Designing with Birds for Multispecies Living

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1 Abstract

This article argues that any effort to imagine better communities must include all forms of life. To give an example, when large old trees disappear, birds lose their homes. Humans attempt to provide replacements but do not know all preferences of birds. Often, replacements occur on urban land where birds live alongside humans. This cohabitation can lead to conflicts as well as opportunities. In these situations, success of remedial actions depends on the approval by interspecies collectives. Can design help? Such help is needed in many situations because human activities overwhelm most of the Earth's communities. Multiple environmental crises confirm that anthropocentric understandings of communities undermine all life, including humans. An ecocentric reimagination of communities is essential for improvement. In response, we redefine community and imagination in more-than-human terms and amplify the resulting framework with techniques of design computing that include artificial-intelligence and simulation. These techniques underpin the central question of this article that asks how nonhuman lifeforms such as birds can participate in communal imagination. Our work proposes that 1) humans and nonhumans can imagine together and 2) that products of this imagination can create more equitable communities and help their members live better lives.

2 Keywords

More-than-human design, interspecies participation, ecocentric design, more-than-human community, participatory imagination, data-driven design

3 Introduction: Toward More-than-Human Community

Figure 1. A large old tree near Canberra, Australia. Red: branches preferred by birds. Image by the authors.

Research discussed in this article seeks to expand the notion of community to include nonhuman lifeforms as empowered contributors to collective imagination. We argue that this imaginative redefinition of communities is necessary in the era where human-centred approaches fail to address the environmental crises. As design researchers, we interpret imagination as a form of design and seek to design *with* nonhuman participants such as birds or trees.

To explore the notion of inclusive, or more-than-human design (Roudavski 2018; 2020), we consider interactions in a severely degraded ecosystem that is losing its trees. When large old trees (Figure 1) disappear, insects, birds, and bats lose their homes. Humans do not know all needs of these tree dwellers but need to provide replacement structures. Some such structures prove to be successful (Hannan et al. 2019) but many questions remain open. These open questions include uncertainty about the habitability of possible designs and their attractiveness to introduced species. We suggest that humans can only find answers to these questions through an approach that invites contributions from birds, trees, and others.

This approach finds precedents in a variety of fields. For example, reviewing the situation in environmental planning, Metzger (2020) insists that more-than-human approach holds special promise. He also notes that it remains underdeveloped and calls for further experimentation. Our article is a response to such calls. To frame our contribution, this section uses an inclusive more-than-human approach to provide working definitions of community and imagination that underpin the subsequent discussion.

3.1 Community

Community is a highly contested concept used by multiple groups. Our understanding of community seeks to include nonhuman participants by combining evidence from multiple disciplines, from political studies to community ecology.

Community ecology understands community as ‘a group of species that occur together in space and time’ (Mittelbach and McGill [2012] 2019, 1). This definition does not exclude humans, but the discipline tends to ignore humans or consider them as an external force. In humanities a common understanding is that a community is a group whose members share location (Rabinowitz [2001] 2015). In a mirror image of the views in community ecology, this interpretation often presumes that communities consist only of humans.

Human communities increasingly recognize the importance of ecosystems (Avolio et al. 2018). Responding to this recognition, cities engage in the practical work of restoration (Ross et al. 2015). However, the attitudes that presume human superiority stifle further progress. Continuing human expansion leads to global biodiversity collapse (Watson et al. 2016). In Australia, a review of environmental laws (Graeme 2019) concluded that the government is failing to protect habitats.

Recent theory recognises the importance of ‘communing’ that seeks to enfranchise disempowered participants. These arguments call for inclusion of your children, elderly, and disabled into decision making. Similarly, research seeking to support wild life finds that restoring autonomy in ecological systems is an effective measure of resilience and restoration (Strassburg et al. 2020). However, research on enfranchisement also tends to focus on humans (Studdert and Walkerdine 2016) or presumes that nonhuman communities are incompetent and unimaginative.

Responding to this context, researchers in environmental humanities call for the abandonment of the habitual binaries between human and nonhuman worlds (Plumwood 2002). This work calls for multispecies approaches (Bastian et al. 2017; Bresnihan 2016) and the recognition of the shared fate of all planetary life. In comparison to alternative environmentalisms that include resource conservation, human welfare ecology, preservationism, and animal liberation, ecocentrism emerges as most fair (Eckersley 1992). For example, the common commitment to human welfare ecology fails to provide protection to species that are of no use to humankind.

In this article, we define ‘community’ as patterns of mutually affecting encounters which create fuzzy, emergent groups consisting of humans as well as nonhumans. Recent work called for better interspecies relationships within such communities and emphasised the need for concrete recipes (Houston et al. 2018).

3.2 Imagination

This section accepts that imagination of all concerned will be necessary in the unavoidable novel ecosystems. Continuing the discussion about community, we accept that communities are constantly reimagining themselves and set out to explore how this imagining can empower nonhuman community members.

To date, typical conceptualisations of imagination presume the need for cognitive capabilities (Mitchell 2016; Picciuto and Carruthers 2016). These interpretations are human-centric and tend to exclude nonhumans by definition. By contrast, other research emphasizes the embodied nature of perception and cognition (Varela, Thompson, and Rosch 1991; Di Paolo and Di Paolo 2018). This work argues that all organisms experience the world subjectively. Living and evolving together, they enter complex relationships by modifying themselves and the others. Such interpretations allow us to propose an ecocentric understanding of imagination. This understanding suggests that imagination occurs in communities through multiple bodies, perceptions, practices, and environments (Roudavski 2016). Biological studies also recognize that many organisms design their own environments as ecosystem engineers and niche constructors (Jones, Lawton, and Shachak 1996; Laland, Matthews, and Feldman 2016). Many of such biological innovations do not require cognition to create new ways to resist entropy (Avery 2012). This background leads us to a pragmatic, outcome-oriented definition of imagination as a more-than-human, shared ability to invent new forms of living.

3.3 Participatory Design

This understanding overlaps with the notions of participatory design and codesign as activities that aim to broaden the authorship of creative processes. Participation makes imagination political (McBride 2005) and requires negotiation because communal life always has conflicting requirements (Wienhues 2018; Mouffe 1999).

Supporting this need to negotiate, design theory has challenged injustices of design and participation (Manzini 2015; Björgvinsson, Ehn, and Hillgren 2012). A growing body of work that aims to decolonise design (Tlostanova 2017), develop queer and feminist design (Ghassan 2014), and inform design by disability studies (Hamraie 2017) contests the assumption that design exists for the already-powerful users in commercial settings. To date, such work rarely extends towards the inclusion of nonhuman participants. Relevant attempts at such inclusions do exist (Clarke et al. 2019; Jönsson and Lenskjold 2014; Gatto and McCardle 2019) but tend to be speculative with their authors calling for further research.

In response, we propose a theoretical framework that rethinks the Arstein’s (1969) Ladder of Citizen Participation. This Ladder described participatory involvement in degrees, from low to high: Nonparticipation (Manipulation, Therapy), Tokenism (Informing, Consultation, Placation), Degrees of Citizen power (Partnership, Delegated Power, Citizen Control). With modifications and reinterpretations, this ladder found much use in many disciplines including participatory design, sometimes with a mention of nonhuman actors under the influence of actor-network theory (Andersen et al. 2015). However, current literature does not include a systematic reconsideration of this ladder with the inclusion of nonhuman stakeholders. Recent research into sensory ecologies and animal behaviour in combination with ecocentric analysis of environmental and ecological justice (Donaldson 2020; Donaldson and Kymlicka 2011; Schlosberg 2013) provide an opportunity to contribute.

Seeking to use this opportunity, we ask how nonhuman lifeforms such as birds can improve design outcomes by participating in communal imagination. Our work proposes that 1) humans and nonhumans can imagine together and 2) that products of this imagination can create more equitable communities and help their members live better lives.

4 Methods: Designing by Birds, Trees, and Humans

In exploring its research question, the article organises the findings and the analysis of the experiments in four layers: 1) technical operations (Methods section); 2) capabilities that support more-than-human imagination (Findings section); 3) a framework of interactions within more-than-human communities (Findings section); and 4) effects of the capabilities on more-than-human imagination structured by the proposed framework (Analysis section).

4.1 Case-Studies

Figure 2. Case-study context. Left: Molonglo development region in the Canberra metropolitan area (solid purple: new development; A1, B: case sites; A2: the sample tree used in Design Experiment I). Right: grassy woodland abutting the development (A); degraded restoration site (B). Images by the authors.

To explore more-than-human imagination in action, we focus on the Molonglo region of Canberra, Australia, an area that includes significant grassy woodlands (Flapper et al. 2018). European settlers converted 90% of the Australian woodland to pasture and undermined faunal habitats (Threatened Species Scientific Committee (TSSC) 2006). Despite this degradation, birds, mammals, reptiles, amphibians, and invertebrates use the remnant grasses, herbs, shrubs, and trees for foraging, roosting, nesting, raising young, and migration. Human-induced pressures continue to increase as the government plans to develop the region into a community of some 50,000 new human residents (Treasury and Economic Development Directorate 2019) (Figure 2, solid purple).

Figure 3. Some birds of Molonglo: clockwise from top-left: the Superb Parrot (*Polytelis swainsonii*), the Swift Parrot (*Lathamus discolor*), the Little Eagle (*Hieraaetus morphnoides*) and the Gang-Gang cockatoo (*Callocephalon fimbriatum)*. Images by, from top-left: rubvyr, Henny Thynne, James Bailey, and dhfischer.

Our exploration focuses on three groups of stakeholders that typify the resulting tensions: birds, trees, and humans. Isolated old trees persist in Molonglo (Figure 2, green hatching). Research demonstrates that they are crucial for many ecosystem interactions (Lindenmayer et al. 2013) including those involving birds. Some 20 declining species live in the area (Sharp, Osborne, and Taws 2015) (Figure 3). 30% of these birds exclusively use large old trees for nesting and perching (Le Roux et al. 2015). Research predicts that the number of old trees will likely decline by 87% during next 300 years (Le Roux et al. 2014) in Molonglo's urban regions and may disappear in 40-185 years in pastures (Reid and Landsberg 1999). Continuing human practices lead to further reductions. Trees retained during extensive clearing in the 1800s will senesce and die, local authorities continue allowing tree removal on private land; and eucalypts do not regenerate on grazed or cultivated ground (Gibbons and Boak 2002). Further urbanisation brings additional pressures and requires imaginative solutions.

Effects from the losses of large old trees include deaths of individual birds, increased competition for remaining habitat, and species-level disruption of migration, dispersal, and exchanges of genetic material (The Envirofactor 2010). This loss is representative of conditions in other Australian regions where 40% of the continent's forests have been lost to agriculture, forestry, urban growth, and other activities (Bradshaw 2012). This situation is also common around the world, which has lost 46% of all trees since the beginning of 'human civilization' (Crowther et al. 2015).

Uncertainties of management and planning in such conditions provide a useful test case. In response, this article explores approaches to more-than-human imagination in two related bird-human-tree communities. One focuses on community construction through understanding and communication while the other addresses the application of more-than-human imagination to design.

4.1.1 Case A: A Large Old Tree in a Changing Context

Figure 4. A paddock with a highly valuable old *Eucalyptus blakelyi* (left). Image by the authors.

Case A community includes birds, trees, but – currently – few humans. Here, we focus on one of the region's oldest trees, a remnant *Eucalyptus blakelyi* that survives in a paddock (Figure 4). This tree has spatial and structural properties that are valuable for birds but absent in younger trees. Although this tree lives in the north of Canberra (Figure 2, A1), Molonglo has similar trees (Figure 2, A2). We focus on this tree because it has many dead and overhanging branches that humans consider unappealing and unsafe. Local councils respond to such concerns by removing trees. (Le Roux et al. 2014). This is unfortunate because surviving old trees in urban and peri urban areas link local and regional habitats of many birds (Sharp, Osborne, and Taws 2015; Le Roux et al. 2014). In this case, the challenge is to understand the value of large old trees to birds and to demonstrate it to humans.

4.1.2 Case B: Artificial Trees in a Degraded Landscape

Figure 5. The restoration site. Shown: planted seedlings (top left), translocated snags (top right), human-installed habitat structures (bottom left and right). Bottom right image by Mitchell Whitelaw, other images by the authors.

Case B (Figure 2, B) is a degraded community that includes no human residents, but also has no trees (Figure 5). Birds exist on its periphery, and ecologists seek to reintroduce trees to establish a greater number of birds on the site. Due to the past land use, including a commercial pine plantation that was cleared in 2015, there are currently no old trees at the site (Hannan et al. 2019). To ensure the long-term viability of the existing biological community, regulations asked developers to fund a research project to offset additional habitat losses (ACT Planning and Land Authority 2011). Researchers estimate that the 10,000 seedlings planted at the site will be not be able to replicate habitat affordances of living mature trees for 172 years (Hannan et al. 2019). As an intermediate solution, ecologists are investigating if translocated dead trees and utility poles can replicate absent habitat structures. The challenge of this case is to design suitable artificial trees for the future avian users.

4.2 Design Experiments

To explore these cases, we conducted design experiments that aim to support imagination within more-than-human communities. The detailed technical discussion of this work is beyond the scope of this article. Instead, we provide a brief overview of the technical operations and use them to consider design capabilities and their support for more-than-human imagination.

4.2.1 Design Experiment I: Feature Recognition and Interpretation

The first experiment (Figure 6) focuses on feature recognition. It uses a LiDaR scan of an exemplar large old tree with significant habitat resources.

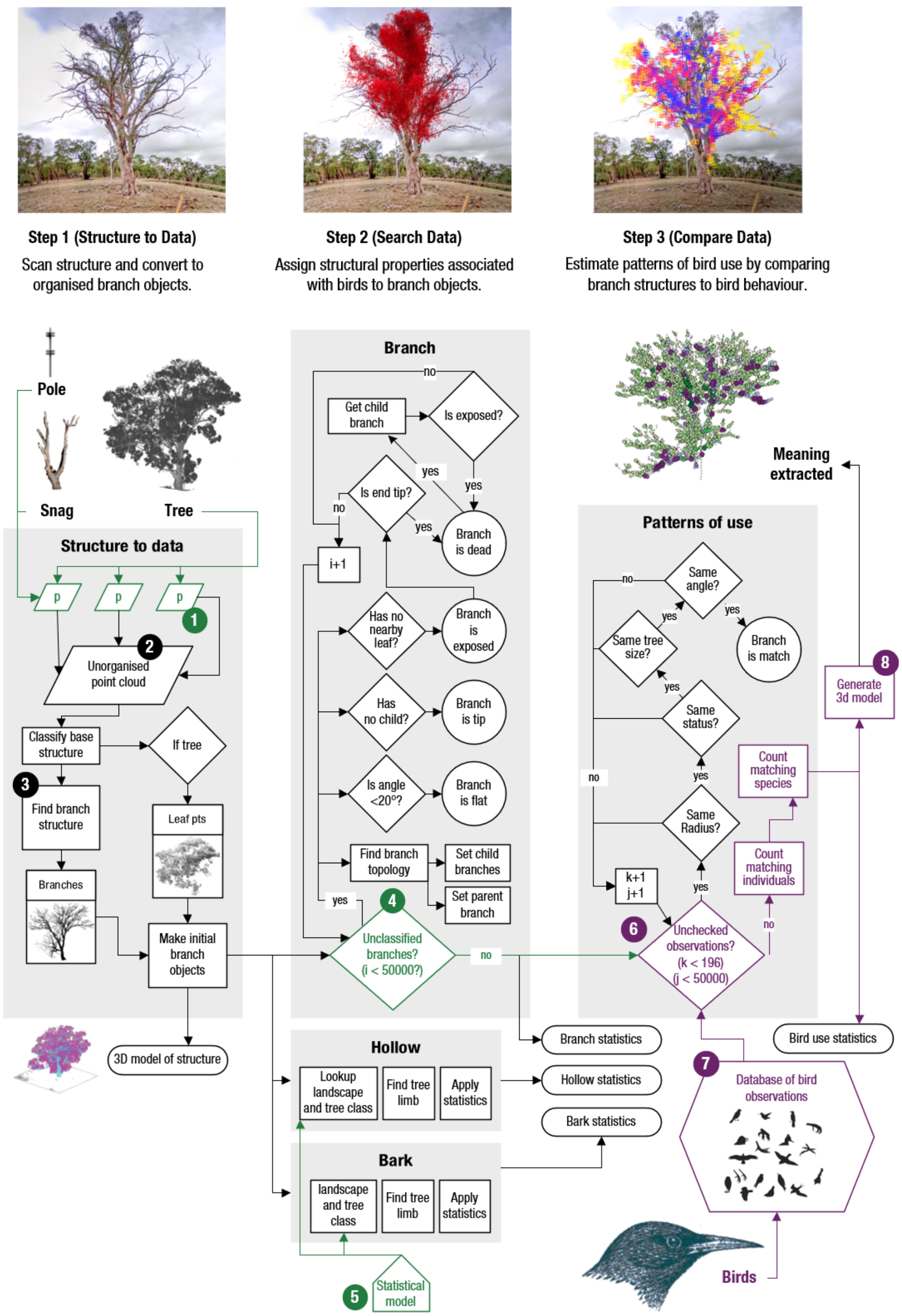

Figure 6. Feature recognition and interpretation. Purple: nonhuman input. Green: nonhuman influence. Black: prevalence of human control. Image by the authors.

The key technical operations include:

1. **Scan Structure** from different positions to ensure a comprehensive scan.
2. **Create point cloud**. Merge scans containing coordinates and colours of points on the tree's surface into a single point cloud.
3. **Extract tree features**. Use algorithms separate data points describing wood and leaves (Belton, Moncrieff, and Chapman 2013), and to produce a dataset of branch objects that have position, orientation, radius, and a list of connected branches (Hackenberg et al. 2015).
4. **Recognise branch properties**. Specify rules that recognise whether each branch is alive or dead and determine its inclination, size, and exposure.
5. **Predict branch properties**. Use observational data (Le Roux et al. 2015) to predict whether a branch is likely to have hollows or peeling bark.
6. **Compare with observations of bird behaviour**. Compare measured branch objects to bird-branch interactions observed by Philip Gibbons et al. of the Australian National University. This study surveyed birds over 3 years (2012–2014) at 72 trees of three sizes (small (20–50 cm diameter at breast height), medium (51–80 cm), large (≥80 cm)). Surveys recorded the abundance and identity of bird species that came into direct contact with the tree, as well as the radius, angle relative to horizontal, and dead/living status of the contact branch.
7. **Predict bird behaviour**. For each branch component, search the database for bird-branch interactions with matching branch properties such as angle, radius, and alive/dead status. Count the number of unique species within this list to find the potential species richness of each branch.
8. **Share with human observers the ways birds value tree features.** Visually represent what a tree means to birds by cross-referencing predicted bird behaviour with the model of tree features generated in operation 3.

4.2.2 Design Experiment II: Analysis and Design

The second experiment (Figure 7) implements an algorithm that automatically distributes artificial perches based on input parameters using a generative tensegrity routine.

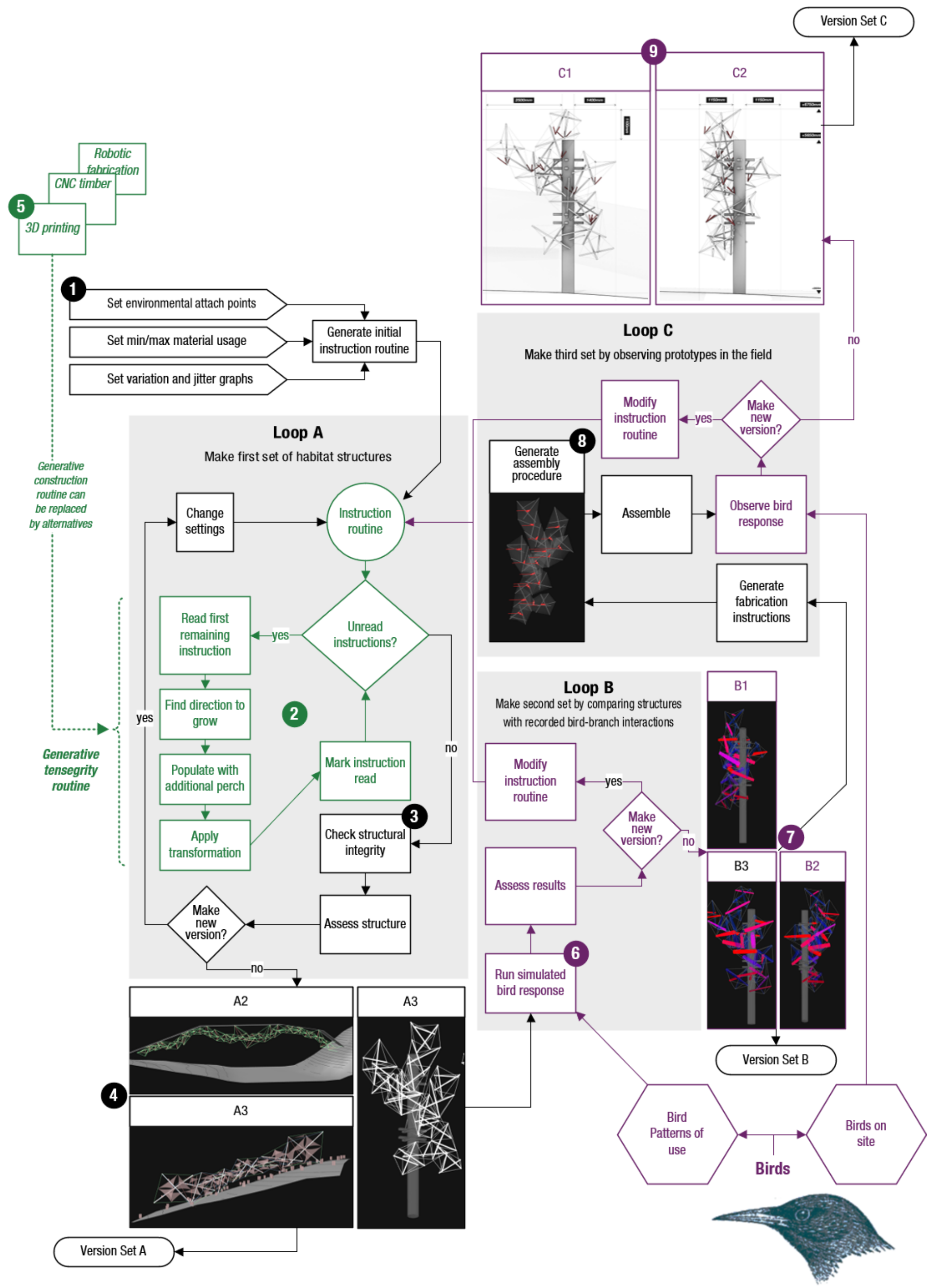

Figure 7 Analysis and design. Purple: nonhuman input. Green: nonhuman influence. Black: prevalence of human control. Image by the authors.

The key technical operations include:

1. **Set initial parameters** including points of attachment to existing structures, maximum strut length and the desired density and distribution of perches.

2. **Run base routine**. Generate an initial distribution of perches matching the specified design constraints. The routine uses a tensegrity ‘x-strut’ system (Snelson 2012) where components under compression become structurally stable when suspended inside a cord network of continuous tension.
3. **Check logistics.** Ensure the structural stability of the proposed tensegrity structure using a finite-element solver. Estimate logistics and costs.
4. **Generate initial set of habitat structures based on feedback from human experts.** Human experts modify settings to create the first set of designs.
5. **Make routines swappable.** Alternative making methods, such as 3D printing, CNC routing, or robotic fabrication are also compatible with this construction routine.
6. **Simulate bird response**. Compare the angle, size, and dead/alive status of all artificial perches to the database of bird use. Quantify the difference in bird response between design versions.
7. **Generate an updated set of habitat structures based on feedback from simulated birds.** Humans use visualisations to appraise the designs using the previous visualisation system (operation 8, Design Experiment I. As the system already quantifies the difference between configurations (operation 6, this experiment), a future iteration of the design system can automate this step. Create the second set of designs.
8. **Support fabrication and assembly**. Produce specifications for parts that will attach to existing structures, necessary scaffolding, and other components. Create an augmented reality instruction routine to help builders link connecting cords and struts.
9. **Generate a further iteration of habitat structures based on the feedback from birds.** Compare bird responses to different versions in the field

4.3 Theory Construction: Reframing the Ladder of Participation

These design experiments inform the steps in a participatory framework that considers degrees of participation in more-than-human communities.

Together, these approaches allow us to confirm the hypotheses by showing how:

1. Both humans and nonhumans can imagine.
2. Humans and nonhuman can imagine together.
3. Communal imagining can benefit justice and wellbeing.

5 Findings: Reimagined Communities

5.1 Support for More-than-Human Imagination

This section aims to express the technical operations described above in terms of capabilities that can be useful for more-than-human design.

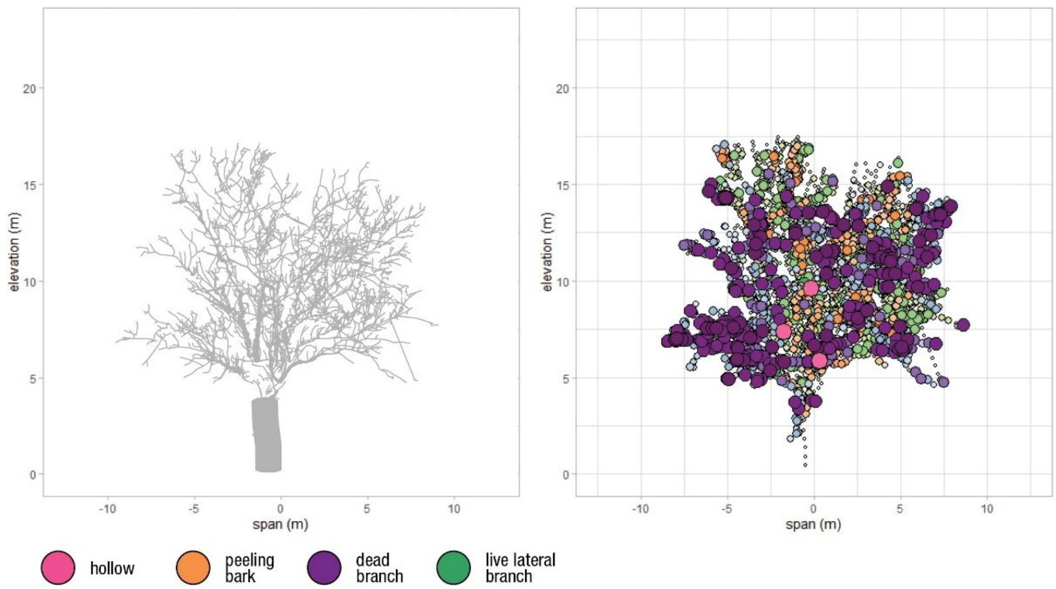

Figure 8 Relationship between tree structure (left) and tree features (right) expressing potential bird-branch interactions. Image by the authors.

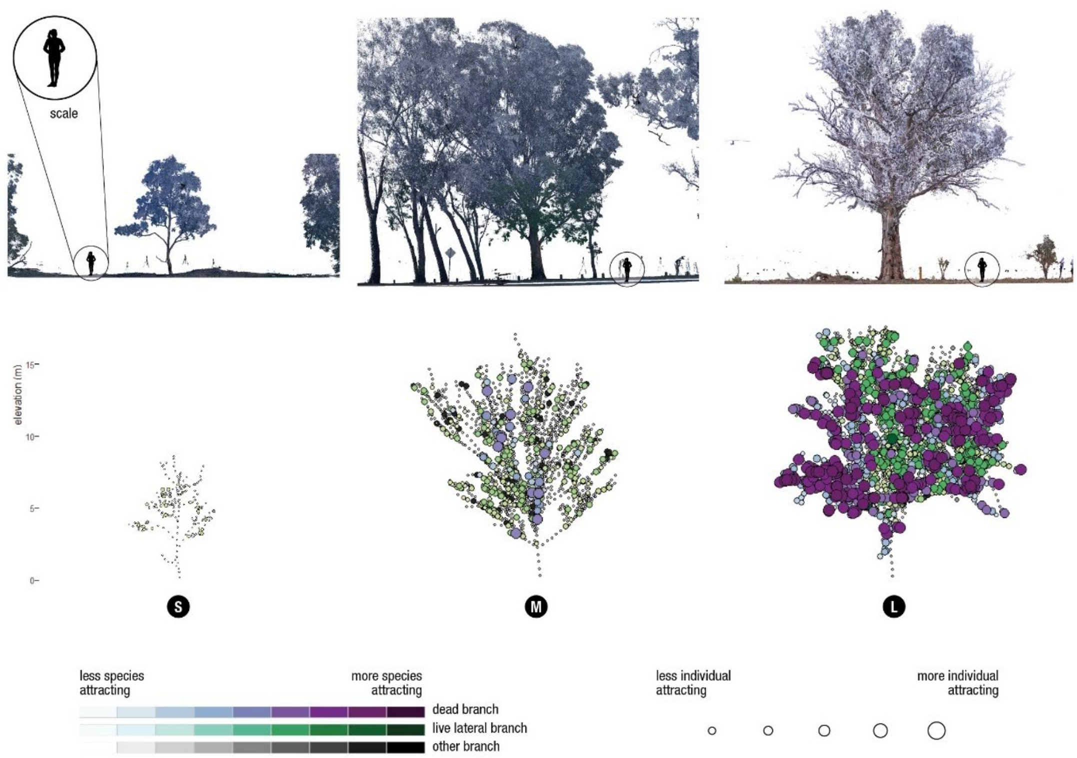

Figure 9. Relationship between tree age and habitat availability. Columns: young (S), middle-aged (M), and old (L) trees. Bottom row: availability of habitat resources and predicted patterns of use. Image by the authors.

The five capabilities of our system for the support more-than-human imagination include:

1. ***Extract*** *the meaning of habitat structures as perceived by nonhumans.* This capability can approximate birds' preferences for types of branches (operations 1-7, Design Experiment I). Features meaningful to birds include: exposed dead branches (purple, Figure 8) that are easy to fly to; lateral branches (green, Figure 8) comfortable to perch on for extended periods of time; areas of peeling bark (orange, Figure 8) that are home to invertebrates, which birds eat; and trunk hollows (pink, Figure 8) where birds can raise their young.
2. ***Translate*** *between species by visualising birds' preferences for human designers.* This translation exposes the relationship between the ages of trees and the availability of habitat resources such as dead and lateral branches (operation 8, Design Experiment I). This approach allows humans to create models that suggest why birds prefer large old trees. While unassisted human observers can recognise that smaller trees (top left, Figure 9) have less value, they cannot easily distinguish the differences between middle-aged (top middle, Figure 9) and old (top right, Figure 9) trees. For birds, the old tree is significantly more preferable (bottom right, Figure 9).
3. ***Direct*** *the construction of habitats by specifying geometrically adequate structures*. We use semi-automated generative routines to produce feature-rich, site-specific habitat structures (operations 1-2 in Design Experiment II). Existing artificial structures such as snags (middle image, Figure 10) or telegraph poles (left image, Figure 10) omit smaller or most branches. This simplicity leads to lower biodiversity (Hannan et al. 2019). Higher complexity of our designs (right image, Figure 10) not only provides more branch length for perching but also creates a variety of perch types including exposed, hidden, highly inclined and lateral sites.

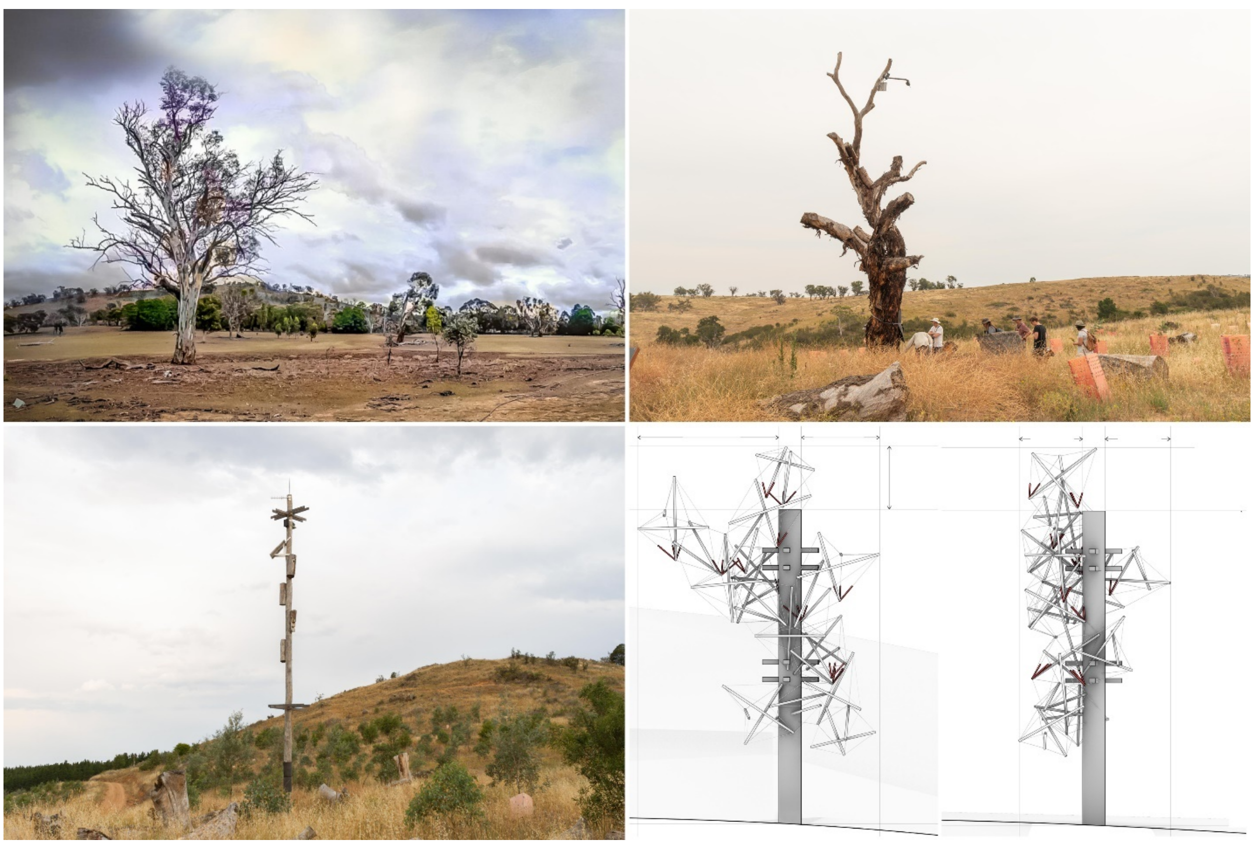

Figure 10 Natural and artificial vertical habitats at Molonglo. Clockwise from top left: large old tree, a translocated snag with artificial habitats, a utility pole with artificial habitats, generated designs. Images by the authors.

Further, provisional, and experimental capabilities allow us to:

4. ***Deliberate*** *on design options by responding to human and nonhuman community members.* The system uses comparative analysis to support more-than-human deliberation. We create and assess designs in three iterative loops (Figure 7). In Loop A , humans representing birds specify constraints and setup algorithms (refer capability 3, Direction) to produce design options (operations 3-4 in Design Experiment II). In Loop B, humans select promising designs and assess them using simulated bird responses by comparing information contained in the branches (refer capability 1, Extraction) with properties of artificial perches. The outcome of this operation is a set of revised habitat options (operations 6-7 in Design Experiment II). In Loop C, humans install successful habitats in the field for the birds to test. The outcomes inform further design options (operations 8-9 in Design Experiment II).

   These loops support deliberation by expanding the range of possible designs and implementing mechanisms that support evaluation by nonhuman stakeholders.

5. ***Adapt*** *by responding to environmental change and usage.* Further development can extend the generative routine to automatically produce and compare alternatives in response to changing conditions (operation 5 and extended versions of steps 6 and 8 in Design Experiment II). Such algorithms can collect feedback and assess the performance of different options while updating the constraints of the generative process and producing new proposals. Such an iterative and adaptive system can support adaptive modifications and promote the persistent influence of the deliberative assessment outlined above.

5.2 Steps to Inclusive (More-than-Human) Communities

In a parallel move, we provide a definition of The Stair of the More-than-Human Community.

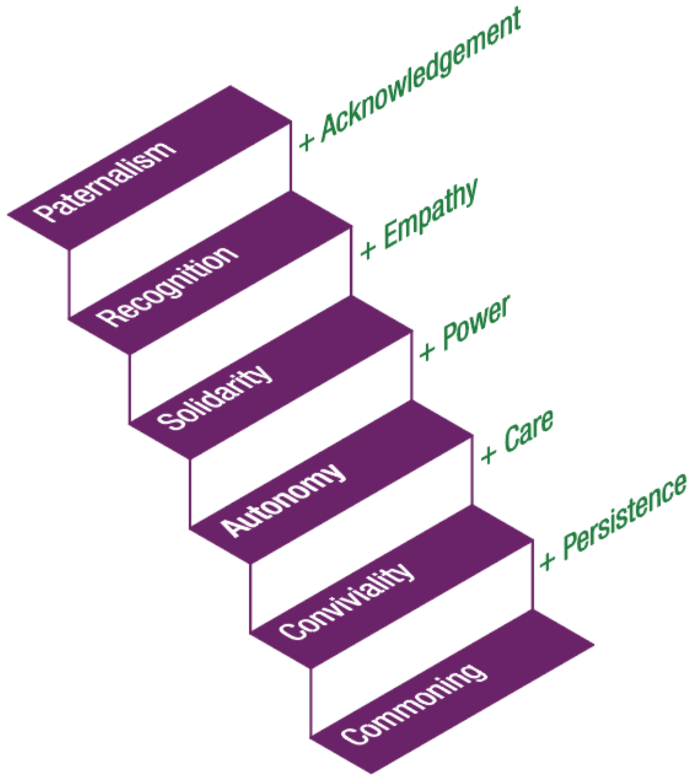

Figure 11 Steps to Inclusive Communities. Image by the authors

It consists of two groups and six treads. We organise the Steps in the descending order to emphasise that more inclusive and just conditions tend towards an ontological flatness where no beings or systems possess an *a priori* superiority. The Steps components include:

The 'Selfish-bias' group: agents imagine as individuals, types, or interest groups.

- **Paternalism**: humans decide what is best for nonhumans and distribute accordingly.
- **Recognition = paternalism + acknowledgement**: humans recognise nonhuman agents such as organisms, genes, and ecosystems as constituents of societies and cultures.
- **Solidarity = recognition + empathy**: humans foster empathy towards nonhuman by exposing commonalities and the possibilities for imaginative exchange.

The 'Relational-bias' group: agents imagine as communities

- **Autonomy = solidarity + power**: human and nonhuman agents pursue their own interests.
- **Conviviality = autonomy + care**: humans and nonhumans express their interests while caring for others.
- **Commoning = conviviality + persistence**: humans and nonhumans engage in persistent institutions of democratic governance.

6 Analysis: More-than-Human Imagination at Work

This section combines the support for more-than-human imagination described earlier with the treads and risers of the Steps outlined earlier. The scope of this article does not permit an in-depth analysis of this framework. Instead, we indicate its usefulness through case-study examples that show how humans and nonhumans can imagine together.

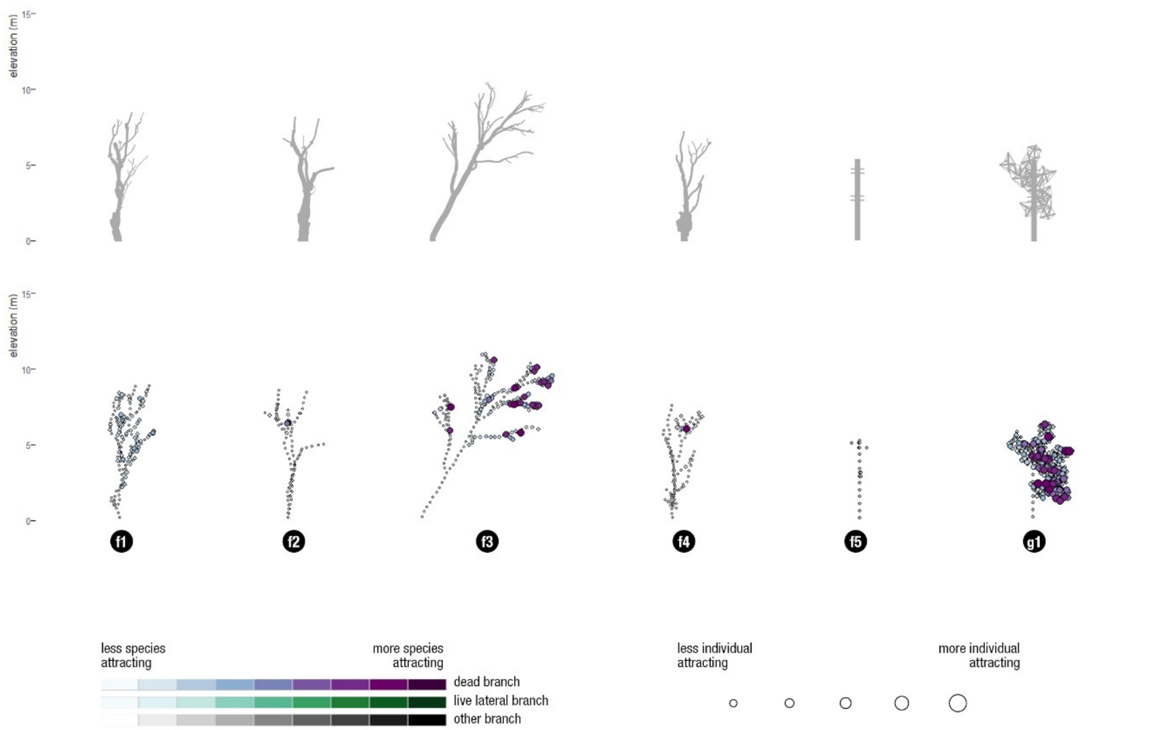

Figure 12. Loop B of the second design experiment showing simulated bird preferences. A proposed generative tensile structure (g1) has considerably more resources than erect dead trees (f1 to f4) or utility poles (f5). Image by the authors.

Paternalism. These approaches can provide important support, for example by funding tree planting and artificial structures for birds. However, paternalism sees birds as incompetent. Therefore, humans undertake to manage the environment. Birds have no power in decision-making. Humans do not recognise birds as community members and do not use their imaginative contributions. In doing so, they fail to distribute benefits and risks with equity. These approaches tend to produce benefits for humans but harms for the birds. Examples of drawbacks include prioritisation of narrow timeframes that ignore long processes of arboreal habitat formation, misinterpretation of nonhuman needs, and failure to act in the face of the available knowledge as is the case with the loss of large old trees.

Recognition. Existing work on participatory approaches demonstrates that disadvantaged humans can benefit if more powerful humans acknowledge their existence and needs. In an extension to such acknowledgements, we propose that humans should recognise birds' and other nonhuman lifeforms' ability to imaginatively construct their worlds. Birds imagine when they invent novel ways to use structures for habitation. Trees contain affordances and information that birds can use. However, human designers cannot interpret this information without the birds' knowledge and help. Our approach is to provide a technical system that can **extract the meaning** of tree structures for birds (refer capability 1 in Section 5.1) This meaning increases the visibility of underrepresented stakeholders and expands the scope of possibilities. Unavoidably, meaning extraction depends on the existing human knowledge and can lead to errors. Further, human knowledge about nonhuman lives can support further exploitation.

Solidarity. Our experiments demonstrate approaches that can expose lifestyles, behaviours, and preferences of birds. These approaches provide a foundation for empathy by emphasizing that birds are self-directed, intelligent agents who are experts in their lives and valuable members of their communities. Humans do not have the adaptive, historically shaped living bodies of birds and cannot directly access bird perception or follow and understand the nuances of bird behaviour. In response, our experiments implement data interpretation and visualisation layers that **translate** birds' perceptions of trees for humans (refer capability 2 in Section 5.1). The approach that makes birds' imaginative use of their habitats visible to humans can increase comradery but is not guaranteed to do so.

Autonomy. Participatory approaches argue that autonomy can resist exploitation or inaction. In line with this reasoning, our experiments demonstrate how humans can empower birds to express their embodied knowledge and subjective preferences. Our Case B provides a characteristic example where humans' attempt at providing artificial habitats can benefit from the integration of birds' choices. In our experiments, humans establish the rules that can generate many versions of geometry in response to constraints that humans formulate through observations of bird behaviour. This approach allows birds to **direct** the generative process towards compatible outcomes (refer capability 3 in Section 5.1) The resulting structures are more complex and varied than those possible through direct modelling by humans. They can support many microhabitats with varying exposures to the wind and sun, visibility, or perching comfort. This approach is an example of a step that can empower nonhuman lifeforms providing them with greater autonomy in more-than-human communities. We acknowledge that this redistribution of power can lead to uneven application and requires further support.

Conviviality. Participatory approaches accept that friction between autonomous members is normal and healthy in communities. Care and respect for the needs and capabilities of others become an important attitude for compromise. The cases introduced above affect multiple simultaneous stakeholders including birds, trees, and humans. In response, our approach is to offer support for the selection of options in the context of more-than-human design collectives. As all lifeforms, birds have capabilities that make some forms of participation feasible and others impossible. For example, they cannot assess written briefs or review drawings but can express preference through everyday behaviour. Consequently, our experiments facilitate **deliberation** between parties (refer capability 4 in Section 5.1) by providing techniques for selecting among multiple design options. Our experiments can compare the performance of diverse structures ranging from existing living and dead trees (f1-5, Figure 12) to novel proposals (g1, Figure 12). This approach allows human and nonhuman stakeholders to act on such preferences as functionality, safety, and costs while expressing respect and care for the birds. Such approaches can be hard to implement in typically time-bound and resource-limited design projects.

Commoning. The discourse on the importance of commons demonstrates that beneficial initiatives and successful designs cannot persist without institutional support. This support might and should take form of legislation, education, management guidelines, focused research, guaranteed funding, and other measures. The discussion of these issues is beyond the scope of this article. Instead, we suggest that our experiments contribute to the objectives of persistence and resilience by implementing capabilities for adaptation. Urban development and warming climate are among many causes that drive continuous and accelerating environmental change. In response, our system **adapts** to unfolding transformations (refer capability 5 in Section 5.1) by supporting generative design and procedures for the comparison of iterative outcomes. This capability supports continuous deliberation where all community members can change their choices under new circumstances and information.

7 Conclusion: Communal Imagination *for*, *with*, and *by* Birds

Seeking to encourage action that can address environmental crises, this article redefined the notion of community to include nonhuman lifeforms as empowered contributors to collective imagination. To explore this notion, we considered two sites and conducted two design experiments. We asked how birds can participate in communal imagination. Our results suggest that humans and nonhumans can imagine together. Our analysis also indicates that products of this imagination can create more equitable communities and help their members live better lives. In conclusion, our narrative highlights that humans can only improve the conditions of co-living through an approach that invites contributions from birds, trees, and others.

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Disclosure Statement

The authors declare no conflict of interests.

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