Towards More-Than-Human-Centred Design: *Learning from Gardening*

Anton Poikolainen Rosén [1, 2, *], Maria Normark [1], and Mikael Wiberg [2]

[1] *Media technology, Södertörn University, Stockholm, Sweden*
[2] *Informatics, Umeå University, Sweden*

More-than-human-centred design is a growing field in HCI (human-computer interaction) that account for non-human actors in design processes (such as animals, plants, and microbes but also autonomous technologies). While the rationale for more-than-human-centred design is clear, there is a lack of design methods grounded in this thinking. We articulate the idea of *noticing* as a method for approaching design spaces as systems of mutual interdependence between organisms. The findings are based on a longitudinal ethnographic study of urban farming—including the study of urban farmers' practices and use of technologies with a focus on the interplay between humans and non-humans, such as plants and microbes. We articulate *noticing* as a phenomenon and show examples of urban farmers' practices of noticing. We discuss principles for designing with the interdependencies of several organisms based on what is noticed in a setting. We argue that the way we have separated ideas about the environment and human experience is a part of the sustainability problem—and suggest *noticing* as an approach that instead combines positive human experiences and the needs of the environment.

Keywords – Design Research Methods, Ethnography, More-than-human-centred Design, Noticing.

Relevance to Design Practice – HCI and interaction design are increasingly oriented towards more-than-human-centred design. In this ongoing turn, this paper offers an empirical case and methodological principles for *noticing* and designing with the interdependencies of several organisms in the environment.

Citation: Rosén, A. P., Normark, M., & Wiberg, M. (2022). Towards more-than-human-centred design: Learning from gardening. *International Journal of Design, 16*(3), 21-36. https://doi.org/10.57698/v16i3.02

Introduction

User-centred design processes have been a fundamental part of the development of successful technology in the last decades. However, this inclination toward understanding, developing, and attending to human needs implies that less attention has been directed at other non-human actors—with environmental destruction as a consequence (DiSalvo et al., 2010; Foth et al., 2020). To broaden the scope and to account for *others*, a more-than-human-centred design field has emerged within human-computer interaction (HCI). Some strands have focused on the agency of autonomous, dynamic, and evolving computational things (Coulton & Lindley, 2019; Giaccardi & Redström, 2020; Wakkary, 2021) while others have focused on design for and with the interdependencies of organisms (such as animals, plants, and microbes) (Akama et al., 2020; Clarke et al., 2018; Nijs et al., 2020)

While the rationale for more-than-human-centred design is clear, there is a lack of more-than-human-centred design methods. In this paper, we take recent work on more-than-human-centred design as a starting point to get a deeper understanding of ways of tending to the complex interdependencies between living organisms, including humans, in the context of gardening. Our empirical study has observed more-than-human-centred processes in urban farming communities for four years. We selected regenerative gardening and farming as a context for our study since it illustrates close interactions and interdependencies between humans and non-humans, such as plants, microbes, and technologies. Taking this study as a point of departure, we provide ethnographic examples of situations where urban farmers notice and intervene in their gardens. We analyze these examples from the perspective of what HCI can learn in terms of more attentive, caring, and nurturing approaches to more-than-human-centred design.

We particularly focus on practices of noticing. To notice is to become aware of and to treat something as worthy of recognition. Our understanding of noticing builds on the work of Tsing (2015 & 2020) who sees noticing as a culturally and politically sensitive skill that recognizes the interconnectedness of ecological, economical, and cultural systems—and how these systems function from more-than-human perspectives. However, we also focus on the situated experience of noticing, and in particular how it moves attention from the experience of self to the experience of oneself as part of the environment. These perspectives tend to be separated within current HCI research. Many examples take a systemic and environmentally conscious perspective on design (e.g., Angheloiu & Tennant, 2020; Börjesson Rivera et al., 2014;

Received June 23, 2021; **Accepted** August 16, 2022; **Published** December 31, 2022.

***Corresponding Author:** anton.poikolainen.rosen@sh.se

Brynjarsdottir et al., 2012; Raghavan et al., 2016) and many approaches focus on details of inner lived experience (e.g., Höök, 2018; Loke & Núñez-Pacheco, 2018; Prpa et al., 2020). However, few holistically combine these perspectives. We see more-than-human-centred design, particularly the experience of noticing (see Figure 2), as a promising approach for aligning positive human experiences with the needs of other organisms.

While this kind of noticing is beginning to be articulated as a theoretical and methodological approach in HCI (Biggs et al., 2021; J. Liu et al., 2018; Liu et al., 2019b; Liu, 2021; Livio et al., 2019), there is still a need for both empirical studies and articulations of noticing practices. In what follows, we argue for synergies between how urban gardeners and farmers practice noticing and how designers and design researchers might notice. Accordingly, we use the idea of noticing both to guide our participant observation studies (how we noticed) and to understand how users (such as urban farmers) notice the environment, sometimes with the support of sensing technologies. This liquid understanding of noticing practices blurs who or what a designer is (e.g., researchers, urban farmers, animals, plants, microbes, autonomous technologies) and what is designed (e.g., relations in a garden). This is in line with the more-than-human-centred field that sees knowledge production in design as situated, embodied, and partial, and hence shared between more than merely trained designers (Wakkary, 2020, 2021)

In sum, this paper offers an empirical case and methodological principles for noticing and designing with the interdependencies of organisms. The main contributions include an articulation of *noticing* as a way to approach design spaces that focus both on interdependent systems and lived experience; and a discussion about principles applicable when designing for and with the interdependencies between organisms, particularly in terms of intervening where needed to strengthen certain processes and slowing down or stopping others, whether through interactive design or other actions.

The rest of this paper is structured as follows: In the background, we situate the study in posthumanism, more-than-human-centred design, sustainable HCI, and HCI studies on urban farming and gardening. We then present our method of studying urban community farms. Thereafter, our theoretical understanding of noticing is articulated in more detail, as grounded in our studies and previous research. We provide ethnographic descriptions of how urban farmers noticed other organisms through actions of smelling, looking, touching, tasting, measuring, and using sensors. Based on these findings, we discuss experiences of noticing oneself as part of the environment and more concrete principles for designing for and with systemic interdependencies. The final discussion focuses on the limitations of our study and opportunities for further research and design.

Anton Poikolainen Rosén is a Ph.D. student in Sustainable Human-Computer Interaction and Informatics at Södertörn University and Umeå University. His research focuses on more-than-human-centred design in urban farming communities.

Maria Normark has a Ph.D. in Human-Computer Interaction and is an associate professor in Media Technology at Södertörn University. Her research fields include critical design, STS, Design for Sustainability (D4S), and CSCW.

Mikael Wiberg has a Ph.D. in Informatics andis a full professor in Informatics at Umeå University, as well as professor of interaction design at Chalmers University of Technology, Sweden. His main research is within the areas of interactivity, mobility, materiality, and architecture.

Background

A considerable amount of academic discourse, especially within the humanities, has in recent years developed the field of posthumanism (Abram, 1997; Barad, 2003, 2007; Bogost, 2012; Braidotti, 2019; Forlano, 2017; Haraway, 2016; Hayles, 1999). This field is critical of the enlightenment ideal of the distinct, rational, and dominant human individual and seeks to understand the human subject and its relationship to the world in a new, non-anthropocentric light. In posthuman epistemologies, knowledge is situated, embodied and partial, meaning that it is pluralistic rather than universal. Nevertheless, posthuman thinkers all have in common that they undermine traditional boundaries (e.g., nature-culture, mind-body, human-technology) and recognize the significance of the non-human contribution to our lifeworld. This often focuses on object-oriented ontologies, such as actor-network theory (Latour, 1996). A central concept within posthumanism is the more-than-human, a term popularized in the book *The Spell of the Sensuous: Perception and Language in a More-than-Human World* (Abram, 1997). Here, *more-than-human* is used to ascribe ideas that are typically associated with humans, such as sentience, intelligence, and agency, to others than humans. This thinking originates in indigenous ontologies that view nature as animate (Escobar, 2018). The idea of the more-than-human is thus far from new but is marginalized in contemporary western society. However, design scholars are beginning to recognize diverse more-than-human indigenous ontologies (Akama et al., 2020; Escobar, 2018) and their sustainability benefits (Brant, 2021; Latulippe & Klenk, 2020; Vásquez-Fernández & Ahenakew, 2020).

The inclusion of more-than-human perspectives in human-centred design can be described as more-than-human-centred design. The primary study object of more-than-human-centred design is the mutual interdependencies of organisms (see Figure 1). This focus on interdependence forefronts that many organisms, including humans, benefit from considering design spaces as holistic and relational. Accordingly, the purpose of the shift to more-than-human-centred design is not to focus less on human users but instead expand the focus to include a larger set of organisms and their interdependencies. This shift has also been discussed with related terms such as post-anthropocentrism (Devendorf et al., 2016; Yigitcanlar et al., 2019) non-anthropocentrism (Luusua et al., 2017), and *decentring the human* (Forlano, 2016; Smith et al., 2017; Smith, 2019).

Sustainable HCI

More-than-human-centred design relates to many themes of Sustainable HCI. Sustainable HCI research is a diverse field that studies the production, use, and disposal of technology (Blevis, 2007; Börjesson Rivera et al., 2014; Choi & Blevis, 2010; DiSalvo et al., 2010; Engelbutzeder et al., 2020; Fors, 2019; Knowles

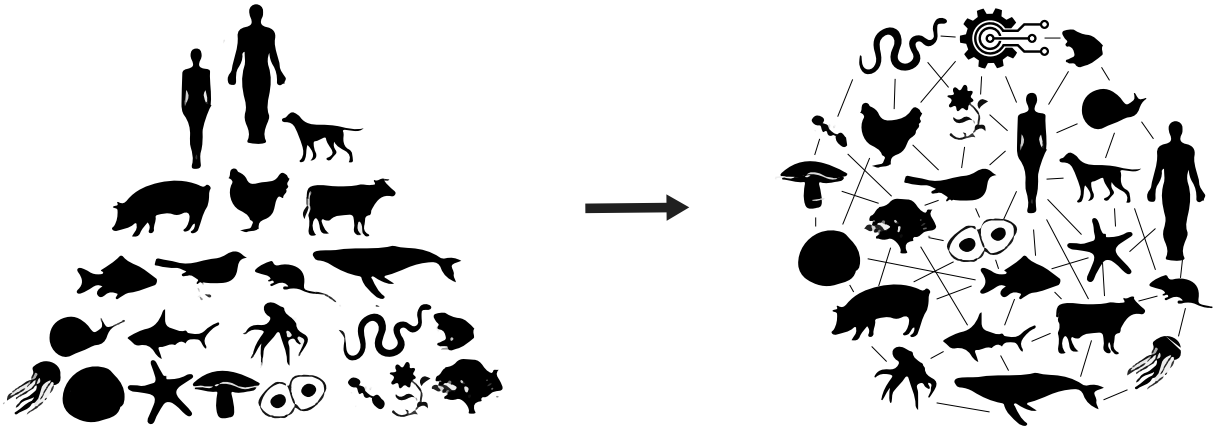

Figure 1. The move from human-centred design to more-than-human-centred design (Adapted from Lehmann, 2019).

et al., 2018; Muntean et al., 2020; Norton, 2019; Raghavan et al., 2016; Ringenson et al., 2017; Røpke, 2012; Wakkary et al., 2013). While much of the field focuses on developing sustainable technologies, there is a strong emphasis on designing and producing less since we need to use fewer resources (Chen, 2015; Nardi et al., 2018; Ringenson et al., 2017). Further, many scholars within sustainable HCI question the tendency to focus on delimited solutions for individual behavioural change on narrowly defined environmental problems (Dourish, 2010; Foth et al., 2020; Knowles et al., 2014; Kuznetsov et al., 2011). As an alternative, research suggests that HCI should focus on systemic perspectives. Here, several human-centric systemic perspectives, such as Life Cycle Assessment (Forchino et al., 2017) and Ecosystem Services (Bolund & Hunhammar, 1999), are prominent examples (Matasov et al., 2020; Penzenstadler et al., 2018). As noted by Yigitcanlar et al. (2019) more-than-human-centred design is distinguished from these other systemic perspectives since it resists how humans and nature are commodified—how humans are reduced to workers and consumers, and nature to assets or resources. More-than-human-centred design thus offers a different way of thinking to sustainable HCI which decouples human well-being from market-led growth and reconnects humans to their ecosystems (Yigitcanlar et al., 2019).

More-Than-Human-Centred Design in HCI

More-than-human perspectives are beginning to be included in design research and HCI. As noted by Cyn Liu (2021), a design project can be more-than-human-centred in several ways: in *ontology & epistemology* drawing on posthuman concepts or theories [Bardzell et al., 2021; Budinger & Heidmann, 2019; Light et al., 2017; J. Liu et al., 2018; Liu et al., 2019a; S.-Y. (Cyn) Liu et al., 2018; Smith et al., 2017]; in *orientation* by taking concrete actions to decentre privileges and empower margins (Akama et al., 2020; Clarke et al., 2019; Foth & Caldwell, 2018; Heitlinger et al., 2019a; Light et al., 2017) in *intended users* by attending to the needs of unconventional users such as animals and plants (Aspling, 2015; Aspling et al., 2016; Carrozzo et al., 2018; Fastnacht et al., 2016; Heitlinger et al., 2014; Isai & Viller, 2010; Kovalchuk & Kovalchuk, 2008; Kuribayashi et al., 2007; Norton et al., 2014; Sheikh et al., 2021); in *form* through challenging dominant expressions of representation, for example by experimenting with unconventional emotional and sensory communication (Fastnacht et al., 2016; Heitlinger et al., 2014; Holstius et al., 2004; J. Liu et al., 2018; Liu, 2021) and in *methodology* that reveals fluid perspectives of other stakeholders than humans (Galloway & Caudwell, 2018; Kirksey & Helmreich, 2010; Liu et al., 2019b; Livio et al., 2019; Nijs et al., 2020).

A related field that considers other organisms within design research is Animal-Computer Interaction (ACI) (Aspling, 2015, 2020; Chung & Hong, 2016; Frawley & Dyson, 2014; French et al., 2017; Jackson et al., 2018; North, 2017). Designs developed within this field tend to focus on domesticated animals who are conducting tasks that are often connected to human needs or *enrichment* (French et al., 2017; Tironi & Hermansen, 2018) for animals in captivity. Nevertheless, there are exceptions within ACI that work closer to the more-than-human themes (Turner & Morrison, 2021; Westerlaken & Gualeni, 2016).

In terms of methods for studying the more-than-human, the broader design field has developed ethnographic methods for studying multiple organisms from social and cultural perspectives (Choi & Galloway, 2021; Ives, 2019; Kirksey & Helmreich, 2010). Other more anticipatory methods of more-than-human-centred design research include putting oneself in the place of other organisms in participatory urban walks (Clarke et al., 2019) and using envisioning cards that prompt focus on multiple organisms as stakeholders of design (King, 2020). Within this field, a particular concern is often directed at participatory processes (Akama et al., 2020; Bastian, 2017; Clarke et al., 2018). As participation usually implies human voice, rights, representation and structures of decision-making, the limits of participation of other organisms are recognized (Bastian et al., 2017).Lastly, several more-than-human-centred design projects are critical, speculative, or fictional (Budinger & Heidmann, 2019; Clarke et al., 2018; Nijs et al., 2020; Robbins et al., 2020; Wolff et al., 2021) which ties back to the roots in posthumanism and the fields' inclination towards imagining alternative worlds and alternative ways of being in the world

Urban Farming and Gardening in HCI

Sensors, AI, and IoT, are implemented to optimize growing conditions in industrial farming and pioneering IT research. Likewise, *smart* applications and devices are developed for more small-scale gardening. Given these developments, HCI research has during the last decade studied how citizens explore opportunities to cultivate their own food (Ardianto, 2014; Clarke et al., 2018; Heitlinger et al., 2018a, 2019a, 2019b, 2013, 2018b; Lyle et al., 2013, 2015; Maddali & Lazar, 2020; Nansen et al., 2011; Odom, 2010). While this research highlights that implementation and development of technology for this context is not always the best solution, it also concludes that the role of digital devices in gardens and farms is typically to organize the practice; and gather, access, and understand information about the environment. In what is reported here, we primarily focus on the latter use of technology (i.e., technologies for noticing). Related HCI research has further studied how professional practitioners *nurture natural sensors* through making interpretations of environmental conditions drawing on biological indicators (Kuznetsov et al., 2011). This research illustrates how we can understand many aspects of environments through learning to thoroughly observe them with our senses.

In what is reported here, we focus on regenerative farming and permaculture communities. Regenerative farming is guided by a particular set of values and aims such as increased biodiversity, carbon sequestration and soil regeneration. Permaculture is one example of a regenerative farming practice that particularly emphasizes systemic thinking and mimicking nature (Mollison, 1997). S.-Y. Liu et al. (2018) have addressed permaculture as a recourse for interaction design to develop alternative aesthetic sensibilities and support experimentation. Egan et al., (2019) have used the design principles of permaculture to inform *blended spaces* where technologies are used in combination with organisms to create *new relationships in the blend that did not exist in the original inputs.* Puig de la Bellacasa (2010) has studied permaculture communities to develop *an ethics of collective empowerment that puts caring at the heart of the search for everyday struggles for hopeful flourishing of /.../ a more-than-human community.* We draw on these previous studies to frame permaculture both as a way to guide concrete design and consider more philosophical, moral, and ethical aspects. Notably, the western movement of permaculture has been critiqued for appropriating indigenous methods of growing instrumentally, without acknowledging the worldviews that accompany these practices (Cultural Survival, 2020).

Methodology

We have studied diverse urban farming communities in Sweden, Germany, Vienna, France, Poland, and the USA for four years [see (Normark et al., 2021; Poikolainen Rosén et al., 2020, 2022) for detailed accounts of the studies]. In what is reported here, we discuss ethnographic findings from urban permaculture farms that were run by amateurs according to regenerative principles, as these communities' demonstrated practices that could be (at least partly) framed as more-than-human-centred. These communities were critical to commercial monocultures and framed their way of growing as a way to experience meaning in life "in harmony with nature" (W1). They further focused on building neighbourhood and social interactions. A community in Stockholm, Sweden described itself on their website:

> We use small, local, and efficient energy flows with inspiration from nature's own ecosystem. Achieving this on a large scale will be an important part of the climate solution. Small solutions in large networks.

In this paper, we primarily include data from four years of participant observation in an urban community farm in Stockholm, Sweden. We further include some data from one-day study visits to three other regenerative urban farms in Paris, France; Berlin, Germany; and Bloomington, IN, US. Data from the one-day visits include 265 images, fieldnotes (eight pages) and four interviews (totalling 263 min). Data from the long-term study includes field notes from visits to the urban farm (80 visits 180 pages); notes from 22 group meetings (120 pages); 1347 images (excluding duplicates of the same event); five interviews (totalling 340 minutes) and 25 videos of interaction in the garden (totalling 40 minutes).

The location of the observations in the long-term study was both physical on-site, and virtual in the community's Facebook group (700 members) and closed group set up for more organizational purposes (23 members). We observed how the urban farmers talked about their practice, what they chose to highlight and how they related to the objects and organisms around them (tools, sheds, plants, insects, etc. We also observed ourselves doing the gardening work, focusing on the sensory, bodily, and affective dimensions of gardening.

The diverse material from our combined studies provides means to *think with* (Biggs et al., 2021; Haraway, 2016) and to approach the design space from several perspectives. Since other organisms cannot express themselves in the same modes as humans, this triangulation of different methods and sources of data has been particularly important in our studies, as argued also by Aspling (2015). Like others studying similar contexts (Liu et al., 2019a; Liu, 2021) we further came to view the most engaged urban farmers in the primary community of the studies as interlocutors who together with us approached the urban farm from more-than-human-centred perspectives and thought us what and how to notice. By having an ongoing conversation with these interlocutors, who themselves *correspond* (Ingold, 2020) with other organisms through noticing them, we argue that design researchers can gain deep insights into more-than-human design spaces.

Interpretative Procedures

Initially, we built an understanding of the overall contents of our data. This understanding gradually developed into sensitivity for the data set in an iterative process alternating between reading theory and analysing our data in a process of mutually informing one another until a picture emerged that resonated with the theoretical resources, urban farmers' discourses and activities, our inquiry goals, and our experiences.

Table 1. Individuals quoted in the paper.

W1	Woman 30 years. Urban farmer, Paris.
W2	Woman 45 years. Founder of an urban farm, Stockholm
W3	Woman 50 years. Community member of an urban farm, Stockholm
W4	Woman 50 years. Founder of an urban farm, Stockholm
M1	Man 40 years. Sustainability activist (Extinction Rebellion), visitor farm Stockholm
M2	Man 50 years. Community member of an urban farm, Stockholm
M3	Man 25 years. Student at a technological university, member of a farm in Stockholm

In the findings and following discussions, we use ethnographic examples to help envision approaches to design that are more-than-human-centred. In doing so, we are inspired by related ethnographic work on farming communities (Bardzell et al., 2021; Galloway 2016) that uses ethnographic examples as *fragmented images* (Bardzell et al., 2021) to creatively and speculatively imagine a world not yet existing, but potentially worth pursuing. In our analysis, we thus focused on how more-than-human-centred practices could be developed further, be more common or operate at a greater scale. As noted by Bardzell et al. (2021) these transformations will likely require years if not decades of experimentation. We offer our study as one such experiment.

We did not set out to study urban community farming from a more-than-human-centred perspective. Nevertheless, our research engagement demonstrated that more-than-human-centred ethnographic data, we have looked for such fragments to help imagine how more-than-human-centred design was a suitable perspective to understand the context. Likewise, we did not initiate this study with a pronounced noticing methodology. Instead, it developed subsequently as we learned from the urban farmers and engaged with related literature. In this section, we reported on the formal/conventional aspects of our method. In the discussion, we reflect more exploratively on *noticing* as a method and approach in more-than-human-centred design.

Theoretical Framing: *Noticing the More-Than-Human*

In this section, we articulate our theoretical stance on noticing the more-than-human. We build on the work of the anthropologist Ana Tsing (2015 & 2020) who addresses a particular form of culturally and politically sensitive noticing. To notice is to become aware of, and to treat something as worthy of recognition and attention. Usually, there is no need to notice the obvious every day. However, the skill of noticing implies that you notice what matters in each situation—beyond the immediately perceptible. Expanding on this idea, design researchers in HCI have explored noticing as a theoretical concept (S.-Y. Liu et al., 2018; Biggs et al., 2021); built prototypes for noticing environmental conditions (J. Liu et al., 2018; Liu, 2021); organized conference workshops on noticing (Liu et al., 2019b); practiced systematic noticing in studies of other organisms (Biggs et al., 2021); and compiled workbooks with methods for noticing (Livio et al., 2019). Common in all these approaches has been a first-person perspective (autoethnographic) where the design researcher has trained sensibilities for noticing and used the resulting subjective insights to articulate design spaces. This relates to broader focusing and articulation practices that are increasingly used in HCI (Höök, 2018; Loke & Núñez-Pacheco, 2018; Prpa et al., 2020) that in turn draw on practices such as *deep listening, focusing, Feldenkrais*, or *meditation.*

Based on earlier literature and our studies, we illustrate the process of noticing in Figure 2. The figure highlights the role of preconceptions in affecting what is noticed; the situated experience of noticing and how this can be affected by technology, and the understanding that may emerge over time through interpreting what is noticed (e.g., understanding systemic relations in a more-than-human world). The arrows in Figure 2 indicate the flow of multifaceted, multimodal, and changing data/information/knowledge, in a process that can be best described as the creation of situated knowledge (Haraway, 1988). Notably, the illustration separates humans from the more-than-human in a way that is not necessarily beneficial for the posthuman aim to dissolve clear boundaries between humans and the environment. However, we believe that this distinction is necessary for understanding noticing as a culturally and politically embedded skill and sensibility that is specific to humans.

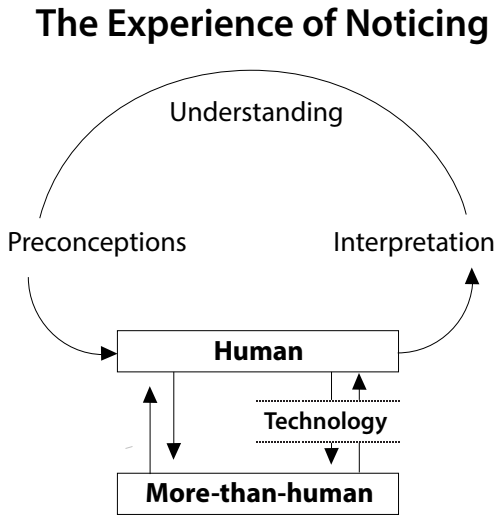

Figure 2. A model of the experience of noticing a more-than-human world.

Noticing is further distinguished from similarly sensory-aware practices such as meditation in how preconceptions and interpretations are invited to the practice rather than avoided. While noticing does not require any underlying reason, the urban farmers we studied noticed because they wanted to care for their gardens. To be able to act. Similarly, in a design process, *noticing* can be understood as the important steps taken to identify where in the immensely complex more-than-human interdependencies it might be beneficial to act/design.

Preconceptions. Research has found that the more individuals learn about a context the more they perceive nuances in that context (Goodwin, 1997). They become better at noticing. What is noticed is thus not only dependent on sensory capacities but also cultural background, values, knowledge, and previous experiences. This frame noticing as tacit knowledge. *Tacit* is often interpreted as *silent.* However, according to Prpa et al. (2020), a more accurate understanding of *tacit* is *pre-understood*. This preunderstanding develops as one becomes more familiar with a particular context through noticing it (J. Liu et al., 2018). Or as expressed by one of the participating urban farmers (W1): "You don't even know what you don't know before you notice it."

Noticing as an experience. Noticing is a situated and embodied experience (something done with the whole body). The experience of noticing is directed at something in the more-than-human world. Something is noticed. This implies that noticing is a bidirectional experience that is both attending outwards to the more-than-human world and inwards to felt experience. While noticing involves opening up, you are simultaneously selective—you open up to take in certain aspects of the environment. This requires intention. Noticing is thus a disciplined act, an active listening. While we are often trained to notice from human perspectives, it requires more effort and recalibration to notice from more-than-human perspectives. Notably, this focus on the experience of noticing is not intended for human-centric *navel gazing*, but rather for understanding experiences of staying open to the environment.

Interpretation & understanding. People interpret and aim to understand what they notice. What is noticed does not necessarily need to be what is immediately perceptible but can be a more underlying pattern or structure. It is this kind of noticing that Tsing (2015, 2020) addresses. While noticing takes the starting point in the human condition of being in the world, it does not stop in this experience. It aims to dig deeper by understanding systemic patterns. This includes how systems from traditionally different disciplines are interwoven. How politics affect ecology, how culture affects biology, how biology affects the economy and so on. Here, the process of articulation is important.

Practices of Understanding Gardens through Noticing

In this section, we outline practices of noticing the more-than-human world that we found in urban farming communities. Urban farmers took an interest in understanding their gardens to better care for them. They sought out species-level knowledge in books, websites, databases, and expert forums. However, to care for other organisms in practice, a more situated understanding of individual organisms and their interdependencies is also needed. Urban farmers used all their senses for noticing. For example, they looked at leaf colouration to identify pests; smelled and felt soil to assess its health; identified plants through tasting; and identified birds through listening. A common sight in the urban gardens was groups of people slowly strolling, looking at the plants and noticing their condition to assess if actions of care needed to be taken. This practice is illustrated in the following discussion:

> **W2:** Soil that comes with these commercial plants can contain this, some kind of hormone that is like inhibiting growth, it's not so good to get larger amounts of it in the cultivations, and it's used because the plants should look compact and robust and like…
>
> **W3:** So, they like to add some kind of hormone to the manure?
>
> **M1:** Few big leaves are developed instead of many. But have you seen the one we got from Marco? It had a few big leaves when it came, but now it's very tall and has many small leaves, it's probably because it [the hormone levels in soil] has dropped.

This discussion illustrates the experience of noticing (see Figure 2). The urban farmers had preconceptions about the phenomenon (soil from commercial plants can contain unwanted hormones that inhibit plant growth). They scientized themselves to indicators of the phenomenon (size, form, and number of leaves). The knowledge was then used to interpret what was noticed (connecting the growth pattern of a plant to the possibility of dropped hormone levels in soil).

Urban farmers further noticed indicator organisms such as poppies indicating light, sandy, and well-drained soil; and goosefoot indicating soil with high pH rich in chalk. While these plants were directly visible, other indicator organisms, such as microbes, required more skill to perceive. This is illustrated by a situation where urban farmers examined rotten wood smelling like "a rainy wheat field" (W2) (see Figure 4, middle). A scent that they identified as produced by anaerobic cyanobacteria: "Cyanobacteria are an indication that the soil is running out of oxygen because it's too compact, so we might want to add more structure to the soil" (W2). In this example, an organism (cyanobacteria) is indicative (through smell) of a particular condition (compact soil) that can be affected by an action (adding organic material). This example illustrates how the noticing of a particular phenomenon (the smell of cyanobacteria) is connected to interdependencies such as the needs of plants which thrive in more airy soil, but also the aesthetic experience of humans "most people think it smells good" (W2).

Noticing with Technologies

Urban farmers further used technologies such as thermometers, moisture sensors, species recognition applications, microscopes, smartphone cameras [see also (Poikolainen Rosén et al., 2020)] and chemical testing of soil samples [see also Poikolainen Rosén, 2022; see Figure 4]. In what follows, we describe the use of one such sensing technology in more detail.

Figure 3. Three methods for noticing soil. Chemical testing, smelling cyanobacteria, microscopic examination.

Figure 4. Using a digital meat thermometer to measure temperature in compost.

The urban farmers in Stockholm practiced heat-composting using a blend of horse manure, green leaves, human urine, and soil. In this practice, it was important to reach a temperature over 55 degrees Celsius (131 degrees Fahrenheit) to kill harmful bacteria and sterilize unwanted seeds. Simultaneously, the compost needed not to reach 80 °C (176 °F), as temperatures above this kill beneficial microbes. The compost was thus continuously monitored using a digital meat thermometer. In a video recording, the urban farmer used the thermometer, inserted her hand holding the thermometer in the compost pile, and made forceful twisting movements with her arm to penetrate the pile deeper (See Figure 4). She kept her hand in the pile and reflected, "this is very bodily in some kind of way, a bit too..." (W2) while smiling and leaning closer to the compost. The device beeped and the woman said, "Fourteen [degrees Celsius], that's great" (W2). She took out her hand from the pile and tapped the compost in a caressing way and moved around leaves to close the hole. In the two following weeks, a group of urban farmers monitored the temperature of the compost and posted updates on the community's Facebook group (700 members):

> We checked on the compost today—it had not reached more than a paltry 25 degrees /.../ Now it is important to add nitrogen in the form of green leaves, manure and urine so we get the temperature up to at least 55 degrees (Facebook post, day 3 of heat composting).
>
> New manure and a lot of green material have been worked into the 18-day compost. It has reached 54 degrees, but it needs to reach a higher temperature to kill diseases and seeds (Facebook post, day 15 of heat composting).

As illustrated by these Facebook posts, the practice of heat composing was mediated to a broader group of people. This practice further implied that information about the temperature on a particular date was saved.

In line with our methodological approach of practicing noticing ourselves, we used the thermometer. We were particularly prompted by the urban farmers' emphasis that the practice was "very bodily in some kind of way" (W2). The first author inserted his right arm and thermometer in the compost:

> I was immediately struck by the hot temperature [39 °C (102°F)] of the compost. It was a surprising contrast to the cold spring air [13°C (55°F)]. It felt like entering something warm and living—as body temperature—not of one being, but the aggregated heat generated by the bodies of billions of microbes. This aligns with what the urban farmers had taught me about seeing soil as living—an ecology of microorganisms, insects, fungi, roots, etc. It was as if my body temperature and the temperature of compost blended (field note, day 8 of heat composting).

This concrete experience of the heat produced by microbes sensitized the first author to notice and reflect on the microbes that are typically on the periphery of the human experience. This experience was surprisingly significant and will be unpacked further in the discussion.

Overall, the practice of heat composting illustrates that humans, microbes, moisture, temperature, and composition of nutrients are all interdependent on each other to create certain conditions in which healthy soil is created. Within this practice, a seemingly mundane and *low-tech* technology of a meat thermometer was used in a way that was perceived as meaningful. From an HCI perspective, the interaction with the device is simple. It is limited to pushing one button and reading a number on a segment display. However, analyzed from the perspective of more-than-human-centred design, the example reveals a much broader space of interactions and meaning. As noted by the participating urban farmers, this example seems worth developing further: "are there like modern thermometers that you can connect to your smartphone as well?" (M2).

Working with Interdependent Systems

To summarize our ethnographic findings, gardens are a great example of more-than-human systems where people actively notice and intervene. They are places in which growers create and explore their gardens as self-sustaining circular systems. As the seasons flow, energy and nutrition are recycled in processes of decomposition and photosynthesis. Gardeners must relate to pests, bugs, weeds, parasites, microbes, fermentation, decomposition, fungi, rain, sun, frost, etc. All these phenomena beyond human control affect the garden. From this perspective, the experience of gardening is an experience of interdependent systems, and the practice of gardening brings growers closer to these systems. One urban farmer expressed this on Facebook "Oh. To be a co-creator of the cycles of life. I'm delighted" (W4).

Some urban farmers in our studies were practicing this kind of systemic thinking through their devotion to the philosophy of permaculture that emphasizes working with and harnessing naturally occurring processes. This structural approach to noticing other organisms and designing gardens includes paying attention to conditions, such as how the sun moves over a day and season, and how water flows through the landscape. The permaculture philosophy further avoids monocultures and emphasizes systemic relational thinking and intervention supporting several organisms. Above all, the permaculture philosophy stresses that issues should not be dealt with or improved in isolation. Instead, it requires the calibration of interdependencies in relation to the needs and capacities of several organisms. Nevertheless, this complexity usually implies that conflicting needs are weighed against each other. In gardening (and similar practices such as agriculture, forest management, and urban planning), humans decide what organisms belong and which do not. Organisms are typically allowed to exist when they contribute to relations in which human and non-human needs align, while what does not contribute to these relations is framed as pests and vermin. This process can be framed as care, responsibility, reciprocity, or domination, depending on whose perspective is taken.

Discussion

In this section, we reflect on our experience of studying urban farming from a more-than-human-centred perspective. We used methods from conventional user research—such as observation and interview. However, over time, their meaning shifted to more-than-human-centred design. This illustrates how, rather than completely inventing new more-than-human-centred methods we can reconsider how to view design spaces from more-than-human perspectives. A foundational change of mindset is required—just as is required to thoroughly empathize with users in user-centred design. However, this is not without challenges, as recognized by Biggs et al. (2021):

Figure 5. Examples of systemic interventions. Left: Communicating the active decision to not mow lawns in Bloomington, IN, USA. Right: A solar-driven automated watering system in Stockholm, Sweden.

> Decentering the human in design is not merely a theoretical stance and/or a methodological move. It is a personal and emotionally difficult journey to reconfigure one's self as a designer and researcher, a psychological labor that, while worth doing, is also part of the reason why this desired paradigm shift in design is so difficult to put into practice. (p. 14)

We had similar experiences, where the main issue of understanding the research site was not only concrete methods for gathering data, but also our foundational attitude towards it. As already established in more-than-human-centred research (Aspling, 2020; Liu, 2021), we for example had to reconsider our ideas about users and use. In the case of heat composting, microbes, fungi, and plants were not actively interacting with the interface of the thermometer. Nevertheless, their very existence was affected by its use (as particular temperatures killed some organisms while benefiting others). This illustrates how we need to be able to address the relations organisms have to technologies, without seeing them as active users of technology. In line with Aspling (2020), we argue that other organisms' relations with technology should be understood on a scale ranging from explicit interactions to implicit exposure. Further, we need to be able to take seriously the subjectivity of organisms, including plants and microbes. Conventional research methods provide few answers on how to understand these non-human ways of being in the world. We found *noticing* to be one particularly promising approach, as it includes systemic and relational thinking but also a deep understanding of the structure of lived experience. In what follows, we first discuss experiences of noticing oneself as part of the environment. We then discuss more concrete principles for how to design for and with systemic interdependencies based on what is noticed.

Noticing Oneself as Part of the Environment

Central in our understanding of noticing is that it is not only about understanding the systemic interdependencies between other organisms, but also about understanding oneself as a part of these interdependencies on an experiential level. Many urban farmers reported that they had turned to gardening as a concrete way to act on the structural problem of unsustainability. They were then positively surprised by the profound joy they also experienced in this practice.

When participants in our studies described positive experiences of being in *nature*, they often described an experience of "opening up" (W3, W4) or "feeling bigger, more expansive" (M1). Some even described it as a "blurring" (M3) or "blending" (W1) of the feeling of self and the environment. Similarly, the first author experienced his body temperature and the environment as seemingly melting together when using a compost thermometer (as described in the findings). He felt like a part of the environment. These kinds of experiences have been explored by HCI researchers Biggs et al. (2021) who explored experiences of *abjection* (Fletcher & Benjamin, 2012) that blur or dissolve boundaries between the experience of *self* and the environment. These experiences relate to posthumanism, which focuses on blurring notions such as nature-culture, self-environment, and human-nonhuman.

Although the focus on inner experiences might initially seem egocentric and human-centred, the experiences described above were expressed by urban farmers as a key to "connecting with nature" (M2). Arguably, experiences of being part of the more-than-human environment are important since they ground the abstract idea of *interdependent networks between organisms* in concrete experiences of being part of these interdependencies. To develop a deep understanding of other organisms we do not only need data and information, but also personal experiences. Indeed, data must be correct, clearly presented, and widely available. However, this is not necessarily enough to provide a deeper understanding. Noticing is also about allowing yourself to be amazed. It is "those moments in life where something shifts within ourselves and we perceive differently, a point from which there is no going back" (Braybrooke, 2022). Accordingly, we found it easier to design for the interdependencies of organisms by taking more subjective experiences of *being part of the environment* as a departure (see also Poikolainen Rosén et al., 2022).

Designing For and With Interdependencies

In this section, we discuss principles for designing for and with systemic interdependencies, based on what urban farmers have taught us. We found that urban farmers intervene in their gardens through, for example, digging, composting, grafting, and implementing technologies, such as watering and monitoring systems (see Figure 5). Based on these findings, we forefront a design process in which designers set the stage based on the needs of several organisms, and then organisms, in turn, develop and co-create the space through various actions. This kind of design process requires open-ended arrangements that allow for other organisms to co-create interdependencies in a selected space. This space is less controlled by the designer and more dependent on other organisms.

Noting What is Noticed

Noticing can mean noting, to take a small note. In this process, the act of documentation formalizes personal experiences as knowledge that can be accessible over time and to a broader public. However, our findings indicate that documentation was typically done in *ad hoc* and unstructured ways in urban farming communities. Instead of ending up in a cohesive database, information (e.g., about compost temperature) was sporadically posted in (often closed) Facebook groups. It is challenging to access such data systematically, algorithmically, and across communities. Given these experiences, we suggest that the role of design researchers might be to notice and document patterns in gardens or similar design spaces in more structured ways before intervening. Previous design research studies (e.g., Lyle et al., 2015; S.-Y. Liu, 2018) have identified general patterns in gardening. However, more local patterns specific to each garden need to be recognized by designers. The principle of permaculture is one way of noting and generalizing thinking about local environmental practices.

Providing Scaffold

Earlier research has suggested some ideas for designers that want to work with patterns of interdependence. For example, Liu et al. (2017) have shown that one design approach can be to provide a scaffold. They create conditions in which processes of decomposition can unfold in desired, but not completely controllable ways. Another example is the co-creation of materials for packaging or furniture by creating scaffolds where fungal mycelium, bacteria, or algae grows in desired shapes and material outcomes (Karana et al., 2020). In some designs, the organisms even continue to live. As they noted, this emphasizes the habitual relationship between design and use in a design process that is not finished as long as the organisms are alive. In our studies, we found that scaffolding is not only a design principle applicable in the context of studio design. It can further be used to understand the co-creation of interdependencies in real-world contexts such as gardens. The practice of heat-composting is an example where naturally occurring processes were scaffolded as gardeners were creating the conditions for desired forms of decomposition. The process was scaffolded by affecting the composition of matter such as green leaves, manure, urine, and water to provide *food* (W2) for the microbes whose metabolism then generated more heat. Without the use of measuring technology, this scaffolding would have been less accurate. This illustrates that sensing technologies can play a crucial role in providing an understanding of what and how to scaffold. These technologies can help to identify, document, and understand patterns in the environment, i.e., those phenomena that could potentially be provided scaffold. The primary environmental conditions affecting the distribution of all organisms are temperature, humidity, climate, soil type, and light intensity (Karana et al.). Further, all organisms have unique abilities to grow, metabolize, respond to external stimuli, reproduce, move, and respire. These are examples of conditions that designers and similar practitioners (such as urban farmers and gardeners) can aim to sense, understand, and affect through providing scaffold.

Relatedly, there is a recent interest in HCI for place/space/land as the central focus of design (Bardzell et al., 2021; Foth, 2017; Foth et al., 2020). Interactive technologies are here seen as tools for infrastructuring (Prost et al., 2019; Seravalli, 2018; Teli et al., 2020), i.e., structures for helping to create the often social) conditions in which certain practices can unfold. From a more-than-human-centred perspective, the goal is to create places of coming together (such as the studied urban farming communities), not only for humans but all kinds of organisms. From this perspective, all citizens participating in the studied urban farms are designers in *a structure that gathers to engage matters of concern and care* (Wakkary, 2021)—and it is this structure that is collectively designed, for example, through providing a scaffold for desired processes to unfold.

Refraining from Intervention

Above, we discussed design as intentional interviewing in various processes. However, sometimes, the best solution for supporting the interdependencies of organisms is to not design anything—to make a conscious decision to refrain from intervention. In our data, we found several examples of not mowing lawns to benefit insect biodiversity. In these cases, the role of design was to communicate the rationale behind an otherwise invisible decision so that the uncut lawns were perceived as having a purpose rather than being neglected (see Figure 5, left). While such communication is targeted toward humans, this kind of communication is necessary to keep humans from intervening in undesired ways and hence maintain the overall good relations of the interdependent system where for example flower meadows are a central component.

There are many tensions between refraining from intervention or providing a scaffold. For example, we showed how composting could proceed faster with particular scaffolding. However, this scaffolding requires human labor. Since all organic matter eventually decomposes, human intervention is not necessarily needed. This example further illustrates how a natural system in balance is replaced with a design that requires continuous human intervention. There is, thus, a risk of playing God in our attempts to intervene in more-than-human relations. Haraway (1991) describes this as the *God trick*, the applying of a *view from above, from nowhere,* that, under the guise of neutrality, hides a particular position (male, white, heterosexual, human) and thus makes this position universal. Similarly, designers (including urban farmers) risks using information/data (i.e., what is noticed) in an overly assertive way—with a false belief that the situation is under complete control or in ways that only benefit themselves while harming others. In contrast, design scholars (De Jong et al., 2016; Wakkary, 2021) offer the idea of humble design that embraces different perspectives by strengthening situated experiences, values, and norms of various stakeholders and creating platforms for discussion rather than stressing a specific view. It is thus far from certain when designers of more-than-human systems should aim to provide a scaffold and when they should refrain from intervention. This should be constantly negotiated with the stakeholders of the design space, including non-humans.

Limitations of our Study and Opportunities for Future Research

We studied the concrete interactions of urban farmers with their environments, particularly how they noticed the needs, capacities, and interdependencies of other organisms. Through this study, we offered methodological reflections on design processes that aim to be more-than-human-centred. We mainly discussed noticing as a way to approach design spaces. We further discussed design as intervening in the interdependencies between organisms, for example, by providing a scaffold to naturally occurring processes such as decomposition or reframing from intervention. In this final discussion, we address the limitations of our study and opportunities for further research on more-than-human-centred design.

In our studies of urban community farmers, we found that they used various tools and sensors to notice and gather data about the environment (e.g., thermometers, moisture sensors, and smartphone photography). Each method provides specific

information and a particular experience. No technique can fully capture the essence of the environment as our perception is reduced and amplified in various ways through technology. Thus, switching between different methods and technologies for noticing is more central than using any single technology. The most common examples were comparatively low-tech (e.g., digital thermometers). Accordingly, we emphasize the benefits of utilizing existing technologies (such as smartphones or repurposed meat thermometers) to gather environmental data that can benefit design processes (design is here understood in a broad, generous sense). Nevertheless, there are opportunities to implement and study more novel and advanced environmental sensing technologies in urban farming communities (e.g., Smartphone LIDAR, bioacoustics, drone footage, image recognition, and machine learning). Caution should be taken whether such technology is necessary. However, as pointed out by several of the participating urban farmers, devices could be shared within or even between communities to use resources more efficiently and share best practices, for example, as facilitated by smartphone applications for resource sharing.

The urban framers further emphasized bodily and attentive engagement with the soil, plants, and other organisms—and noticed their interdependencies through all their senses. In contrast to instruments developed for agriculture or natural science, this context thus requires a higher focus on engaging qualities of use. Our empirical examples suggest that simple tangible technologies that open for rich sensory experience, such as the repurposed meat thermometer, seem like one promising approach. There are further examples in design research of more speculative technologies targeting these issues, including a hand-worn device for sensing the moisture in soil (J. Liu et al., 2018) and instruments for the sonification of soil data (Liu, 2021).

We presented our study as an experiment or exploration. However, this experimentation does not deny the existential urgency (Light et al., 2017) of the climate crisis and the need for swift responses. Previous research has identified the need to move from small pilots and experiments to systemic change and impact (Dourish, 2010; Frauenberger et al., 2018; Teli et al., 2020). While we focused on furthering the situated practice of noticing, we also recognize the value of scaling more-than-human-centred practices such as regenerative urban farming. This implies a need to affect governance and policies. Environmental data could here be used as empirical arguments for more-than-human-centred urban planning. There are further opportunities to investigate if crowdsourced environmental data (such as that produced by the studied urban farmers) could be compiled in meaningful ways and made available in commercial design processes to treat the needs of the environment and organisms in it, as equal to the needs of human users. In this way, other organisms can *tell us* their needs through the data we can gather about them. While this opportunity is clear, there are fewer examples of how to include such data in actual design processes. Our study has merely begun to investigate and identify cases where the use of technology and more-than-human needs align in ways that are not overly simplistic or excessively using resources.

Conclusions

The realities of climate change, species extinction, and increasingly autonomous technologies push the field of HCI in a direction where we need to consider more-than-human needs and understand the human subject and its relationship to the world in a new, non-anthropocentric light. In this paper, we sought to forward the more-than-human-centred design agenda by offering an empirical case that helped us to articulate the process of noticing (see Figure 2) and designing with the interdependencies of organisms. To notice is to become aware of, and to treat something as worthy of recognition. As a method for approaching design spaces, noticing is thus the intentional act of perceiving that which is often overlooked. In this case, how systems function from more-than-human perspectives.

Emphasis was placed on understanding and documenting patterns of interdependence between organisms and framing design as the intentional intervening in these interdependencies, whether through interactive design or other actions. We showed how these practices involve co-creation with other organisms through at least two contradictory principles (providing scaffold and refraining from intervention). This implies that design and the designer are understood in a more open-ended way, where the agency is shared between several stakeholders in the design space. In this way, design becomes a matter of strengthening certain naturally occurring processes and slowing down others—and the challenge is to notice where exactly a beneficial intervention could be made, a process that typically implies balancing conflicting interests. We discussed how computational technologies can be part of this noticing in ways that strengthen both the experience of humans and the systemic interdependencies of organisms. In sum, more-than-human-centred design offers an alternative approach to sustainable development where technology and data can be reimagined to contribute to a future that is ecologically healthy and just.

References

1. Abram, D. (1997). *The spell of the sensuous: Perception and language in a more-than-human world.* Vintage.
2. Akama, Y., Light, A., & Kamihira, T. (2020). Expanding participation to design with more-than-human concerns. In *Proceedings of the 16th participatory design conference* (vol. 1, pp. 1-11). ACM. https://doi.org/10.1145/3385010.3385016
3. Angheloiu, C., & Tennant, M. (2020). Urban futures: Systemic or system changing interventions? A literature review using Meadows' leverage points as analytical framework. *Cities, 104*, 102808. https://doi.org/10.1016/j.cities.2020.102808
4. Ardianto, D. (2014). Understanding social media-enabled participation and resilience in urban farming communities. In *Proceedings of the 26th Australian computer-human interaction conference on designing futures* (pp. 111-114). ACM. https://doi.org/10.1145/2686612.2686627
5. Aspling, F. (2015). Animals, plants, people and digital technology: exploring and understanding multispecies-computer interaction. In *Proceedings of the 12th international conference on advances in computer entertainment technology* (Article 55). ACM. https://doi.org/10.1145/2832932.2837010

6. Aspling, F. (2020). *Unleashing animal-computer interaction: A theoretical investigation of the "I" in ACI* [Doctoral dissertation, Stockholm University]. http://su.diva-portal.org/smash/record.jsf?dswid=9576&pid=diva2%3A1425792
7. Aspling, F., Wang, J., & Juhlin, O. (2016). Plant-computer interaction, beauty and dissemination. In *Proceedings of the 3rd international conference on animal-computer interaction* (Article 5). ACM. https://doi.org/10.1145/2995257.2995393
8. Barad, K. (2003). Posthumanist performativity: Toward an understanding of how matter comes to matter. *Signs, 28*(3), 801-831. https://doi.org/10.1086/345321
9. Barad, K. (2007). *Meeting the universe halfway.* Duke University Press.
10. Bardzell, J., Bardzell, S., & Light, A. (2021). Wanting to live here: Design after anthropocentric functionalism. In *Proceedings of the conference on human factors in computing systems* (pp. 1-24). ACM. https://doi.org/10.1145/3411764.3445167
11. Bastian, M. (2017). Towards a more-than-human participatory research. In M. Bastian, O. Jones, N. Moore, & E. Roe (Eds.), *Participatory research in more-than-human worlds* (pp. 19-37). Routledge.
12. Biggs, H., Bardzell, J., & Bardzell, S. (2021). Watching myself watching birds: Abjection, ecological thinking, and posthuman design. In *Proceedings of the conference on human factors in computing systems* (pp. 1-16). ACM. https://doi.org/10.1145/3411764.3445329
13. Blevis, E. (2007). Sustainable interaction design: Invention & disposal, renewal & reuse. In *Proceedings of the conference on human factors in computing systems* (pp. 503-512). ACM. https://doi.org/10.1145/1240624.1240705
14. Bogost, I. (2012). *Alien phenomenology, or what it's like to be a thing.* University of Minnesota Press. https://doi.org/10.5749/minnesota/9780816678976.001.0001
15. Bolund, P., & Hunhammar, S. (1999). Ecosystem services in urban areas. *Ecological Economics, 29*(2), 293-301. https://doi.org/10.1016/S0921-8009(99)00013-0
16. Börjesson Rivera, M., Håkansson, C., Svenfelt, Å., & Finnveden, G. (2014). Including second order effects in environmental assessments of ICT. *Environmental Modelling & Software, 56*, 105-115. https://doi.org/10.1016/j.envsoft.2014.02.005
17. Braidotti, R. (2019). A theoretical framework for the critical posthumanities. *Theory, Culture & Society, 36*(6), 31-61. https://doi.org/10.1177/0263276418771486
18. Brant, J. (2021). Sand talk: How indigenous thinking can save the world. *International Journal of Lifelong Education, 40*(4), 427-430. https://doi.org/10.1080/02601370.2021.1954393
19. Braybrooke, K. (2022, January 17). To know the individual is to know the collective: Translocal encounters of the virtual community art tech nature culture. *Society for social studies of science.* https://www.4sonline.org/to-know-the-individual-is-to-know-the-collective-translocal-encounters-of-the-virtual-community-art-tech-nature-culture/
20. Brynjarsdottir, H., Håkansson, M., Pierce, J., Baumer, E., DiSalvo, C., & Sengers, P. (2012). Sustainably unpersuaded: How persuasion narrows our vision of sustainability. In *Proceedings of the conference on human factors in computing systems* (pp. 947-956). ACM. https://doi.org/10.1145/2207676.2208539
21. Budinger, K., & Heidmann, F. (2019). Our symbiotic life: An exploration of interspecies relations. In *Proceedings of the conference on designing interactive systems* (pp. 1349-1362). ACM. https://doi.org/10.1145/3322276.3323698
22. Carrozzo, F., Faccini, R., Falci, A., Redaelli, B., Gelsomini, M., Zannoni, G., & Garzotto, F. (2018). IDROPO, a hydroponic planting system to teach gardening through play. In *Proceedings of the conference on human factors in computing systems* (pp. 1-4). ACM. https://doi.org/10.1145/3170427.3186489
23. Chen, J. (2015). Computing within limits and ICTD. First Monday, 20(8). https://doi.org/10.5210/fm.v20i8.6124
24. Choi, J., & Galloway, A. (2021). Movement, time, and space, two ways. *Interactions, 28*(2), 24-25. https://doi.org/10.1145/3450146
25. Choi, J. H., & Blevis, E. (2010). HCI & sustainable food culture: A design framework for engagement. In *Proceedings of the 6th Nordic conference on human-computer interaction* (pp. 112-117). ACM. https://doi.org/10.1145/1868914.1868931
26. Chung, M., & Hong, C.-S. (2016). Monitoring and controlling method of the environment condition in the animal breeding farm by using smart phone. In *Proceedings of the 5th international conference on network, communication and computing* (pp. 316-320). ACM. https://doi.org/10.1145/3033288.3033322
27. Clarke, R., Heitlinger, S., Foth, M., DiSalvo, C., Light, A., & Forlano, L. (2018). More-than-human urban futures: Speculative participatory design to avoid ecocidal smart cities. In *Proceedings of the 15th participatory design conference* (Article 34). ACM. https://doi.org/10.1145/3210604.3210641
28. Clarke, R., Heitlinger, S., Light, A., Forlano, L., Foth, M., & DiSalvo, C. (2019). More-than-human participation: Design for sustainable smart city futures. *Interactions, 26*(3), 60-63. https://doi.org/10.1145/3319075
29. Coulton, P., & Lindley, J. G. (2019). More-than human centred design: Considering other things. *The Design Journal, 22*(4), 463-481. https://doi.org/10.1080/14606925.2019.1614320
30. Cultural Survival. (2020, November 24). *Whitewashed hope: A message from 10+ indigenous leaders and organizations.* http://www.culturalsurvival.org/news/whitewashed-hope-message-10-indigenous-leaders-and-organizations
31. De Jong, A., Önnevall, E., Reitsma, L., & Wessmann, S. (2016). Challenging the role of design(ing) in the sustainability field: Towards a "humble" design approach. In *Proceedings of the 9th Nordic conference on human-computer interaction* (pp. 1-3). ACM. https://doi.org/10.1145/2971485.2987671

32. Devendorf, L., De Kosnik, A., Mattingly, K., & Ryokai, K. (2016). Probing the potential of post-anthropocentric 3d printing. In *Proceedings of the conference on designing interactive systems* (pp. 170-181). ACM. https://doi.org/10.1145/2901790.2901879
33. DiSalvo, C., Sengers, P., & Brynjarsdóttir, H. (2010). Mapping the landscape of sustainable HCI. In *Proceedings of the conference on human factors in computing systems* (pp. 1975-1984). ACM. https://doi.org/10.1145/1753326.1753625
34. Dourish, P. (2010). HCI and environmental sustainability: The politics of design and the design of politics. In *Proceedings of the 8th conference on designing interactive systems* (pp. 1-10). ACM. https://doi.org/10.1145/1858171.1858173
35. Egan, C., Thompson, R., & O'Dowd, A. (2019). The Lions' Gate: Towards a permaculture-inspired blended space. In *Proceedings of the 5th workshop on computing within limits* (Article 7). ACM. https://doi.org/10.1145/3338103.3338110
36. Engelbutzeder, P., Cerna, K., Randall, D., Lawo, D., Müller, C., Stevens, G., & Wulf, V. (2020). Investigating the use of digital artifacts in a community project of sustainable food practices: My chili blossoms. In *Proceedings of the 11th Nordic conference on human-computer interaction* (Article 107). ACM. https://doi.org/10.1145/3419249.3420089
37. Escobar, A. (2018). *Designs for the pluriverse: Radical interdependence, autonomy, and the making of worlds*. Duke University Press.
38. Fastnacht, T., Aispuro, A. O., Marschall, J., Fischer, P. T., Zierold, S., & Hornecker, E. (2016). Sonnengarten: Urban light installation with human-plant interaction. In *Proceedings of the international joint conference on pervasive and ubiquitous computing* (pp. 53-56). ACM. https://doi.org/10.1145/2968219.2971423
39. Fletcher, J., & Benjamin, A. (2012). *Abjection, melancholia, and love: The work of Julia Kristeva*. Routledge. https://doi.org/10.4324/9780203120545
40. Forchino, A. A., Lourguioui, H., Brigolin, D., & Pastres, R. (2017). Aquaponics and sustainability: The comparison of two different aquaponic techniques using the life cycle assessment (LCA). *Aquacultural Engineering, 77*, 80-88. https://doi.org/10.1016/j.aquaeng.2017.03.002
41. Forlano, L. (2016). Decentering the human in the design of collaborative cities. *Design Issues, 32*(3), 42-54. https://doi.org/10.1162/DESI_a_00398
42. Forlano, L. (2017). Posthumanism and design. *She Ji: The Journal of Design, Economics, and Innovation, 3*(1), 16-29. https://doi.org/10.1016/j.sheji.2017.08.001
43. Fors, P. (2019). *Problematizing sustainable ICT*. Uppsala University.
44. Foth, M. (2017). Lessons from urban guerrilla placemaking for smart city commons. In *Proceedings of the 8th international conference on communities and technologies* (pp. 32-35). ACM. https://doi.org/10.1145/3083671.3083707
45. Foth, M., & Caldwell, G. A. (2018). More-than-human media architecture. In *Proceedings of the 4th media architecture biennale conference* (pp. 66-75). ACM. https://doi.org/10.1145/3284389.3284495
46. Foth, M., Mann, M., Bedford, L., Frieuw, W., & Walters, R. (2020). A capitalocentric review of technology for sustainable development: The case for more-than-human design. *Global Information Society Watch.*
47. Frauenberger, C., Foth, M., & Fitzpatrick, G. (2018). On scale, dialectics, and affect: Pathways for proliferating participatory design. In *Proceedings of the 15th participatory design conference* (Article 12). ACM. https://doi.org/10.1145/3210586.3210591
48. Frawley, J. K., & Dyson, L. E. (2014). Animal personas: Acknowledging non-human stakeholders in designing for sustainable food systems. In *Proceedings of the 26th Australian computer-human interaction conference on designing futures* (pp. 21-30). ACM. https://doi.org/10.1145/2686612.2686617
49. French, F., Baskin, S., Wallace, B., Cheok, A. D., Zamanzky, A., & Nannoni, E. (2017). FarmJam 2017: Designing enrichment for farm animals. In *Proceedings of the 4th international conference on animal-computer interaction* (Article 21). ACM. https://doi.org/10.1145/3152130.3152154
50. Galloway, A. (2016). More-than-human lab: Creative ethnography after human exceptionalism. In L. Hjorth, H. Horst, A. Galloway, & G. Bell (Eds.), *The Routledge companion to digital ethnography* (Chapter 43). Routledge. https://doi.org/10.4324/9781315673974
51. Galloway, A., & Caudwell, C. (2018). Speculative design as research method: From answers to questions and "staying with the trouble." In G. Coombs, A. McNamara, & G. Sade (Eds.), *Undesign critical practices at the intersection of art and design* (pp. 85-96). Routledge. https://doi.org/10.4324/9781315526379-8
52. Giaccardi, E., & Redström, J. (2020). Technology and more-than-human design. *Design Issues, 36*(4), 33-44. https://doi.org/10.1162/desi_a_00612
53. Goodwin, C. (1997). The blackness of black: Color categories as situated practice. In L. B. Resnick, R. Säljö, C. Pontecorvo, & B. Burge (Eds.), *Discourse, tools and reasoning: Essays on situated cognition* (pp. 111-140). Springer. https://doi.org/10.1007/978-3-662-03362-3_6
54. Haraway, D. (1988). Situated knowledges: The science question in feminism and the privilege of partial perspective. *Feminist Studies, 14*(3), 575-599. https://doi.org/10.2307/3178066
55. Haraway, D. (1991). *Simians, cyborgs, and women: The reinvention of nature.* Routledge.
56. Haraway, D. (2016). *Staying with the trouble.* Duke University Press.
57. Hayles, N. K. (1999). *How we became posthuman: Virtual bodies in cybernetics, literature, and informatics.* University of Chicago Press.
58. Heitlinger, S., Bryan-Kinns, N., & Comber, R. (2018a). Connected seeds and sensors: Co-designing internet of things for sustainable smart cities with urban food-growing communities. In *Proceedings of the 15th participatory design conference* (Article 18). ACM. https://doi.org/10.1145/3210604.3210620

59. Heitlinger, S., Bryan-Kinns, N., & Comber, R. (2019a). The right to the sustainable smart city. In *Proceedings of the conference on human factors in computing systems* (Article 287). ACM. https://doi.org/10.1145/3290605.3300517
60. Heitlinger, S., Bryan-Kinns, N., & Jefferies, J. (2013). Sustainable HCI for grassroots urban food-growing communities. In *Proceedings of the 25th Australian computer-human interaction conference* (pp. 255-264). ACM. https://doi.org/10.1145/2541016.2541023
61. Heitlinger, S., Bryan-Kinns, N., & Jefferies, J. (2014). The talking plants: An interactive system for grassroots urban food-growing communities. In Proceedings of the conference on human factors in computing systems (pp. 459-462). ACM. https://doi.org/10.1145/2559206.2574792
62. Heitlinger, S., Clarke, R., Clear, A. K., Chopra, S., & Dilaver, Ö. (2019b). Co-creating "smart" sustainable food futures with urban food growers. In *Proceedings of the 9th international conference on communities & technologies* (pp. 114-120). ACM. https://doi.org/10.1145/3328320.3328399
63. Heitlinger, S., Foth, M., Clarke, R., DiSalvo, C., Light, A., & Forlano, L. (2018b). Avoiding ecocidal smart cities: Participatory design for more-than-human futures. In *Proceedings of the 15th participatory design conference* (Article 51). ACM. https://doi.org/10.1145/3210604.3210619
64. Holstius, D., Kembel, J., Hurst, A., Wan, P.-H., & Forlizzi, J. (2004). Infotropism: Living and robotic plants as interactive displays. In *Proceedings of the 5th conference on designing interactive systems* (pp. 215-221). ACM. https://doi.org/10.1145/1013115.1013145
65. Höök, K. (2018). *Designing with the body: Somaesthetic interaction design.* MIT Press.
66. Ingold, T. (2020). *Correspondences.* John Wiley & Sons.
67. Isai, B., & Viller, S. (2010). Meet eater: Affectionate computing, social networks and human-plant interaction. In *Proceedings of the 22nd OZCHI conference on computer-human interaction* (pp. 414-415). ACM. https://doi.org/10.1145/1952222.1952322
68. Ives, S. (2019). "More-than-human" and "less-than-human": Race, botany, and the challenge of multispecies ethnography. *Catalyst: Feminism, Theory, Technoscience, 5*(2). https://doi.org/10.28968/cftt.v5i2.32835
69. Jackson, M. M., Byrne, C., Freil, L., Valentin, G., Zuerndorfer, J., Zeagler, C., Logas, J., Gilliland, S., Rapoport, A., Sun, S., Peet, D., Lau, A., Han, X., Alcaidinho, J., & Starner, T. (2018). Technology for working dogs. In *Proceedings of the 5th international conference on animal-computer interaction* (Article 17). ACM. https://doi.org/10.1145/3295598.3295615
70. Karana, E., Barati, B., & Giaccardi, E. (2020). Living artefacts: Conceptualizing livingness as a material quality in everyday artefacts. *International Journal of Design, 14*(3), 37-53.
71. King, M. (2020). *Forms of intelligence.* Retrieved from https://kwmc.org.uk/projects/formsofintelligence/
72. Kirksey, S. E., & Helmreich, S. (2010). The emergence of multispecies ethnography. *Cultural Anthropology, 25*(4), 545-576. https://doi.org/10.1111/j.1548-1360.2010.01069.x
73. Knowles, B., Bates, O., & Håkansson, M. (2018). This changes sustainable HCI. In *Proceedings of the conference on human factors in computing systems* (pp. 1-12). ACM. http://doi.org/10.1145/3173574.3174045
74. Knowles, B., Blair, L., Walker, S., Coulton, P., Thomas, L., & Mullagh, L. (2014). Patterns of persuasion for sustainability. In *Proceedings of the conference on designing interactive systems* (pp. 1035-1044). ACM. https://doi.org/10.1145/2598510.2598536
75. Kovalchuk, I., & Kovalchuk, O. (2008). Transgenic plants as sensors of environmental pollution genotoxicity. *Sensors, 8*(3), 1539-1558. https://doi.org/10.3390/s8031539
76. Kuribayashi, S., Sakamoto, Y., Morihara, M., & Tanaka, H. (2007). Plantio: An interactive pot to augment plants' expressions. In *Proceedings of the international conference on advances in computer entertainment technology* (pp. 139-142). ACM. https://doi.org/10.1145/1255047.1255075
77. Kuznetsov, S., Odom, W., Pierce, J., & Paulos, E. (2011). Nurturing natural sensors. In *Proceedings of the 13th international conference on ubiquitous computing* (pp. 227-236). ACM. https://doi.org/10.1145/2030112.2030144
78. Latour, B. (1996). On actor-network theory: A few clarifications. *Soziale Welt, 47*(4), 369-381. https://www.jstor.org/stable/40878163
79. Latulippe, N., & Klenk, N. (2020). Making room and moving over: Knowledge co-production, indigenous knowledge sovereignty and the politics of global environmental change decision-making. *Current Opinion in Environmental Sustainability, 42,* 7-14. https://doi.org/10.1016/j.cosust.2019.10.010
80. Lehmann, S. (2019). Reconnecting with nature: Developing urban spaces in the age of climate change. *Emerald Open Research, 1*(2). https://doi.org/10.12688/emeraldopenres.12960.1
81. Light, A., Shklovski, I., & Powell, A. (2017). Design for existential crisis. In *Proceedings of the conference extended abstracts on human factors in computing systems* (pp. 722-734). ACM. https://doi.org/10.1145/3027063.3052760
82. Liu, S. -Y. (2017). To decompose is to create: Supporting creativity by incorporating nature in design. In *Proceedings of the SIGCHI conference on creativity and cognition* (pp. 484-489. https://doi.org/10.1145/3059454.3078696
83. Liu, J., Byrne, D., & Devendorf, L. (2018). Design for collaborative survival: An inquiry into human-fungi relationships. In *Proceedings of the conference on human factors in computing systems* (Article 40). ACM. https://doi.org/10.1145/3173574.3173614
84. Liu, S.-Y., Bardzell, S., & Bardzell, J. (2018). Out of control: Reframing sustainable HCI using permaculture. In *Proceedings of the workshop on computing within limits* (Article 2). ACM. https://doi.org/10.1145/3232617.3232625
85. Liu, S.-Y., Bardzell, S., & Bardzell, J. (2019a). Symbiotic encounters: HCI and sustainable agriculture. In *Proceedings of the conference on human factors in computing systems* (Paper No. 317). ACM. https://doi.org/10.1145/3290605.3300547

86. Liu, S.-Y. (Cyn). (2021). *Posthuman interaction design: Designing with, through and for human-nature interaction.* Indiana University.
87. Liu, S.-Y. (Cyn), Bardzell, J., & Bardzell, S. (2018). Photography as a design research tool into natureculture. In *Proceedings of the designing interactive systems conference* (pp. 777-789). ACM. https://doi.org/10.1145/3196709.3196819
88. Liu, S.-Y., Liu, J., Dew, K., Zdziarska, P., Livio, M., & Bardzell, S. (2019b). Exploring noticing as method in design research. In *Proceedings of the designing interactive systems conference* (pp. 377-380). ACM. https://doi.org/10.1145/3301019.3319995
89. Livio, M., Liu, J., Dew, K., Liu, S., & Zdziarska, P. (2019). *Methods for noticing workbook.* https://files.cargocollective.com/c531133/Methods-for-Noticing-Workbook_May-2020-.pdf
90. Loke, L., & Núñez-Pacheco, C. (2018). Developing somatic sensibilities for practices of discernment in interaction design. *The Senses and Society, 13*(2), 219-231. https://doi.org/10.1080/17458927.2018.1468690
91. Luusua, A., Ylipulli, J., & Rönkkö, E. (2017). Nonanthropocentric design and smart cities in the anthropocene. *It - Information Technology, 59*(6). https://doi.org/10.1515/itit-2017-0007
92. Lyle, P., Choi, J. H., & Foth, M. (2013). HCI for city farms: Design challenges and opportunities. In P. Kotzé, G. Marsden, G. Lindgaard, J. Wesson, & M. Winckler (Eds.), *Proceedings of the conference on human-computer interaction* (pp. 109-116). Springer. https://doi.org/10.1007/978-3-642-40498-6_7
93. Lyle, P., Choi, J. H., & Foth, M. (2015). Growing food in the city: Design ideations for urban residential gardeners. In *Proceedings of the 7th international conference on communities and technologies* (pp. 89-97). ACM. https://doi.org/10.1145/2768545.2768549
94. Maddali, H. T., & Lazar, A. (2020). Sociality and skill sharing in the garden. In *Proceedings of the conference on human factors in computing systems* (pp. 1-13). ACM. https://doi.org/10.1145/3313831.3376246
95. Matasov, V., Belelli Marchesini, L., Yaroslavtsev, A., Sala, G., Fareeva, O., Seregin, I., Castaldi, S., Vasenev, V., & Valentini, R. (2020). IoT monitoring of urban tree ecosystem services: Possibilities and challenges. *Forests, 11*(7), 775. https://doi.org/10.3390/f11070775
96. Mollison, B. (1997). *Permaculture: A designer's manual.* Tagari.
97. Muntean, R., Antle, A. N., & Hennessy, K. (2020). Communicating sustainable consumption and production in 360 video. In *Proceedings of the designing interactive systems conference* (pp. 1259-1271). ACM. https://doi.org/10.1145/3357236.3395460
98. Nansen, B., Pearce, J. M., & Smith, W. (2011). Gardening online: A tale of suburban informatics. In M. Foth, L. Forlano, C. Satchell, & M. Gibbs (Eds.), *From social butterfly to engaged citizen* (Chapter 9). MIT Press Direct. https://doi.org/10.7551/mitpress/8744.003.0015
99. Nardi, B., Tomlinson, B., Patterson, D. J., Chen, J., Pargman, D., Raghavan, B., & Penzenstadler, B. (2018). Computing within limits. *Communications of the ACM, 61*(10), 86-93. https://doi.org/10.1145/3183582
100. Nijs, G., Laki, G., Houlstan, R., Slizewicz, G., & Laureyssens, T. (2020). Fostering more-than-human imaginaries: Introducing DIY speculative fabulation in civic HCI. In *Proceedings of the 11th Nordic conference on human-computer interaction* (Article 36). ACM. https://doi.org/10.1145/3419249.3420147
101. Normark, M., Poikolainen Rosén, A., & Bonow, M. (2021). Articulating and negotiating boundaries in urban farming communities. In *Proceedings of the 10th international conference on communities & technologies* (pp. 296-308). ACM. https://doi.org/10.1145/3461564.3461565
102. North, S. (2017). Hey, where's my hay? Design fictions in horse-computer interaction. In *Proceedings of the 4th international conference on animal-computer interaction* (Article 17). ACM. https://doi.org/10.1145/3152130.3152149
103. Norton, J. (2019). *Information systems for grassroots sustainable agriculture.* University of Irvine.
104. Norton, J., Nayebaziz, S., Burke, S., Pan, B. J., & Tomlinson, B. (2014). Plant guild composer: An interactive online system to support back yard food production. In *Extended abstracts of the conference on human factors in computing systems* (pp. 523-526). ACM. https://doi.org/10.1145/2559206.2574826
105. Odom, W. (2010). "Mate, we don't need a chip to tell us the soil's dry": Opportunities for designing interactive systems to support urban food production. In *Proceedings of the 8th conference on designing interactive systems* (pp. 232-235). ACM. https://doi.org/10.1145/1858171.1858211
106. Penzenstadler, B., Duboc, L., Venters, C. C., Betz, S., Seyff, N., Wnuk, K., Chitchyan, R., Easterbrook, S. M., & Becker, C. (2018). Software engineering for sustainability find the leverage points! *IEEE Software, 35*(4), 22-33. https://doi.org/10.1109/MS.2018.110154908
107. Poikolainen Rosén, A. (2022). Relating to soil: Chromatography as a tool for environmental engagement. In *Proceedings of the designing interactive systems conference* (pp. 1640-1653). ACM. https://doi.org/10.1145/3532106.3533503
108. Poikolainen Rosén, A., Normark, M., & Wiberg, M. (2020). Relating to the environment through photography: The smartphone camera as a tool in urban farming. In *Proceedings of the 32nd OZCHI conference on human-computer interaction* (pp. 506-519). ACM. https://doi.org/10.1145/3441000.3441026
109. Poikolainen Rosén, A., Normark, M., & Wiberg, M. (2022). Noticing the environment – A design ethnography of urban farming. In *Proceedings of the Nordic human-computer interaction conference* (Article 34). ACM. https://doi.org/10.1145/3546155.3546659
110. Prost, S., Vlachokyriakos, V., Midgley, J., Heron, G., Meziant, K., & Crivellaro, C. (2019). Infrastructuring food democracy: The formation of a local food hub in the context of socio-economic deprivation. *Proceedings of the ACM on Human-Computer Interaction, 3*(CSCW), Article 57. https://doi.org/10.1145/3359159

111. Prpa, M., Fdili-Alaoui, S., Schiphorst, T., & Pasquier, P. (2020). Articulating experience: Reflections from experts applying micro-phenomenology to design research in HCI. In *Proceedings of the conference on human factors in computing systems* (pp. 1-14). ACM. https://doi.org/10.1145/3313831.3376664
112. Puig de la Bellacasa, M. (2010). Ethical doings in naturecultures. *Ethics Place and Environment, 13*(2), 151-169. https://doi.org/10.1080/13668791003778834
113. Raghavan, B., Nardi, B., Lovell, S. T., Norton, J., Tomlinson, B., & Patterson, D. J. (2016). Computational agroecology: Sustainable food ecosystem design. In *Proceedings of the conference extended abstracts on human factors in computing systems* (pp. 423-435). ACM. https://doi.org/10.1145/2851581.2892577
114. Ringenson, T., Eriksson, E., Börjesson Rivera, M., & Wangel, J. (2017). The limits of the smart sustainable city. In *Proceedings of the workshop on computing within limits* (pp. 3-9). ACM. https://doi.org/10.1145/3080556.3080559
115. Robbins, H., Frens, J., Kuijer, L., & Wakkary, R. (2020). Speculative energy futures: Post-human design for the energy transition. In *Proceedings of the 11th Nordic conference on human-computer interaction* (pp. 1-3). ACM. http://doi.org/10.1145/3419249.3420073
116. Røpke, I. (2012). The unsustainable directionality of innovation – The example of the broadband transition. *Research Policy, 41*(9), 1631-1642. https://doi.org/10.1016/j.respol.2012.04.002
117. Seravalli, A. (2018). Infrastructuring urban commons over time: Learnings from two cases. In *Proceedings of the 15th participatory design conference* (Article 4). ACM. https://doi.org/10.1145/3210586.3210593
118. Sheikh, H., Gonsalves, K., & Foth, M. (2021). Plant(e) tecture: Towards a multispecies media architecture framework for amplifying plant agencies. In *Proceedings of the biennale of media architecture* (pp. 87-99). ACM. http://doi.org/10.1145/3469410.3469419
119. Smith, N., Bardzell, S., & Bardzell, J. (2017). Designing for cohabitation: Naturecultures, hybrids, and decentering the human in design. In *Proceedings of the conference on human factors in computing systems* (pp. 1714-1725). ACM. https://doi.org/10.1145/3025453.3025948
120. Smith, N. E. (2019). *Decentering design: Bees, biomimicry and the sixth mass extinction.* Indiana University.
121. Teli, M., Foth, M., Sciannamblo, M., Anastasiu, I., & Lyle, P. (2020). Tales of institutioning and commoning: Participatory design processes with a strategic and tactical perspective. In *Proceedings of the 16th participatory design conference* (pp. 159-171). ACM. https://doi.org/10.1145/3385010.3385020
122. Tironi, M., & Hermansen, P. (2018). Cosmopolitical encounters: Prototyping at the national zoo in Santiago, Chile. *Journal of Cultural Economy, 11*(4), 330-347. https://doi.org/10.1080/17530350.2018.1433705
123. Tsing, A. (2015). *The mushroom at the end of the world.* Princeton University Press.
124. Tsing, A., Deger, J., Keleman, A., & Zhou, F. (2020). *Feral Atlas: The more-than-human anthropocene.* Stanford University Press.
125. Turner, J., & Morrison, A. (2021). Designing slow cities for more-than-human enrichment: Dog tales–Using narrative methods to understand co-performative place-making. *Multimodal Technologies and Interaction, 5*(1), Article 1. https://doi.org/10.3390/mti5010001
126. Vásquez-Fernández, A. M., & Ahenakew, C. (2020). Resurgence of relationality: Reflections on decolonizing and indigenizing 'sustainable development.' *Current Opinion in Environmental Sustainability, 43*, 65-70. https://doi.org/10.1016/j.cosust.2020.03.005
127. Wakkary, R. (2020). Nomadic practices: A posthuman theory for knowing design. *International Journal of Design, 14*(3), 117-128.
128. Wakkary, R. (2021). *Things we could design: For more-than-human-centered worlds.* MIT Press.
129. Wakkary, R., Desjardins, A., Hauser, S., & Maestri, L. (2013). A sustainable design fiction: Green practices. *ACM Transactions on Computer-Human Interaction, 20*(4), Article 23. https://doi.org/10.1145/2494265
130. Westerlaken, M., & Gualeni, S. (2016). Becoming with: Towards the inclusion of animals as participants in design processes. In *Proceedings of the 3rd international conference on animal-computer interaction* (pp. 1-10). ACM. https://doi.org/10.1145/2995257.2995392
131. Wolff, A., Knutas, A., Pässilä, A., Lautala, J., Kantola, L., & Vainio, T. (2021). Designing SciberPunks as future personas for more-than-human design. In *Proceedings of the conference on human factors in computing systems* (Article 61). ACM. https://doi.org/10.1145/3411763.3443443
132. Yigitcanlar, T., Foth, M., & Kamruzzaman, Md. (2019). Towards post-anthropocentric cities: Reconceptualizing smart cities to evade urban ecocide. *Journal of Urban Technology, 26*(2), 147-152. https://doi.org/10.1080/10630732.2018.1524249