans as stakeholders. We propose that just as HCI researchers decades ago called for championing the user, and the field responded with a richer and more powerful multidisciplinary base of theory and methods than those who called for it could have hoped for, so now there is a role for HCI to do the same for nonhuman stakeholders. As user experience research outcomes now shape organizational strategy, so knowledge of and empathy towards nonhuman life must shape organizational strategy in the future. HCI has tools—theories and methods—that could help further the goal of improving interspecies relationality. HCI has already developed tools for cats [66] and fungi [54]. Next up: gut bacteria.

6 WEEDS, THEN THE WORLD

Reflecting on his farming practice, Xing-Yan explained,

> the foundation of farming lays on the soil, and the healthiness of the crops have a lot to do with the microorganisms within it, so the most important task for me is to cultivate soil with compost.

He paused for a few seconds and continued,

> I think I'm probably not even thinking about growing crops but about taking care of the microorganisms in my soil… if you provide a good cultivation environment the crops naturally will grow well, it's not even my task to worry about the pests.

In his playful way of repurposing idioms, Xing-Yan summarizes his practice as follows: "to understand the world through weeds." His soil is his product, in other words, not his produce. We went to farms in Taiwan in hopes of learning about innovation in the sustainability domain. We did, of course, learn about innovation, e.g., how a software engineer and open source advocate

translates that discipline onto the ("Open Hack") farm, or (in another case) how a former Manhattan architect moved his family to rural Taiwan to apply and develop the permaculture agricultural philosophy.

Yet over the course of such encounters, we reflexively wondered if we—city-raised technologists bearing laptops and mud-spattered boots—were also a metaphorical companion species. At times, we felt as if we had entered a different world; we worked with the farmers, weeding, hauling equipment, and helping to compost. Yet we believe we were useful to them, not only because of the extra hands we provided in the field, but also because of the questions we asked from our other world: questions from design research, possible applications of research through design, the co-construction during tea-time breaks of What-If scenarios. These questions sometimes intrigued them, prompting new ways of thinking about their work. In those moments of walking alongside one another, we had glimpses of what might be. So it was that our well vetted and carefully crafted research questions, printed on clean white sheets of paper and nestled in binders as we made the journey from the city to the country, would come to be soiled.

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