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Multispecies sustainability

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Non-technical summary

The sustainability concept seeks to balance how present and future generations of humans meet their needs. But because nature is viewed only as a resource, sustainability fails to recognize that humans and other living beings depend on each other for their well-being. We therefore argue that true sustainability can only be achieved if the interdependent needs of all species of current and future generations are met, and propose calling this 'multispecies sustainability'. We explore the concept through visualizations and scenarios, then consider how it might be applied through case studies involving bees and healthy green spaces.

Technical summary

The sustainability concept in its current form suffers from reductionism. The common interpretation of 'meeting the needs of the present without compromising the ability of future generations to meet their own needs' fails to explicitly recognize their interdependence with needs of current and future non-human generations. Here, we argue that the focus of sustainability on human well-being – a purely utilitarian view of nature as a resource for humanity – limits its conceptual and analytical power, as well as real-world sustainability transformation efforts. We propose a broadened concept of 'multispecies sustainability' by acknowledging interdependent needs of multiple species' current and future generations. We develop the concept in three steps: (1) discussing normative aspects, fundamental principles underlying the concept, and potential visual models, (2) showcasing radically diverging futures emerging from a scenario thought experiment based on the axes sustainable-unsustainable and multispecies-anthropocentric, and (3) exploring how multispecies sustainability can be applied to research and policy-making through two case studies (a multispecies stakeholder framework and the Healthy Urban Microbiome Initiative).

Social media summary

A new multispecies definition of sustainability recognizes that living beings and their well-being are interdependent.

1. Why reductionism makes sustainability unsustainable

> 'Meet[ing] the needs of the present without compromising the ability of future generations to meet their own needs'. (Brundtland, 1987, p. 41)
>
> 'The health of ecosystems on which we and all other species depend is deteriorating more rapidly than ever. We are eroding the very foundations of our economies, livelihoods, food security, health and quality of life worldwide'. Robert Watson, IPBES Chair, 2019

Why are global efforts to achieve sustainability failing? From climate change to the ongoing sixth mass extinction, states and corporations publicly commit to often unambitious targets that are missed nevertheless (Howes et al., 2017). The political costs of such failures are mostly negligible. Meanwhile, internationally, parties with neoliberal growth ideologies that range from conservative to neo-fascist enjoy ballot success with programmes advertising their indifference to problems that researchers show to threaten all life on earth, e.g. Trump's support for coal (USA) and Bolsonaro's goal of accelerating exploitation of the Amazon (Brazil). In this paper, we argue that the reductionist anthropocentric focus on human needs at the core of the sustainability concept limits our ability to meet those needs. In short, by reducing sustainability to a concern for human needs without acknowledging their intrinsic, complex interdependence with more-than-human needs, humanity is unable to meet the needs of the present, while also risking that future generations of all species will be unable to meet their own needs. Only a broadened concept of sustainability that includes more-than-human well-being is likely to successfully support diverse life on earth, because species' needs are inherently and irreducibly interdependent.

The current sustainability concept focuses on a perceived generational conflict, namely between those currently living and those yet to be born, rather than situating this relationship in broader contexts of intrahuman and interspecies relationships. We will focus here on the underexplored latter, although we recognize that the former kind of relationship is far from caring for all human beings, since poverty, inequality, homelessness are left out of many narratives on sustainability (Gonella, 2019). Although the wording in the Brundtland Report does not explicitly limit the needs of the present to human needs, this emerges from the discourse around sustainable development which is often reported as in contrast to the notion of sustainability (Latouche, 2004; Springett, 2013). The report named 'the satisfaction of human needs and aspirations' as 'the major objective of development' (Brundtland, 1987, p. 41). Living beings beyond the human are listed alongside soils, waters, and atmosphere, reduced to 'natural systems that support life on earth' (ibid., p. 42), in essence embracing a form of Cartesian dualism. Not unique to the development context, Morton (2007) argues more romantic notions of 'nature' that are tied to environmentalism also have the effect of framing nature as something 'out there' and engagements with it as essentially in a consumerist aesthetic mode, rather than engagement that recognizes the complex ecological entanglement between human and non-human species. The current sustainability concept thus focuses on meeting human needs, recognizes the dependence of human needs on other organisms; yet, fails to conclude that the needs of non-humans must also be met. Such reductionism of complex, interdependent ecosystem and species entanglements to a monolithic 'other' can be seen as one form of anthropocentrism. This term has been widely used in the environmental literature, yet its usage has been problematized (Kidner, 2014). Kidner asserts that the tendency of mainstream societies to focus overwhelmingly on human needs above all others owes largely to the domination exerted by industrialism and the industrial symbolic system that emerged within the specific historical frame of Western modernity. Human beings or putative 'human nature' lack any intrinsic greedy or individualist natural feature. On the contrary, within the long-term view of human existence, the real human centric way of thinking has tended to value a healthy natural environment and recognize the relationality among people and non-human inhabitants of the natural world. The actual tendency towards viewing the natural world in terms of resources for exploitation indicates the specific emergence of a hegemonic industrialist and imperialist human-centric world view. The critique of this paper thus aims not at sustainability's concern with human well-being, but at the reductionist attempt to satisfy human needs and aspirations without considering the associated complex and interdependent multispecies entanglements. Understanding human needs without a multispecies context is likely impossible, as has long been recognized and argued by various First Nations and Indigenous scholars and philosophers (Graham, 1999; Little Bear, 2000; Todd, 2016; Watts, 2013; Whyte, 2017). These insights and knowledges have been ignored and even erased by mainstream Western scientific approaches. Yet, today these are increasingly recognized as vital, their methodologies and findings are slowly being replicated and verified (Deloria, 2018; Woelfle-Erskine, 2019). Decades of research across humanities and natural and social sciences now point to the inseparable multispecies entanglement of human needs (Albrecht et al., 2007; Flies et al., 2018; Hanski et al., 2012; Keniger et al., 2013; Rupprecht & Byrne, 2014; Soga & Gaston, 2020; Swanson et al., 2018; Woelfle-Erskine, 2019). Beyond direct effects on human health, strong evidence confirming complex interactions and interdependencies also mandates applying the precautionary principle in assuming that all species are indirectly linked in some ways. Even those in extreme environments such as deep sea vents are still part of tremendously complex food webs and trophic cascades (Govenar, 2012). Human-induced global changes to the earth system, such as climate change, ocean acidification and microplastic pollution, further make unlikely the existence of species being wholly independent and unaffected (Capra & Luisi, 2016; Doney et al., 2009; Hale et al., 2020; Pecl et al., 2017; Steffen, et al., 2015a). The ecosystemically-related zoonotic origin of the recent Covid-19 pandemic represents another hint in this direction (Bonilla-Aldana et al., 2020). By failing to account for both the direct and indirect interspecies relations that underpin human and more-than-human well-being, the reductionist anthropocentric sustainability concept thus allows conditions vital for its success to go unmet. This becomes clear through an examination of how decisions and actions surrounding sustainability are primarily made.

Underrepresentation of actors and stakeholders in decisions and actions around sustainability issues can be identified as a leading cause of failure. Through negotiation, parties with an interest (e.g. corporations pursuing business opportunities, or residents improving their quality of life) aim to see their interests furthered or protected in the outcome. In negotiations, participation of stakeholders is seen as vital in achieving successful compromises (Hadorn et al., 2008). In democratic elections, the circle of those who may participate has been successively widened in terms of age, social standing, and gender (Przeworski, 2009). In the context of sustainability, multi-stakeholder dialogues have been explored as new modes of governance that aim to counter democratic and implementation deficits (Bäckstrand, 2006). We are not claiming that all of this is necessarily sincere and effective, yet an increasing participation of human actors in decision-making is at least present in debates. In political economy, the issue of the labour of living beings *beyond* humans, including both value derived from being alive as well as reframing beyond-human contributions as more than use value, is also receiving increasing attention by scholars (Barua, 2017; Kallis & Swyngedouw, 2018). However, needs and interests of living beings beyond humans remain insufficiently represented, if at all. For example, in a scientific context, a tree only enters negotiations indirectly, as a local source of timber, an abstract tool for carbon

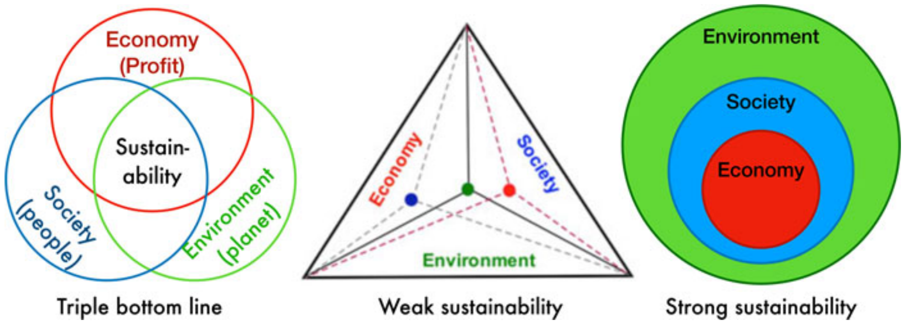

Fig. 1. Visualizations of the sustainability concept (adapted from Wu, 2013).

storage and sequestration, or (less frequently) for cultural ecosystem services such as its perceived aesthetic, cultural, health-giving, or religious properties (Daniel et al., 2012). Its recognized value is therefore wholly dependent on how useful humans perceive it to be (Davidson, 2013). Absent from the negotiations are the tree itself as well as the multitude of species interacting with and depending on it, from fellow plants and root-associated microbes to lichen, insects, birds, and others. Consequently, this lack of representation in the negotiation leads to outcomes skewed against the trees' interest (and that of its natural stakeholders) (Donoso, 2017), which in turn results in an overall unsuccessful compromise for everyone. The way actors are excluded from negotiations through their labelling as resources in the reductionist sustainability concept thus leads to a failure to represent and protect the complexity and interdependence inherent in natural systems. This is most visible in conceptual representations of the sustainability concept.

The Brundtland concept of sustainability can be divided into three parts, which comprise the three elements of mainstream visualizations (Figure 1): society (needs of the present), environment (ability of future generations to meet their own needs), and economy (the method through which needs are met). As Wu (2013) notes, these visualizations demonstrate how reductionist-anthropocentric sustainability-based varieties are concerned with how the three dimensions interact (triple bottom line), whether one can be substituted by the other (weak sustainability) or not (strong sustainability). Recently, such research has been further developed by breaking the environment and society aspects down into more detailed categories, a prominent example being Raworth's (2017) doughnut economics model (Figure 2). The progression of these visual models allows several observations. First, the role of the economy is relegated from a separate entity in the triple bottom line model to a subset of society in strong sustainability, and reconceptualized as an interface in the doughnut model. Second, the depiction of the environment transitions towards an entity encompassing rather than existing alongside humanity. These changes arguably bring the models closer to portraying the interdependence of species, but several issues remain.

The foremost issue of both classic sustainability visualizations (Figure 1) and newer ones (Figure 2) is their reductionist view of the environment, and with it all life beyond humans, as a resource for exploitation and tool to achieve human ends. Strong sustainability oversimplifies its representation of the environment as it collapses all species beyond the human into one residual, binary 'non-human' category, simultaneously conflating them with non-biological elements such as the atmosphere, geosphere, and hydrosphere. In contrast, the doughnut model only represents the environment through the different ways it is affected by humans, borrowing from the planetary boundaries model (Steffen, et al., 2015b). Non-humans are only referred to indirectly through biodiversity loss and food. Newer definitions of landscape sustainability reviewed by Wu (2013) remain resource- and human-focused. Another issue of all the visual sustainability models examined here is their tendency to hide the complexity present in a system. Just as there are many human societies with radically different social and economic organizations as well as different relationships to living beings beyond humans, living beings have been observed to vary significantly in their behaviour within species (Escobar, 1998, 2018; Kothari et al., 2019). Finally, the interdependence and agency of living beings remain absent in all visualizations of sustainability concepts.

2. Towards a multispecies concept of sustainability

The reductionist anthropocentric sustainability concept has dominated scientific and political discourse, but in the original meaning of the concept, many other approaches to sustaining human life exist and may be more likely to yield success. For example, the reduction of non-human beings to resources contrasts with a view of non-humans as actors with agency that cannot simply be managed as resources, but must be negotiated and compromised with as beings in their own rights, with their own needs and interests (Chapron et al., 2019; Davies & Riach, 2018; Johnson & Larsen, 2017; Rose et al., 2003). Such views can be found in societies, and belief systems all over the world are implemented in diverse forms through laws, customs, teachings, and traditions, and are often intricately linked with what has been labelled traditional ecological knowledge in the academic discourse. Although a detailed review of alternative approaches to sustainability are beyond the scope of this paper, previous studies suggest that many of these approaches have a vastly better historical track record of success in achieving sustainability (Berkes et al., 1994, 2000; Escobar, 2011; Fraser et al., 2015; Rose et al., 2003). Moreover, recent conceptual advances in integrating the interdependence inherent in multispecies interactions have been made in fields primarily associated with humanities and social sciences, from social theory to anthropology, geography, and philosophy (Braidotti, 2013; Houston et al., 2017; Kirksey & Helmreich, 2010; Locke & Muenster, 2015; Morton, 2007; Ogden et al., 2013; Puig de la Bellacasa, 2017; Tsing, 2015; van Dooren et al., 2016; Wolch et al., 1995). These advances are heavily indebted to the rich knowledge found across diverse, often Indigenous human cultures resulting from a slowly but steadily increasing visibility and representation of Indigenous knowledge in academic discourse (Graham, 1999; Larsen & Johnson, 2016; Little Bear, 2000; Todd, 2016; Watts, 2013; Whyte, 2017). In this paper, we focus on one such conceptual advance, known as multispecies or more-than-human thinking. In a definition of

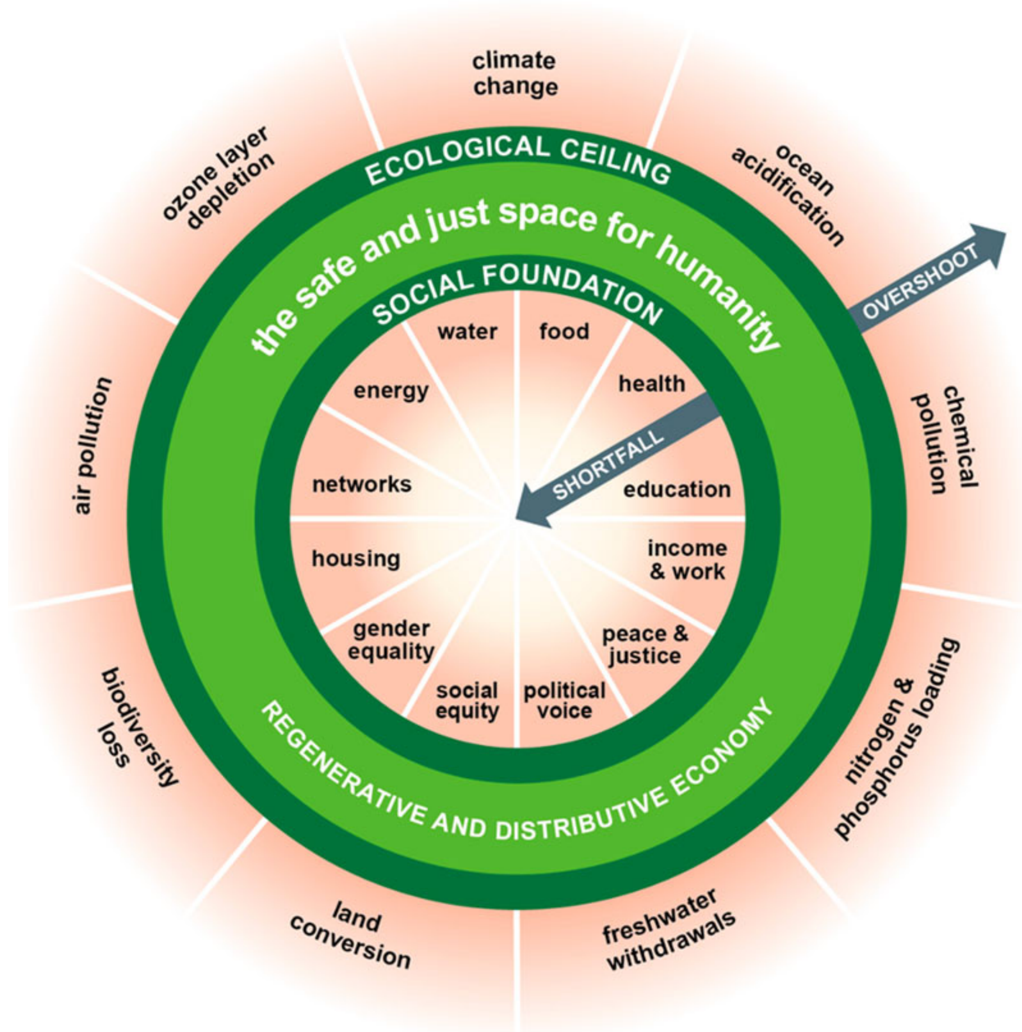

Fig. 2. Doughnut economics model representing sustainability as a space for humanity that does not overshoot ecological ceilings while providing a social foundation (Raworth, 2017).

multispecies ethnography (but not limited to ethnography), Locke and Muenster use the term for

> 'work that acknowledges the interconnectedness and inseparability of humans and other life forms, and thus seeks to extend ethnography beyond the solely human realm. Multispecies investigations of social and cultural phenomena are attentive to the agency of other-than-human species, whether they are plants, animals, fungi, bacteria, or even viruses, which confound the species concept. This entails a challenge to the humanist epistemology upon which conventional ethnography is predicated, specifically its ontological distinctions between nature and culture, human and nonhuman, subject and object. Multispecies ethnography must thus be seen as a part of a larger quest in the social sciences and humanities to replace dualist ontologies by relational perspectives, to overcome anthropocentrism by pointing to the meaningful agency of nonhuman others, and to highlight the intersections between ecological relations, political economy, and cultural representations'. (Locke & Muenster, 2015)

We argue that multispecies thinking applies beyond the realms of social science and the humanities. It provides a powerful frame for developing an improved sustainability concept built on the interdependence of life, not the supremacy of a single species – a task we take up in this paper. We develop a multispecies concept of sustainability in three steps. First, we discuss the normative aspects of multispecies sustainability, arguing its necessity to achieve normative goals whether they are limited to human flourishing or explicitly include non-human flourishing. We then propose six principles which underpin a new definition and models that visualize the interdependence of species. Second, we develop four different future scenarios as a thought-experiment to explore why futures cannot be derived from an axis based on resource sustainability alone, but differ radically based on another axis: 'reductionist anthropocentric to multispecies'. Third, we explore how multispecies sustainability can be applied to real-world problems using research on human–Japanese honeybee co-shaping of the landscape and insights from the Healthy Urban Microbiome Initiative. Finally, we conclude with directions for further research.

As sustainability is at its core an ethical concept with normative assumptions, we begin by examining whether multispecies sustainability requires its own distinct ethical standpoint. Because a comprehensive discussion of the ethical complexity of more-than-human ethics lies beyond the scope of this paper (Cohen, 2012; Droz, 2020; Puig de la Bellacasa, 2017), we only compare two simplified normative premises: (1) that human well-being should be sustained, a view often taking a utilitarian perspective in focusing on individuals, and (2) that both human as well as more-than-human well-being should be sustained, a view often rejecting simple utilitarianism in favour of a distributed, network approach to well-being. In the latter case, the need for a multispecies-inclusive concept of sustainability follows directly from the normative premise, and such relational ethics have long informed First Nations and Indigenous ethical frameworks (Graham, 1999; Little Bear, 2000; Watts, 2013; Woelfle-Erskine, 2019). However, given the variety of moral statuses assigned to more-than-humans across human individuals and groups, disagreement on their precise nature might threaten commitment to strive for multispecies sustainability. Moreover, arguments in mainstream, capitalist political discourses often stress the need to prioritize human well-being and economic growth (Hickel, 2018). We thus believe making the strongest case possible for multispecies sustainability benefits from an argument that does not rely solely on valuing more-than-human well-being as a normative premise. Instead, following our critique of the reductionist understanding of sustainability above, we argue that traditional and Indigenous knowledges as well as scientific evidence support the hypotheses of complex, fundamental interdependence between species, and of human flourishing as fundamentally dependent on other species. To achieve sustained human flourishing as a normative goal will thus require abandoning a reductionist approach in favour of a multispecies approach to sustainability, regardless of the moral status assigned to more-than-humans based on individual or group beliefs. This may explain why, as outlined above, over time many cultures and societies have developed mechanisms of engaging with more-than-human actors. Here we thus propose multispecies sustainability not as an argument for changing values and beliefs held to include more-than-humans (although such an argument certainly merits consideration), but as a broadening of the ethical concept of sustainability required to account for the fundamental interdependence of species' wellbeing, and ultimately achieve sustainability goals.

To propose a preliminary definition of multispecies sustainability, we build on study by Davies and Riach (2018) who, to our knowledge, first proposed broadening sustainability into a multispecies context. Their analysis of bee–human relations in industrial beekeeping concluded with the question what bee-focused, multispecies sustainability would entail. Here, we attempt to generalize the findings of this analysis in the context of other studies towards a broader multispecies sustainability, that nevertheless affirms the complexity and flexibility inherent in multispecies relations. Multispecies sustainability might thus be grounded in these six principles:

(1) Needs of one species cannot be met independently, but rather require needs of other species to be met. The state of two or more species' interdependent needs being met can be called multispecies well-being.
(2) Multispecies well-being emerges from and depends upon a set of complex relations shaped by the agency and transformative potential of all members involved, even if this agency and potential is expressed in different ways. From this derives the need for multispecies stakeholders; especially stakeholders representing the needs of other species in human multi-stakeholder spaces.
(3) Multispecies well-being exposes the logical fallacy of maximizing human well-being at the expense of others in a trade-off calculation. Well-being is relation-based, not resource based, thus not a zero-sum game. Meeting the needs of the present should enhance, not compromise, the ability of future generations to meet their needs with the goal of increasing multispecies well-being over time.
(4) Multispecies well-being is too complex to be controlled top-down. Following Ashby's law of requisite variety (Ashby, 1956; Beer, 1979; Pickering, 2010), a management system requires equal or higher variety than the system it seeks to control. Diverse, changing, interdependent, and inseparable needs of multiple species possess very high variety. Anthropocentric management systems would thus require equal or higher variety to regulate in detail the complexity involved in achieving multispecies wellbeing. Abstractions can help to attenuate variety, but will not be effective without the participation of autonomous local multispecies actors. Effective management therefore requires the enrolment of these actors to realize viable co-existence.
(5) Diverse, interdependent, changing, and inseparable needs can only be met through adapting, self-regulating systems. This calls for systems based on representations of and experimentations around continuously renegotiating complex, entangled multispecies interests. Such systems rely on and respect multispecies agency, and aim to provide to all species the operational autonomy necessary to meet their needs (Droz, 2019). Many best practices have been developed by Indigenous peoples and are part of traditional ecological knowledge systems.
(6) Different species have very diverse anticipatory features and capacities – from the cellular level to the level of multiple communities of interacting species – that anticipate future conditions (Poli, 2010). Human anticipatory capacities, based on self-reflexivity and empowered through language and technology, are unique in some ways, but also limited in other ways when compared to the anticipatory capacities of other species. Moreover, human anticipatory capacities have mostly been used to dominate and exploit other species. Multispecies well-being therefore seeks to draw on, translate between, and combine the different ways of anticipating futures that exist among different species, while seeking to employ the specific anticipatory capacities of the human species for better futures for the entire earth system.

Based on these principles, we propose the following preliminary definition:

> Multispecies sustainability means meeting the diverse, changing, interdependent, and irreducibly inseparable needs of all species of the present, while enhancing the ability of future generations of all species to meet their own needs.

How might this definition of multispecies sustainability be represented visually? One way might be to focus on the interdependency at the core of the concept (Figure 3). Here, visual elements (biosphere, microbial societies, plant societies, etc.) are dependent on those containing them, and affected by those they contain. The model thus may be read as human societies depending on but also affecting plant and animal societies, as well as fungi, microbes and other life forms. Each element contains in itself a high diversity and complexity, as indicated by the use of the plural form for 'societies' formed by different kinds of living beings. In contrast to the classic models reviewed above, this model explicitly identifies formal economies as one aspect of human economic activities overshadowing informal practices that may be more sustainable

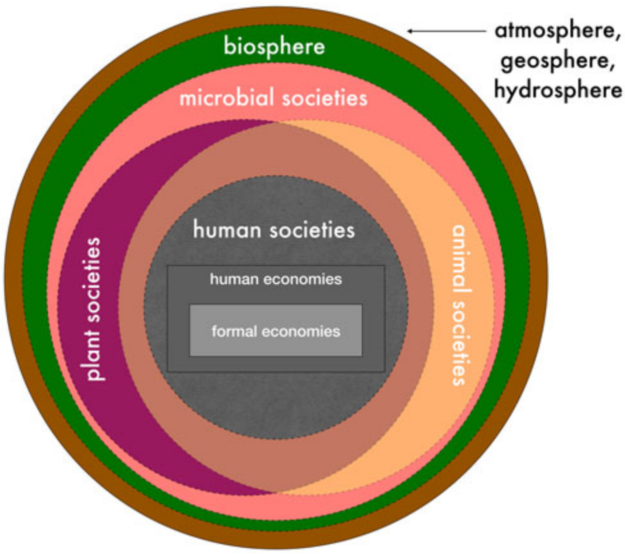

Fig. 3. Visual model of multispecies sustainability focused on interdependence. Elements depend on those containing them, and are affected by those they contain.

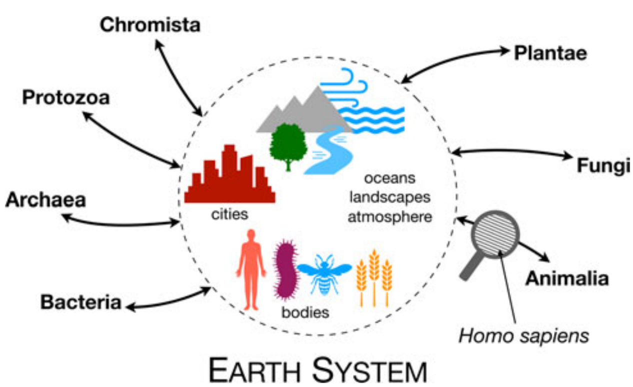

Fig. 4. Visual model of multispecies sustainability emphasizing shared agency in shaping the earth system.

(Jehlička et al., 2013; Smith & Jehlička, 2013). Yet visually, the model remains centred on humans. Another approach might be to take inspiration from recent updates to the biological tree of life (Hug et al., 2016) and centre the earth system and elements in it to emphasize the diverse, entangled agency shaping them (Figure 4). Similar to the definition proposed above, both visual models should be regarded as preliminary and are offered as first steps and an invitation to the sustainability community to improve them. In the next step, we apply this model to examine how multispecies sustainability affects the generation of future scenarios.

3. Multispecies sustainability-derived future scenarios: a thought experiment

How might a different concept of sustainability affect future pathways? In the context of sustainability, scenarios are frequently used to identify desirable and undesirable potential outcomes (Merrie et al., 2018; Vervoort et al., 2015; Wiek et al., 2006). In a thought experiment, we here consider two axes to structure four different possible future scenarios. The horizontal axis represents sustainability, from a condition in which the means required to meet needs are shrinking (left) to one where the means are growing (right). Given the inherent uncertainty about future needs, it seems wise to consider simply maintaining the means as a bare minimum condition for sustainability. Many examples show living beings, including but not limited to humans, succeeding in managing their surroundings in a way that enhances their ability to meet their needs over time (Jones et al., 1997). The vertical axis represents the contrast between a reductionist-anthropocentric approach (bottom) in which only human needs count (and more-than-humans are seen as resources that can be perfectly controlled and managed, rather than beings with agency whose needs require representation), and a multispecies-oriented (top) approach as outlined by the principles above. The scenarios we arrive at show that both axes radically affect the outcomes (Figure 5).

3.1 Business as usual/race to the bottom

Not much imagination is required to consider how a future plays out in which the means to meet the needs of living beings are constantly shrinking, and meeting beyond-human needs is considered at most instrumental to the end of meeting human needs. In today's capitalism-dominated, exploitative business-as-usual, the resulting race to the bottom is already playing out at a global level: capitalism and its addiction to growth drive a consumerist approach in which human needs, and more so, human wants, are never satisfied. Nevertheless, increasing inequality means a very small number of people control most means, and despite the anthropocentric orientation of this scenario, many human needs go unmet. Moreover, continuing overconsumption leads to widespread pollution, climate change, and a reduction in biocapacity, all of which contributes to a vicious circle of rampant extinctions and further reduced biocapacity until the point of system collapse. Social strife turns into wars over dwindling resources, further accelerating the downward spiral.

3.2 Playing 'musical chairs' with species extinctions

In this scenario, multispecies needs and wellbeing are explicitly acknowledged and aimed for. But as the means to meet human and nonhuman needs shrink due to prior human overconsumption, shortage, and rationing eventually dominate all considerations. Whose needs take priority? Who decides whose needs take priority? Who is left behind, or is even (if reluctantly) deemed unsaveable? Unless the means stop shrinking, deliberate reductions in well-being will eventually be required. This can lead to internal contradictions about tradeoffs despite human–nonhuman wellbeing not being a zero-sum game, environmental conservation based on species popularity rather than systemic perspectives, and environmental injustice. At best, efforts similar to those proposed by the degrowth movement aim to slow the reduction of means through overconsumption, satisfying multispecies needs while abandoning purely consumption-based wellbeing in pursuit of the 'shared futures of multispecies well-being' scenario. At worst, power disparities exacerbate already existing environmental injustices, pitching the well-being of one species against that of another (or a subgroup). Although this scenario could offer potential hints for transitions to a multispecies future with stable or growing means, it also serves as a cautionary tale fraught with spectres of traumatic loss and eco-fascism.

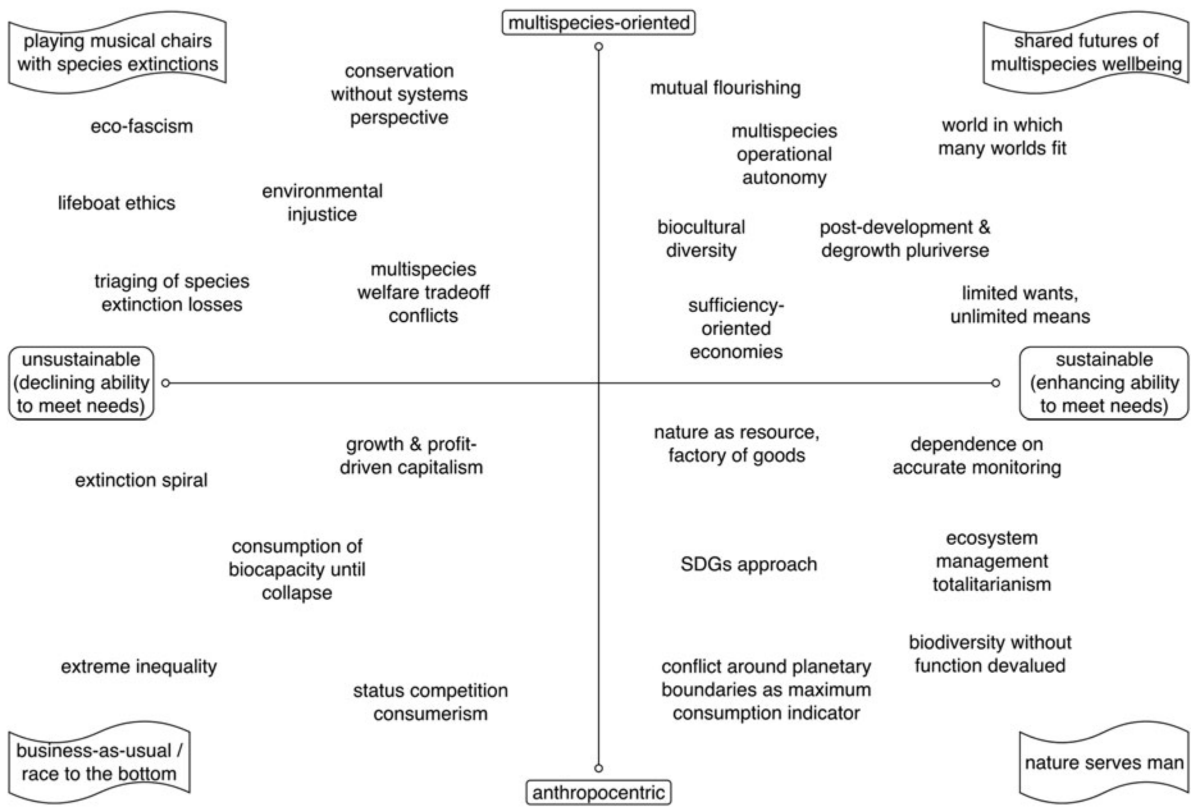

Fig. 5. Future scenarios along two axes: unsustainable/sustainable and reductionist-anthropocentric/multispecies-oriented.

3.3 Nature serves man

A future in which well-managed means of nature are harnessed towards the top priority of human wellbeing is one that can be found across much of the sustainability literature, including the Sustainable Development Goals (SDGs). Aware of and mindful not to cross perceived planetary boundaries, the value of biodiversity and natural systems in providing ecosystem services that meet human needs is well understood as a vital asset of humanity. Nature is conceived as a complex, yet manageable, factory of goods. Its components, including its non-human labourers (Barua, 2017; Kallis & Swyngedouw, 2018), are seen as parts of a machine that needs to function, rather than interdependent beings with agency and valid interests of their own. However, the use of this machine depends on understanding how it functions and how to manage it. Following the law of requisite variety (see principle 4), such a management system would require a variety equal or larger than that of all ecosystems on earth. The ongoing struggle of science in fully understanding biodiversity loss and climate change dynamics therefore suggests a precautionary approach, as failure to understand the role of one species in the system could, at any time, lead to malfunctions. In practice, control-based systems relying on reduced complexity, such as industrial agriculture, compare unfavourably with systems that leave room for non-human agency and embrace complexity, such as agroecology. Meanwhile, the anthropocentric focus could also cause humans to overlook aspects of well-being that emerge from coexisting with other living beings based on mutual flourishing. In criticism directed at the SDGs, concerns have also been voiced about how democratic decision-making would be in a system characterized by a one-fits-all approach. Designing such a vastly complex system as a convivial technology in the sense of Illich, meaning 'in a way that does not fully subject humans to the whim of experts', seems a daunting task at best.

3.4 Shared futures of multispecies well-being

In futures where multispecies well-being is supported by maintained or growing means, the interdependence of this well-being redirects efforts away from a trade-off based thinking towards a goal of mutual flourishing. Sufficiency-oriented economies, whether rooted in degrowth or post-development ideas, have the leeway to explore what unforeseen benefits may lie in forgoing the exploitation of resources and living beings of all kinds. New approaches to democratically planned economies provide human and non-humans alike with autonomy in pursuing diverse goals, negotiated collectively by multispecies stakeholders. Free from the necessity to control non-human and human workers' every action, adapting, self-regulating systems pursuing multispecies well-being (see principle 5) could leverage the agency and transformative potential of all living beings (see Figure 4) to experiment with and negotiate bioculturally diverse ways of living, and thriving, together. Such a world would thus necessarily be a 'world in which many worlds fit', a pluriverse of multispecies wellbeing and sustainability (Escobar, 2018; Kothari et al., 2019).

4. Applied multispecies sustainability I: a policy framework for co-shaping landscape with bees

Scenario-based thought experiments show that many possible futures exist. To increase the likelihood of realizing a future

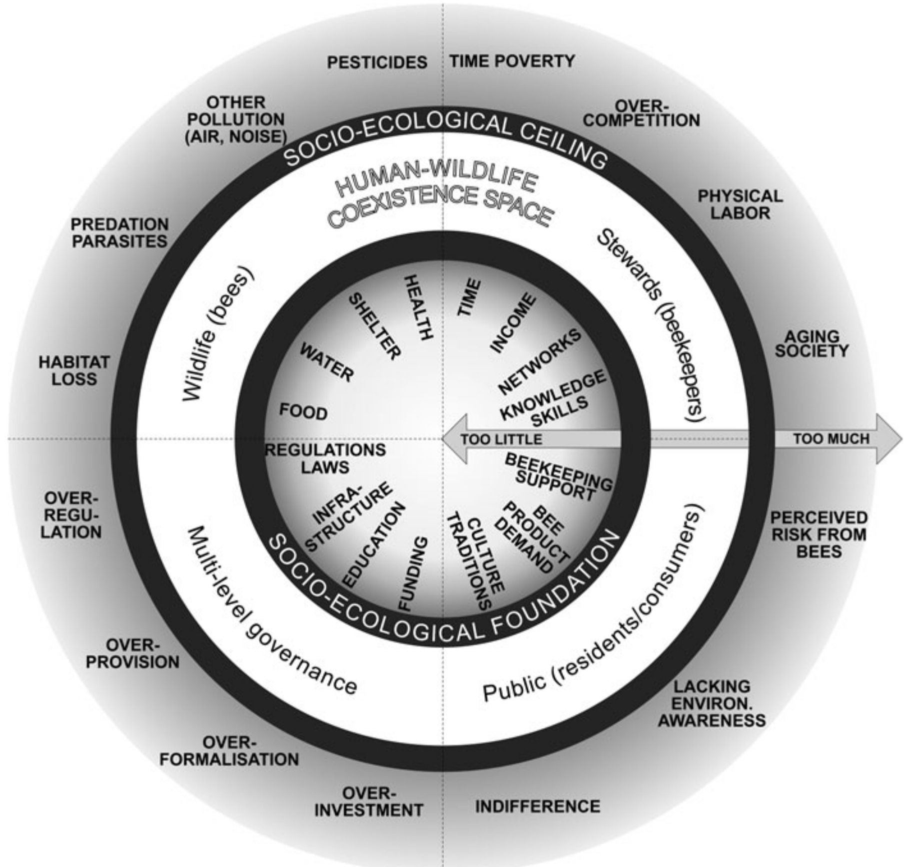

Fig. 6. Conceptual draft of a multispecies stakeholder policy framework to support identifying and creating holistic policies for human–wildlife coexistence.

similar to the 'shared futures of multispecies well-being' scenario, the multispecies sustainability concept can underpin policies aiming to improve human–nature relations. In particular, taking multispecies agency and well-being seriously requires new policy tools that integrate these factors, as such tools may influence whether wildlife–human interactions turn into sites of conflict or co-flourishing (Houston et al., 2017; Rupprecht, 2017). We here present two examples where multispecies sustainability is applied in real-world efforts to improve multispecies well-being.

Beekeeping has developed over thousands of years and can be a symbiotic, multispecies relationship, in which bees enjoy increased colony survival and honey provides humans with nutrition and medicinal uses. Its capitalist industrialization is one example where reductionist anthropocentrism and the absence of a multispecies perspective is now endangering this relationship due to a multitude of factors (Davies & Riach, 2018). This need not be the case. In many traditional and alternative practices, humans and non-human stakeholders interact in complex ways and co-shape both ecological and policy environments in which the interactions take place. Based on 2 years of transdisciplinary research into Japanese honey bee keeping in Japan, some of the authors drew on Raworth's (2017) doughnut economy concept (Figure 2) to develop a multispecies stakeholder policy framework to define a space where humans and bees can coexist (Figure 6). Preliminary analysis of beekeeper surveys showed these practitioners to often consider bees as partners in co-shaping the landscape rather than livestock, and through this practice taking on the role of stewards mediating between bees, humans, flowers, pests, and predators. With the goal of creating a holistic policy tool based on these insights to inform how multispecies stakeholder interactions might be organized, four groups of stakeholders were identified: bees, beekeepers, residents/consumers, and multi-level governance actors. Although the doughnut economy model is based on a social foundation and ecological ceiling, our Japan-based research showed both ceiling and foundation to be socio-ecological in nature. Limiting ceiling and foundation factors were thus identified for all four stakeholders. The process highlighted targets for policy intervention as well as interdependencies in the system that can enable or prevent positive outcomes. For example, urban beekeepers rely on the support of the public for beekeeping as a foundational factor that can be fostered through educational policies. A lack of environmental awareness of local residents paired with a high perceived risk from bees could, on the other hand, lead to restrictive overregulation.

Successful projects already resemble the proposed framework, and demonstrate that such bee–human interactions are only the tip of an iceberg of complex multispecies interactions involving the entire span of taxonomic life: diverse pollinators, vegetation as sources of nectar and pollen, diverse species benefiting from reductions in pesticide use and regenerating soil biomes. 'For the Love of Bees' (For The Love Of Bees, 2019), led by visionholder Sarah Smuts-Kennedy, is a multifaceted project in Tāmaki Makaurau, Aotearoa (Auckland, New Zealand) which invites residents to imagine their city as the safest city in the world for bees. As an artwork and platform for collaboration, the project provides an example of what a cohesive (yet welcoming and open to chance encounters) programme of activity for the creation of a shared future of multispecies wellbeing could look like. FTLOB initiated and brought together diverse projects: the OMG Organic Market Garden (a pilot urban farm on a precarious inner-city site); a network of small-scale compost hubs throughout the city; a free bee school; the Urban Farmers Alliance (a peer-to-peer mentoring platform); advocacy for behaviour change in weed control; multiple pilot regenerative parks in schools and art centres throughout the city; and a public programme of events. FTLOB combines these into one cohesive action through the lens of bees, describing their approach as follows: 'We take a bee's eye view on nature's operating system … to reveal innate interconnectedness and the power of small actions … leaving you inspired and capable to co-create safe spaces for bees and all life' (For The Love of Bees, 2019). The project co-creates human–wildlife coexistence space (Figure 6) by progressively folding in collaborators and interested parties while generating and spinning-off new initiatives. In the process, different actors (e.g. schools, art centres, and restaurants) move from being passive-supportive members of the public to becoming new types of active stewards. The project's positioning as an artwork and social sculpture (Biddle, 2014) has thereby allowed it to bridge the four quadrants of the framework, bringing together human and non-human stakeholders. As these two examples show, the seemingly two-species human–bee interaction is thus an entry point for people and their institutions to explore direct and indirect ecological connections in the web of life, initializing a multispecies process of building knowledge and capacity for the more-than-human planning practices Houston and colleagues call for (2017).

5. Applied multispecies sustainability II: the Healthy Urban Microbiome Initiative

The second example of applied multispecies sustainability showcases the Healthy Urban Microbiome Initiative. There is now widespread awareness of the crucial role that microbial communities play in shaping the health of humans and other species. At its narrowest realization is the impact of the gut microbiome on everything from how we process food (Ridaura et al., 2013) and pharmaceuticals (Vétizou et al., 2015) to our physical (Honda & Littman, 2012) and mental (Valles-Colomer et al., 2019) health. However, there is a growing awareness of the ways human microbiomes are connected to the microbiomes of the surrounding environment (soil, air, plants, animals, etc.), which are connected to the surrounding biosphere, atmosphere, geosphere, and hydrosphere (Figures 3 and 4). Foundational to all these concepts is the awareness that biodiversity stabilizes ecosystems and allows them to maintain function in the face of threats and shifting environmental conditions (Tilman, 1996). Although an in-depth discussion of the role of diversity in driving ecological stability is beyond the scope of our paper, evidence for pervasive indirect links between species and the application of the precautionary principle in assuming interdependence rather than independence suggest treating no individual species as expendable without ecological consequences. Importantly, biodiversity of the human microbiome is beneficial to human health; people exposed to greater microbial diversity are less likely to have allergies (Hanski et al., 2012; Ruokolainen et al., 2015) and asthma (Ege et al., 2011). By emphasizing the importance of (microbial) biodiversity for human health, the Healthy Urban Microbiome Initiative (HUMI; http://www.HUMIcity.org) provides an opportunity to showcase the co-benefits between human health, conservation, and multispecies well-being and provides a template for applying this knowledge in ways that benefit health.

As humans have created the built environments that now house over 50% of the population, we have altered the habitat for non-human life as well. Unsurprisingly, cities house animal communities that are less biodiverse than those in wilderness areas (McKinney, 2006) which can be reflected in the microbial communities in the air (Després et al., 2007; Flies et al., 2020) and soil (Liddicoat et al., 2019). As is predicted by the 'biodiversity hypothesis' (von Hertzen et al., 2011), people living urban and westernized lifestyles are likely to have less diverse microbiomes (Hanski et al., 2012; Vangay et al., 2018) and also experience higher rates of many allergic, auto-immune, and inflammatory diseases (Flies et al., 2019). Indeed, in a randomized controlled mouse trial, mice exposed to trace levels of more biodiverse soils showed lower rates of anxiety-like behaviour (a mental health issue more common in cities), and this effect was modulated by soil bacteria that colonized the gut of the mice (Liddicoat et al., 2020).

Under HUMI, biodiverse urban green spaces can be used to (1) restore human health, (2) improve urban biodiversity, and (3) facilitate human–nature interactions critical to support a multispecies way of thinking (Flies et al., 2017, 2018; Liddicoat et al., 2019; Mills et al., 2017; Robinson & Breed, 2019). Although the focus of HUMI is on humans and microbes, itself an incredibly diverse category of life including archaea, bacteria, fungi, viruses, micro-eukaryotes, HUMI argues that biodiverse microbial communities depend on biodiverse plant and non-human animal communities, thus epitomizing multispecies sustainability. It is due to these interconnections that HUMI efforts focus on the restoration of ecosystems as a public health intervention (Mills et al., 2017; Robinson & Breed, 2019, 2020); re-planting a diverse array of species can return a functional and biodiverse environmental microbiome (Baruch et al., 2020; Mills et al., 2020). These environmental microbiomes are formed in soil, the air, on plants, and on other surfaces, from which they can transfer to people. HUMI emphasizes that this is beneficial for human health (Grönroos et al., 2019). HUMI thus exemplifies an endeavour that is anthropocentric without being reductionist, instead applying a multispecies sustainability lens to strive for more-than-human mutual flourishing. Importantly, to create biodiverse urban green spaces, HUMI also underlines the necessity of cross-sectoral collaboration. Successful projects will be led by communities, supported by local government, and guided by public health and research professionals. This cross-sectoral collaboration forces different views and aims to be discussed and the potential for a multi-species well-being emphasis to emerge.

6. Conclusion: applying multispecies sustainability to global environmental challenges

In this paper, we have shown that the current sustainability concept is unlikely to succeed if concerned solely with human needs because failing to acknowledge their intrinsic, complex interdependence with more-than-human needs leaves conditions required for success unmet. In its stead we proposed a broadened, multispecies concept of sustainability which draws on empirical and conceptual advances around multispecies ethnography and more-than-human research in humanities and the social sciences. Importantly, we demonstrated how this broadened concept can be reached from different ethical standpoints. Through exploring four scenarios we outlined how reductionist anthropocentric and multispecies versions of sustainable futures would diverge profoundly. Through showcasing two examples of applied multispecies sustainability, we demonstrated how multispecies thinking can inform policies aiming to improve multispecies well-being on the ground.

We intend this paper to be a starting point for exploration and discussion. How can multispecies sustainability change our perspective of pressing global environmental challenges and sustainability issues? What would multispecies cities look like? Could a multispecies health concept be the key to issues highlighted by One Health and ecohealth research? How might one measure multispecies well-being, and how much measuring is possible and required if not control but operational autonomy is the goal? And how could human anticipatory capacities be used for multispecies futures, complemented by the anticipatory capacities of other species? Since the initial draft of this paper, SARS-CoV-2 has led to a global pandemic ongoing at the time of publication, painfully emphasizing the urgent need for better understanding the principles and consequences of multispecies entanglements. Concepts such as agroecology and permaculture design already provide alternative models to the industrial agriculture practices implicated in the emergence of pathogens (Haraway & Tsing, 2019), models that are designed to acknowledge and work with, not against, the agency of living beings beyond humans. As new findings in microbiome research rapidly change our image of the world and what it means to be human, some ideas around multispecies thinking that may seem challenging today could enter mainstream sustainability thinking sooner rather than later. With sustainability challenges becoming more and more daunting, being aware of a bigger picture in which human needs and well-being are necessarily situated may just be what is needed to become better at acting in our own interest as well.

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Publishing ethics. The manuscript is our own original work, and does not duplicate any other previously published studies. The manuscript has been submitted only to this journal – it is not under consideration, accepted for publication or in press elsewhere. All listed authors know of and agree to the manuscript being submitted to the journal. The manuscript contains nothing that is abusive, defamatory, fraudulent, illegal, libellous, or obscene.

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