



Embodied Traces: Multispecies Entanglements in Urban Spaces

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Fig. 1

The author documents a bird-building collision on the way home.

ABSTRACT

Collisions with man-made structures such as buildings, vehicles, and energy infrastructure are a significant threat to bird populations. Throughout the U.S., groups of volunteers monitor bird-building collisions to better understand the environmental impact of collisions and to advocate for the use of bird-safe building materials. The first author participated in monitoring bird-building collisions in Atlanta during the spring and fall migration seasons of 2023. This pictorial is a reflection on the experience of producing this data based on interviews with volunteers and the experiences and photographs of the first author. We contribute a rich account of the experiential elements of data production and a discussion of more-than-human entanglements in urban spaces.

Authors Keywords

More-than-human, critical data studies, citizen science

CSS Concepts

- Human-centered computing~Empirical studies in HCI

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INTRODUCTION

We live in a time of environmental destruction. Along with work aiming towards sustainability at individual and societal levels [12, 15], HCI researchers have pushed for work exploring ways of coming to terms with existential threats [25], inevitable collapse [38], and loss [29]. One method for doing so is to decenter the human through multi-species thinking. This approach has been discussed in a variety of different fields, including STS [23] and feminist technoscience [19, 39]. In HCI, recent work has begun to acknowledge the varied and heterogeneous relations between humans and non-humans in a wide variety of settings including food systems [1, 13, 14, 20], microbes [4, 5], and the body [21, 34]. Broadly, the *post-human*, and related concepts such as *non-human*, the *multispecies*, the *anthropocene*, and the *more-than-human*, expands modes of thinking by acknowledging the “multiple agencies, dependencies, entanglements, and relations that make up our world” [17]. The posthuman resists binaries -- distinctions between human and non-human, nature and culture, or, as we discuss here, humans, birds, and the built environment.

This project examines the experience of producing data on bird-building collisions in Atlanta. Bird-building collisions are a significant threat to bird populations,

CONTENT WARNING:

This work contains graphic images of dead birds.

resulting in the deaths 365 million to 1 billion birds each year in the U.S alone. Safe Flight volunteers cover standardized routes in Atlanta, walking 3-4 miles as early as four in the morning multiple times each week during the Spring and Fall. Volunteers photographed traces of bird-building collisions and collected bird bodies, which were donated to university collectors to use for educational purposes in the classroom. The volunteer efforts are aimed at advocating for window retrofits and bird-safe building legislation in Atlanta to protect birds from collisions. Between 2017 and 2022, the group documented over 3,000 bird deaths.

Here we explore how the city is experienced by these data producers and how this data work facilitated acts of noticing [3, 26, 39], attuning volunteers to the more-than-human. While we often think of data as objective, here we unpack the subjective, emotional, embodied, relational experiences that data is produced within. Through intimate and hostile experiences, volunteers occupied city spaces as data producers, developed local knowledge about human impacts on bird populations, and responded emotionally to the visceral traces of these violent relations. We contribute reflections on the experience of data production and discuss the potential of data to attune to the more-than-human.

Informed by interviews and participation in Project Safe Flight, we explore the images taken over the course of the project, contribute reflections on the experience of data production, and discuss the potential of data work to attune to the more-than-human. The first author conducted this work with additional authors in co-advisory roles, but due to the reflective nature of this publication, we will continue our discussion in first person. In this pictorial, we share images, including images of dead birds, to contribute a rich description of the experiences of data collection and encounters with the more-than-human entanglements.

METHODS

I partnered with Project Safe Flight to explore the affective aspects of data production and the relationship

between data and policy. Taking a qualitative approach, I conducted 20 interviews with volunteers and stakeholders of bird-building collisions and participated in monitoring during fall and spring migration in 2023. This pictorial focuses on 9 interviews with volunteers, who were asked about their motivation, experiences, and tools that supported their work, and field notes and visual media from my experience volunteering, during which I documented 23 collisions and salvaged 8 bird bodies.

Interview data was analyzed through iterative thematic analysis, resulting in three major overarching categories: messy material data, digital data, and experiences. This pictorial focuses on the final collection of themes, experiences, which included sub-categories of emotional responses, local knowledge, partnerships, urban spaces, human impacts, mutuality, and finding bodies. As these themes developed, I reviewed my field notes and images to examine how these themes appeared in my personal reflections. This pictorial was informed by interpretations of themes in the stories reported by volunteers and my reflections on my own experience monitoring bird-building collisions. The images shared here include both my contributions as a participant in Project Safe Flight and the data I collected as a researcher studying Project Safe Flight. Throughout this publication, line annotations draw attention to these themes.

While not the intended subject of these photographs, I appear as a body in these images. My shadow stretches along the sidewalk (Fig. 2), my hand splays to demonstrate the relative size of a bird, and my reflection stands in the glass that likely killed the bird at my feet (Fig 1). Similarly, while not the intended subject of research, my opinions, emotions, and experiences show up in this pictorial, as I reflect on my own experiences monitoring collisions and observing monitoring collisions. The presence of a body in these images also reminds us that data production, in this case, is an embodied experience. It relies on participation, observation, and interpretation by volunteers who occupy city spaces at unusual times and in unusual ways. Instead of examining data products, this pictorial seeks to attend to the embodied aspects of data production.

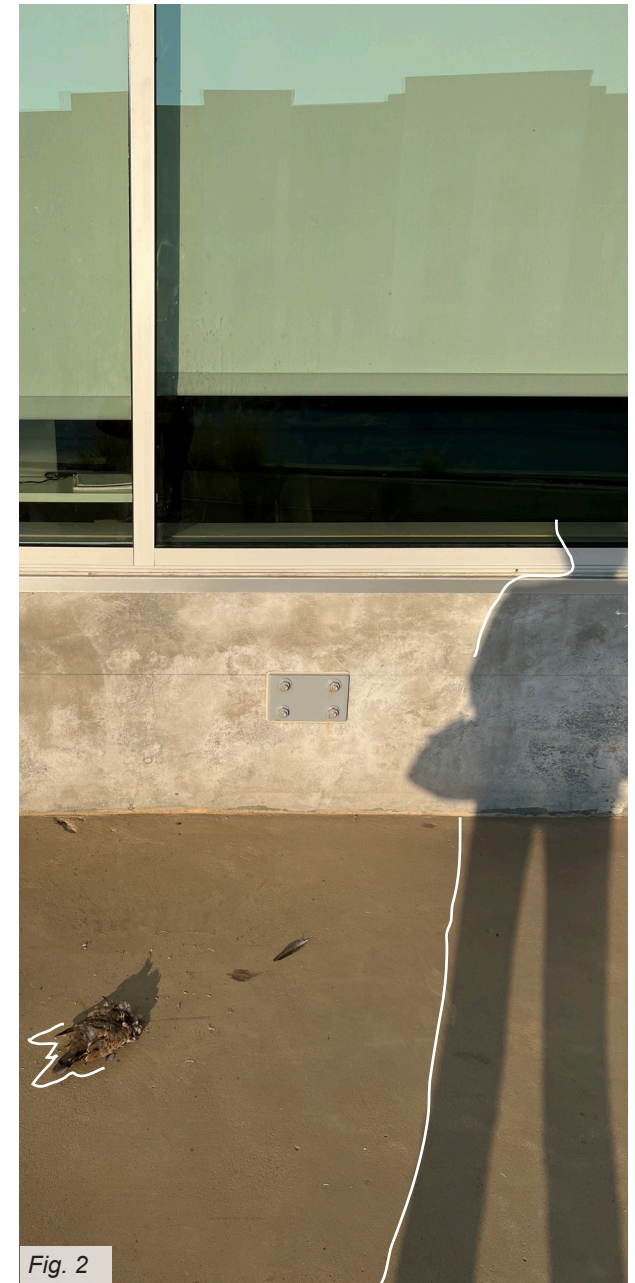




Fig. 3



Fig. 4



Fig. 5



Fig. 6



Fig. 7



Fig. 8

URBAN SPACES

Searching for traces of bird-building collisions takes time, skill, and rigorous attention, facilitating a unique experience in the urban environment. Volunteers stared intently at the ground (Fig. 4), peered into corners (Figs. 3, 7), and navigated around landscaping. AK reported “*I tried to look very closely at everything, just making sure I wasn’t missing anything.*” For EM, the “*main strategy was just be as observant as possible*”. KS discussed how her experience walking routes for the Audubon seeped into their everyday life, “*I walk around one eye on the ground.*” Field notes from the first author note that “*You really can’t do a birdwalk fast. It takes time to look. You have to walk up to leaf piles to see if there’s actually a bird there*” (Fig. 6). Volunteers also had strategies they used to find traces. RB told me that ideally, volunteers would look in every planter, behind the planters, and even in rotating doors. MG stressed the importance of checking all awnings and covers. EM reminded me that the birds that hit high windows can fall further back from the building wall and that they also make sure to look under bushes in landscaping. The images to the left capture this experience, highlighting the smallest scale of urban spaces that often go unnoticed.

On the other hand, volunteers expressed discomfort in occupying these spaces. As my regular route covered a carefully landscaped college campus, the unpleasantness of a city landscape designed for cars was greatly reduced, but there was a stark difference in occupying different parts of the city. Volunteers who were also experienced birders highlighted the differences in environments between the spaces they typically bird in and the spaces they occupy for monitoring. They complained about automobile noise. One volunteer reported that their hatred of this form of urban spaces was one of the motivating factors that led her to participate in monitoring (RB). They wanted to call attention to inhospitable urban landscapes -- what another volunteer called “*the grim asphalt expanse*” (BN). The image on the following page captures the discomfort of occupying spaces that are vast, noisy, and hostile (Fig. 9).



Fig. 9

KILLER BUILDINGS

Volunteers had a specific lens for looking at the city, generating local knowledge about bird-building collisions in Atlanta [8]. They recognized characteristics of buildings that they associated with bird deaths, specifically glass surfaces (Figs. 13, 14), proximity to green spaces, lights (Fig. 12), and reflected foliage (Fig. 10). For years, volunteers witnessed buildings on their routes where they had found more or less dead birds. They knew which ones were killer buildings, and they recognized building features that exacerbated collisions. LH explained how lights contributed to bird-building collisions: *“there’s one particular place downtown where they get caught in this light funnel and they absolutely get exhausted.”* As I walked routes with volunteers, they pointed out buildings and told me about the birds they had found there, and conversely, buildings where they rarely or never found birds. Volunteers were also aware of changes in the urban environment, including newly constructed buildings and altered landscaping, and had theories about how these changes might affect birds.

Volunteer knowledge about collisions extended beyond the buildings on their route. The program manager joked that they annoyed their partner by constantly pointing out buildings that were unsafe for birds. Similarly, KS reported that *“Now I’ve kind of identified these sorts of buildings tend to be an issue. So those will stick out to me now, and I would be like, oh, that’s a glass bridge (Fig. 11). That’s usually a bad sign. And then I’ll look around and sometimes my fears will be confirmed.”* Similarly, EM reported that they feel *“a drop in [their] stomach”* seeing buildings that are fully reflective, thinking of the impact these buildings have on birds. I found myself making the same conjectures, although my familiarity with features of killer buildings was also heavily shaped by talking to others about bird-building collisions.

Some interviewees expressed frustration over the use of glass in the international architectural style, which in their perspective was a harmful aesthetic trend, This stance further decenters the human by highlighting the impact of social and cultural forces on birds.



Fig. 10

*“this building is
shit for birds”*



Fig. 11

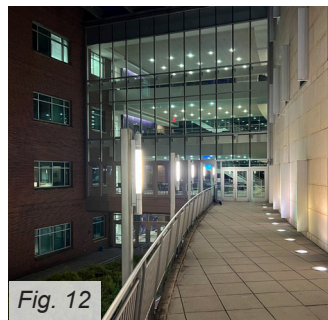


Fig. 12

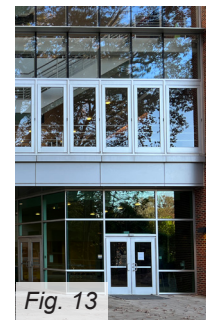


Fig. 13

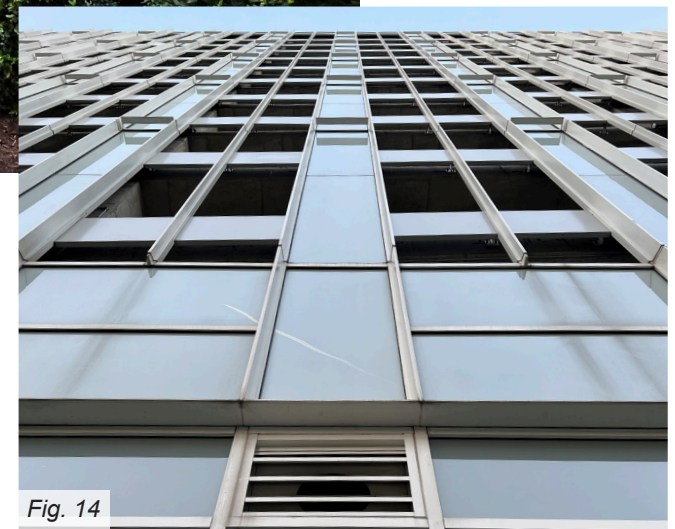


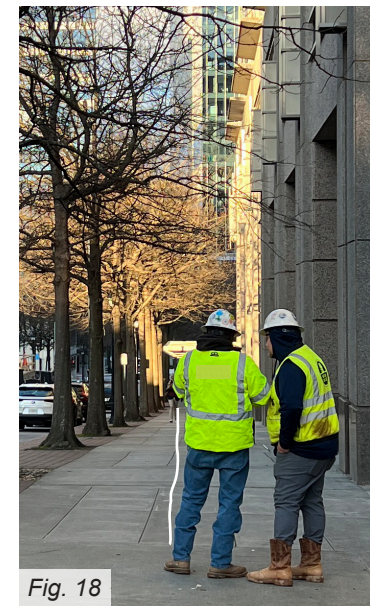
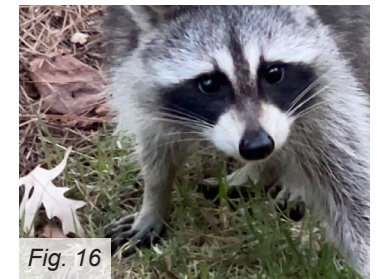
Fig. 14

URBAN ECOLOGIES

Beyond attuning volunteers to relations between birds and buildings, data work was shaped by a wide variety of urban entanglements. City spaces are shared by a wide variety of human and nonhuman actors, which influenced data collection experiences. This section will discuss the interplay of different groups of humans and nonhumans, and how these broader ecologies impacted data collection and the experiences of data production.

The images displayed here depict different urban actors that laid claim to bird bodies. Safe Flight volunteers were asked to monitor their routes early in the morning in order to find traces of bird-building collisions before they were cleaned by city cleaning crews or building facilities staff (Fig. 18). Small predators, like cats (Fig. 17) and raccoons (Fig. 16), were also suspected to scavenge the bird carcasses. If not removed by one of these city actors, the birds would be left to decay, advanced by insect activity (Fig. 15).

Volunteers imagined themselves in adversarial positions against other actors in the city, racing to find traces of bird-building collisions before they were moved or deteriorated, and shared imagined narratives about people who were involved in the urban environment, such as building managers, landscapers, and maintenance teams. One volunteer explained that they believed a small barrier, erected after they were questioned by a security guard, was a response meant to deter their presence. Multiple volunteers had encounters with security guard, asking about their activities. Volunteers all had access to state-issued permits to collect birds, which they were instructed to present if challenged, although only one interviewee had ever used it. Nevertheless, volunteers widely believed that building managers, street cleaning crews, and facilities employees were working to clean up traces of bird-building collisions, sometimes with the express purpose of hiding the scope of bird-building collisions.



EMOTIONAL RESPONSES

The emotional responses that come with finding and handling dead birds are complex and multiple: sadness, anger, disgust, surprise, disturbed, detachment. For many volunteers, handling these birds was the closest they ever got to these animals, an experience which is both intimate and disturbing.

Unsurprisingly, finding dead birds surfaced negative emotions like sadness, dismay, surprise, and anger. Volunteers “deeply care” (MG) about birds and they are angry about the impact of urban spaces on bird populations. They mourn the loss of life -- one volunteer apologizes to each bird and says a prayer. The emotional response is a potential route to action: one volunteer, also an advocate for bird-safe building materials, explained that they feel angry and through their advocacy they hope that other people will feel angry too. At the same time, volunteers noted some positive emotions, such as appreciating the beauty of birds in a more intimate way (RB, EM).

Some volunteers spoke to the mixed emotions that come with finding birds -- they hoped not to find anything, but if birds had died they wanted to be there to observe it (MG). Others described becoming desensitized to the bird deaths (LH, KS), as finding and handling birds becomes routine, although they felt they were still emotionally affected by surprises, such as finding a large quantity of birds or a different species. I too felt this detachment in the routine of data work, but finding an unusually large bird was enough to surprise and disturb me, and I found myself thinking about this bird for days afterward.

While we often think about data as objective fact, here we see the rich and complex emotional worlds that accompanied data production. These emotions were an important aspect of the experience of data collection but is not captured in the collision records.





Fig. 20: (top rows) traces of bird-building collisions photographed by the first author (bottom row) traces of bird building collisions by anonymous dBird users ©dbird.org.

PHOTOGRAPHING DEAD BIRDS

Volunteers created visual records of collisions, typically on smart phones. Photography is a common feature of citizen science naturalist work [33], often used to address concerns about the quality of data produced by citizen scientists [30]. Project Safe Flight trained volunteers to record a detailed image of the bird and an image capturing the context where the bird was found. The detailed images were used by the project manager to verify species identification. The contextual images were meant to capture building features that may have caused the bird's death, including nearby window panes that could be targeted for retrofitting. However, at the time of this study, images had not yet been used to identify specific parts of the building that caused the most damage to birds.

Volunteers had emotional connections to the photographs of dead birds, but these meanings and behaviors varied between participants. For example, MG explained that she always uploads photos directly within the ArcGIS monitoring app so that the images

would not occupy her photo stream alongside images of friends and family. Contrastingly, RB kept images on her phone as a personal record of the birds she had found and collected. RB and KS both described showing images of dead birds to acquaintances when they explained their work with bird-building collisions to illustrate the scope of harm. I frequently struggled with balancing the effectiveness of images in illustrating my work on this project with concerns about disturbing my audience, appropriating or objectifying the birds, or engaging in disaster porn [36]. Despite concerns about sharing images of dead birds, it is undeniable that photographs taken by volunteers were powerful tools for provoking emotional responses and communicating about bird-building collisions.

Photographing dead birds called for a closer examination, relation, and approach than one might normally do with the body of a dead bird. It feels counterintuitive to approach a bird carcass, even from behind the camera lens, when the instinct is to stay far away from a broken, bloodied, feathered thing

[3]. While the act of photographing puts us in closer contact with the bird body, ultimately the camera creates a certain kind of relation between photographer and subject -- one “that feels like knowledge--and therefore, like power” [35]. Challenging or shifting power dynamics in data collection about the natural world remains a potential direction for future work.

In addition to altering the relationships between the bird and observer, we might consider relations, both real and implied, captured by the camera lens. For example, Liboiron argues that the use of artist Chris Jordan's images showing plastic in the stomach of rotting albatross carcasses to illustrate environmental damage more broadly “misses the wider relations, the Land relations, of albatross and plastics, and turns them into a Resource for shock, awe, and charismatic academic presentations” [24:106]. That the wider relations are severed when the images are shared out of context highlights the importance of local knowledge that should accompany and give meaning to the relations captured by traces of bird-building collisions.



Fig. 21

A White-throated Sparrow, photographed by the author.



Fig. 23

A White-breasted Nuthatch, photographed by the author.



Fig. 25

A Rose-breasted Grosbeak, photographed by the author

SPECIES MATTERS

Volunteers expended significant effort in correctly identifying bird species. Understanding that species matters means attending to and respecting the unique behaviors of different species. Bird identification seemed to come naturally to experienced birders, but identification was a source of anxiety for others. The program manager regularly reviewed observations in ArcGIS to enter or correct bird species. Volunteers and stakeholders were interested in the capacity of collected data to speak to the relative impact of bird-building collisions on different bird species.

The attention and care paid to identifying the species of the bird calls to question why species matters. As someone with very little birding experience, this was puzzling at first: why expend significant time, effort, and emotional energy to record bird species? Policy makers and building managers were unlikely to be interested in information about bird species. However, in this practice, we see a refusal to homogenize and respect for the unique roles of bird species. The images here (Figs. 21-26) pair images of dead birds I encountered with photographs of the same species in their natural environment. I contrast these images to contextualize the unique behavior of different bird species and illustrate limitations of technology mediated bird identification.

There are multiple tools available to aid in bird identification, but they are often inaccurate at identifying dead birds. Algorithmic identification tools were not very accurate, presumably because the models are trained on images of living birds rather than dead birds. Apps that identify birds based on a series of questions also presented challenges because the observed bird behavior (on ground) typically did not match the living behavior of the bird. Finally, I resorted to searching features of the bird along with the location the bird was observed in. This would produce many possibilities, which I compared to the body in front of me. Between these tools, I sometimes found the correct species, but as we were asked to only enter species we were confident about, I often left the bird species “unknown”.



Fig. 22

A living White-throated Sparrow ©Keenan Yakola [41]



Fig. 24

A living White-breasted Nuthatch ©Taylor Long [27]



Fig. 26

A living Rose-breasted Grosbeak © Yves Darveau [9]

DISCUSSION

In this pictorial, we share a rich account of data production and examine the ways data workers attended to more-than-human entanglements in urban spaces. Safe Flight volunteers, including the first author, monitored and recorded bird-building collisions in Atlanta. Instead of focusing on the data produced by volunteers, this pictorial uses images to highlight the experience of producing data, particularly the affective responses and local knowledge that was developed by occupying urban spaces in this capacity.

Through data work, Project Safe Flight generated emotional responses to dead birds and local knowledge about urban spaces and bird species. The experiences of volunteers suggests that data work can be a mechanism for attuning to the more-than-human. Previous work has explored technology for the “arts of noticing” by extending human capabilities for sensing, for example by equipping mushroom foragers with various sensors [26] or using chromatography to create portraits of soil health [31]. Our interpretation of work done by Safe Flight Volunteers suggests that attuning to the more-than-human may actually be about directing, rather than expanding, capacity for attention. Data production, motivated by the need to collect evidence to use in advocacy towards the use of bird-safe building materials, required procedural attentiveness: regular observation and recording of more-than-human entanglements. The practice of regularly monitoring reflects Liu’s tactics of *engagement*, *attunement*, and *expansion* by blurring lines between nature and culture, putting human volunteers in shared physical spaces, and attuning us to the well-being of non-humans [26]. This procedural attention created emotionally charged encounters with the non-human and developed a body of local knowledge that extended beyond the survey route, as volunteers recognized characteristics of killer buildings as they moved through urban spaces in their daily lives.

Focusing on non-humans highlights the violence of urban entanglements. We already know that urban spaces are used to control, and that their forms can

enact violence, for example anti-homeless design [32]. Considering the environmental impacts, we know that habitat loss harms ecologies, but we rarely see the results of these harms in the stark way we encounter bird bodies in this publication. Counting dead birds asks us to reflect on how we encounter environmental harm in our daily lives and the character of our personal and collective relationships with other beings. Encountering birds, photographing birds, and attending to urban ecologies attunes us to scales of violence and coexistence in a complex web of relations that constitute the anthropocene.

The anthropologist Anna Tsing introduces collaborative survival to characterize species that survive and coexist in the midst of environmental destruction [39]. Similarly, HCI authors have called for the smart-city to account for collaboration [16] or co-habitation [18, 28] in urban spaces. In many ways project Safe Flight addresses a failure of collaborative survival, drawing attention to building forms and materials that make co-habitation impossible. In taking a non-anthropocentric approach, the human “does not disappear: it becomes one entity among many entities, all of which are granted legitimacy in a kind of radical pluralism among objects and things, human and otherwise” [11]. Similarly, this mode of data production does not eliminate the human, rather it attunes human perspectives to urban materials, spaces, and animals that occupy them. As we see in the findings reported here, this attunement shifted experiences of these urban spaces, generating local knowledge, emotional responses, and awareness of urban ecologies. As discussed by DiSalvo and Lukens, the experience of decentering has the potential to challenge assumptions and change individual attitudes or beliefs [11]. Volunteers participating in Project Safe Flight experience regular decentering by engaging in data production. In addition to producing data that stands as evidence for the impacts of bird-building collision, the data work produces a public engaged in entanglements between humans, birds, and the built environment.

Looking more broadly at urban ecologies uncovers a

much more complex system of relations that shape data practices in less visible ways. For example, volunteers were asked to walk their routes before dawn to beat human cleaning crews and non-human scavengers, a key feature of Safe Flight data work that made it difficult to recruit new volunteers. In this way, the data work done by volunteers responded to diverse actors within the urban ecology, not only human-bird relations. Though human encounters of dead birds are the most visceral and take center stage in the data work, the experience of volunteers is also a response to a more complex web of human and non-human actors with shared claims to contested urban spaces. We echo calls to imagine the non-anthropocentric city [6, 7, 16, 17, 18, 28, 37], which is needed if the future city is to address the challenges of the anthropocene [28].

Our analysis of Project Safe Flight expands previous work in more-than-human HCI by presenting data work as an approach to attuning to the more-than-human. Not only does data work offer opportunities to learn from data producers who already engage the more-than-human, data practices are also a potential resource for designing more-than-human interactions by crafting relationships with the natural world. As HCI scholars are increasingly designing for more-than-human interactions [40, 22, 2] we highlight data practices as potential material for designing more-than-human attunement. This pictorial can also inform critical data studies by presenting visual media as an approach to understanding the affective and embodied nature of data work. Photographs, video, and illustrations provides a route for critical data scholars to “elevate emotion and embodiment” [10]. Because they enable visual storytelling, non-traditional formats like the pictorial may be more appropriate communicating the embodied and affective aspects of knowledge than a traditional research paper.

While we argue here that data practices performed by a particular group of humans worked to attune a public to contested multispecies spaces, we urge caution in datafying more-than-human entanglements. While data may afford visibility to urban ecologies which often

remain invisible, it also subjects humans and non-humans to surveillance, categorization, quantification, study, and control -- a colonialist agenda. Additionally, the data products, photographs, maps, and statistics abstract, reduce, and flatten relations and the spaces they occur in. Considering everything that is tracked in the contemporary city (automobiles, parking, traffic, public transit, entrances to buildings, health, air quality, heat) and increasing datafication across all sectors, we might imagine a future city in which all entanglements are carefully recorded and cataloged. Ultimately, this kind of datafication of more-than-human relations would only serve to recenter the human. Instead, experiential features of data production, procedural attentiveness, regular decentering, emotional responses, and local knowledge may be more valuable at forming a public than the data produced by these activities.

CONCLUSION

In this pictorial, we reflect on the experience of data production in the context of bird-building collisions. We discuss how volunteers encountered urban spaces, developed local knowledge about buildings impact on non-human species, the emotional impacts of findings and handling dead birds, the role of volunteers as photographers of bird-building collisions, and the broader urban ecologies that shaped data work in this context. This project highlights opportunities to explore the subjective, embodied, affective aspects of data and data production. We argue that 1) visual media can be used to elevate the emotional and embodied experience of data production and 2) these aspects of data production create an experience which attuned volunteers to the more-than-human. Data practices are one method to reconsider our relationships with both humans and non-humans, an essential step towards collaborative survival in the midst of environmental destruction.

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REFERENCES AND CITATIONS

- [1] Ferran Altarriba Bertran, Samvid Jhaveri, Rosa Lutz, Katherine Isbister, and Danielle Wilde. 2019. Making Sense of Human-Food Interaction. In Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems (CHI '19). Association for Computing Machinery, New York, NY, USA, Paper 678, 1–13. <https://doi.org/10.1145/3290605.3300908>
- [2] Fiona Bell, Joshua Coffie, and Mirela Alistar. 2024. Bio-Digital Calendar: Attuning to Nonhuman Temporalities for Multispecies Understanding. In Proceedings of the Eighteenth International Conference on Tangible, Embedded, and Embodied Interaction (TEI '24). Association for Computing Machinery, New York, NY, USA, Article 38, 1–15. <https://doi.org/10.1145/3623509.3633386>
- [3] Heidi R. Biggs, Jeffrey Bardzell, and Shaowen Bardzell. 2021. Watching Myself Watching Birds: Abjection, Ecological Thinking, and Posthuman Design. In Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems (CHI '21). Association for Computing Machinery, New York, NY, USA, Article 619, 1–16. <https://doi.org/10.1145/3411764.3445329>
- [4] Laurens Boer, Harvey Bewley, Tom Jenkins, Sarah Homewood, Teresa Almeida, and Anna Vallgård. 2020. Gut-Tracking as Cultivation. In Proceedings of the 2020 ACM Designing Interactive Systems Conference (DIS '20). Association for Computing Machinery, New York, NY, USA, 561–574. <https://doi.org/10.1145/3357236.3395588>

[5] Dominique Chen, Young ah Seong, Hiraku Ogura, Yuto Mitani, Naoto Sekiya, and Kiichi Moriya. 2021. Nukabot: Design of Care for Human-Microbe Relationships. In Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems (CHI EA '21). Association for Computing Machinery, New York, NY, USA, Article 291, 1–7. <https://doi.org/10.1145/3411763.3451605>

[6] Rachel Clarke, Sara Heitlinger, Marcus Foth, Carl DiSalvo, Ann Light, and Laura Forlano. 2018. More-than-human urban futures: speculative participatory design to avoid ecocidal smart cities. In Proceedings of the 15th Participatory Design Conference: Short Papers, Situated Actions, Workshops and Tutorial - Volume 2 (PDC '18). Association for Computing Machinery, New York, NY, USA, Article 34, 1–4. <https://doi.org/10.1145/3210604.3210641>

[7] Rachel Clarke, Sara Heitlinger, Ann Light, Laura Forlano, Marcus Foth, and Carl DiSalvo. 2019. More-than-human participation: design for sustainable smart city futures. *interactions* 26, 3 (May - June 2019), 60–63. <https://doi.org/10.1145/3319075>

[8] Jason Corburn. 2005. *Street science: Community knowledge and environmental health justice*. MIT Press.

[9] Yves Darveau / Macaulay Library at the Cornell Lab of Ornithology (ML162239781)

[10] Catherine D'Ignazio and Lauren F. Klein. 2023. *Data Feminism*. MIT Press.

[11] Carl DiSalvo and Jonathan Lukens. 2011. Nonanthropocentrism and the Nonhuman in Design: Possibilities for Designing New Forms of Engagement with and through Technology. in *From Social Butterfly to Engaged Citizen*, M. Foth, L. Forlano, C. Satchell, and M. Gibbs, Eds., The MIT Press, 2011, pp. 421–436. doi: 10.7551/mitpress/8744.003.0034.

[12] Carl DiSalvo, Phoebe Sengers, and Hrönn Brynjarsdóttir. 2010. Mapping the landscape of sustainable HCI. In Proceedings of the SIGCHI

Conference on Human Factors in Computing Systems (CHI '10). Association for Computing Machinery, New York, NY, USA, 1975–1984. <https://doi.org/10.1145/1753326.1753625>

[13] Markéta Dolejšová, Sjeff van Gaalen, Danielle Wilde, Paul Graham Raven, Sara Heitlinger, and Ann Light. 2020. Designing with More-than-Human Food Practices for Climate-Resilience. In Companion Publication of the 2020 ACM Designing Interactive Systems Conference (DIS' 20 Companion). Association for Computing Machinery, New York, NY, USA, 381–384. <https://doi.org/10.1145/3393914.3395909>

[14] Markéta Dolejšová, Danielle Wilde, Ferran Altarriba Bertran, and Hilary Davis. 2020. Disrupting (More-than-) Human-Food Interaction: Experimental Design, Tangibles and Food-Tech Futures. In Proceedings of the 2020 ACM Designing Interactive Systems Conference (DIS '20). Association for Computing Machinery, New York, NY, USA, 993–1004. <https://doi.org/10.1145/3357236.3395437>

[15] Paul Dourish. 2010. HCI and environmental sustainability: the politics of design and the design of politics. Proceedings of the 8th ACM conference on designing interactive systems.

[16] Laura Forlano. 2016. “Decentering the Human in the Design of Collaborative Cities,” *Design Issues*, vol. 32, no. 3, pp. 42–54. doi: 10.1162/DESI_a_00398.

[17] Laura Forlano. 2017. Posthumanism and Design, *She Ji: The Journal of Design, Economics, and Innovation*, vol. 3, no. 1, pp. 16–29, 2017, doi: 10.1016/j.sheji.2017.08.001.

[18] Marcus Foth. 2017. The next urban paradigm: Cohabitation in the smartcity. *Information Technology*, vol. 59, no. 6, pp. 259–262, doi: 10.1515/itit-2017-0034.

[19] Donna J. Haraway. 2016. Staying with the trouble: making kin in the Chthulucene. in *Experimental futures: technological lives, scientific arts, anthropological voices*. Durham: Duke University Press.

[20] Sara Heitlinger, Lara Houston, Alex Taylor, and Ruth Catlow. 2021. Algorithmic Food Justice: Co-Designing More-than-Human Blockchain Futures for the Food Commons. In Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems (CHI '21). Association for Computing Machinery, New York, NY, USA, Article 305, 1–17. <https://doi.org/10.1145/3411764.3445655>

[21] Sarah Homewood, Marika Hedemyr, Maja Fagerberg Ranten, and Susan Kozel. 2021. Tracing Conceptions of the Body in HCI: From User to More-Than-Human. In Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems (CHI '21). Association for Computing Machinery, New York, NY, USA, Article 258, 1–12. <https://doi.org/10.1145/3411764.3445656>

[22] Yuta Ikeya, Ron Wakkary, and Bahareh Barati. 2023. Metamorphic: A Reflective Design Inquiry into Human-Silkworm Relationship. In Proceedings of the 2023 ACM Designing Interactive Systems Conference (DIS '23). Association for Computing Machinery, New York, NY, USA, 808–819. <https://doi.org/10.1145/3563657.3596053>

[23] Bruno Latour. 2007. *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford University Press.

[24] Max Liboiron. 2021. *Pollution is Colonialism*. Duke University Press Books.

[25] Ann Light, Alison Powell, and Irina Shklovski. 2017. Design for Existential Crisis in the Anthropocene Age. In Proceedings of the 8th International Conference on Communities and Technologies (C&T '17). Association for Computing Machinery, New York, NY, USA, 270–279. <https://doi.org/10.1145/3083671.3083688>

[26] Jen Liu, Daragh Byrne, and Laura Devendorf. 2018. Design for Collaborative Survival: An Inquiry into Human-Fungi Relationships. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18). Association for Computing Machinery, New York, NY, USA, Paper 40, 1–13.

<https://doi.org/10.1145/3173574.3173614>

[27] Taylor Long / Macaulay Library at the Cornell Lab of Ornithology (ML61764931)

[28] Anna Luusua, Johanna Ylipulli, and Emilia Rönkkö. 2017. Nonanthropocentric design and smart cities in the anthropocene. *IT-Information Technology* 59.6: 295–304.

[29] Tim Morton. 2016. *Dark Ecology: For a Logic of Future Coexistence*. Columbia University Press.

[30] Gwen Ottinger. 2010. Buckets of Resistance: Standards and the Effectiveness of Citizen Science. *Science, Technology, & Human Values*, vol. 35, no. 2, pp. 244–270, doi: 10.1177/0162243909337121.

[31] Anton Poikolainen Rosén. 2022. Relating to Soil: Chromatography as a Tool for Environmental Engagement. In Proceedings of the 2022 ACM Designing Interactive Systems Conference (DIS '22). Association for Computing Machinery, New York, NY, USA, 1640–1653. <https://doi.org/10.1145/3532106.3533503>

[32] Robert Rosenberger. 2017. *Callous objects: Designs against the homeless*. University of Minnesota Press.

[33] Jaime Snyder. 2017. Vernacular Visualization Practices in a Citizen Science Project. In Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing (CSCW '17). Association for Computing Machinery, New York, NY, USA, 2097–2111. <https://doi.org/10.1145/2998181.2998239>

[34] Marie Louise Juul Søndergaard and Nadia Campo Woytuk. 2023. Feminist Posthumanist Design of Menstrual Care for More-than-Human Bodies. In Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems (CHI '23). Association for Computing Machinery, New York, NY, USA, Article 38, 1–18. <https://doi.org/10.1145/3544548.3581083>

[35] Susan Sontag. 1977. “In Plato’s Cave,” in *On Photography*.

[36] Alexandra To, Angela D. R. Smith, Dilruba Showkt, Adinawa Adjagbodjou, and Christina Harrington. 2023. Flourishing in the Everyday: Moving Beyond Damage-Centered Design in HCI for BIPOC Communities. In Proceedings of the 2023 ACM Designing Interactive Systems Conference (DIS '23). Association for Computing Machinery, New York, NY, USA, 917–933. <https://doi.org/10.1145/3563657.3596057>

[37] Martin Tomitsch, Joel Fredericks, Dan Vo, Jessica Frawley, and Marcus Foth. 2021. Non-human personas: Including nature in the participatory design of smart cities. *Interaction Design and Architecture (s)*, 50(50), pp.102-130.

[38] Bill Tomlinson, Eli Blevis, Bonnie Nardi, Donald J. Patterson, M. SIX Silberman, and Yue Pan. 2013. Collapse informatics and practice: Theory, method, and design. *ACM Trans. Comput.-Hum. Interact.* 20, 4, Article 24 (September 2013), 26 pages. <https://doi.org/10.1145/2493431>

[39] Anna Tsing. 2015. *The Mushroom at the End of the World*. Princeton University Press.

[40] Ron Wakkary, Doenja Oogjes, Nazmus Sakib, and Armi Behzad. 2023. Turner Boxes and Bees: From Ambivalence to Diffraction. In Proceedings of the 2023 ACM Designing Interactive Systems Conference (DIS '23). Association for Computing Machinery, New York, NY, USA, 790–807. <https://doi.org/10.1145/3563657.3596081>

[41] Keenan Yakola / Macaulay Library at the Cornell Lab of Ornithology (ML63894671)