Do we need Artificial Pollination if we have Multispecies Justice in the Anthropocene?

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Abstract

The era we now live in is termed the Anthropocene. Climate change, land use change, pesticide and insecticide use, and pollution are all contributing to pollinator loss. To ensure food crops continue to be pollinated, artificial pollinator technologies are being developed. This article asks the question: do we need artificial pollination if we have multispecies justice in the Anthropocene? Three examples of artificial pollination technologies, Edete, Olombria, and RoboBee, are provided to help address this question. However, the companies designing and developing artificial pollination technologies do not aim to address the underlying problems of pollinator decline such as habitat loss and climate change. Addressing problems such as pollinator loss with the use of digital technology puts humanity onto the course of uncertain futures. For more just futures, there are calls for a turn towards multispecies justice. Considering pollinator loss through the lens of multispecies justice puts us on an altogether different course from that of using artificial pollination. With multispecies justice there is the potential for futures which are democratic, just, diverse, and sustainable for humans and the more-than-human world.

Keywords: Multispecies justice; insect pollinators; pollinator crisis; artificial pollination; industrialised agriculture; digital technology

Introduction

The era we now live in has been termed the Anthropocene. According to Steffen et al. (**2007: 614, emphasis in original**), the term '*Anthropocene* suggests that the Earth has now left its natural geological epoch, the present interglacial state called the Holocene. Human activities have become so pervasive and profound that they rival the great forces of Nature and are pushing the Earth into planetary *terra incognita*'. The world is changing and the alteration of the global carbon cycle, the escalating loss of biodiversity, toxic chemicals, and the depletion of water and other physical resources all illustrate how the Anthropocene is the result of humans being disconnected from the world we live in (**Bonneuil & Fressoz, 2017; Kolbert, 2014; Standing, 2019; Wright, 2017**). Environmental impacts do not affect humans and the more-than-human world equally (**Fox & Alldred, 2020**), and inequalities between humans are also widened by environmental issues.

Scientific and technological developments are also increasing in the Anthropocene. Rosi Braidotti (**2019**) argues we are positioned between the Fourth Industrial Revolution and the Sixth Extinction. The development of artificial intelligence, the Internet of Things (IoT), robotics, biotechnology, and nanotechnology are part of the Fourth Industrial Revolution and are put forward as solutions to the problems humanity faces. However, these technologies can create more problems than they solve as they can create social inequalities and deplete the Earth's resources (**Braidotti, 2019**). The Fourth Industrial Revolution is characterised by the 'bio-genetic capitalisation of all living systems, and a pervasive use of self-correcting technologies, driven by artificial intelligence' (**Ibid: 32**). The Sixth Extinction, the dying out of species as a result of human activity, is forecast to be more devastating than the previous other five (**Kolbert, 2014**). This 'slow violence' (**Nixon, 2011: 2**) of species loss is occurring gradually, going relatively unnoticed and is distributed across space and time (**Jørgensen et al., 2022**). This positioning between the Fourth Industrial Revolution and the Sixth Extinction means the human and more-than-human world is being subjected to the accelerations of both capitalism and climate change simultaneously (**Braidotti, 2019**). Continued economic growth and attempts to reduce emissions which contribute to climate change are conflicting forces which may prove impossible to strike a balance between. Disasters resulting from the conflicting forces of climate change and capitalism along with other forces are already occurring (**Tsing, 2015**). For example, with industrialised agriculture, the appetite for profits and increasing yields due to consumer demand has led to the use of excessive fertiliser and pesticide applications. This in turn threatens biodiversity, destroys soils, and can lead to super-weeds.

Before moving on, it is important to note that I use the terms wild insect pollinators and honeybees throughout the article. Wild insect pollinators are taken to be bees (e.g. bumblebees, carder bees, and leafcutter bees), moths, butterflies, hoverflies, flies, and beetles. Whilst it is noted that honeybees can be wild insect pollinators, in this article, honeybees are taken to be those which are kept in managed beehives. They are also noted separately to other insect pollinators because they are used commercially in agricultural systems and are worth hundreds of billions of dollars to the agricultural sector (**Nimmo, 2015**). This separation is not intended to privilege honeybees but to illustrate their importance in the agricultural sector for food production.

Wild insect pollinators are at risk of extinction at local and global levels because of climate change, habitat loss, land use changes, pesticide and insecticide use, pollution, and the introduction of non-native species (**Ellis et al., 2020; Memmott et al., 2007**). Climate change is altering the timing of the flowering of some plants, and this is affecting the interactions between pollinators and plants (**Memmott et al., 2007**). If there is a mismatch between plants flowering and the emergence of pollinators, the opportunity for interactions between the two are altered (**Gérard et al., 2020; Memmott et al., 2007**). This could potentially lead to the extinction of certain species of pollinators and certain species of plants (**Memmott et al., 2007**). Additionally, colony collapse disorder (CCD) has led to a rapid decline in honeybees (**Lorenz, 2016; Nimmo, 2015**). CCD occurs when adult honeybees abandon a hive even if the colony appears productive and healthy (**Lorenz, 2016**). This is not the only problem associated with honeybees. Due to inadequate breeding practices by commercial breeders, honeybees have suffered a loss of genetic diversity (**Nimmo, 2015**). This may impact the long term viability of honeybees, especially if they were to suffer from disease.

The most valuable pollinators for agriculture are honeybees (**Kevan, 1999**). In the UK, honeybee numbers have been declining over the last 20 years, and this could have serious implications for food crops which rely on insect pollination (**Breeze et al., 2011**). The importance of insect pollinators should not be underestimated. Nimmo (**2021: 14**) argues that ‘insect pollinators reproduce and propagate themselves of their own volition and undertake pollination activities at no or remarkably low cost to beekeepers and farmers’. Insect pollinators carry out free work for farmers and gardeners. A third of food consumed by humans worldwide are pollinated by insects, and a further third of food products have relied upon insects for pollination at some point in the production process (**Nimmo, 2015**).

In the UK, honeybees are required for pollinating industrialised crop systems because there are insufficient wild insect pollinator numbers (**Breeze et al., 2011**). However, the decrease in wild insect pollinator numbers has arisen because of industrialised agriculture and the associated heavy use of insecticides and pesticides (**Ellis et al., 2020; Goulson, 2020; Lorenz, 2016**), habitat loss, climate change, non-native invasive species, the spread of diseases, and light pollution (**Goulson, 2020**).

Whilst declining wild insect pollinator numbers could be seen as a problem of collapsing biodiversity, Nimmo (**2021: 7**) points out that the 'pollinator crisis is inscribed as a delimited economic problem of markets, prices, labour and production'. Without honeybees or wild insect pollinators, humans would have to take over and hand pollinate crops. This practice already takes place. Since the 1980s, apple trees have been hand pollinated in Sichuan Province, China, due to the decline in pollinator numbers caused by habitat loss and the overuse of pesticides (**Partap & Tang, 2012; Price, 2022a**). In the UK alone, hand pollination would cost £1.8 billion a year (**The Wildlife Trusts, 2022**). However, instead of dealing with the problem of collapsing biodiversity, the answer is to look for technological solutions to ensure food crop pollination continues. Declining numbers of honeybees and wild insect pollinators has led to the development of artificial pollination techniques in an attempt to prevent the need for human intervention.

This article examines what the future may hold for insect and artificial pollinators. To investigate possible futures, I ask the question: do we need artificial pollination if we have multispecies justice in the Anthropocene? In the next section, I introduce three emerging artificial pollination technologies. I then discuss industrialised agriculture and the pollinator crisis, before moving on to entanglements and pollination. The discussion then moves to humility, multispecies justice and pollinator loss, before I turn my attention to how we can rethink food crop pollination with multispecies justice. The article concludes arguing that the use of digital technology such as artificial pollination does not address declining insect pollinator numbers. This puts us onto the course of uncertain futures. With a turn to multispecies justice, there is the potential for futures which are democratic, just, diverse, and sustainable for humans and the more-than-human world.

Artificial Pollination Technologies

Humans depend on insect pollinators for the pollination of many food crops. With the pollinator crisis and the decline of insect pollinator numbers, artificial pollination is proposed as a potential solution. Chechetka et al., describe artificial pollination:

> *There is currently substantial interest in understanding and designing bio-inspired robotics, to command naturally occurring properties such as morphologies, movements, and control mechanisms in artificial settings in order to improve performances. Recent advances in bio-inspired robotics promise to bridge the performance gap with respect to animals. Among the various bio-inspired robots being developed, aerial robots represent a class of emerging robotics with the expectation of solving the issues arising from the global decline in the population of honeybees, which are normally involved in the pollination of plants.* (**Chechetka et al., 2017: 224**)

This quote by Chechetka et al. illustrates how artificial pollination is put forward as a solution for addressing the pollinator crisis. I now provide three examples of artificial pollination technologies. These are all different, but all require digital technologies.

The first example is the Edete pollen harvester. This is an artificial pollination service which mirrors the work of honeybees by collecting and distributing pollen. Step 1 is pollen harvesting and is carried out in the following way:

> *(1) Edete mechanically harvests flowers, (2) separates the pollen from the flower, (3) then stores the viable and germinable pollen for more than one year using our proprietary method, overcoming the problem of desynchronization of different cultivars' blooms. (4) Ensures fertilization and fruit setup by matching the best pollinizer with each commercial variety regardless of the timing of their bloom, guaranteeing, and even increasing, crop yield.* (**Edete, 2021**)

Step 2 is pollen distribution:

> *During blooming, the stored pollen is loaded into Edete's proprietary high-efficiency artificial pollinator which disperses dry pollen on the trees. The 2Btm pollinator uses LIDAR sensing to algorithmically reach as near as required to each tree contour, and use electrostatic deposition onto the targeted flowers. Edete's 2Btm mechanical pollinator units can operate day and night, rapidly and thoroughly covering any open flower in its range and are not limited by daylight or low temperatures conditions.* (**Edete, 2021**)

This technology has been used successfully by almond growers in the USA and Australia, with artificial pollination fertilisation increasing yields (**Edete, 2021**). The company puts the technology forward as a solution for crop pollination following the decline in wild insect pollinators and honeybees, and any mismatches between plants flowering and the emergence of insect pollinators due to climate change.

The second example is a different type of artificial pollination which is being developed by Olombria in the UK:

> *Olombria encourages flies to be more efficient pollinators, in scenarios where bees are no longer as viable. Flies are already adept pollinators, being the main pollinators in urban environments, and in total, accounting for over 30% of all pollination.*
>
> *Olombria provides horticultural growers with information on pollinators and environmental conditions and uses chemical volatiles to manage pollinating fly species, thereby increasing crop productivity, and ensuring sustainable food harvests for the future.* (**Olombria, 2021**)

Agri-TechE describes the flies as being easily bred and because they die at the end of each season, they require little care. Olombria is also working with organisations in the UK to further enhance the artificial pollination technology:

> *Olombria is working with leading agricultural research organisations including Imperial College, Rothamsted Research, and NIAB-EMR to develop an Internet-of-things (IoT) system consisting of a network of small nodes spread throughout an orchard. The nodes collect data and curate the behaviour of flies in the field. Olombria aims to work with natural systems to manage and support rather than exploit local ecosystems.* (**Agri-TechE, 2021**)

Olombria is a technology which manipulates the behaviour of flies in order to manage crop pollination. The company has developed this technology as a solution for crop pollination due to declining wild insect pollinator numbers caused by pesticide use, climate change, and pathogens.

The third example are RoboBees which are being developed by the Wyss Institute at Harvard University. These miniature robots could be used for crop pollination along with weather, climate and environmental monitoring. The RoboBee consists of three components which are the body, brain and colony. The construction is described by the Wyss Institute as follows:

> *Body development consists of constructing robotic insects able to fly on their own with the help of a compact and seamlessly integrated power source; brain development is concerned with "smart" sensors and control electronics that mimic the eyes and antennae of a bee, and can sense and respond dynamically to the environment; the Colony's focus is about coordinating the behaviour of many independent robots so they act as an effective unit.* (**Wyss Institute, 2021**)

These RoboBees are being designed to fly in a swarm, with hundreds or thousands completing a task (**Harvard Magazine, 2017**). This requires complex programming to ensure the RoboBees are all completing the same task. There is potential for RoboBee to be used for crop pollination.

These three examples of artificial pollination technologies are all designed to carry out the work of insect pollinators. Whilst natural ecosystems are failing, the agricultural industry could be looking at approaches to reduce agrochemical inputs. In the UK, agrochemical use has been central to changes in how agricultural land is farmed and has contributed to declining biodiversity (**Lang, 2021**). The Pesticide Action Network UK (PAN-UK) is the NGO that monitors pesticide use and impact in the UK. They point out that since 1990, the amount of land treated with pesticides has increased by 63%, while the number of times farmland is treated with pesticides has almost doubled. For example, a UK potato crop is sprayed 32 times (**Pesticide Action Network UK, 2022**). This has had a detrimental impact on insect numbers. In the UK, there are now 50% fewer insects than in 2005 (**Goulson, 2020**). Instead of addressing these issues, there is a turn to artificial pollination technologies designed to replace insect pollinators. Artificial pollination is engineered to overcome the collapse of natural systems, but fails to address the fundamental and underlying issues of pollinator loss including climate change, habitat loss, land use changes, pesticide and insecticide use, pollution and the introduction of non-native species.

Industrialised Agriculture and the Pollinator Crisis

The systems which established and maintain industrialised agriculture are at the heart of the pollinator crisis. It is these systems which exploit nature. This is illustrated by honeybees who are already commodified (**Cilia, 2019; Ellis et al., 2020; Nimmo, 2015, 2021**). Honeybees and wild insect pollinators are seen as a technology in agricultural production as opposed to insects in ecosystems threatened by an ecological crisis (**Nimmo, 2021**). As Nimmo (**2015: 5**) argues, 'the role of technology in industrialised animal agriculture is grasped as a means to enable ever more precise and totalising control over the animal's body and its bodily activity in the interests of increased productivity, efficiency, and profitability'. Honeybees and wild insect pollinators are part of this industrialised system of productivity, efficiency, and profitability. As Braidotti (**2002: 126**) points out, animals are used and treated as an 'industrial production plant' and are often used as 'prototypes for engineering'. This is certainly the case as the examples of Edete and RoboBee described in this article mirror insect pollinators. Discussing ants, Braidotti (**2002**) explains how these insects are portrayed in books and films as industrious workers or as prototypes of industrial robots. This is why insect pollinators are so important for agriculture. It is because they are industrious workers. Without these pollinators, the food system would collapse.

Another problem with industrialised agriculture is the commodification of life and the complexities this brings. To illustrate this, I turn my attention very briefly to commodified seeds. Commodified seeds, especially those which are gene edited or genetically modified, are produced through technological processes (**Price, 2022a; Shiva, 2016**). These commodified seeds reduce biological diversity as well as dispossessing farmers of their seed rights (**Shiva, 2016**). The way in which commodified seeds are produced means farmers have to purchase new seed every year from seed providers, and are forced into monoculture farming where only a single crop type is grown (**Moore, 2015, Vasavi, 1994**). Commodification is problematic because it concerns power and control. The power and control associated with monocultures is a form of ecological violence and is a 'declaration of war against nature's diverse species. The violence not only pushes species toward extinction, but controls and maintains monocultures themselves' (**Shiva, 2016: 102**). A diversity of crops and crop varieties are lost (**Moore, 2015; Patel, 2013**). Monoculture crops are also where agrochemicals are widely used (**Moore, 2015; Shiva, 2016**). Besides biodiversity loss, commodification and the owning of life also removes agriculture from its broader social, cultural and environmental functions (**Thivet, 2014**). As Vasavi (**1994: 294**) argues, where commodification occurs 'it largely displaces the local knowledge and autonomy of agriculturalists and substitutes the uniform and market-oriented prescriptions of the bureaucracy'. In the case of commodified seeds, farmers are prevented from saving, using, selling, and exchanging seeds (**Shiva, 2016; Thivet, 2014; Vasavi, 1994**). Instead of local communities shaping food systems, it is corporate actors (**Clapp, 2022**).

Artificial pollinators are similar to commodified seeds. Patents to these pollination technologies belong to the companies who develop and design them. Without insect pollinators, power and control of crop pollination lies with those who develop and design artificial pollinators. The companies designing and developing artificial pollination technologies do not aim to address the underlying problems of insect pollinator decline such as habitat loss and climate change (**Price, 2022a**). Not addressing insect pollinator decline means artificial pollination will likely be required.

Sustainability can imply continuity and survival in agriculture (**Lang, 2021**). Artificial pollination is a digital technology that falls under the remit of the fourth agricultural revolution or Agriculture 4.0 (**Barrett & Rose, 2020; Klerkx et al., 2019; Klerkx & Rose, 2020; Price, 2022a; Rose & Chilvers, 2018**). The technological solutions developed as part of Agriculture 4.0 are changing the manner in which problems are dealt with. Artificial pollination is particularly complex.

The choices made by farmers will depend on how problems are framed and how uncertainties are dealt with. Scoones and Stirling make an eloquent point about uncertainties:

> *Too often, ideas of transformation and sustainability are framed around particular, expert-defined "solutions", with uncertainties blanked out. Typically asserted with great confidence, burgeoning notions around, for example, "smart cities", "climate-smart agriculture", "clean development", "geo-engineering", "green growth" or "zero-carbon economies" act to suppress appreciation of many forms of uncertainty.* (**Scoones & Stirling, 2020: 1**)

With agriculture, there is the uncertainty of a lack of honeybees or wild insect pollinators to pollinate crops. Uncertainties can create anxieties, fear, and concerns (**Scoones and Stirling, 2020**). Pollination is an area where uncertainties could be amplified especially in relation for the need for pollination of food crops. Artificial pollination could be used to address the uncertainties surrounding pollination. However, it is important to recognise the uncertainties surrounding pollination have been created by humans. By not addressing the problems creating these uncertainties, technological solutions will be required. As Jasanoff (**2021: 846**) argues, it is difficult to 'roll back behaviours that had for so long treated nature mainly as a resource for satisfying the hunger of human wants'. This is why there are pollinator declines. Nature has been exploited to ensure human survival.

From a techno-fix perspective, ensuring the continued survival of humans means artificial pollination will be required. However, if the emphasis is on science and technology to provide solutions to problems, innovation and progress tends to focus on who is leading the way and who must catch-up rather than who is gaining and who is losing from new innovations (**Scoones & Stirling, 2020**). Solving a problem with a technical approach involves a singular pathway of technological progress (**van Zwanenberg, 2020**). Proceeding with artificial pollination could potentially mean abandoning the idea of trying to address the pollinator crisis. In industrialised agriculture, insect pollinators are valued only for their pollination function and for the benefits they bring to humans as opposed to the pollination role they play in ecosystems and the plant-insect interactions necessary for sustaining life (**Nimmo, 2021**). If insect pollinators are only valued for the benefits they bring to humans, it is easier to turn to a digital technological solution. This idea of abandonment may be further enhanced when you consider technology can potentially 'reduce costs, restore reliability, and increase productivity and profitability' (**Nimmo, 2021: 8**). If artificial pollination increases industrialised agriculture's productivity and profitability, it is likely to be adopted by large scale farming operations. This may disenfranchise farmers with small agricultural operations especially as they may have skills unsuited to working with digital technologies, a lack of capital, and be situated in rural areas which lack infrastructure (**Price, 2022a**). Digital technologies such as artificial pollination may reinforce existing power structures (**Rose et al., 2022**).

The pollination of crops is a concern for farmers. The decline in honeybees and wild insect pollinators is a problem that requires solving. However, it is also important to consider who is providing solutions to problems such as pollinator loss. Jasanoff (**2021: 850**) argues that 'engineers still conceive of big technological solutions for big problems'. This is why the route to solving a problem is often technological. The problems 'that get chosen and solutions that are offered reflect the values of the people involved in innovation' (**Stilgoe, 2020: 33**). These innovations will not always benefit the needs of society or the environment. Who actually benefits is exacerbated when technologies are developed. Technologies are not independent of social influences, and human values enter into the design and use of technologies (**Jasanoff, 2016**). The designers of artificial pollination technologies will be bringing their own values to the table. This means that moral codes are developed for technological systems with public values catching up later (**Ibid**). What needs to be asked is: do farmers want artificial pollinators to replace honeybees and wild insect pollinators? Or do they want to try and avert the decline of honeybees and wild insect pollinators?

Entanglements and Pollination

Entanglements between the more-than-human world and humans are essential for agriculture if food is to be successfully grown or reared. Anna Lowenhaupt Tsing (**2015**) in the book, *The Mushroom at the End of the World*, describes how agriculture consists of polyphonic assemblages with rhythms between plants, animals, humans, climate, weather, seasons, and daylight. There are relationships between plants and pollinators, sowing and harvesting. What happens when these rhythms are interrupted by artificial pollination? Who is controlling pollination? In trying to answer these questions, it is useful to refer to Karen Barad and Donna Haraway.

If farmers become reliant on artificial pollination, then entanglements alter. Artificial pollination means turning to machinic labour. The reconfiguring of labour is alluded to by Barad who suggests:

> *Machinic agency is part of the ongoing contestation and reconfiguring of relations of production. The point is not that management and workers become cyborgs in their relationship to machines, but rather the point is that machines and humans differentially emerge and are iteratively reworked through specific entanglements of agencies that trouble the notion that there are determinate distinctions between humans and nonhumans.* (**Barad, 2007: 239**)

A cyborg is a rejection of the boundaries which separate human from other species and humans from machines. Cyborgs are organisms when concerned with labour and communication, humans when involved with the practices and objects of technoscience, and machines with connections to information and systems (**Haraway, 2016**). With artificial pollination, power moves away from the systems found on Earth which exist within and between ecosystems, and instead moves to technological systems. The rhythms which once existed between pollinator and crop are replaced by a new rhythm between the farmer, the crop and artificial pollination. It is the algorithms controlling the artificial pollination technologies that become responsible for crop pollination. Power lies with the algorithms.

Addressing problems such as pollinator loss with the use of digital technology puts humanity onto the course of uncertain futures. There is no reconciliation between the human and more-than-human entanglements present on Earth (**Lorimer, 2017**). Instead of acting with humility, the favoured response is hubris (**Bonneuil & Fressoz, 2017; Jasanoff, 2021**) as nature is replaced by digital technology. The Earth becomes 'simply a cybernetic machine, rather than a dynamic becoming and a history' (**Bonneuil & Fressoz, 2017: 86**). The high speed modification of Earth through technological interventions also means the slow violence of ecological degradation which harms both humans and the more-than-human world (**Nixon, 2011**). Insect pollinators are one part of this ecological degradation. Biodiversity loss and ecological degradation is troubling. Conditions such as the temperature or the ecosystems found on Earth act as boundaries for humans' existence (**Chakrabarty, 2009; Liboiron, 2021; Morton, 2013; Rose et al., 2017**). There are nine key Earth processes which act as planetary boundaries. These are changes to the climate system, land use, biodiversity loss, freshwater availability, the biogeochemical cycles of nitrogen and phosphorus, stratospheric ozone depletion, aerosol loading, ocean acidification, and novel entities (**Rockström et al., 2009; Sage, 2022a; Steffen et al., 2015**). Whilst the thresholds of these planetary boundaries are seen as the limits of safe operating space for human societies (**Rockström et al., 2009; Steffen et al., 2015**), I argue these should also been seen as the thresholds for the limits of safe operating spaces for the more-than-human world. Humans are now disrupting and destabilising these parameters.

Humility, Multispecies Justice and Pollinator Loss

An altogether different future is possible if humans act with humility. I briefly explain why humility is important before explaining what humility means for the pollinator crisis. The term 'Anthropocene' is troubling for Bonneuil and Fressoz (**2017: 71**) because it masks 'the great differentiation of responsibilities and incidences between the classes, sexes and peoples'. This in turn impacts the solutions which are put forward in order to address issues such as climate change, biodiversity loss and ecological destruction. In addressing these fundamental issues, I will argue that the turn needs to be made towards humility. This means recognising and acknowledging there is much for western cultures to learn. For example, the binary distinction of humans and non-humans and nature and culture which are central to European thought, do not feature in many other cultures (**Braidotti, 2020**). The binary between nature and culture means that scientific knowledge dominates and traditional knowledges are swept aside (**Haraway, 1988; TallBear 2014**). As TallBear (**2011**) argues, 'for many indigenous peoples, our nonhuman others may not be understood in even critical western frameworks as living'. Inanimate objects and natural forces including stones, trees, and thunder are important to Indigenous communities (**Nadasdy, 2007**). This connection with the world means that Indigenous peoples 'often see themselves as participating in cultural and political systems that, from hundreds even thousands of years of experience, are explicitly designed to adapt to environmental change' (**Whyte, 2017: 102**). These cultural and political systems enable landscapes to be cultivated, ensuring sustainability whilst also maintaining resilience against environmental change (**Whyte, 2018a, 2018b**).

Dismissing Indigenous knowledge when addressing problems such as climate change or biodiversity loss is counterproductive. Western scientific thinking has a lot to learn from Indigenous knowledge making practices. Indigenous Environmental Studies and Sciences (IESS) is an emerging field which focuses on Indigenous 'historical heritages, living intellectual traditions, research approaches, education practices, and political advocacy to investigate how humans can live respectfully within dynamic ecosystems' (**Whyte, 2018a: 138**). In building resilience, emphasis is placed on responsibility, justice and spirituality. By considering alternative knowledges alongside scientific knowledge, humans can act with humility.

The research of Fikile Nxumalo with preschool children on understanding declines of Western bumble bee populations and bee deaths shows how we can learn with other species (**Nxumalo, 2018, 2020**). This work took place with preschool children from Greater Vancouver on unceded Coast Salish territories in British Columbia, Canada. Nxumalo (**2020**) argues that if children's learning is only centred on Western scientific knowledge, bees are considered as 'workers' and are required for pollination for crops for settler humans, and can lead to the erasure of Indigenous knowledge which sees bees and Indigenous people in complex and entangled relationships. Instead, if children learn with bees, they are more attuned to the world they have inherited and the issues contributing to pollinator decline (**Nxumalo, 2018**).

Being attuned to the world means being present in the moment. With this in mind, when navigating problems such as pollinator loss, it is useful to turn to Haraway's discussion on staying with the trouble. This idea is particularly pertinent with pollinator decline:

> *In urgent times, many of us are tempted to address trouble in terms of making an imagined future safe, of stopping something from happening that looms in the future, of clearing away the present and the past in order to make futures for coming generations. Staying with the trouble does not require such a relationship to times called the future. In fact, staying with the trouble requires learning to be truly present, not as a vanishing pivot between awful or edenic pasts and apocalyptic or salvific futures, but as mortal critters entwined in myriad unfinished configurations of places, times, matters, meanings.* (**Haraway, 2016: 1**)

Staying with the trouble means taking moral responsibility and acknowledging humans and the more-than-human world are in difficult and troubling times. It is not about preventing something from happening or imagining safe futures. Staying with the trouble means ''We'-who-are-not-one-and-the-same-but-are-in-this-convergence-together' (**Braidotti 2019: 182**) rely on one another in unexpected collaborations and entanglements. Staying with the trouble also means we enact response-ability. Response-ability is about 'absence and presence, killing and nurturing, living and dying' (**Haraway 2016: 28**). Response-abilities need to be shared. This enables humans to confront and respond to uncertainties (**Scoones & Stirling, 2020**). Living with pollinator loss means response-ability needs to be enacted. It is important that 'response-abilities toward "others" with whom we are bound together, visibly or not, in everyday practices of production, consumption, and reproduction' are nurtured so that the world changes (**Tschakert et al., 2021: 6**). Enacting response-ability means employing and engaging with fundamentally different ways of knowing, thinking and being (**Celermajer et al., 2021**) whilst always trying to do better (**Haraway, 2016, 2018**). Response-ability means dismissing the belief that humans are superior and attending to imaginings that are sympathetic to humans and the more-than human world (**Celermajer et al., 2021; Tschakert et al., 2021**). Insect pollinators need to be recognised as being just as important as humans. One approach to enact response-ability is to consider multispecies justice.

There are already scholars arguing for justice to be addressed through a multispecies lens (**Celermajer et al., 2020; Celermajer et al., 2021; Chao, 2021; Chao et al., 2022; Haraway, 2018; Roy, 2018; Tschakert, 2020; Tschakert et al., 2021**). For Tschakert et al. (**2021: 4**) multispecies justice means 'shifting the focus and subject of justice from the individual and exceptional human being to a wide range of living and non-living entities, and their interactions and processes. Such a relational approach acknowledges the differential histories and practices of environmental and ecological violence while opening pathways toward more just, even if uncertain, futures'. Although uncertain, these futures have the potential to offer hope for multispecies flourishing (**Kirksey & Chao, 2022**). This approach will help humans ethically navigate the problems facing the world, including the pollinator crisis.

Rethinking Food Crop Pollination with Multispecies Justice

Thinking through pollinator loss through the lens of multispecies justice puts us on an altogether different course from that of using artificial pollination. With multispecies justice, honeybees and wild insect pollinators are considered just as important as humans. Instead of saving insect pollinators purely for the survival of humans, insect pollinators are saved because they are considered important in their own right. Multispecies justice for honeybees and wild insect pollinators requires rethinking how our food is produced. As Tim Lang (**2021: 243**) argues: 'The future of food security requires nature to be protected by food production as well, not despite it'. Industrialised agriculture has enabled cheap food to be produced through cheap labour, care, raw materials and energy (**Patel & Moore, 2020**). This has led to food outputs being maximised in the short-term, but has created less resilient and more fragile food systems (**Standing, 2019**).

In the UK, farming organisations are reassessing approaches to agriculture. Although the emphasis is on addressing climate change and reaching net zero in the agricultural sector, The National Farmers Union is looking towards land sparing (**Ward, 2023**). This is likely to enable land to be given over to other uses such as planting trees or wildflower meadows which would benefit wildlife (**Lang, 2021; Sage, 2022b; Ward, 2023**). An alternative approach is suggested by the Food, Farming and Countryside

Commission (**2022**) which is a move to agroecology. The Food and Agriculture Organisation of the United Nations (FAO) define agroecology as:

> *A holistic and integrated approach that simultaneously applies ecological and social concepts and principles to the design and management of sustainable agriculture and food systems. It seeks to optimize the interactions between plants, animals, humans and the environment while also addressing the need for socially equitable food systems within which people can exercise choice over what they eat and how and where it is produced.* (**FAO, 2022**)

Not only is this approach endorsed by The Food, Farming and Countryside Commission, but also the Food Ethics Council (**2022**). There is the potential for multispecies justice to be enacted due to the principles of agroecology. Colin Sage outlines four of the principles of agroecology:

1) Diversity: a diversity of plant and animal species and varieties, intercropping, and crop rotations. The enhancement of ecosystem services including pollination and soil health. The simultaneous cultivation (polyculture) of different crops.

2) Knowledge: knowledge tailored for local situations so it is context-specific. The co-creation of knowledge and knowledge exchange.

3) Efficiency: the avoidance of external inputs such as chemical fertilisers and agro-chemicals. Integrated pest management replaces chemical pesticides, and planting legumes fixes nitrogen in the soil mitigating the need for chemical fertilisers.

4) Circular and solidarity economy: local markets are prioritised and local economic development is supported. (**Adapted from Sage 2022b: 24 – 25**).

Whilst Sage (**2022b: 24**) states that 'agroecology restores the essential connection between food, people, and place', it is also possible to see how the entanglements between humans and insect pollinators can be restored. Insects (both pollinators and non-pollinators) are foregrounded as essential to healthy and resilient food systems. Although healthy and resilient food systems speak as though humans are favoured, it is never possible to set humans apart from the more-than-human world (**van Dooren, 2017**). As Anna Tsing (**2012: 144, emphasis in original**) notes: '*Human nature is an interspecies relationship*' with 'varied webs of interspecies dependence'. Humans cannot survive without the more-than-human world.

Whilst humans need insect pollinators for food crop pollination, insect pollinators are also needed by wild plants. 80% of European wildflowers are dependent on insect pollination (**Friends of the Earth, 2022**). Once pollinated, plants and trees will set seed, providing food and habitat for other species. These different forms of life are entangled in knowing and living together (**Rose et al., 2017**). Industrialised agriculture has broken these entanglements of life through the chemical control of perceived pests and diseases (**Paredes, 2022**), and land use change resulting in habitat loss (**Moore, 2015**). Changes to the way our food is produced are needed if the pollinator decline is to be halted. If we do not, we are likely to be facing extinction events with some of our insect pollinators (**Rose et. al., 2017**).

Although futures may be uncertain, they are less likely to be unjust when applying a multispecies approach to problem solving. There is also the opportunity to address ecological degradation which pollinators are part of. Addressing pollinator loss through a multispecies approach means acknowledging the harms (**Celermajer et al., 2020**) that have been caused to honeybees and wild insect pollinators through the heavy use of insecticides and pesticides, habitat loss, climate change, non-native invasive species, the spread of diseases and light pollution. Once these harms are acknowledged it is then possible to move forwards with an approach that helps navigate the pollinator loss crisis. A more ethical and just future can be built when we understand the processes and the ties which unite humans and insect pollinators. Whilst industrialised agriculture has caused a decline in honeybee and wild insect pollinator numbers, by enacting response-ability, pollinators can be helped to recover. Rethinking how our food systems operate to include approaches such as agroecology could enable response-ability to be enacted and encourage multispecies flourishing.

Conclusion

In the introduction of this article, I asked the question: do we need artificial pollination if we have multispecies justice in the Anthropocene? I have shown that declining pollinator numbers is a catastrophe for both the human and more-than-human world. The entanglements of life have been broken by industrialised agriculture through the chemical control of perceived pests and diseases (**Paredes, 2022**), and land use change resulting in habitat loss (**Moore, 2015**). This has contributed to the decline in honeybee and wild insect pollinator numbers. Industrialised agriculture has exploited ecosystems to such an extent that eventually they will no longer support human survival (**Moore, 2015**). However, due to the overexploitation of ecosystems, artificial pollination should not be viewed as a silver bullet. Questions still need to be addressed. What happens if we proceed with digital technologies such as artificial pollination which do not address the issues causing insect pollinator loss? Can we effectively find solutions for the collapse of natural ecosystems if artificial pollination appears to fill the gap of missing insect pollinators?

Whilst artificial pollination could present a solution to pollinating food crops due to declining insect pollinator numbers, we should not overlook why this problem is arising. Looking to the problem of industrialised agriculture could help us save our insect pollinators and address the pollinator crisis. We should be trying to solve the problems which are causing insect pollinators to decline before turning to digital technology. Artificial pollination should be a technology of last resort.

Addressing problems such as pollinator loss with the use of digital technology puts humanity onto the course of uncertain futures. Artificial pollination could potentially mean abandoning the idea of trying to reduce honeybee and wild insect pollinator decline. In this scenario, human survival is the important outcome and this is achieved by ensuring food crops will be pollinated. In order to eliminate the need for hand pollination by humans, artificial pollination technologies such as Edete, Olombria, and RoboBee are being developed.

An alternative future could be achieved if we turn to multispecies justice as this would enable 'us to reimagine our futures and transitions to these futures, ensuring they are just, democratic, diverse and sustainable for both humans and the more-than-human world' (**Price, 2022b: 542**). This would mean that changes to the way food is produced would need to occur. In the UK, farming organisations are already reassessing approaches to food production. One suggestion is a move to agroecology (**Sage, 2022b**). By adopting this approach, the broken entanglements resulting from industrial agriculture could potentially be restored. Food systems could become more healthy and resilient and there is the potential to halt the decline of wild insect pollinators and honeybees. Because it is never possible to set humans apart from the more-than-human world (**van Dooren, 2017**), changes to agricultural production systems are required in order to prevent ecosystem failures which would be catastrophic for both the human and more-than-human world.

Finally, humanity is at a crossroads and faces a choice. Humanity continues on its current path or it turns towards humility and multispecies justice whilst acknowledging previous mistakes. It considers not only the inequalities which exist in the human world but also those that exist between the human and more-than-human world. Addressing the insect pollinator crisis with humility and multispecies justice would be a better path to take. Instead of a world without insect pollinators, there is hope for multispecies flourishing.

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