From dingoes to AI: Who makes decisions in more-than-human worlds?

STANISLAV ROUDAVSKI
Deep Design Lab, University of Melbourne
stanislav.roudavski@deepdesignlab.online

DOUGLAS BROCK
Deep Design Lab, University of Melbourne
douglas.brock@deepdesignlab.online

There is a pressing need for improved decision-making in a rapidly changing, unpredictable world. In response, we integrate ecocentric and technocentric perspectives to develop a more-than-human framework for understanding creative decisions that direct action in environmental governance, management, and design. Technocentric and ecocentric approaches often pursue distinct and incompatible goals but also share a commitment to amplifying power, reach, accountability, fairness, and beneficial consequences of decision-making processes. Current frameworks for urban and environmental management often prioritize human decisions and technologies at the expense of nonhuman voices. This results in widespread harm to nonhuman lifeforms and, by extension, to human societies. This study introduces an integrated approach to decision-making, one that draws on the creative potential of both human and nonhuman agents. We argue that embracing a more-than-human perspective can foster just relationships, enhance care, promote resilience, and support wellbeing in multispecies communities. To evaluate this framework, we examine decision-making processes in nonhuman organisms, compare these with technical systems, and explore hybrid decision-making in diverse contexts. As a case study, we examine the challenges facing alpine dingoes in Australia. The goal is to assess the impact of smart technologies on these apex predators in three future human-altered landscapes. The outcomes illustrate how more-than-human decision-making can contribute to environmental design and management. This, in turn, offers actionable insights for building equitable and sustainable futures. Our work also contributes to research on more-than-human approaches to algorithmic management in relation to cities, landscapes, and the communities that inhabit them.

KEYWORDS: decision-making; participatory governance; more-than-human design; algorithmic accountability; more-than-human justice

1 Introduction

In this article, we integrate ecocentric and technocentric perspectives to develop a more-than-human framework that has the potential to promote beneficial creative decision-making in urban and environmental management. The motivations for this are both pragmatic and conceptual. Our work in designing artificial habitat-structures for arboreal wildlife represents one example of a pragmatic approach. Such approaches often involve decision-making that must reconcile the extensive, uncertain needs of both human and nonhuman stakeholders with the constraints of limited financial resources, time, or knowledge (Parker, Soanes, and Roudavski 2022). Often, remedial actions must align with processes that occur beyond the typical scope of scientific studies, traditional cultural knowledge, and even human experience itself. We have argued in earlier research that nonhuman entities such as birds and trees not only merit consideration as beneficiaries of thoughtful design but can also contribute to design choices and even serve as leaders of design projects (Holland and Roudavski 2024; Rutten, Holland, and Roudavski 2024). For example, trees and microorganisms naturally create hollows where birds can successfully raise their chicks. When artificial hollows are necessary, humans can do no better than follow these existing blueprints.

Design teams working on such projects might cast trees as designers, birds as clients, and humans as attentive facilitators. We define such collaborative activities as more-than-human design. Opportunities for benefits that emerge only through more-than-human participation highlight the need to reframe conceptualisations of how decisions are made to overcome biases favouring human-centric spatial, temporal, and organisational perspectives. Our published work demonstrates that designers can overcome these biases by empowering nonhuman stakeholders. Failing to do so risks overlooking significant challenges that human designs struggle to accommodate, such as temporal scales beyond typical human timeframes — for example, the rapidly evolving dynamics of bacterial ecosystems or the centuries-long lifecycles of trees (Holland and Roudavski 2024; Roudavski 2024).

Our motivations thus align closely with the views of scholars who advocate for innovative approaches and actionable frameworks across multiple disciplines. For instance, our work engages with research in nature-positive, ecocentric, more-than-human, animal-aided, and pluriversal design (Apfelbeck et al. 2020; Escobar 2018; Sheikh, Mitchell, and Foth 2023; Tironi et al. 2024). These emerging interdisciplinary approaches challenge anthropocentric norms and explore design practices that seek to accommodate both human and nonhuman perspectives. By emphasizing interconnection and co-agency, they also support broader efforts to translate theoretical insights into practical applications.

Our design and research work also intersects with key themes in environmental and ecological humanities, particularly those that address justice and political representation for human and nonhuman beings (Westerlaken et al. 2022). This involves recognising animal agency — a concept that is increasingly acknowledged in conservation biology (Edelblutte, Krithivasan, and Hayek 2023). We are also contributing to debates around algorithmic governance and ethical algorithms (Coghlan and Parker 2024). Our work should, in turn, resonate with the "critical digital turn" in geography and environmental humanities, which examines algorithmic epistemologies and automation's impact on conservation (Adams 2019; Maalsen 2023).

Our research also contributes to future studies by advocating for all agents' constructive capabilities (human and nonhuman alike). In an era of rapid technological and environmental change, disciplines such as engineering, urban design, land management, and business already deploy technologies to make decisions. This often happens without adequate — or any — consideration of the relevant ethical implications. Such actions change the terrain for all and highlight the imperative for design research to act responsibly and inclusively. Practical design situations demand an approach that neither succumbs to scepticism about science and technology nor dismisses nonhuman capacities. Instead, our research seeks to bridge the widening gap between the growing dominance of human technology and ethical goals that aim to benefit nonhuman beings. By making these aims more tangible and plausible, we seek to promote design practices that account for both intentional technological effects and unintended consequences.

1.1 The need for creative decision-making

Participatory design that aims to include all stakeholders engages with political approaches to justice, such as democracy. Although interpretations of democracy and its systems vary, they universally emphasize decision-making processes. Design also serves as a form of political participation (Binder et al. 2015) because it inherently involves decision-making (Roudavski 2024). However, even frameworks that view decision-making as a property of networked collectives often prioritize human, deliberative modes of engagement. Indeed, when addressing nonhuman participation, such approaches often conceptualize design as a human-centric conversation, one that nonhuman beings merely influence (Rice 2018).

Building on these interpretations, we aim to advance the study of participatory decision-making by forging stronger connections between ecocentric and technocentric perspectives. We argue that integrating these viewpoints is important because the inclusion of all stakeholders in decision-making can foster justice, resilience, and well-being in multispecies communities (Roudavski 2021). Without such integrations, many design approaches — such as decisions to preserve large dead trees in urban environments (Roudavski and Davis 2020) — remain underexplored in current practice. Indeed, human stakeholders often dismiss these approaches as overly ambitious, utopian, or lacking societal support (Cork et al. 2023; Lloyd 2009; Pyyhtinen 2016).

Effective and equitable decisions are essential for creating futures that can engage with multiple stakeholders and their heterogenous needs. In our interpretation, a *decision* represents a commitment to action based on possible outcomes; it involves preferencing some options over others. This article focuses on *creative decisions* — novel actions in response to challenges. Here, *novelty* is the introduction of new elements that represent a significant departure from the norm. This can involve new behaviours, strategies, or structures that enhance the survival and adaptability of organisms or collectives within their environments.

Novelty is an emergent property of interactions in complex systems (Pagni and Simanke 2021). Creative processes occur across cultural, species, and evolutionary levels (Gigliotti 2022), and they progress through stages of initial ignorance about the challenges involved in exploration, connection-making, problem-solving, and evaluation (Moruzzi 2020). *Innovations* are, in turn, creative decisions implemented in practice (Amici et al. 2019; Carr, Kendal, and Flynn 2016). Creative decisions are increasingly necessary as living communities face challenges where routine choices often prove inadequate or harmful.

Anthropogenic ecosystems display novelties at every scale: the Earth's climate is warming owing to atmospheric carbon dioxide (CO^2) levels that have not occurred for four million years (Bonneuil and Fressoz 2013). Rising sea levels are threatening water supplies, agriculture, and biodiversity (Intergovernmental Panel on Climate Change 2018). Extinction rates for all species currently surpass historical rates by 1,000 times, with projections of up to 10,000 times this rate (De Vos et al. 2015). These challenges illustrate the failures of anthropocentric decision-making, which values other beings only to the degree that they are useful to humans (Goralnik and Nelson [1966] 2012). This often aggravates planetary crises and perpetuates injustices toward nonhuman communities. In response, both ecocentric and technocentric worldviews seek to propose solutions for a better future.

1.2 Limits of existing approaches

Technocentric approaches have driven unprecedented advances in decision-making that directs governance of complex organisations, engineering processes, or habitable spaces. They have also put forward ambitious and alluring visions, from general-purpose artificial intelligence (AI) to space colonies. There are, however, significant concerns about their limitations and potential harms. For example, these approaches often assume that exponentially accelerating technological progress will continue to resolve social and environmental challenges. The problem is that such expectations disregard warnings that sustaining life on a resource-limited planet will require the most profligate societies to restructure their economies and significantly curtail consumption-based lifestyles (Alexander and Rutherford 2019).

Techno-optimists imagine resilient, liveable futures through smart cities, AI-managed landscapes, and decision-making algorithms (Data 61, CSIRO, and Temperley 2018). Expectations of increased efficiency, innovation, and growth fuel these developments despite concerns about unsustainable energy consumption, loss of privacy, corporate monopolization, and job displacement as a result of automation (Howcroft and Taylor 2023).

Ecocentrism values ecosystems beyond their utility to humans (Gray, Whyte, and Curry 2018), and advocates argue for post-capitalist, degrowth alternatives that promote living within Earth's limits (Alexander, Chandrashekeran, and Gleeson 2021). Earth Jurisprudence, in turn, seeks a thriving Earth community that does not exist solely for human benefit (Burdon 2012). Personhood-based rights have also emerged in some areas, for instance, legal rights granted to the Whanganui River in New Zealand (Hutchison 2014). Additionally, supporters of biocentric approaches argue that sentient organisms deserve protection within human decision-making processes (Singer [1975] 2002; Cochrane 2018). They also value biodiversity for sustaining stable and productive ecosystems (Cardinale et al. 2012).

Holders of ecocentric positions aim to prevent mass extinctions, biodiversity loss, and human-caused planetary crises (Washington et al. 2017). Techno-optimists, in contrast, justify their approach by emphasizing potential improvements to human health, wealth, and happiness (Danaher 2022). A common impression is that ecocentric and technocentric approaches to decision-making are incompatible (Brand and Fischer 2013). Figure 1 introduces common attitudes toward decision-making that we reconfigure as an integrated more-than-human framework in Section 3.

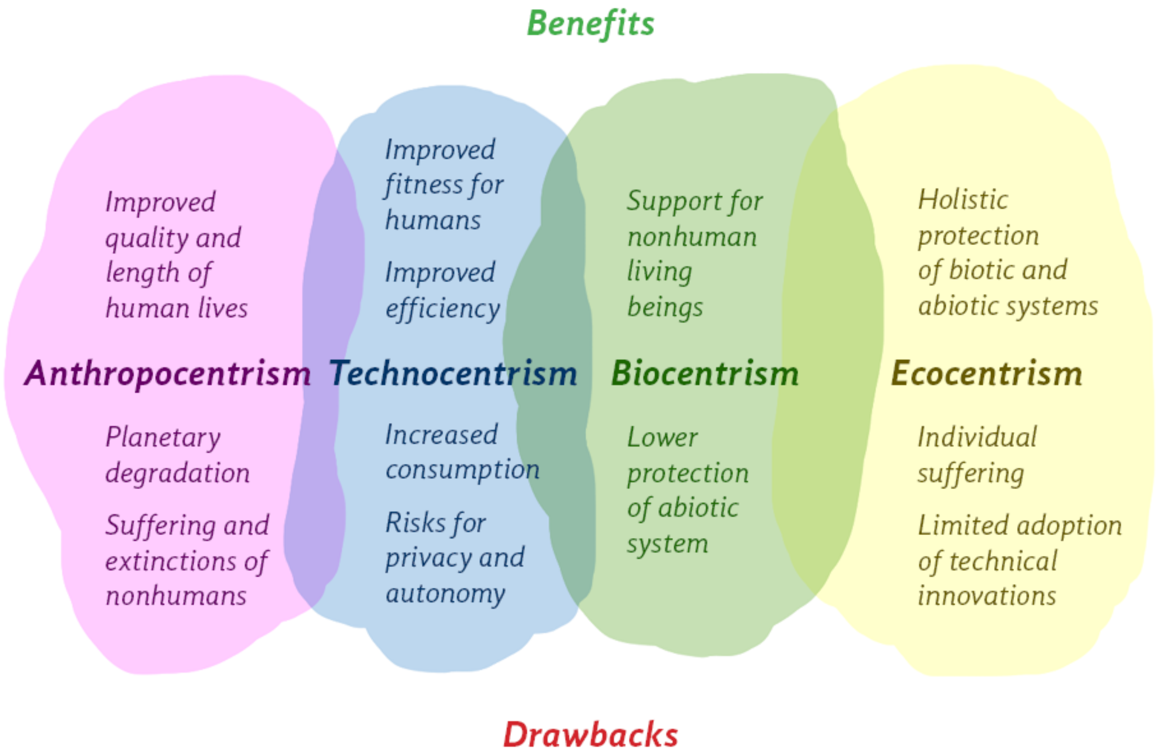

Figure 1. Attitudes to decision-making. The diagram's upper section lists benefits, whereas the lower section lists drawbacks. Image by the authors.

In this diagram, anthropocentric decisions (shown in pink) engender actions that often prioritize human needs at the cost of other species and ecosystems. For instance, decisions to construct shelters, build dams, and use agriculture improve human lives but degrade environments. This results in deforestation, soil alteration, air pollution, and land degradation (Laybourn-Langton, Rankin, and Baxter 2019). Efforts to offset this damage often lead to permanent losses, as demonstrated with the automated flood barriers in Venice, which protect the city but disrupt the sedimentation that is essential to coastal wetland communities (Tognin et al. 2021).

Technocentric decisions (shown in blue) emphasize efficiency over privacy or resource conservation. Smart city designs, for instance, rely on citizen data and decision-making algorithms (Sidewalk Labs 2019). Although technology brings solutions, it also accelerates crises through energy and material demands, thereby increasing emissions and endangering privacy and autonomy (Belkhir and Elmeligi 2018; Coghlan and Parker 2023). Concerns range from military drones' capacity for indiscriminate harm (Gusterson 2016) to catastrophic risks from an artificial superintelligence (Bostrom 2014). Human technological societies are, however, unlikely to scale back willingly.

Biocentric approaches (shown in green) focus on resilience and biodiversity.

They can, however, inadvertently prioritize familiar lifeforms over less visible ones or neglect the non-living processes such as climate, weather, ocean currents, sedimentation, and erosion that are essential to ecosystems (Singer 2009). Conservation and rewilding debates illustrate this, where programmes aiming to improve ecological health of populations or species can inadvertently harm individual organisms (Coghlan and Cardilini 2022; Nogués-Bravo et al. 2016). This can occur, for instance, when humans confine animals in harmful conditions at zoos to preserve reproductive capabilities or conduct painful and lethal experiments to maintain genetic diversity on behalf of a species.

Ecocentric approaches (shown in yellow) advocate for ecosystem-focused decisions such as Earth Jurisprudence and Half-Earth initiatives. These can help to balance entire ecosystems but might also undervalue individual suffering and disrupt fragile ecological networks. This can happen, for instance, when humans allow animals to starve in rewilded areas, as has happened in Oostvaardersplassen. Emphasis on larger, charismatic species can also create problems by diverting attention and resources from smaller, less known lifeforms. Informed by science, both biocentric and ecocentric approaches can support top-down, human-centered decisions regarding conflicting needs, resource distribution, land use, and the adoption of innovations. This can also lead to overlooking the agency of nonhuman life (Carver 2016) in creating soils, constructing habitats, regulating nutrient flows, and establishing local cultures, among many other examples. Despite the orientation suggested by the term *ecocentric*, approaches in this cluster can be paternalistic, overlooking the potential of technology to empower both human and nonhuman stakeholders by improving data collection, facilitating knowledge exchange between stakeholder types, exposing solutions to communal scrutiny, and implementing other supportive measures.

Conflicts between anthropocentric, technocentric, biocentric, and ecocentric approaches complicate the human governance of shared ecosystems by creating silos (Dietz, Ostrom, and Stern 2003). Efforts to address planetary crises become even more challenging when they consider nonhuman stakeholders, whether these are microorganisms and animals or artificial algorithms and robots (Bodin 2017). A better conceptualization of decision-making is thus necessary to escape the ongoing failure of dominant frameworks.

1.3 Toward fairer futures

In preparing for considerations of a decision-making framework that can overcome these limitations, we rely on accumulating multidisciplinary evidence to assume a view from which that all living beings, as well as some technical gadgets, can make decisions.

Section 3 provides numerous examples supporting this position, but its adoption, even if provisional, is also pragmatic. This is because nonhuman decision-making agents possess valuable knowledge and skills that humans lack. Mammals, plants (Trewavas 2014), and fungi (Dighton [2003] 2016) excel in their own lives with a proven record of evolutionary success. Indeed, decision-making — such as when to move or stay still, what to eat or avoid — occurs in many organisms without higher-level cognition, including insects and bacteria (Budaev et al. 2019; Lyon 2015; Matthews and Matthews 2010). They innovate genetically, phenotypically (Kirschner and Gerhart 1998), behaviourally, culturally, and systemically (Ramsey, Bastian, and Schaik 2007). And they do so in environments and situations in which humans struggle to cope. Many lifeforms — such as doves, rats, cockroaches, and dandelions — not only survive but thrive in anthropogenic and unfamiliar evolutionary environments (Douglas and Goode 2011).

Creative decisions by nonhuman innovators might offer valuable approaches that extend and contextualize human ingenuity. Given the above, we have two objectives in this article:

1. In the *Outcomes* section, we propose an integrated, more-than-human understanding of decision-making. We do so by presenting evidence of interrelated decision processes, agents, purposes, and interpretations across both living and technical domains.

2. In the *Discussion* section, we hypothesize that adopting a more-than-human perspective on decision-making can reframe practical actions by engaging overlooked agents, emphasising undervalued relationships, posing critical questions, and presenting scenarios of alternative futures. We argue that these outcomes have the potential to enhance justice, care, resilience, and wellbeing within more-than-human communities.

Methods: Qualitative mapping and the three horizons framework

To achieve the above-mentioned objectives, we begin by comparing the decision-making processes of nonhuman creatures with those of technical gadgets. Next, we conceptualize decision-making as a more-than-human process. Finally, we examine the example of alpine dingoes in Australia to explore scenarios of creative decision-making.

2 Conceptual approach

Ontologically, we conceptualize the world as processual: phenomena unfold over time and are characterized by dynamism, interrelatedness, and path dependence. When considering the future, we regard it as inherently plural and uncertain. This ontological stance necessitates an *epistemology* capable of constructing pluralistic, context-sensitive knowledge networks. Ultimately, this approach's *praxiological* orientation seeks to ensure that theoretical insights inform practical strategies while addressing human agency's ethical implications.

2.1 Qualitative mapping

To study more-than-human decision-making processes, we review perspectives and examples from relevant domains. Specifically, we organize cases from the literature using indicative scatter plots by drawing on "big-picture" methods for qualitatively and visually structuring complex issues, including qualitative systems mapping and evidence mapping (Hanger-Kopp, Lemke, and Beier 2024; Miake-Lye et al. 2016). We view these plots as a catalyst for researchers across disciplines to advance the development of explanatory matrices or taxonomies — both of which are widely used in qualitative studies.

Plot construction involves the following steps:

1. *Defining dimensions and regions:*
    - The *x-axis* represents the degree of anthropocentrism. It indicates how strongly decisions prioritize human interests over nonhuman considerations. The variability of the anthropocentric influence along this axis parallels the stages of participatory collaboration in the 'ladder' of more-than-human participatory design (as discussed by one of the authors in a prior publication [see, Roudavski 2024]). It also aligns with analyses of human attitudes toward conservation (Fortuna, Wróblewski, and Gorbaniuk 2023).
    - The *y-axis* represents organizational complexity as one of three key scales in ecological applications (alongside spatial and temporal scales) (Wu and Li 2006).
    - *Regions* represent clusters of processes with similar decision-making attributes.
2. *Data collection* involves a review of the literature and practice that captures cases of decision-making in biological, ecological, and technical systems.

3. *Data plotting*:
    - Cases under consideration are perspectives on decision-making processes supported by existing or emerging pluriversal bodies of expertise and practice.
    - Each plotted point represents a group of cases positioned to reflect the anthropocentrism and organizational complexity of decision-making processes.
    - Relationships within scatter plots help to identify additional examples that would otherwise remain unexamined.
4. *Relationship analysis*:
    - Relative positions of points and regions help to identify patterns, correlations, or trends.
    - Clusters and outliers reveal unique or shared characteristics.

To support an imaginative interpretation of the plots in various applications, consider two decision-making contexts:

- *High anthropocentrism, medium complexity*: An example here would be a traditional family farm, where humans dominate decision-making and treat nonhuman beings as resources or commodities. The humans might value animals for their utility (e.g. livestock) or enjoyment (e.g. rare-breed cats or horses). Social conventions shape decision-making.
- *Low anthropocentrism, high complexity*: An animal sanctuary serves as an example here, where animals drive governance and human carers, funders, and the public collaborate to support their well-being. Previously classified as "livestock," "pets," or "wildlife," these animals now serve as pioneers in advocacy efforts to establish legal rights for nonhuman beings. Decision-making involves challenges, such as interpreting nonhuman agency, ensuring fair resource allocation, and scaling up solutions to address mass suffering in intensive animal farming.

2.3 Case-study Scenarios

To illustrate how environmental management and design decisions can reshape practical actions and emphasize ethical considerations, we examined biocentric, technocentric, and more-than-human decision-making. We did so through scenarios extrapolated from a real-world case study.

2.3.1 Stakeholder species

We selected alpine dingoes because they face multiple decision-making controversies. These animals are a species of dog endemic to Australia. They probably arrived from Asia around 12,000 years ago (Ballard and Wilson 2019). Some were tame, while others were not, but none were domesticated in the same way as agricultural animals or pets, which live separately from their wild counterparts and whose morphology and reproduction humans strictly control. Although some dingoes spent part of their lives with humans, they remained "free agents," foraging and reproducing independently (Brumm 2021). Within Indigenous communities, dingoes played roles of hunting partners, protectors, companions, and sources of warmth and food (Smith 2009). Some researchers have argued that dingoes served as "live technology" for Indigenous peoples. They affected decisions that enhanced hunting efficiency, reshaped labour structures, and expanded the range of food sources (Balme and O'Connor 2016). As kin, they were collaborators, competitors, teachers, political agents, friends, and family members actively living and co-creating human worlds (Rose 2000). Around 8,300 years ago, the dingo diverged into two ecotypes: desert and alpine (Cairns and Wilton 2016). The alpine dingoes are the ones we shall use as an example.

2.3.2 Current challenges

For over a decade, researchers believed that dingoes had vanished from the Victorian High Country (an alpine region in southern Australia) owing to extinction, migration, or genetic assimilation by wild dogs. However, observers have recently documented several pure dingo pups in the area, forming a small breeding group of six members (Jestrimski and Monk 2020). This has dispelled fears of extinction. In the broader region of eastern Victoria, recent counts estimate that the dingo population is between 2,600 and 8,800 individuals (Stock 2024). This population has a small impact on farming, with livestock losses at around 0.009% of the sheep population (Stock 2024). However, in 2024, Victoria approved culling until 2028, with 478 dingoes killed the previous year. Pastoralists worry that dingoes will prey on their livestock and that growing numbers of human tourists might lead to displays of aggression in these animals. These tensions have led to calls for expanded dingo culls in some communities and suspicions of illegal baiting (Colman et al. 2014). Ecologists have, however, highlighted the importance of dingoes as apex predators (Fleming et al. 2012) and established protection programmes to track and monitor the animals.

Dingoes serve as a representative case because they interact with humans and their technologies in diverse ways. They are predators, protectors, wild dogs, domesticated animals, pets, and even food. They also take, influence, and prompt multiple decisions. Alpine dingo populations are smaller and more fragile than those of desert dingoes, and the former's habitats are also typically closer to human settlements, which more frequently brings them into conflict with tourists, hunters, and livestock (Allen et al. 2017).

Humans make multiple and often incompatible decisions that affect dingoes. For instance, they construct the world's longest fences to guard livestock (Letnic and Koch 2010) but also create laws to protect dingoes from hunters and issue guidance about maintaining physical distance to avoid aggression. Alpine dingoes also face threats from competitors such as red foxes and feral cats, not to mention the baiting systems that are intended to eradicate invasive species (Jestrimski and Monk 2020).

2.3.3 Alternative scenarios

We shall consider various future scenarios to illustrate the potential benefits and drawbacks of decisions made with regard to alpine dingo communities. Futurists often imagine and compare potential states: the possible, plausible, probable, and preferable (Dunne and Raby 2013). One systematic approach — the 'Three Horizons' framework — considers a current state (Horizon 1), an emerging long-term successor state (Horizon 3), and a disruptive intermediate state where innovation occurs (Horizon 2) (Sharpe et al. 2016).

We applied this method to alpine dingo communities in south-eastern Australia. Our study compares a devastating short-term future, a plausible near-term period of technical innovation, and a preferable long-term future. The goal is to help illustrate the benefits and implications of a more-than-human understanding of creative decisions that affect more-than-human communities.

3 Framework: Forms of decision-making

To illustrate that decision-making is widespread and distributed, rather than exclusively human, we begin this section with familiar examples of anthropocentric decision-making. We then broaden the scope to include cases involving nonhuman organisms and less familiar non-organismal processes, such as animal cultures and epigenetics. Finally, we examine instances of technical decision-making that are commonly used and provide examples of emerging processes in spatial design contexts.

The perceptual shift required to recognize decision-making as occurring beyond the human rational mind is substantial and often counterintuitive. To support this shift, the following diagrams use labels positioned relative to the axes to indicate different types of decision-making. These types are grouped into regions based on the existing attitudes introduced in Figure 1. The labels' positions and colours reflect their association with specific regions. The relationships between labels, regions, and axes are suggestive, as some labels could belong to multiple regions depending on the perspective or mode of analysis. Each subsequent diagram introduces an additional region, illustrating further examples and relationships. The final diagram in Figure 7 removes the axes and reorganizes the decision-making types into an integrated whole.

3.1 Creative decisions by creatures

In this section, we examine decision-making as a fundamental aspect of all life, extending beyond humans. Traditionally, fields such as economics, psychology, politics, organizational management, and dominant approaches in design focus on human decisions. This often comes at the expense of excluding nonhuman beings or reducing their actions to instinct (Blumberg 2017). The result is an overestimation of human autonomy (Schneeweiss 2012).

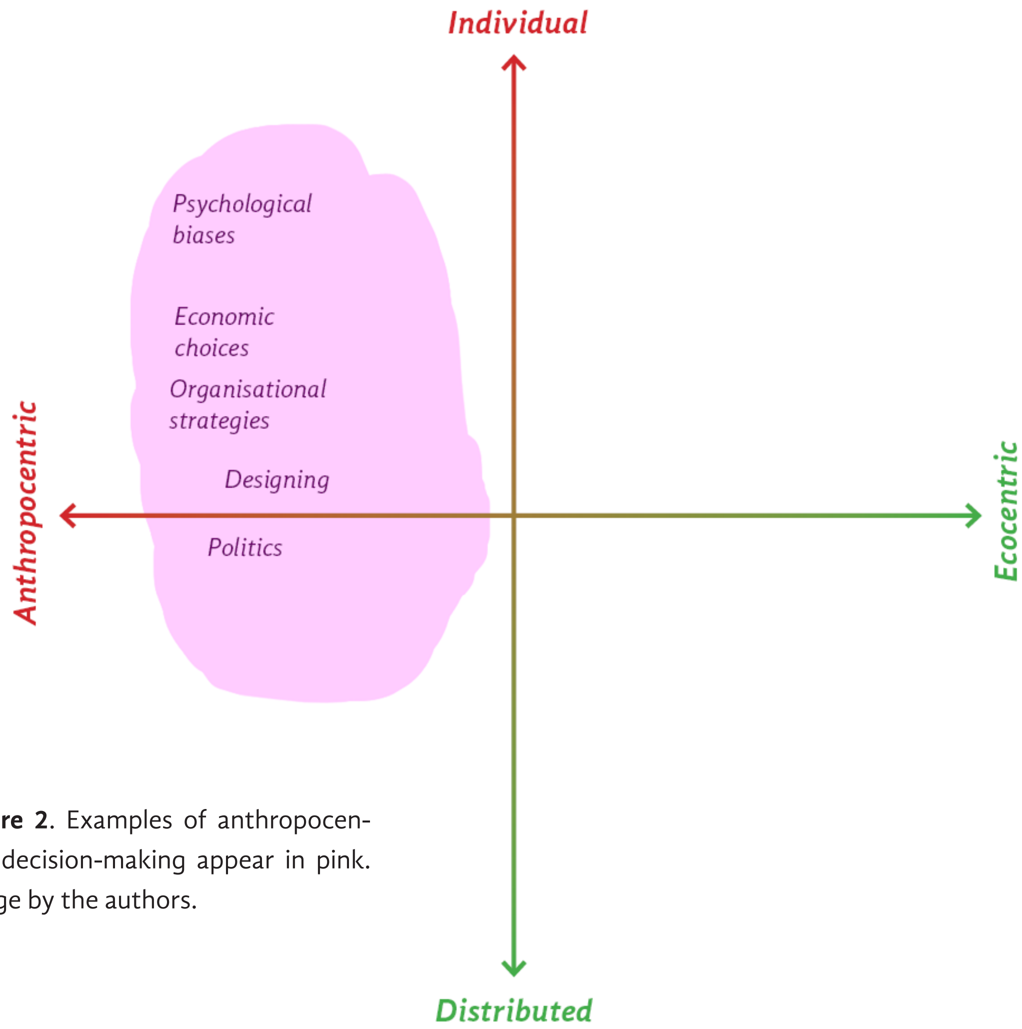

Figure 2. Examples of anthropocentric decision-making appear in pink. Image by the authors.

The placement of the pink region in Figure 2 reflects dominant perspectives that frame decision-making as primarily human and driven by individual actors. This aligns with anthropocentric notions of intelligence, rationality, and creativity. It is, however, important to note that growing research across these fields increasingly challenges human-centred assumptions (even if a genuine paradigm shift is yet to take place).

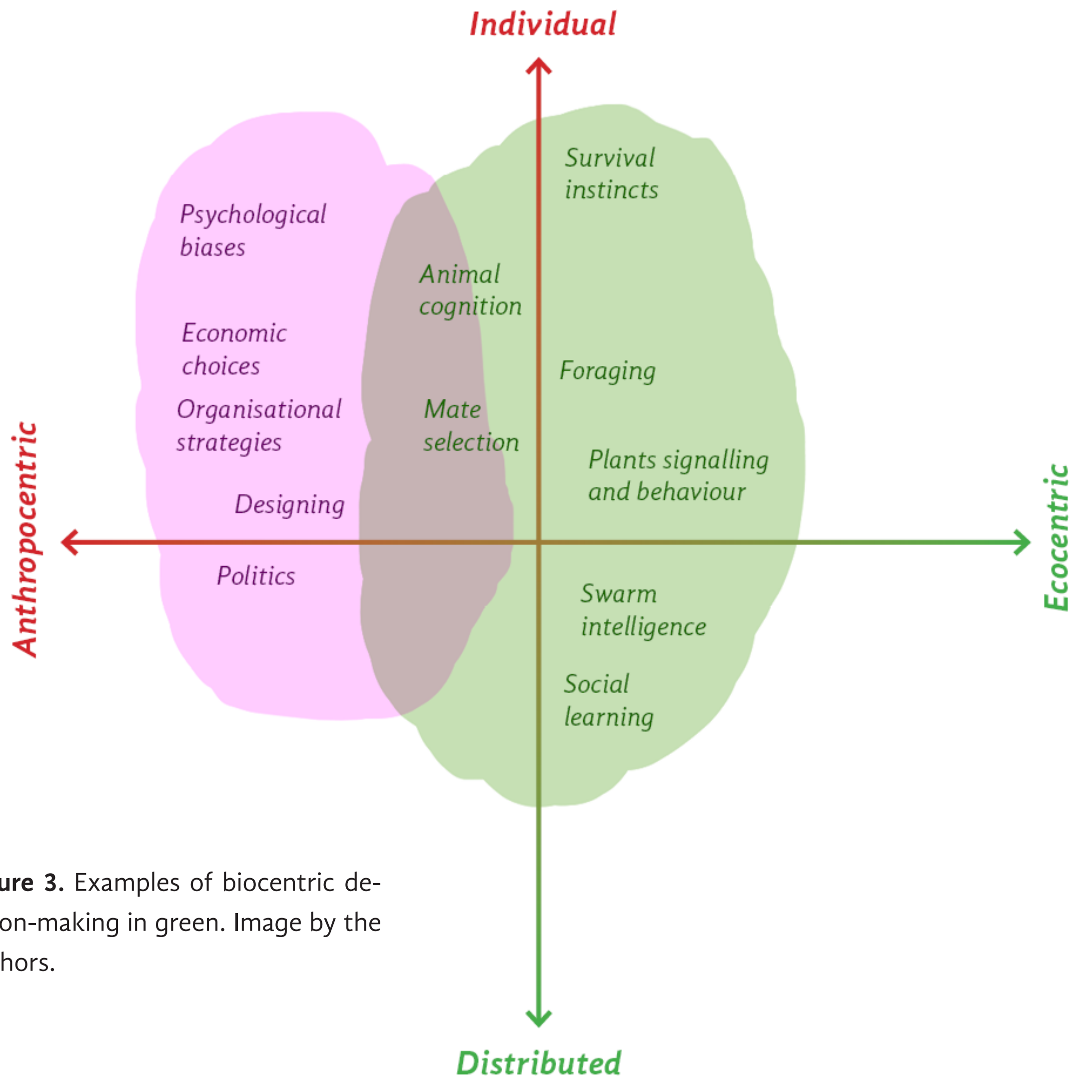

Figure 3. Examples of biocentric decision-making in green. Image by the authors.

Contrary to presumptions of anthropocentric exclusivity, all creatures (whether human or nonhuman) must make decisions in response to their environments (Margulis and Sagan [1995] 2000). We define "creatures" as sentient or intelligent beings, which reinforces kinship across species and resists the human–nonhuman divide (Haraway 2008, 250; Korsgaard 2018). For instance, processes of animal cognition, foraging, and mate selection in Figure 3 allow wolves and dogs choose how to evade heat, decide what to eat, and evaluate trust (Bekoff 2013). Likewise, birds make choices about migratory routes, hunger, and fatigue (Harel et al. 2016); while fish determine shoal membership and mating tactics (Salena et al. 2021). Invertebrate animals also make decisions, with swarming honeybees choosing nest locations in response to scout signals representing just one example (Seeley 2010).

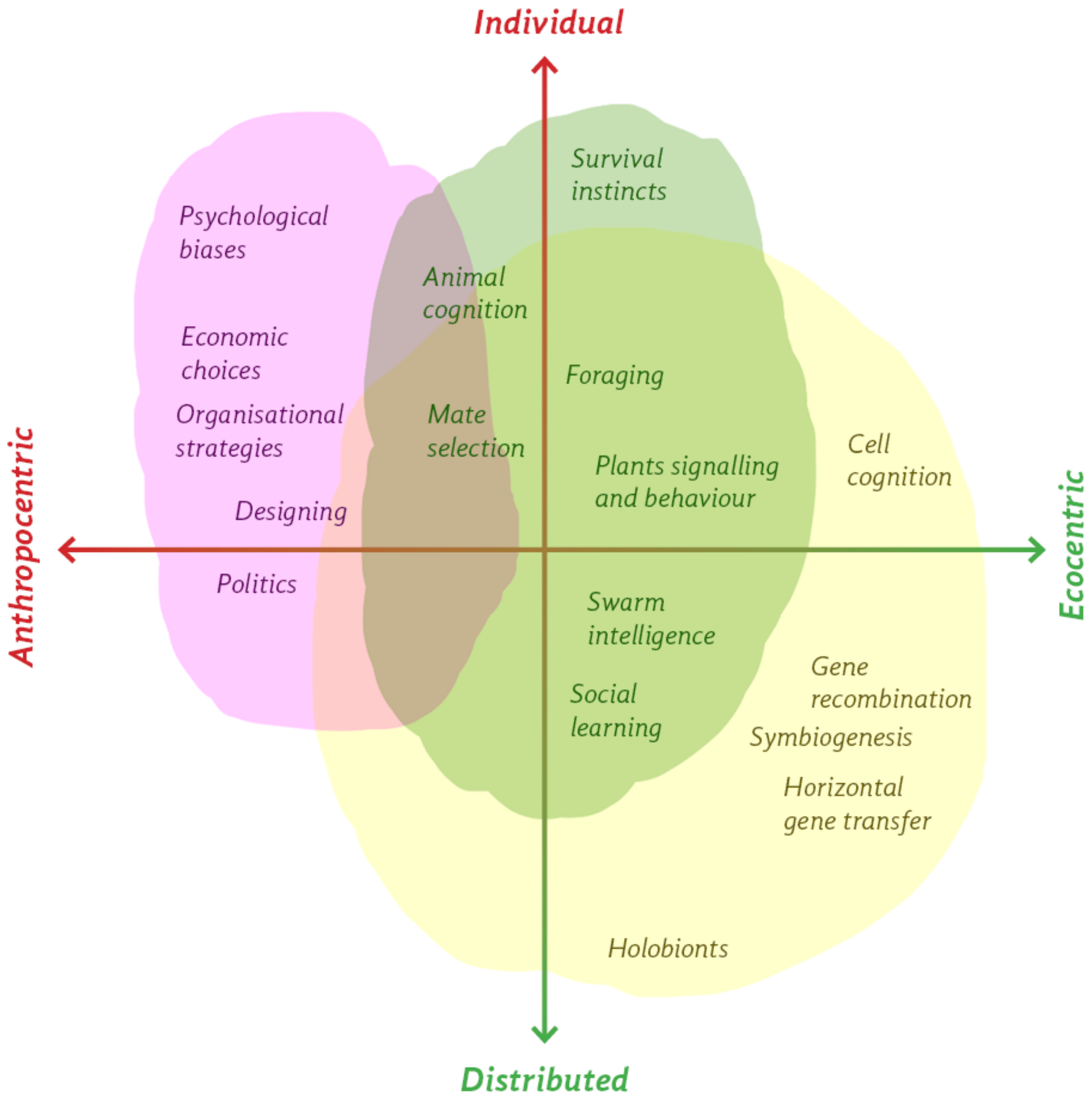

Figure 4. The yellow region highlights distributed decision-making processes. Image by the authors.

Decision-making can depend on many processes, including cognition, intelligence, sentience, and evolutionary adaptation (Hammerstein and Stevens 2012; Shadlen and Kiani 2013). For example, lifeforms without brains — such as plants and microorganisms — also have decision-making abilities (Figure 4). Plants optimize root distribution (Calvo Garzón and Keijzer 2011), while slime moulds balance food rewards and exploration (Reid et al. 2016). Bacteria use chemotaxis to pursue goals, which showcases decision-making at a microscopic level (Balázsi, van Oudenaarden, and Collins 2011). In social species, learning, habits, and cultural transmission influence decision-making. This results in behaviours like optimal foraging (Barack 2024) and niche construction (Laland, Matthews, and Feldman 2016). The placement of the green region in Figure 4 shows the biocentric group, with a focus on organisms and groups of individuals. We positioned this region closer to the centre because, while decisions in this group do not involve human rationality or organisational processes, human interpreters perceive them as analogous to human decisions but less sophisticated. This perception stems from the assumption that organisms, acting as distinct selves, make these decisions independently.

As indicated in Figure 4, decisions also occur at sub-organismal levels that include both cellular and sub-cellular processes. These decisions often occur in numerous parallel, distributed instances and challenge the intuitive association of choice-making with individual organisms, which justifies placing the large yellow region that groups them in the bottom-right part of the diagram. For example, cells process noisy signals to estimate current and future states of their environments, evaluate the costs and benefits of potential responses, and determine a course of action while accounting for the presence of other decision-makers (Perkins and Swain 2009). Genetic codes, in turn, enable basic decision processes such as sourcing food or managing life cycles (Stearns 1976). Decision-making is, thus, a widespread phenomenon that extends across organisms, bodies, and generations. It is tied to each system's dynamic interactions with other systems and processes.

Creativity in decision-making can occur in response to environmental conditions that require or afford novel responses. Humans acknowledge some cases of nonhuman creativity, such as bees' nest-building, termite mound constructions, and primate tool use (Kawai 1965; Laland, Matthews, and Feldman 2016). Other examples include lyrebirds mimicking urban sounds (Ortega 2012) and cockatoos opening garbage bins while searching for food (Klump et al. 2021). However, humans continue to ignore much nonhuman creativity. Alternatively, they dismiss this creativity as mechanical stimulus-response reactions or mere coincidence. Examples of such processes include seagrass meadows that support marine ecosystems by reducing currents and enhancing sediment deposition (Bos et al. 2007). Another example is trees that modify their habitats by shedding branches and increasing nutrient availability (C. G. Jones, Lawton, and Shachak 1996). On a cellular level, genetic mutations and epigenetic responses can also enable adaptation and innovation (Hochberg et al. 2017).

Non-living systems also exhibit creative processes. Environments like oceans and deserts form continuously, and earth processes create geological layers from modern materials like plastic (Nail 2021). Although lacking cognition, these systems form novel, meaningful interaction patterns. We therefore propose that many lifeforms and environmental systems make creative decisions within shared habitats.

As mentioned, we are focusing on alpine dingoes in Victoria's High Country to illustrate the interaction of perspectives on decision-making. These animals exhibit diverse decision-making patterns. They adapt their hunting strategies to prey type, adjust behaviours to coordinate social tasks (Smith 2015), and regulate breeding in response to environmental stressors like droughts (Ballard and Wilson 2019). Dingoes also affect other species' decisions (e.g. feral cats and foxes alter hunting schedules to avoid them [see, Brawata and Neeman 2011]). Dingoes' knowledge of water sources can, in turn, aid human navigation (Philip 2020). As apex predators, dingoes shape ecosystems, and their absence can trigger cascading ecological effects (Letnic, Ritchie, and Dickman 2012).

However, humans often misinterpret dingos' behaviour owing to difficulties relating to reading the animals' signals (Smith 2009). This leads to management choices that do not fully leverage these animals' knowledge.

Recognition of nonhuman decision-making leads to ethical and practical challenges. All creatures face biases, limited resources, and constraints from evolutionary history, which restrict their decision-making capacities (Budaev et al. 2019). While lifeforms excel at making decisions suited to their evolved niches, rapid changes caused by human activities leave many species vulnerable. A recognition of the creative decisions made by diverse living beings can motivate more inclusive studies of decision-making processes and enrich their application in design. This can, in turn, be facilitated by drawing on a broader range of choice-making processes.

3.2 Creative Decisions by Gadgets

To address limitations in human decision-making, societies increasingly turn to technical systems. In this section, we examine such systems' capacities and constraints, then compare these with the decisions made by nonhuman creatures. By highlighting shared characteristics — such as the distributed nature of decision-making — this discussion reinforces our article's broader argument: understanding all forms of decision-making, including ecocentric, technocentric, and others, within a holistic framework can lead to more insightful and beneficial actions.

Technologies — such as dwellings, tools, and machines — are systems produced by creatures to enhance their biological fitness (Aunger 2010). In this article, 'gadgets' refer to devices that extend capacities in novel ways. For humans, decision-making gadgets help to select optimal choices and foster connections with others. This aligns with our term "creature" for all life forms. Gadgets, in turn, express identities, support functions, and connect to broader concepts of "things" and "beings." This aligns with the idea of a "Parliament of Things," which was introduced to blur the lines between living and non-living entities (Latour [1991] 1993).

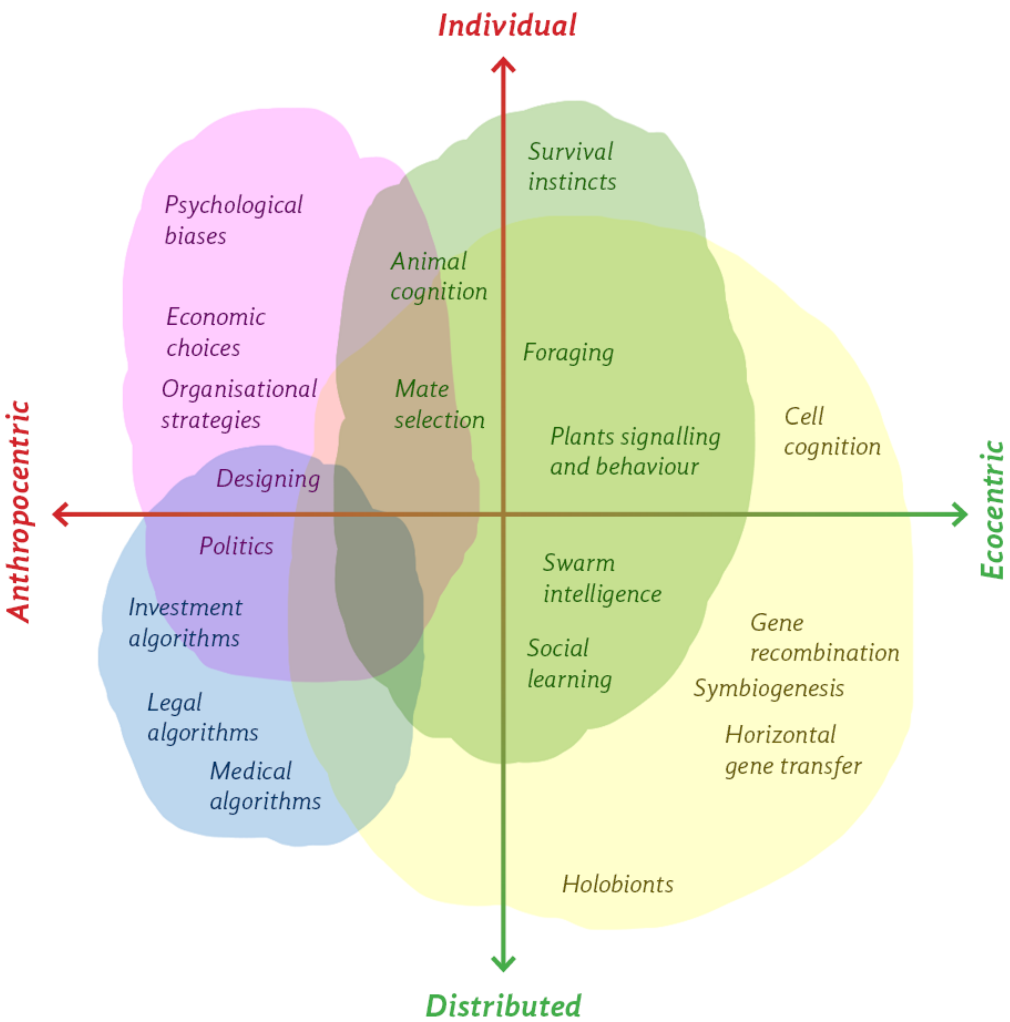

Figure 5. Decision-making by technical systems is shown in blue. Image by the authors.

Today, human technologies increasingly rely on algorithms to analyse data, infer patterns, and offer insights into causes and consequences of events (Mahmud et al. 2022). Algorithms operate in various fields, including in legal systems to set bail terms, in finance to automate trades, and in public policy to understand human priorities. Healthcare also benefits from decision-making algorithms, which enhance diagnostic accuracy and treatment planning. In these contexts, human–technical decisions represent collective processes that blend human expertise with algorithmic functions. The result is a single, collaborative cognitive system (Hutchins 2000). Figure 5 illustrates examples of such systems applied to anthropocentric concerns. Commentators often recognise these processes as societal and distributed but continue to view them as predominantly human-driven, which justifies placing this region in the bottom left corner of the diagram.

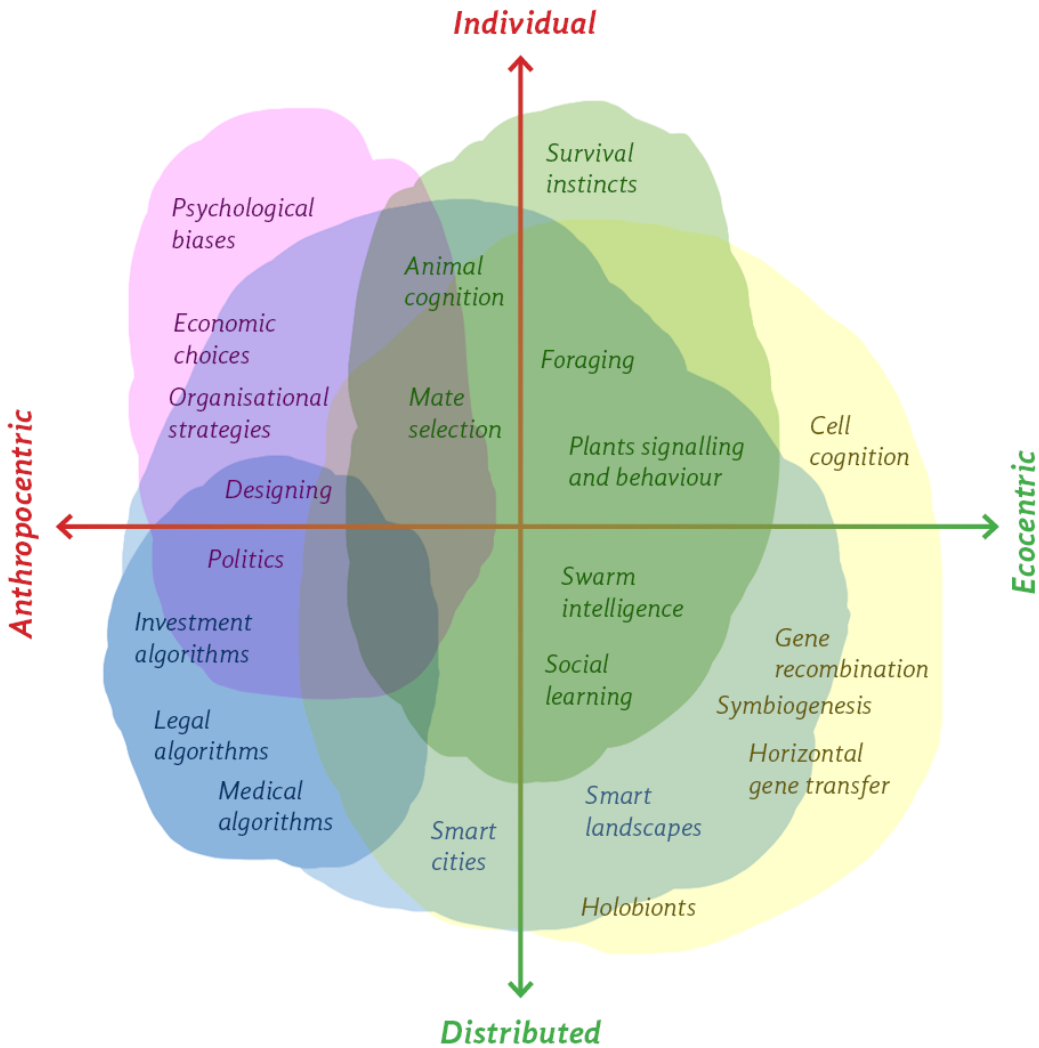

Figure 6. The expanded potential of more-than-human technical systems is represented by the large light blue area. Image by the authors.

Technical systems now permeate living environments and gadgets facilitate automation in various domains. AI systems streamline design work, support analysis, handle repetitive tasks, and reduce costs (Bernstein 2022). Smart homes automate household tasks through connected devices (Alam, Reaz, and Ali 2012), while smart cities use data and sensors to promote sustainability and efficiency (Tomičić, Okreša Đurić, and Schatten 2018). Gadgets also support fire-smart landscapes (Alexandridis et al. 2011), intelligent water management (Ewing and Demir 2021), precision agriculture (Walter et al. 2017), geoengineering (Shepherd 2012), and space exploration (Stoick et al. 2019). These developments mean that humans and nonhuman beings are increasingly coexisting within technical decision-making systems (see Figure 6).

Gadgets offer advantages such as reducing human biases such as sexism, ageism, or speciesism (Wieringa 2020), accelerating decision-making — for example, by providing rich data on stakeholder responses to design prototypes (Diakopoulos 2016) — and generating new insights by comparing management scenarios. In some areas, decision-making algorithms surpass human capabilities, particularly when it comes to forecasting behaviours, health outcomes, and some types of academic performance (Mahmud et al. 2022). Gadgets can also respond creatively to established challenges. Examples include optimizing logistics systems (Huang 2023), improving crop strategies (Wolfert et al. 2017), developing game strategies (Silver et al. 2016), producing generative art (Moruzzi 2020), and identifying extraterrestrial biosignatures (Farley et al. 2020).

However, these systems also present distinct and accumulating challenges. They often depend on incomplete data and can also be susceptible to manipulation, thereby perpetuating harmful biases that lead to social harms or reduced opportunities (Castelluccia and Le Métayer 2019; Fazelpour and Danks 2021). When gadgets fail (as in autonomous vehicle crashes or medical procedures), accountability becomes complex owing to the layered involvement of designers, engineers, operators, and the technology itself (Elish 2019). Some critics even describe data collection as a new form of colonization, one that exploits both human and nonhuman beings through surveillance and reduces life to just another capitalist resource (Banwell 2023; Couldry and Mejias 2019). These systems often rely on living agents' creativity and labour without recognition, compensation, or opportunities for direct stakeholder input. This increases the risk of reinforcing prejudices and biases.

Decision-making gadgets are becoming integral in alpine dingo habitats. Camera traps monitor dingo distribution, temporal activity, and interactions with other fauna. Drones can track the dingoes' movements and predatory behaviours by identifying individual coat patterns (Pollock et al. 2022). Machine learning algorithms can, in turn, analyse video footage to study dingoes' hunting strategies, social interactions, and responses to environmental changes. AI technologies are also used to understand the genetic diversity and health of alpine dingo populations (Owens and Wolch 2019). At landscape scales, snow machines now support winter tourism in the Victorian Alps. This compensates for the climate change impacts that shorten snow seasons, which is a growing trend in alpine areas around the world (Rixen et al. 2011).

3.3 More-than-human decision-making and design

We have framed creative decision-making as a varied capability of creatures and gadgets that interact with physical contexts, interpret information, assess options, assign values, select preferred choices, and innovate when necessary. We now discuss creative decision-making as a distributed, more-than-human process.

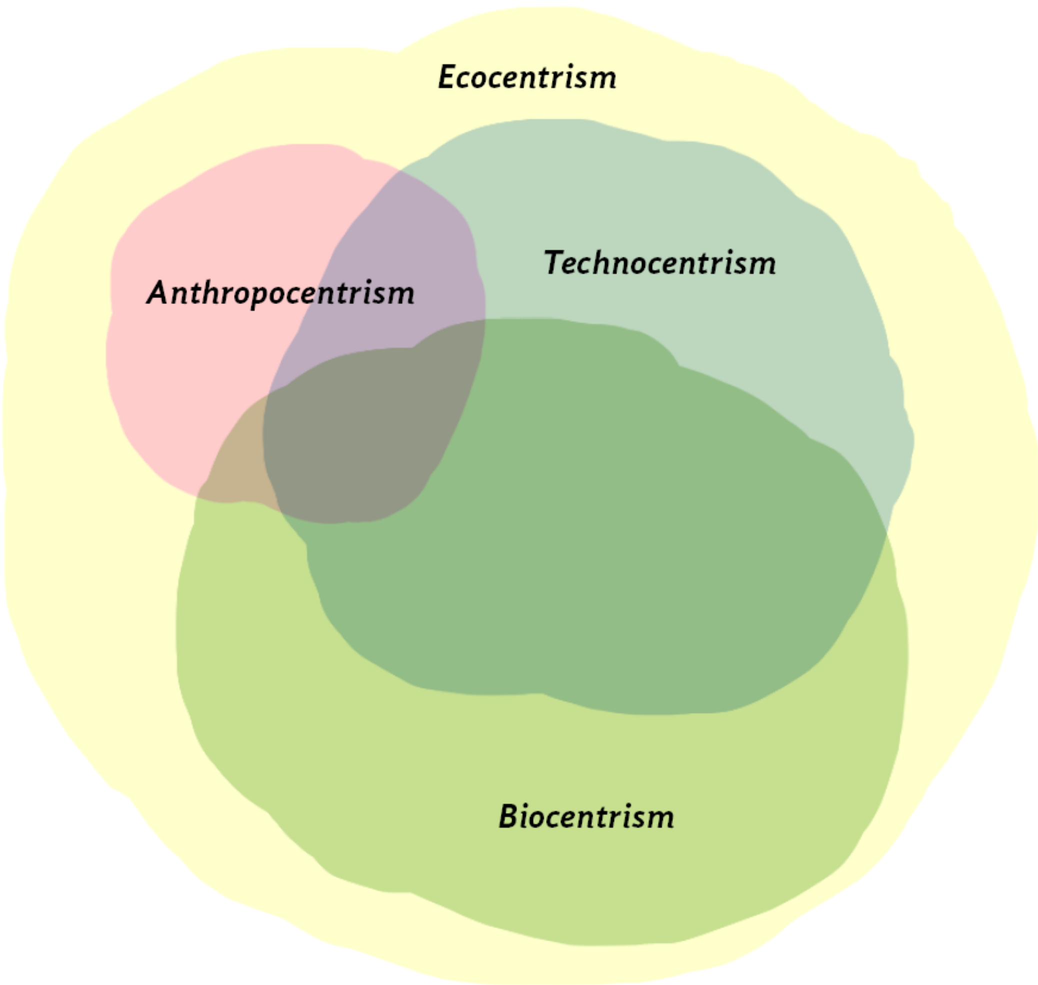

Figure 7. Integrated decision-making. Image by the authors.

Nearly every organism engages in mutualistic interactions at least once in its lifetime (Margulis and Sagan [1995] 2000). This involves participating in intricate physical, chemical, informational, and social networks. In keeping with this reality, the term "more-than-human" emphasizes the continuity between human techno-cultural systems and nonhuman patterns of self-organization. As shown by the overlapping regions in Figure 7, we do not privilege humans, biological nonhuman beings, or synthetic systems. Instead, we see them as interconnected decision-making communities.

In our practical work, we explore more-than-human decision-making in diverse contexts within the concept of more-than-human design (Roudavski 2018; 2020; 2021). Relevant projects include constructing prosthetic nests for owls using laser scanning, parametric modelling, 3D printing, and augmented-reality assembly (Parker et al. 2022); reimagining the roles of bald cypress trees in the Mississippi Delta (Gordon and Roudavski 2021); and artificially recreating preferred bird perches using algorithms informed by laser scans (Holland et al. 2023). These projects illustrate how future design can incorporate collaborative, more-than-human creative decision-making for both human and nonhuman clients. This challenges the gap between anthropocentric and technocentric approaches (Holland and Roudavski 2024; Rutten, Holland, and Roudavski 2024).

In Victorian High Country dingo habitats, gadgets like drones, camera traps, snow machines, and mapping systems facilitate many decisions. In similar landscapes, sensor networks detect and manage fires, observe deforestation in real-time, track ecological growth, and guide reforestation drones (Gabrys 2020). Technologies now even extend to individual nonhuman lives. This is evidenced in satellite-tracking collars that record dogs' scratching, eating, and drinking, among other activities (Zamansky et al. 2019). The spread of decision-making technologies in wild spaces and their integration with ecological processes have led to discussions of "algorithmic conservation" and views of the planet as a programmable or "smart" environment (Bakker and Ritts 2018; Gabrys 2016; Scoville et al. 2021). However, these systems often reinforce anthropocentric biases in decision-making, thereby propagating multiple harms to animals and ecosystems (Coghlan and Parker 2023; Hagendorff et al. 2022). Creative decision-making is, nonetheless, essential for managing dingo habitats. A return to past ecosystems is now unfeasible owing to pressures from grazing, feral horses, tourism, and dingo sanctuaries. These conditions demand new relationships and spaces that foster the harmonious coexistence of humans, domesticated animals, plants, and their wild counterparts.

Next, we simulate the proposed framework in action by exploring how emerging technologies can contribute to creative decision-making in the context of dingo futures. Earlier, we defined 'creative decisions' as 'novel actions.' For alpine dingoes, gadgets could disrupt their autonomy by reinforcing anthropocentric control. However, a more-than-human framework could help to convey these animals' capabilities, needs, and preferences (Parker, Soanes, and Roudavski 2022).

4 Case-study scenarios: Alternative futures

When it comes to justice, the creativity of all stakeholders (human and nonhuman) can help to overcome the limitations of anthropocentric decision-making. To illustrate the implications, we now return to the example of alpine dingoes in Australia and examine three possible future scenarios. The first, set in 2030, envisions a continuation of current trends in dingo management. The second, in 2050, depicts advances in technical decision-making that remain anthropocentric. The third, in 2150, explores a future in which alpine dingoes actively shape their environments, and multiple stakeholders collaborate to create a fairer world. We introduce these hypothetical future scenarios to contrast decisions made with and without the direct participation of nonhuman stakeholders. All scenarios are presented in the past tense, as if they have already occurred. References within the scenarios cite empirical evidence supporting the plausibility of the aspects we have selected as examples.

4.1 Local extinction by 2030

By the year 2030, alpine dingoes were extinct in Victoria's High Country. Two decades earlier, they had first vanished from the region, but reappeared in 2020. However, hope for their reestablishment in the area faded in 2024 when the Victorian government permitted dingo killings on both public and private lands through trapping, baiting, and shooting (Stock 2024).

Meanwhile, global efforts to combat climate change stalled. Warmer summers, frequent droughts, and shorter snow seasons reshaped the Victorian Alps. This reduced vegetation, shrunk small mammal populations, and deprived dingoes of vital prey. With insufficient food to sustain breeding, the dingo numbers collapsed, raising concerns about the region's trophic cascade and ecological resilience. Local government prioritized livestock safety and the financial interests of the agricultural industry over dingo conservation, despite the species' role as a keystone predator. Decision-makers rejected alternative strategies, even as the threat of extinction grew. They dismissed technologies like camera tracking, drones, and algorithmic territory management, considering them too costly for communities already strained by the shrinking snow season.

Although some scientists tried to protect the alpine dingo, a limited understanding of the species' needs hampered conservation efforts amid rapid environmental decline.

The thylacine, or Tasmanian tiger, was another apex predator that disappeared in 1933 owing to overhunting (Freeman 2010). The alpine dingo likewise vanished before scientists could understand its ecological role (Figueirido and Janis 2011). Extinctions of such species not only reduced biodiversity but also erased the nonhuman knowledge that sustained complex multispecies communities for thousands of years. In this scenario, anthropocentric priorities led to the extinction of alpine dingoes. This outcome highlights the dangers of relying solely on human-centred decision-making while disregarding more-than-human perspectives. By dismissing nonhuman contributions and neglecting technology's potential to support decision-making, policymakers entrenched injustices against nonhuman communities and overlooked opportunities to promote positive coexistence.

4.2 Technical solutionism in 2050

By 2050, decision-making technology restored the alpine dingo to near pre-colonization population levels. Confronting the dingo's potential extinction, local authorities launched an intensive technical programme. National park officials placed camera traps with software able to recognize individual animals at water points and trails, supplied dingoes with global navigation satellite system devices (Boronyak and Jacobs 2023), and deployed drone swarms to monitor changes in snow coverage, vegetation, and nonhuman behaviours (Saffre, Karvonen, and Hildmann 2024).

Technologists used this data to create a live digital twin of the alpine region (D. Jones et al. 2020). They mapped dingo locations, territories, feeding zones, water sources, travel corridors, and responses to extreme weather or human interference. Data scientists linked this digital twin with decision-making algorithms to analyse dingo preferences, select habitat protection areas, and optimize for multiple species' spatial needs. Inspired by the thylacine's upcoming de-extinction enabled by genome editing (Feigin, Frankenberg, and Pask 2022), a more radical group of scientists edited the dingo genome to enhance genetic diversity. Although the initial impacts of such approaches seemed minor, the alpine dingo population's decline eventually slowed and reversed. In this scenario, technological systems suggested rapid, adaptive decisions for alpine dingoes in a shifting environment. But they also introduced costs. The presence of drones and camera traps disrupted dingo behaviour (Walker, Sheaves, and Waltham 2023), causing agitation and affecting the animals' decision-making. Environmentalists criticized the approach as an unethical invasion of animal privacy and a form of intervention that disrupts power dynamics within both informal and organizational governance (Scoville et al. 2021; York et al. 2023). For instance, the technocentric approaches exposed dingo locations to hunters and prompted farmers to retaliate against protections for perceived pests by destroying monitoring devices. During one summer, a drone crash nearly ignited a bushfire, risking countless plant, animal, insect, and microbial lives.

Critics contended that the technocentric approach failed to address the region's original threats: anthropocentric and paternalistic decision-making with a long history of injustice (Roudavski 2024). Although dingo populations returned to pre-colonial levels, the programme ignored or de-emphasized the decision-making abilities of dingoes and other species, which curbed their autonomy. Ultimately, this approach imposed a managed, domesticated-like existence on beings that had long thrived with a high degree of self-determination despite extensive interactions with humans.

4.3 The promise of more-than-human design by 2150

By 2150, a more-than-human decision-making framework restored alpine dingoes in Victoria's High Country to a wilder state. This prevented their extinction and avoided the domestication common to most canine species. After the failures of anthropocentric and technocentric methods in the previous century, a new approach empowered alpine dingoes with both autonomy and the support of decision-making gadgets. This framework liberated dingoes from human control, prevented domestication or feralization, safeguarded the species' role as ecosystem engineers, and re-established a population that could shape its own future.

Decision-making communities adopting a more-than-human perspective allowed dingoes to define their own spatial and social boundaries. Dingoes naturally make risk–reward decisions when hunting, judging friend or foe, and exploring (Smith 2015). Their interactions with humans are, moreover, a blend of wildness, curiosity, and tameness (Ballard and Wilson 2019). Humans had previously ignored this dingo knowledge, creating parks, roads, and pastures that prioritized human boundaries. Under the new approach, technical amplifications of dingo decisions made in their habitats and communities informed identifications of their preferred habitats, water sources, hunting grounds, and wildlife corridors. Computational analysis also registered locations and incidents of human–dingo interactions to determine needs, densities, and opportunities for expanding their territory. Over time, this mapping created a dingo-driven digital twin of the alpine region (Nativi, Mazzetti, and Craglia 2021). Algorithms used this model to adjust ski fields, livestock pastures, and road networks. This, in turn, reshaped the landscape to better suit the dingo movements, dietary needs, and cultural interactions, thereby empowering them as key stakeholders in the alpine region design.

The framework also benefited other alpine species. Fleets of drones planted seeds and distributed water before forecasted droughts. This enhanced biodiversity and provided stable habitats and food sources (Jiménez López and Mulero-Pázmány 2019). Larger dingo territories, in turn, reduced habitat encroachment and thus decreased livestock predation. Non-living processes contributed as well. When algorithms anticipated warmer winters, machines produced artificial snow in areas that were vulnerable to early melting (Rixen et al. 2011). This created snowpacks to shelter small animals and protect alpine plants, thereby filling a critical ecological role in warmer winters (Berteaux et al. 2017).

The more-than-human decision-making framework prevented alpine dingo extinction and domestication by combining decision-making technologies with the more-than-human value frameworks that can account for dingos' needs and capabilities. This approach restored autonomy to alpine dingoes, preserved their role as apex predators, and supported their contributions as ecosystem engineers. It also fostered more resilient and biodiverse more-than-human communities. While a complete return to pre-colonial, pre-industrial multispecies cohabitation was no longer possible, a more-than-human approach to decision-making provided pathways to fairer futures for the diverse lifeforms in the Victorian alpine region.

4.4 Scenarios as a guide for practice

We introduced the three scenarios discussed above to demonstrate that alternative futures are both possible and worth imagining. These futures may encompass multiple possibilities, including those in which technologies cause harm and those in which they provide clear benefits. The contrast between the first two, more pessimistic scenarios — which overlook the agency of dingoes — and the final scenario — which considers how dingo contributions could positively reshape design — illustrates how the same events and actions can be interpreted differently and serve distinct purposes.

The scenarios we propose are preliminary sketches; however, with further empirical evidence and stakeholder feedback, they could enhance future literacy (Mangnus et al. 2021) and expand the range of possible futures. Building on the diagrams presented in this article, future efforts could construct more-than-human taxonomies of decision-making such as those we also outline in our ladder of more-than-human participation (Roudavski 2024) or by assessing nonhuman stakeholder capabilities, as we have done in the case study about owls (Parker, Soanes, and Roudavski 2022).

5 Conclusions

Using a literature review supported by qualitative mapping in two-dimensional plots, we have presented a more-than-human framework of creative decision-making. This is the kind of framework that spans human, biological, ecological, and artificial systems. We then examined a case study of the alpine dingo in Australia, exploring alternative scenarios related to three future horizons: (1) a continuation of current trends, (2) a reliance on technical solutionism, and (3) a vision of more-than-human collaboration.

More-than-human approaches seek to foster coexistence in modified environments by enabling autonomous decision-making across all forms of life. These include cells, organisms, biological taxa, cultural groups, and socio-technical communities. That said, no decision is perfect. Some choices might lead to harmful consequences, and all are inherently limited in scope and subject to bias. Actions taken by any group of agents must, therefore, be balanced against the needs of others, particularly when one considers the constraints of limited resources. Despite these limitations, our article shows that support for more-than-human decision-making engenders the potential to enhance environmental management and address unmet needs by embracing multimodal approaches to prevailing uncertainties. Existing research already emphasizes the need to integrate formal and informal, accredited and lay, experiential and conceptual forms of knowledge to support creative actions that can lead to alternative futures (Scoones and Stirling 2020).

We are advocating for extending this framework by granting greater recognition and influence of nonhuman beings' expertise and creative decision-making. This approach has the potential to resist the accidental, but also purposefully generated, ignorance and imperceptions that human groups use to manipulate decisions based on their interests (see McGoey 2012). This inclusive framework supports efforts to empower dingoes and other taxa as key stakeholders. These stakeholders can then take on the roles of co-locutors, assessors, co-designers, and leaders in decision-making processes. This will involve moving beyond top-down human governance and instead fostering platforms for sharing, reusing, and erasing knowledge. Such an approach can lead to decision-making that is more justified, transparent, and accountable.

We recognize that integrating diverse forms of human and nonhuman expertise into more-than-human decision-making is a complex challenge. Addressing issues like spatial biases, observer variability, taxonomic biases, and data misapplication will require careful strategies. In this pluriversal domain, stakeholder concerns and debates will invariably persist. Despite these challenges, human societies can strive to expand opportunities for addressing environmental crises by fostering inclusivity, drawing on diverse contributions, and adopting the approaches outlined in this article. The key takeaway is that, contrary to common human intuitions, a more-than-human understanding of decision-making is empirically supported by observations in biological and technological systems, logically sound, and promising. This makes it a worthy focus for further research and practical experimentation.

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