Towards morally-inclusive coexistence

Barriers, pedagogy, & opportunities for expansive conservation

by Esty Yanco, MSc.

Thesis submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy

under the supervision of Daniel Ramp & Jeannine McManus

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Certificate of Original Authorship

I, Esty Gayle Yanco, declare that this thesis is submitted in fulfilment of the requirements of the award of Doctor of Philosophy, in the TD School at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

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List of Papers and Statement of Author Contribution

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Thesis Abstract

The intrinsic value of wildlife is widely acknowledged by conservationists, but at the same time, conservation interventions often inflict harm on wildlife individuals. One explanation for this incongruity is that the Western mentality of human exceptionalism dampens the moral significance of nonhuman beings, driving a wedge between conservation ethics and practice. The juxtaposition of human exceptionalism and the widespread recognition that wildlife possess intrinsic value creates an unresolved tension around how to, or what it means to, coexist in a way that respects the moral significance of all inhabitants of shared landscapes.

My thesis asks what happens when conservation and, more specifically, coexistence on production landscapes are reframed by moral inclusivity and seeks to uncover whether mutualistic pathways improve the ethical and practical outcomes of coexistence. To answer these questions, I aim to identify barriers to conservation that arise when the moral significance of wildlife is overlooked, to investigate pedagogy for expanding circles of moral consideration, and to explore opportunities for coexistence when the discipline practices moral expansiveness. I begin in chapters 1 & 2, where I detail the Western ethical and normative foundations of conservation and discuss my positionality and case study methodology. I address my research objectives in three parts that together forge a pathway toward morally inclusive coexistence.

In *Part 1: Barriers of human exceptionalism in conservation practice* (chapters 3 & 4)*,* I reveal how normative constructs can lead to poor decision-making and justifications of harm and provide a pathway to improving transparency and ethical decision-making. I then explore how the normative conservation paradigm limits

holistic contextualisation of multispecies landscapes in the coexistence literature and discuss how the adoption of morally inclusive coexistence can encourage a more holistic interrogation of complex coexistence systems. In *Part 2: Pedagogy of moral inclusion* (chapter 5)*,* I substantiate the efficacy of a morally inclusive pedagogical approach and contend that education programs that affirm the value of all living beings may inspire the public to engage in morally inclusive coexistence. Lastly, in *Part 3: Entanglement in practice* (chapters 6 & 7), I present two practical examples of morally inclusive coexistence to demonstrate the viability of this approach and its holistic contribution to conservation goals. Together, my PhD research supports the argument that a holistic, morally inclusive coexistence that reorientates humans as part of nature, rather than separate to it, is critical to supporting the progress of conservation in shared landscapes.

Chapter 1. Introduction

The far-reaching consequences of a growing human population dominate wildlife conservation literature. Buzzwords such as ‘human-dominated landscapes’, ‘land-use conversion’, and ‘anthropogenic’ permeate the discipline (Ripple et al. 2014; Keil et al. 2015), highlighting the estrangement between people and wildlife and the need to find new pathways towards peaceful coexistence and environmental sustainability. But while it is widely acknowledged that wildlife have intrinsic value (Lute et al. 2016; Batavia & Nelson 2017a; Bruskotter et al. 2019), tensions around how humans promote their own endeavours without infringing on the lives of wildlife can complicate progress in coexistence (Santiago-Ávila et al. 2018).

My thesis asks what happens when conservation and, more specifically, coexistence on production landscapes, are reframed by moral inclusivity and seeks to uncover whether mutualistic pathways improve the ethical and practical outcomes of coexistence. I pursue this in three sequential parts – barriers, pedagogy, and opportunities – that seek to identify barriers to conservation that arise when the intrinsic value and moral significance of wildlife are overlooked, to investigate a pedagogical approach to expanding circles of moral consideration to include wildlife, and to explore opportunities for conservation on coexistence landscapes when the discipline practices moral expansiveness.

Historically, moral inclusion of wildlife has been conspicuously absent from western views of nature conservation. A symptom of this is the tension that results in conflict of interests between humans and wildlife, often to the detriment of wildlife. Conflict between humans and wildlife on shared landscapes has therefore garnered increasing attention from the conservation community as a key conservation issue over the last 20 years (Treves & Santiago-Ávila 2020). Problems surrounding the language of human-wildlife conflict, however, have come into focus as being antagonistic to conservation objectives. The amplification of negative interactions between humans and wildlife as *conflicts* exacerbates the dichotomous relationship that pegs wildlife as antagonists to human interests (Peterson et al. 2010; Frank 2016; Bhatia et al. 2020). This framing impedes on conservation's goal of encouraging humans to coexist with wildlife. In contrast, *human wildlife coexistence* is increasingly being used to encourage a more positive framing of the persistence of wildlife in shared landscapes (Peterson et al. 2010; Frank 2016). This trend is revealed when tracking the trajectory of coexistence research (using a Boolean search term of "human wildlife coexistence"), which is beginning to follow that of its more negative antecedent ("human wildlife conflict", Fig. 1A). However, in depth analysis of the conflict and coexistence literature suggests that the transition to a more positive lexicon is only slowly gaining traction (Bhatia et al. 2020).

The transition towards coexistence reflects a broader cultural paradigm shift away from the wildlife orientation value of domination towards that of mutualism (Dietsch et al. 2016; Manfredo et al. 2020). Compared to domination values, which view wildlife as serving the needs of humans, mutualistic values hold wildlife as morally significant and deserving of compassion, which is consistent with the ethical underpinnings of *compassionate conservation* (Ramp & Bekoff 2015; Wallach et al. 2018; Manfredo et al. 2020). Mutualistic values, as well as the recognition of the intrinsic value of wildlife, are indicative of conservation support and engagement in conservation behaviours (Dietsch et al. 2016; Lute et al. 2016). Likewise, conservationists overwhelmingly agree that wildlife have intrinsic value and that humans are obligated to be concerned for their welfare (Bruskotter et al. 2019).

Accordingly, human wildlife coexistence is increasingly promoting more positive framing of the *mutualistic cohabitation* of wildlife in shared landscapes, which prioritises the protection of wildlife individuals as legitimate constituents of shared landscapes (Boonman-Berson et al. 2016; Santiago-Ávila et al. 2018; Toncheva & Fletcher 2021).

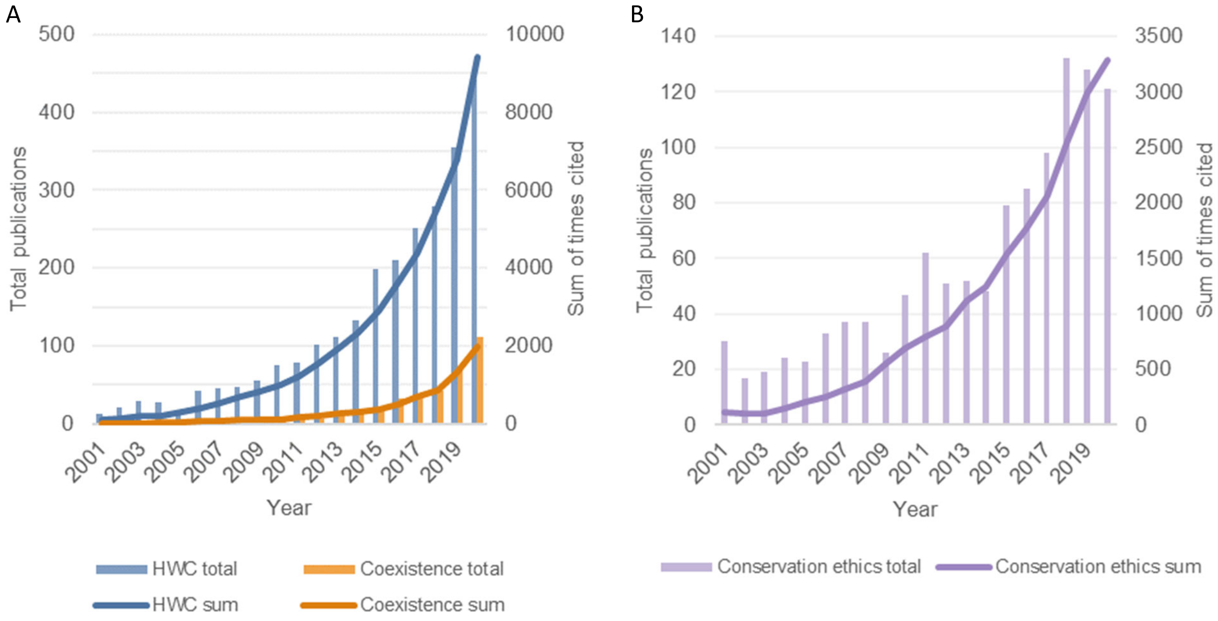

Figure 1. Growth of A) HWC, coexistence, and B) conservation ethics in the literature demonstrated by analysed search results from Web of Science using Boolean search terms “human wildlife conflict”, “human wildlife coexistence”, and “coexistence”, respectively.

Paradoxically, despite evidence that mutualism, views of intrinsic value, and moral inclusion of wildlife are inextricably tied to conservation and pro-environmentalism (Bratanova et al. 2012; Dietsch et al. 2016; Lute et al. 2016; Bruskotter et al. 2019), conservation interventions often inflict harm on nonhuman individuals (Hampton et al. 2019). One explanation for this incongruity is that the normative western mentality of human exceptionalism, or the separation of humans from nature, can drive a wedge between conservation ethics and practice (Plumwood 1993; Wallach et al. 2020). Human exceptionalism effectively dampens the moral significance of those who are not human (Wallach et al. 2020). In the context of conservation, and more specifically coexistence, human exceptionalism manifests as a human-nature dualism, whereby the needs of humans are positioned over or against those of other living beings (Plumwood 1993; Peterson et al. 2010; Wallach et al. 2020).

Despite growing awareness that human positionality within nature drives systemic issues that are paramount to defining the discipline of conservation (Plumwood 1993; Bratanova et al. 2012; Mace 2014; Boonman-Berson et al. 2016; Dietsch et al. 2016; Lute et al. 2016; Bruskotter et al. 2019; Wallach et al. 2020), the juxtaposition of human exceptionalism and the widespread recognition of the intrinsic value of wildlife creates an unresolved tension around how to, or what it means to, embody mutualistic cohabitation on shared landscapes (Boonman-Berson et al. 2016; Knox et al. 2020; Pooley et al. 2020). While one PhD dissertation cannot fully resolve this incredibly complex challenge, my thesis offers a journey towards cohabitation as a contribution to the body of literature on holistic approaches to morally inclusive and compassionate coexistence.

In this introductory chapter, I briefly explain how conservation is not just an empirical discipline, but also an ethical one that is inherently relational with nature. I then examine nature as a normative construct and discuss how societal interpretations of the relational position of humans within nature can inform the ways in which conservation is practiced. I further interrogate the western view that humans are superior to nature, and how this normative position is entrenched in conservation decision-making and practice. Lastly, I provide a brief overview of the thesis sections and overall findings.

Conservation as an ethical discipline

Conservation is not purely an empirical discipline, but rather a “crisis discipline” that utilises empirical information to decide how practitioners ought to respond to or remedy biodiversity decline (Soulé 1985). The conservation discipline is therefore predicated on science *and* ethics. Science develops a deeper understanding of measurable outcomes, but it does not tell practitioners how to, or whether it is necessary to, act upon the information derived from scientific investigation. Instead, it is the ethical component of conservation that informs practitioners on how they ought to respond (Vucetich & Nelson 2012).

Ethics aims to understand how we ought to behave (e.g., right and wrong, good and bad). It examines societal values, expectations, and ethical positions that are used to justify an action or behaviour and uses structured methods grounded in logic to understand, justify, or refute positions on how we ought to relate to others around us given a set of empirical data. Ethics, in this sense, is relational. Given the information we are acting on is about nature, conservation ethics is therefore fundamentally concerned with our relationship with nature, including whether we consider humans to be part of or separate to it. (Vucetich & Nelson 2012).

Social construction of nature and human entanglement

The definition of nature, however, is not objective. In other words, not everyone defines nature in the same way (Simberloff 2012). This is because nature is a normative construct, which is a word that represents a social norm, value, or expectation. Normative constructs are built upon 3 components: 1) a factual definition, 2) a socially constructed judgment of what fits that definition, and lastly 3) an implicit value statement on how it ought to be or ought to look (Lapinski & Rimal

2005). Importantly, the second component is predicated on social values and expectations, which can be informed by different worldviews or cultures (Lapinski & Rimal 2005; Simberloff 2012). In the context of nature, this translates into the question of whether humans are valued or viewed as part of nature or as separate from it.

In his 1874 piece “On Nature”, English philosopher John Stuart Mill proposed two definitions of nature based on the context of human intervention: nature is a collective name for everything that is, including humans, or nature is the name for everything that is of itself, without human intervention (Mill 1874). Nature is ultimately defined by the degree to which humans perceive to be entangled with nature. At one end of the scale of entanglement lies Mill’s definition that excludes humans from nature entirely; nature is that which does not include modern human touch. The other end is best captured by the indigenous and non-Abrahamic religious perspectives of kinship ecology, wherein humans are participants in nature (Salmon 2000, De Groot and van Den Born 2007). Humans are “part of an extended ecological family that shares ancestry and origins…[where] all the natural elements of an ecosystem” are kin (Salmon 2000). Humans, in other words, are inextricable from nature.

The middle of the scale of entanglement is populated by the work of Georgina Mace (2014), who reflects on the general western approach to the relational position of humans in nature. In her seminal article, *Whose conservation?*, Mace (2014) explored the evolution of contemporary western human relationships with nature, spanning “nature for itself”, “nature despite people”, “nature for people”, and, most recently, “people and nature”. While Mace recognised the reciprocity and enmeshment of humans and nature in conservation practice, humans are still positioned as separate from nature itself. Indeed, some practices separate humans from nature more than others, but they remain categorically separate nonetheless. Mace's work does, however, clearly demonstrate how the fluidity of the human relationship with nature has driven changes in western conservation priorities and actions in the 20th and 21st century. The degree to which humans are included as part of nature continues to influence how conservation practitioners picture nature, and therefore behave towards it.

Human exceptionalism in conservation practice

Western conservation often adheres to the "humans as separate from nature" end of the scale because it is predicated on the western tradition of human exceptionalism, whereby humans are a categorically separate and inherently superior class of being (Opotow 1990; Plumwood 1993). This is problematic because the predominant social order largely determines who is deserving of moral attentiveness. Human exceptionalism affords humans categorically higher moral status (Opotow 1990). This does not deprive other beings from moral consideration, but that humans generally come first. Those who are included in one's moral circle of inclusion, or conceptual space that delineates who is deserving of moral consideration, are subject to rules of fairness and justice, and are deemed deserving of compassion and ethical consideration. Those who are cast beyond the boundaries of moral inclusion are relegated as "non-entities, expendable, or undeserving" (Opotow 1990). While conflicts with entities who are morally included often play out as regulated, fair, and equal negotiations, conflicts with outsiders take the form of unregulated power struggles in which harmful words and actions by the in-group are either justified or go unquestioned (Opotow 1990).

Most, if not all, conservationists recognise the intrinsic value of the living world (Soulé 1985). However, even if a conservation intervention aims to protect an animal for no reason other than its own sake, human exceptionalism and narrow moral inclusion still permeates into the ways in which that goal is achieved (Wallach et al. 2020). For example, red foxes (*Vulpes vulpes*) were introduced to Australia by European settlers in the 1870s but are now indiscriminately and inhumanely persecuted across the country because they predate on native species (Saunders et al. 2010; Wooster et al. 2019). Native species and individuals are bestowed intrinsic value, and persecution of foxes is encouraged to reduce extinction pressures on native species and to alleviate suffering of native individuals (Wallach et al. 2020). Because humans are viewed as separate from nature and therefore unnatural, red foxes in Australia, which are present due to human facilitated migration, are also considered unnatural by extension (Simberloff 2012; Wallach et al. 2020). Despite general consensus that mammals are sentient beings, this unnaturalness relegates foxes to being unworthy of moral consideration (Wallach et al. 2020), which is reflected in the absence of welfare regulations for the lethal control of foxes, a lack of scrutiny over the suffering inflicted on them, and a widespread vitriolic attitude towards their existence embedded in discourse around fox presence. While also introduced by humans, humans of European descent, as well as their living assets such as livestock, are exempt from this line of reasoning under the notion of human exceptionalism (Plumwood 1993; Wallach et al. 2020). This example demonstrates that while intrinsic value and moral significance is attributed to native animals, human exceptionalism and exclusion from nature still permeates conservation by fuelling the violence that is argued as necessary to protect those animals that are deemed worthy of moral consideration.

This paradox underpins ongoing ethical debate between compassionate conservation and what is referred to as traditional conservation over how conservation practice ought to respond to empirical evidence of biological decline (Ramp & Bekoff 2015). While many traditional conservation practices justify harm as a necessary means to a conserved biodiversity end, compassionate conservation calls for addressing the global biodiversity decline in ways that reposition humans as part of nature and extend moral significance to all sentient beings (Wallach et al. 2018, 2020). Ultimately the debate rests on the ways in which different interpretations of nature, and more specifically, perceived human entanglement with nature, shape conservation practice.

Thesis overview

My dissertation demonstrates how a western view of nature manifests in conservation and argues that the reorientation of humans as part of nature, rather than separate to it, can enhance conservation practice. In chapter 2, I offer an in-depth interrogation of my position as a researcher and how this has informed my overall research aims and design. The research chapters of my thesis then present a series of case studies dispersed throughout three separate parts – barriers, pedagogy, and opportunities – that together build a pathway towards morally-inclusive coexistence. In *Part 1: Barriers of human exceptionalism in conservation practice,* I reveal how normative constructs underpinned by mainstream conservation can stifle progress in conservation through poor decision-making, public backlash, and justifications of harm and provide a pathway to improving transparency and ethical decision-making within the discipline. I then explore how the normative position within conservation lends itself to a more limited understanding of multispecies coexistence landscapes and discuss how the adoption of morally inclusive coexistence can encourage a more holistic interrogation of complex coexistence systems. In *Part 2: Pedagogy of moral inclusion,* I substantiate the efficacy of a morally inclusive pedagogical approach to primary school science instruction and contend that education programs that affirm the value of all living beings may inspire the public to engage in morally inclusive coexistence. And in *Part 3: Entanglement in practice*, I present two practical examples of morally inclusive coexistence, wherein humans are entangled with the rest of nature rather than separate to it, to demonstrate the viability of this approach and its holistic contribution to conservation goals. Together, the three parts of my PhD research support the argument that a holistic, morally inclusive coexistence is critical to the progress of conservation in shared landscapes.

Cohabitation: a morally-inclusive coexistence

The three components of my research coalescence to highlight how the western view of coexistence requires significant evolution to reshape how humans relate to nature. A word that articulates this sentiment exceptionally well is *cohabitation*, because it captures the relational components of shared landscapes; *cohabitation* extends beyond co-occurrence or mere tolerance for others by acknowledging the mutualistic interactions between morally significant beings. As a discipline, conservation is far from viewing landscapes as teeming with moral significance. But when it finally does, we will be better able to explore complex reciprocal relationships, shared experiences, and the entanglement of the diverse assemblage of beings who collectively cultivate a dynamic living systems. To view current western conservation as possessing few flaws, or else already acting compassionately towards nature, is the epitome of human exceptionalism. Life demands we do better.

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Chapter 2. Positionality and Methodology

Upon external review of my dissertation, I was encouraged to write a positionality statement to affirm my background and sources of knowledge and worldview, and to use this to discuss how my perspective contributes to my research approach and interpretations throughout my dissertation. After a bit of research on how to convey one’s positionality, it is obvious to me that this should be an essential part of any wildlife conservation thesis, but my understanding was not always this way. I am therefore enthusiastically writing this positionality statement, not only because I want to be clear about my history and position that have informed this research, but also because it has opened up an opportunity to make a social commentary about the discipline of conservation.

Personal positionality and background

My undergraduate and early professional background centred around more “straightforward” sciences of genetics and wildlife medicine, and my introduction to conservation sciences followed as I started to question the sources of harm that plague wildlife medicine. Even then, my understanding of conservation as an inherently ethics-based practice was minimal; my mindset was that the world is suffering biodiversity decline, that there are a few, mostly anthropogenic sources of this decline, and therefore we must fix it however we can. It was not a question of how, just that we must. I did not realise that there were any other perspectives informing conservation practices. Perhaps this is because I was trapped in the mainstream paradigm of conservation, where species that belong must be protected at all costs.

I did not question this approach until one specific lecture in my Master's degree, where a conservation researcher attempted to justify a program on the west coast of the US that sought to protect the threatened spotted owl from interspecies competition with barred owls by killing barred owls who landed in spotted owl habitat (Lynn 2020). I was completely dumbfounded; why is it that they both cannot reside together, and how do we decide who has the right to belong? At this moment I became aware of two unsettling crutches entrenched in mainstream conservation: 1) the meaning of belonging and reliance on its power to justify harm, and 2) the widely accepted solution of killing as a method for protecting wildlife (Wallach et al. 2018). Conservation as a positive contribution to the world slowly faded for me as I saw these issues manifest in public service announcements released by New Zealand encouraging children to kill rats as their greatest contribution to conservation efforts (Russell et al. 2015), in studies where conservationists captured and relocated dingoes to unknown territories as a source of biological control, only to kill them when their usefulness has expired (Schwartz 2016), and in conversations with colleagues lamenting over the idea of eliminating "nuisance" beavers. I mean, nuisance beavers? The only beings they are a nuisance to are humans. And maybe a fish trying to swim upstream. One could argue that beavers are the most skilled ecological engineers on the planet.

My discomfort with the discipline was finally affirmed when my path crossed with the Centre for Compassionate Conservation, a research group dedicated to achieving biodiversity conservation in a way that respects all living beings. There are four guiding principles of Compassionate Conservation: 1) do no harm, 2) the lives of individuals matter, 3) inclusivity of all species, and 4) peaceful coexistence (Wallach et al. 2018). Compassionate conservation is strongly aligned with virtue ethics, which:

> [u]nlike frameworks prescribing general rules or guidelines for proper conduct…focus[es] on the character traits, or virtues, manifested in proper conduct. Examples from across Western and Eastern traditions include respect, humility, generosity, integrity, patience, and, of course, compassion…. A virtuous person will carefully attend to the capacity of others to experience both joy and pain and make efforts not to inflict intentional and unwarranted suffering as a manifestation of one's compassionate character (Wallach et al. 2018).

In effect, Compassionate Conservation adopts a morally inclusive approach to conservation, where the needs and wellbeing of all lives are treated fairly and respectfully. Comparatively, the ethical underpinnings of mainstream conservation approaches are rooted in consequentialism and speciesism, whereby the ends (e.g., protecting native species) justifies the means (e.g., unethical persecution of non-native species) (Batavia & Nelson 2017b). This is not to say that the mainstream conservation paradigm does not have its merits in achieving biodiversity conservation targets, nor that it has a blatant disregard for the sanctity of life. Conservationists are not flagrantly encouraging harm as the best mechanism for achieving conservation goals, but at the same time, harm is widely accepted as an unfortunate yet necessary step to achieving these targets.

Unlike other sciences, where quantitative data answers a yes or no question, conservation receives quantitative data and then decides how we ought to respond to that information (Soulé 1985; Vucetich & Nelson 2012). That "ought" is the indication that conservation is grounded in ethics, and is therefore strongly informed by practitioners' worldviews and ethical underpinnings (Soulé 1985; Vucetich & Nelson 2012; Batavia & Nelson 2017b). Aside from adopting a virtue ethics foundation, how compassionate conservation differs from mainstream conservation is that it makes an active effort to explore the ethical nature of conservation sciences through its foray into the crosshairs of conservation ethics and practice, challenging the accepted ethical principles, and therefore practices, of mainstream conservation (see Wallach et al. 2019, 2020, Batavia et al. 2020, 2021, Nelson et al. 2020).

A call for positionality in conservation

When I was encouraged to write a positionality statement on my research, I was surprised that I had not thought to do so myself. Recognition of one's positionality is par for the course in social sciences, where it is widely recognised that one's epistemological and ontological beliefs (I have promised to myself that I wouldn't use the previous words for a largely science audience, but alas, I have), or in other words, their beliefs about knowledge and understanding of reality and being, inform the way they design, implement, and interpret their research (Moon et al. 2019; Holmes 2020). Why then didn't I think to write one for my own research, where the reader will clearly see that I scrutinize this exact issue in conservation? Indeed, referring to the published version of the third chapter of this dissertation, Boyce et al. 2021 write, that "[b]y cautioning conservation biologists about the influence of personal and professional value systems on conservation outcomes, Yanco et al.'s (2019) analysis indirectly illustrates the ongoing impact of an absence of formal methods and expectations regarding reflexivity among conservation science practitioners". If conservation is inherently ethical, and therefore informed by a practitioner's worldview, why is a positionality statement not standard in the conservation literature? Moreover, if a positionality statement is not generally expected in conservation research, why am *I* being asked to write one?

Perhaps positionality statements are not common in conservation because the mainstream consequentialist and speciesist approach in conservation research and practice is widely accepted within the discipline (Batavia & Nelson 2017b; Nelson et al. 2020; Wallach et al. 2020)? The trap of a position, set of values, or views being accepted as mainstream can lead to a lack of scrutiny and interrogation (Nelson et al. 2020; Boyce et al. 2021). Without critical thinking, positions and the methods they inform can be viewed as correct, uncontested, and acceptable (Boyce et al. 2021). Perhaps conservationists also fear that a statement of positionality may appear as an admission of research subjectivity, which, despite being widely recognised as inescapable and also formative to research methodology, is misinterpreted within the science community as a violation of objectivist scientific philosophy (Moon et al. 2019). If mainstream values are framed as facts, however, then logic would suggest that scientific objectivity is upheld (see Nelson et al. 2020 for an explanation of *stealth advocacy*). Mainstream positions are therefore often not stated, never mind defended.

However, as demonstrated in the third chapter of this dissertation, disregard for the positionality of mainstream paradigms often does generate a slant in research objectives, experimentation, interpretation, and recommendation (Yanco et al. 2019; Holmes 2020; Beck et al. 2021; Boyce et al. 2021). Mainstream conservation, like many other sciences, has an angle, and regardless of whether that angle is widely accepted or refuted, it still ought to be clearly stated because it informs their practice. Nevertheless, unlike other disciplines such as medicine, economics, and law, that have readily integrated statements of positionality into research over the last few years, conservation as a discipline continues to be reluctant to adopt this practice despite growing calls amongst conservation social scientists (see Moon et al. 2019, Beck et al. 2021, Boyce et al. 2021).

So why do *I* need to state my position, if conservation generally doesn't require this type of scrutiny? Because my position, alongside those of my compassionate conservation colleagues, is in the minority. In attempts to marginalise and silence compassionate conservation, our position is loudly criticised by the dominant discipline as threatening, antithetical to conservation, and wrong (see Nelson et al. 2020, Batavia et al. 2021) Positionality, though, "not only shapes [one's] work but [also] influences their interpretation, understanding, and, ultimately, their belief in the truthfulness and validity of other's research that they read or are exposed to" (Holmes 2020). Problematically, the positionality of our critics and their understanding of how being the normative paradigm in conservation informs their view of compassionate conservation is never stated in their criticisms of compassionate conservation work. I must prove my position because it is not readily accepted within the normative paradigm, but the normative paradigm is not challenged to do the same hard work.

The in-fighting that I have witnessed over the last five years as a PhD student has been fuelled by the unstated positionalities in conservation, which stifles the ability for all of us to reflect, observe, and understand one another. Why must we compete against one another when we all agree that our sole objective is to protect earth's beauty and wonder? This question could lead me down the path of an entire essay on the threat of capitalism and academic funding structures to the free-flow of knowledge (and the longevity of environmental protection), but as an incidental victim of intentional silencing within the discipline that led to my transfer out of the

School of Life Sciences and into the Transdisciplinary School only 5 weeks before submitting this dissertation for examination, I am more interested in clearly stating that this kind of political competition only stifles our progress as a global movement to halt biodiversity decline. We all must be open to exploring the alternative paths to protecting the environment that arise, rather than shutting them down. To do so, we must expand our circles of moral consideration and value the positionalities of all of those that are joining us in the long fight for planet earth. While this may be difficult, and I must admit I continue to work on this level of acceptance every day, requiring the inclusion of a positionality statement in our research, and engaging with the hard work of reflection and challenging our own beliefs that such a statement demands of us, can easily be the first step.

Thesis positionality and aims

For this thesis, I was interested in examining how conservation practices and thinking fared when they were reframed according to the moral position adhered to by myself and my compassionate conservation colleagues that *all* individuals matter, regardless of their background, belonging, or behaviour. I therefore actively chose not to engage in the discourse of invasion ecology that permeates mainstream conservation, which relies on pejorative labels of wildlife, such as “pest” and “invasive”, to exclude them from ethical consideration, justifying broad scale harm (my argument for which is made in Chapter 3). One can liken this form of speciesism to the ongoing immigration crisis in the United States, where humans are actively othered through the use of terms such as “illegal aliens”, and then treated as such a term allows not only by the government, but also by their neighbours (Thomas 2020). Whether a human, or a fox in the case of my dissertation, is introduced or native does not influence his or her sentience and intrinsic value, and their labelling as either should not carry the weight of their lives.

While the co-evolution of introduced nonhuman species or lack thereof may dictate certain behavioural repertoires (the empirical evidence for which is limited because of a lack of interest in the behavioural ecology of introduced species, another outcome of unstated speciesist normative positions (Wallach et al. 2018, 2019; Boyce et al. 2021)), my practical research as a whole was agnostic to their immigration status; whether a method of coexistence works in practice on livestock production landscapes is independent of whether we think the wildlife should be there or not. A position of moral inclusion requires that we do not neglect, ignore, or discount their status as moral subjects. In this approach, it is not coexistence if moral subjects are actively excluded.

It is also important to state at the outset that my research interrogates conservation and coexistence within an entirely Western context, both in theory and practice. For example, discussions of coexistence on production landscapes refer mostly to large-scale commercial livestock properties, rather than subsistence grazing in developing countries. This was an intentional decision, primarily justified by the understanding that the demands of Western neoliberal capitalism are overwhelmingly responsible for large-scale habitat destruction and government-supported persecution of wildlife (Collard & Dempsey 2017). It is important to also recognise that there are many other cultural approaches to this discussion that could contribute greatly to progress in the discipline as a whole and that in many of these places, colonial expansion has driven and overwritten the invaluable cultural knowledge of sustainability by First Nations people (Trisos et al. 2021). My intent here, as the author, is to acknowledge my background of white privilege and to recognise that the decision to root my work in a Western tradition was done with full awareness of the sense of entitlement that Western scholars before me have carried.

An important component of a positionality statement includes the identification of the researcher as an insider or an outsider, because being either one can alter one's perspective of, and therefore approach to, their research (Holmes 2020). Historically, Western scholars have infused the discipline of conservation with the dominant social order of human exceptionalism, whereby humans are positioned as separate from and above nature (Plumwood 1993; Wallach et al. 2020). The human-nature dualism this perspective creates is reflected throughout the discipline in the language used in the literature, such as human-wildlife conflict (Peterson et al. 2010; Bhatia et al. 2020), in the development of anthropocentric, market-driven sub-disciplines used to encourage conservation behaviours, such as new conservation and ecosystem services (Mace 2014; Batavia & Nelson 2017b), and in the general drive to manage the environment and wildlife. In this way, mainstream conservation positions its researchers as outsiders to the subjects of research and humans as being an external influence on and beneficiary of nature's existence.

Trends in conservation have shifted away from the paradigm of the 2000s that positioned nature as serving the needs of humans (Mace 2014), yet the positioning of humans outside of nature persists. Perhaps one reason for this is because, despite efforts to diffuse the rhetoric of domination over nature, we still have not yet fully expanded our circles of moral consideration to include nonhuman forms of life. If we, however, view the planet as teeming with moral significance, then we can see that humans are a piece of the larger puzzle of life, rather than the puzzle builder. In this way, humans, and therefore researchers, are in fact insiders. We, too, are a part of nature, not external to it. And adopting this perspective may lend us to practicing a more compassionate approach to helping protect the lives of our fellow nonhuman inhabitants of the world.

Methodology and detailed chapter overview

Given the widespread acknowledgement that conservation is underpinned by ethics and values, there is a lack of engagement with available ethical tools to explore this cornerstone of the discipline (Nelson et al. 2020; Boyce et al. 2021; Ferraro et al. 2021). Reasons for this may include a misunderstanding of the discipline of critical thinking (one may think they are engaging in critical thinking, but are not), a disinterest in challenging one’s own (likely normative) position, or a general lack of exposure to the subjective element of conservation (I would put myself in this category). With this in mind, I have shaped my dissertation into a composition that would provide guidance and clarity to my younger self, who did not question nor explore the ethical context of conservation, not because I did not want to, but because I did not know how to. My dissertation therefore operates under the assumption that this may be the reader’s first foray into the ethical underpinnings of conservation, which explains my earlier reluctance to use complex social science language and my approach to topics in a way that may appear as a cursory examination to the well-versed social scientist; my goal is to welcome my readers as apprentices in conservation science and conservation ethics, rather than to overwhelm them with theory and language that requires them to have a dictionary on hand.

Overall, my thesis reflects my own journey to develop a deeper understanding of conservation as both a scientific, ethical, and social discipline. As my interests broadened over the last five years, so too did my understanding of the ways in which coexistence between species in shared landscapes can be envisaged. This process lent itself to developing a dissertation that explores a narrative of moral inclusion in conservation through a series of case studies.

Often used in the social sciences, case studies utilise “analytical eclecticism” to holistically investigate unique systems in real-life contexts (Thomas 2011). This offers what is considered a valuable trade-off: “rather than looking at few variables in a large number of cases, the case inquirer looks at the complex interaction of many factors in few cases: The ‘extensiveness’ of the former is discarded for the ‘intensiveness’ the latter offers” (Thomas 2011). As a reader progresses through my thesis, they will come to understand that multispecies landscapes are teeming with complexity and that a holistic framing of these landscapes is paramount to fostering morally-inclusive coexistence. The intensive investigation required for exploring the complexities of coexistence therefore lends itself to the case study design frame. With this approach, I was able to frame my research within the premise of moral inclusion, which is a reframing of the human exceptionalist positionality, and utilise a holistic One Health systems approach to structure the way in which I examined shared space. While case studies are sometimes criticised for lacking the ability to generalise findings (Noor 2008), they can provide insight into trends across complex systems and, as in the case of my thesis, provide applied examples of the theories I discuss.

Given the holistic nature of the case study design frame, my thesis evolved into a truly transdisciplinary examination of conservation and, more specifically, coexistence. Together, the five research chapters of my dissertation explore elements of ecology, animal behaviour, social science, ethics, livestock production science, global food policy, and environmental pedagogy; I also chose to discuss the ethical and/or social contexts of my research in each chapter, including those that are largely quantitative. Each individual chapter contributes a unique perspective of my journey as a budding conservation practitioner who is continuing to explore her position within the discipline.

Unlike other case study compositions in which the research chapters either draw the same information from different cases or extract different elements of information from one case, this dissertation is composed of standalone literary works that together adhere to a theme of reframing conservation within a lens of moral inclusion; while together they shape a pathway towards morally inclusive coexistence, they do not necessarily follow a neat linear chronology. Indeed, they reflect my personal journey within conservation that was all but linear, however strongly bound by a common thread of compassionate conservation. The cases are therefore organised into three distinct parts – barriers, pedagogy, and opportunities – that as a collective build a case for repositioning humans within nature as a way to improve conservation success.

In Part 1, I present a case study and a systematic literature review that shed light on the barriers to conservation that are created when humans position themselves as outsiders to nature. This section sets a precedent for the adoption of morally inclusive coexistence, which can help surpass the barriers erected by human exceptionalism that I have identified. In Part 2, I offer a case study that demonstrates a pedagogical approach to expanding circles of moral inclusion. While not directly aimed at conservation practitioners, this part demonstrates that human positionality within nature is not immutable and that practical mechanisms exist for evolving the moral context of conservation. Lastly, in Part 3, I examine two case studies of morally inclusive coexistence in practice to offer a small but meaningful glimpse into opportunities for achieving conservation goals when conservation is predicated on positioning humans as part of a natural world that is teeming with moral significance.

Part 1: Barriers of human exceptionalism in conservation practice

In Part 1, I identify barriers to conservation that arise when conservation practice is informed by human exceptionalism and moral exclusion of wildlife. In the two case studies included in this part, I ask how and why human exceptionalism can underpin harm within the discipline and limit the scope of scientific investigation in coexistence landscapes. I explore this question by providing a pathway towards transparent and ethical decision-making that brings awareness to normative influence in conservation and discussing how moral inclusion can encourage a more holistic interrogation of complex coexistence systems.

Normative constructs, such as nature, are critical for calling conservationists to action and for prioritising where to allocate limited resources. Such terms, however, are socially constructed, and therefore reflect the mainstream paradigm (Lapinski & Rimal 2005); in conservation, this means that words such as tragedy and pest are underpinned by human exceptionalism and moral exclusion. It is critical that the values and expectations that inform normative constructs used in conservation are made transparent, or they risk being used inconsistently to support intervention (e.g., Artelle et al. 2014). Problematically, conflicts that arise from lack of transparency, inconsistency, and poor logic can create a distrust within the conservation community and with the public; this distrust generated by poor conservation decision-making can permeate into future conservation efforts, inhibiting progress and success (van Eeden et al. 2017; Riley et al. 2018).

In chapter 3, published in *Conservation Biology*, I investigate how and why normative constructs such as nature can contribute to poor decision-making, public backlash, and justifications of harm. I begin by introducing a case study on a controversial conservation program in Queensland, Australia that led to global outcry and ultimately termination of the program. I used argument analysis, a tool that breaks down arguments into a series of premises that lead to a conclusion, to deconstruct a central argument provided by a local government official to justify the program to eradicate goats using poison-laced dingoes. The logical construction of the argument fails to pass muster because it hinges on a loosely defined interpretation of nature.

This case study demonstrated the ways in which poor transparency of inconsistent interpretations of nature and other normative constructs can lead to poor logical decision-making and allow conservation practitioners to discount the welfare implications for wildlife, overlook scientific evidence, and ultimately justify harm. Whether the program was warranted based on other arguments or not, the program generated considerable discord within the conservation community as well as public backlash, both of which can stifle progress in conservation. This work ultimately found that the strength of the decision-making process is revealed when values are made transparent.

It is evident that this program was built on the framing that nature should thrive despite humans, a paradigm that took hold in the 1980s (Mace 2014). This framing, however, is problematic because it positions humans outside of nature entirely and dichotomises the interests of humans and wildlife. In contrast, the most recent paradigm of “people and nature” aims to reconcile the needs of both humans and wildlife by realising their entanglement (Mace 2014). Human wildlife coexistence is one practice that reflects this new paradigm. In my second research chapter (chapter

4), I ask to what degree does the contemporary HWC and coexistence literature engage with the paradigm of “people and nature” and examine why shifting from human exceptionalism towards moral inclusion, which is better framed as “people and *the rest* of nature”, may improve coexistence outcomes.

The discipline of human wildlife coexistence has gained momentum in the last decade as a direct response to increasing conflicts between humans and wildlife on shared landscapes (Madden 2004; Peterson et al. 2013; Nyhus 2016). In essence, human wildlife conflict reflects situations when the needs or goals of humans impede on those of wildlife, or vice versa (Madden 2004). Conflicts between humans and wildlife often stem from human population growth, such as land use conversion and encroachment on wildlife habitat (Nyhus 2016). While these interactions can be dangerous for humans, human wildlife conflict is also recognised as a leading threat to global biodiversity (Nyhus 2016). Problematically, the term human wildlife conflict fosters a human-nature dualism that frames humans and wildlife as adversaries and situates animals as willing perpetrators of harm (Peterson et al. 2013). This framing reinforces human exceptionalism and moral exclusion of wildlife as others who do not follow rules of fair play. Recognising that HWC is quite negative, conservation discourse is shifting to the use of the term *coexistence* as a way to refocus attention away from the human versus nature dichotomy and towards a more nuanced understanding that humans and wildlife both have rights to shared space (Madden 2004; Peterson et al. 2013). Problematically, an entrenched coupling of HWC and coexistence stymies a shift towards positive framings of coexistence on multispecies landscapes.

By examining coexistence within a holistic framework that reflects the entanglement of socio-ecological relationships between stakeholders where all needs are considered, the challenge of promoting coexistence in production environments may be explicitly addressed. I therefore proposed two prerequisites – moral inclusion and a holistic approach – to help evolve practices and systems for the sharing of food production environments into those that prioritise the needs of all stakeholders of shared landscapes. In this systematic review, I chose to fulfil these prerequisites by framing this chapter within the context of cohabitation and One Health. Cohabitation, a morally inclusive and holistic approach to coexistence, captures the entanglement of socio-ecological relationships between stakeholders in a way that promotes multispecies landscapes where all needs are considered (Boonman-Berson et al. 2016; Toncheva & Fletcher 2021), while One Health, which posits that the health outcomes of humans, animals, and the environment are inextricably related (Zinsstag et al. 2011; Gibbs 2014), provides a suitable framework for examining engagement with the principles of cohabitation within the disciplines of HWC and coexistence. I used these prerequisites to gauge the current level of holistic contextualisation of multispecies landscapes in the HWC and coexistence literature and then explored reasons for why moral expansiveness and One Health together may incentivise humans to share space and embolden a coexistence landscape that fosters empathy for all its inhabitants.

Given the critical importance of food production landscapes for the survival of humans and wildlife alike, my interest was to investigate how moral inclusion and a holistic approach manifest in the literature on human wildlife coexistence specifically on production landscapes; I therefore modified the traditional One Health spheres into human, farm, and environmental health to better reflect the relevant stakeholders. I gathered the literature on HWC and coexistence from 2009 to 2019 that met our selection criteria, which amounted to 88 articles. I then used NVIVO, a qualitative data analysis program to code each article for the outcomes or impacts of sharing space that were mentioned or considered in the text, such as crop loss, wildlife disease, or livestock productivity. Each of these codes corresponded to one of the three modified One Health spheres.

We then counted the total number of codes that each article referenced in each sphere. From our analysis, we found that most articles only mentioned one or two codes from each sphere, most of which represent the key interests of humans, farm production, and the environment, such as crop loss or species conservation. This was to be expected, as the dominant narrative of conflict positions certain metrics, and therefore codes, above others. Notably, however, topics that are critical for ensuring that stakeholder needs are equitably addressed in shared landscapes, such as livestock intrinsic value and wildlife autonomy, were largely absent from our analysis. Those that were present in the literature, such as wildlife intrinsic value and livestock welfare, were not dominant in the literature and were, for the most part, mentioned only in articles that better engaged with the holistic context of their research. We also looked at how often codes occur together in the literature and found that the most common codes were heavily concentrated together. In other words, the articles were narrowly focused on the few predominant themes, rather than realising the breadth of outcomes that are associated with sharing space.

The narrative of conflict can result in a narrow contextualisation of coexistence in the literature, which was reflected in a cursory engagement with the relational entanglement of humans and wildlife and the ways that their interactions co-shape the landscapes in which they live (Harihar et al. 2013; Boonman-Berson et al. 2016). The discussion in this chapter aims to address this issue by examining the social and moral context of conflict and coexistence and offering pathways that cohabitation and One Health together can provide to support equitable coexistence outcomes in multispecies landscapes.

Part 2: Pedagogy of moral inclusion

With a grounded understanding of the subjectivity of nature and the ways in which the relational position of humans as separate from nature can act as a barrier to conservation, in Part 2 I explore a pedagogical approach to repositioning humans within nature. One way to mitigate human exceptionalism is by expanding circles of moral inclusion (Plumwood 1993; Knutson 2013). In chapter 5, published in *Biological Conservation,* I investigate whether a Humane Education pedagogical approach can soften the Western foundations of attitudes towards wildlife and encourage moral inclusion.

Expanding circles of moral inclusion is critical for conservation because compassion intrinsically motivates actions that care for and safeguard the wellbeing of others (Goetz et al. 2010). In other words, it effectively bridges the gap between knowing something and acting on it. Previous research on moral inclusion has found that moral expansiveness is predictive of pro-social and pro-environmental behaviours (Laham 2009; Bratanova et al. 2012), which suggests that increasing moral expansiveness has the potential to dismantle the barriers discovered in chapters 2 and 3. Fortunately, moral inclusion, and compassion by extension, is not static; humans are constantly utilising cues from their social environments and experiences to inform how they construct their circles of moral inclusion (Opotow 1990; Laham 2009).

The teaching method of Humane Education imparts core learning objectives through the lens of compassion for all living beings, while challenging students to apply critical thinking and investigate global issues (IHE 2020). While people can be challenged with humane education at any age, primary school is particularly interesting because it prioritises instruction in both foundational learning skills and prosocial skills at a critical stage of social development (Schonert-Reichl et al. 2012). My goal was to evaluate whether focusing on compassion and moral inclusion in primary school education could influence the construction of children’s moral circles. Utilising an existing relationship with a local primary school, I redesigned the 5th grade science curriculum using a humane education framework. The new lesson plans consisted of interactive activities that achieved curriculum objectives while introducing concepts of intrinsic value, the moral circle, and sharing space with wildlife. The goal was to encourage a deeper understanding of and connection to the lives of wildlife.

I used a pre-post quasi-experimental design to evaluate how this curriculum influenced the animals that children included in their moral circles, as well as their justifications for why they included them. The survey asked students to place seven species inside or outside their moral circles and then to explain why they chose to include or exclude them. I used NVIVO to identify and analyse normative trends in their justifications, such as aesthetics, intrinsic value, and perceived danger. Following the treatment, we saw a significant increase in the number of animals included in children’s moral circles, as well as a significant decrease in perceptions of danger and a significant increase in intrinsic value compared to the pre-test survey. Though this was a small study, it clearly demonstrates that moral circles are amenable to expansion. By successfully promoting greater compassion for nonhuman animals, implementing interventions like coexistence education programs, and establishing policies that replace negative norms with those that affirm the value of all living beings, the public may develop deeper connections with other living beings and ultimately feel inspired to coexist with and protect earth's biodiversity.

Part 3: Entanglement in practice

While more expansive moral inclusion is critical to improving conservation outcomes, it would be remiss to conclude that simply acknowledging the moral significance of wildlife would resolve competing interests between humans and wildlife. In Part 3, I explore opportunities for conservation on coexistence landscapes when humans are positioned as entangled with, rather than separate from and above, the rest of nature. The two case studies in this part each offer an example of morally inclusive coexistence in practice.

Numerous non-lethal methods are used to mitigate the challenges of competing interests, but they vary in impact and effectiveness. Non-lethal tools that rely on exclusion, such as fencing, can be detrimental to wildlife movement and habitat connectivity, and causes considerable physical harm (Woodroffe et al. 2014). The use of effective tools to mitigate these impacts and foster sustainable coexistence is therefore of critical importance. Though these tools may temporarily alter wildlife movement or landscape use, deterrents do not exclude wildlife from the landscape altogether (Stone et al. 2017b). By using these devices, wildlife can continue to freely pursue their needs and objectives, just like humans already do.

Empirical studies that exist to support the utility of non-lethal tools such as fladry, livestock guardian dogs, and night-time corralling, most often quantify the functional effectiveness of non-lethal tools by measuring success in conflict reduction (see Eklund et al. 2017, van Eeden et al. 2018). While this approach is undoubtedly practical, it does not directly provide information on the mechanism driving behavioural change in wildlife. Investigation into behavioural effects demands urgent attention because evidence that can be used to refine non-lethal deterrent technology and therefore improve outcomes can assist in reducing emphasis on culturally normative lethal control of wildlife and help codify non-lethal practices into evidence-based policy. In chapter 6, I test the efficacy of Foxlights, a non-lethal and temporary night-time predator deterrent manufactured by Foxlights Australia Pty Ltd (Foxlights 2021). Equipped with 9 night-activated lights that randomly flash in three colours (red, blue, and white), Foxlights were designed to reduce predation on livestock by mimicking night-time human presence.

Foxlights are promoted and used globally, though few scientifically-rigorous studies exist to substantiate the effect of Foxlights on deterring wildlife from using human-cultivated spaces; the success of Foxlights is largely supported by anecdotal evidence. Studies that measure the deterrent’s effectiveness do so mostly in terms of levels of livestock predation (van Eeden et al. 2018a; Ohrens et al. 2019). While these types of investigations are pragmatic for livestock producers, they do not evaluate the effectiveness of the device on its target – the predator – which ultimately overlooks the unique behavioural ecologies of wildlife and accompanying calculations of risk that the device seeks to exploit (Lima & Bednekoff 1999; Ramp et al. 2005; Fischer et al. 2017). I sought to address this by using a camera trap study to examine how Foxlights alter the behaviour of red foxes (*Vulpes vulpes*) and eastern grey kangaroos (*Macropus giganteus*) in food production landscapes.

Our study used a Before-After Control-Impact (BACI) to evaluate changes in behaviour. I set up two camera trap transects at each of two sites along the fence lines of pastures that border wildlife habitat. Following a two-week control camera trapping period, I activated three Foxlights for two weeks on one randomly selected transect at each location while maintaining the control period at the other. The utility of the BACI design lies in its ability to isolate the treatment effect from the local natural variability inherent in field trials (Stewart-Oaten & Bence 2001). We analysed the camera trap images to determine how the activation of Foxlights impacted the presence of foxes and kangaroos, the duration of their behaviour when they were present, and diurnal patterns of activity.

While our study did not detect major aversion to the Foxlights, we found utility in the BACI design for investigating the efficacy of a non-lethal deterrent under field conditions. The BACI design provides a robust method for controlling for innate differences across environmental landscapes and production management that can confound experimental results; however, the design cannot control the highly variable nature of animal behaviour. Nevertheless, best practice in research design into non-lethal methods for conflict reduction are needed to influence wildlife decision-making and to embolden efforts to change the ways in which we interact with our nonhuman neighbours. Studies such as this one are critical for supporting people’s desires to cohabit.

Lastly, in chapter 7 I evaluate the utility of wildlife-friendly farming as a One Health approach to sustainable food production. Food production is a leading driver of biodiversity decline, climate change, and environmental degradation (Milton et al. 1994; Godfray et al. 2010; Foley et al. 2011; Ripple et al. 2015) and has itself has become vulnerable to these consequences (Milton et al. 1994; Mann & Sherren 2018). There is therefore an increasing global focus on the development of policy and practical mechanisms that promote and secure the health and resilience of production landscapes. The adoption of sustainable food production practices has been proposed as a vital strategy for meeting the demands of a growing human population and nature conservation (Godfray et al. 2010; Foley et al. 2011; Tscharntke et al. 2012).

Sustainable food production is outlined in global policy as a clear target for simultaneously improving global food security and protecting biodiversity. Policies from the United Nations Sustainable Development Goals and Conventional on Biological Diversity underscore the inextricable relationship between human and wildlife health and their mutual dependence on ecological health and resilience (UN 2017; CBD 2020). Through these policies, it is clear that holistic approaches to revitalising mutually beneficial outcomes for nature and people are needed to transform the concept of sustainable food production into practical solutions. In this study, I asked whether holistic wildlife-friendly farming could be a suitable option for meeting the global demand for sustainable food production.

We constructed a One Health network diagram of livestock production landscapes as a framework for evaluating the capacity of different food production strategies to realise sustainable food production. The diagram sheds light on the complexity of the interactions between spheres on production landscapes by illustrating the directions of health relationships between the spheres and by presenting a selection of key indicators of health. Our interest was to use our diagram to guide a case study that investigates how One Health relationships actualise on a wildlife-friendly farm in South Africa relative to neighbouring conventional farms.

We collected data on livestock foraging activity, livestock body condition (an indicator of performance), and vegetation patch cohesion on three farms in the Nama Karoo region of South Africa. Two farms employed conventional livestock management strategies that entail long-term grazing in large pastures and lethal persecution of wildlife, and one farm employed wildlife-friendly practices of shepherding and night-penning, which enable high density short duration grazing and non-lethal protection of livestock from wildlife. We found that the three farms examined followed very different journeys through our One Health network diagram, only to arrive at relatively similar productivity targets with respect to livestock but vastly different measures of wellbeing in other One Health spheres. Unlike conventional farming, the wildlife-friendly farm aimed to revitalise the critical landscape processes that are needed to begin rebuilding resilient landscapes that can support both food production and wildlife. In this practical case, morally inclusive and holistic coexistence offered an equally productive food production strategy that also served as a promising approach to sustainable food production.

Conclusion

My dissertation explores how and why human exceptionalism manifests in conservation and offers moral inclusion as an antidote to this entrenched norm. The three parts create a pathway towards morally inclusive coexistence by identifying barriers to conservation created by human exceptionalism, validating a pedagogical approach predicated on moral inclusion as a mechanism for mitigating this entrenched Western norm, and evaluating opportunities for conservation that exist when morally inclusive coexistence is prioritised. Ultimately, this pathway shows that conservation, and more specifically coexistence, that is reframed by moral inclusivity can support progress in the ethical and practical outcomes of coexistence.

My goal with this dissertation is to offer a positive contribution to the world of wildlife conservation, where we can protect biodiversity in a way that *all* wild animals, regardless of their origins, aesthetic, or impacts are viewed as morally relevant members of multispecies societies. I aim to provide a pathway to re-envisioning conservation as a discipline that encourages the moral inclusion of those deemed as others, whose lives are oft considered morally inconsequential. The only way I see that we can do this is to stop making conservation about human needs, preferences, and dignities, both in academia and in practice, and instead infuse the discipline with principles of moral expansiveness, acceptance, and collaboration.

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Part 1: Barriers of human exceptionalism in conservation practice

My dissertation uses a case study approach to investigate what happens when conservation and, more specifically, coexistence on production landscape, are reframed by moral inclusivity and seeks to uncover whether mutualistic pathways improve the ethical and practical outcomes of coexistence. I pursue this in three sequential parts – barriers, pedagogy, and opportunities – that together support the argument that a holistic, morally inclusive coexistence is critical to the progress of conservation in shared landscapes.

Part 1 seeks to identify barriers to conservation that arise when the intrinsic value and moral significance of wildlife are overlooked. I reveal how normative constructs underpinned by mainstream conservation can stifle progress in conservation through poor decision-making, public backlash, and justifications of harm and provide a pathway to improving transparency and ethical decision-making within the discipline. I then explore how the normative position within conservation lends itself to a more limited understanding of multispecies coexistence landscapes and discuss how the adoption of morally inclusive coexistence can encourage a more holistic interrogation of complex coexistence systems.

Chapter 3. Cautioning against overemphasis of normative constructs in conservation decision making

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Abstract

Questions around how to conserve nature are increasingly leading to dissonance in conservation planning and action. While science can assist in unravelling the nature of conservation challenges, conservation responses rely heavily on normative positions and constructs to order actions, aid interpretations, and provide motivation. However, problems can arise when norms are mistaken for science or when they stymy scientific rigor. To highlight these potential pitfalls, we used the ethics-based tool of argument analysis to assess a controversial conservation intervention, the Pelorus Island Goat Control Program. The program proponents' argument for restorative justice was unsound because it relied on weak logical construction overly entrenched in normative assumptions. Overreliance on normative constructs, particularly the invocation of tragedy, creates a sense of urgency that can subvert scientific and ethical integrity, obscure values and assumptions, and increase the propensity for flawed logic. This example demonstrates how the same constructs that drive biodiversity conservation can also drive poor decision-making, spur public backlash, and justify poor animal welfare outcomes. To provide clarity, a decision-making flowchart we devised demonstrates how values, norms, and ethics influence one another. We recommend practitioners follow 3 key points to improve decision-making: be aware of values, as well as normative constructs and ethical theories that those values inform; be mindful of overreliance on either normative constructs or ethics when deciding action is justified; and be logically sound and transparent when building justifications. We also recommend 5 key attributes that practitioners should be attentive to when making conservation decisions: clarity, transparency, scientific integrity, adaptiveness, and compassion. Greater attention to the role of norms in decision-making will improve conservation outcomes and garner greater public support for actions.

Introduction

Questions of how to engage with nature and rectify human global impacts continue to inundate the conservation community. Urgent action is needed in the face of unprecedented wildlife species extinction rates and population declines (Bellard et al. 2012; WWF 2016). The rapid and far-reaching changes taking place – driven by a multitude of processes and threats – continue to overwhelm policy makers, conservation practitioners, and the general public, leading to dissonance and confusion. Conservationists agree that action ought to be taken to conserve biodiversity, but how that should be achieved remains divisive.

Although empirical information (e.g., scientific evidence, observation) can assist in unravelling global environmental changes, it cannot advise on how conservationists ought to respond. Instead, conservation decision makers, both those in policy and those responsible for designing and implementing science-based intervention, rely on social norms (i.e., societal expectations and codes of conduct) to help garner a clear conservation mandate and develop ethical conservation practices (Chew & Laubichler 2003; Lapinski & Rimal 2005; Manfredo et al. 2017; Batavia et al. 2019). These social norms are often communicated using terms that are amenable to socially constructed interpretations (Proctor 1998), also known as normative constructs. The definition and declaration of normative constructs are open to interpretation and guided by the values of decision makers and the societal context (Chew & Laubichler 2003; Lapinski & Rimal 2005; Estévez et al. 2014). Generally speaking, normative constructs have 3 components: a factual definition (e.g., pest: “a plant or animal detrimental to human concerns” [Merriam-Webster Dictionary 2018]); the socially constructed judgment of what fits that definition (e.g., Is this animal a pest? When? To whom?); and an implicit value statement or justification for action (e.g., pests ought to be removed) (Proctor 1998). Both social norms and normative constructs serve as heuristics in decision-making processes, and are therefore fundamental to motivating practitioners and assisting in the prioritisation of scarce resources (Lapinski & Rimal 2005). More importantly, in the conservation decision-making model we devised for this study (Fig. 1), normative constructs are critical for interpreting available empirical information (i.e., normative interpretations) and initiating a call to action. Exactly how one ought to act, however, is informed by the ethical theories (e.g., deontology, consequentialism) held by the decision makers themselves (Estévez et al. 2014). Combined, norms and ethics are important drivers of decision-making. The challenge is to be cognisant of the power of norms and ethical theories in the decision-making process.

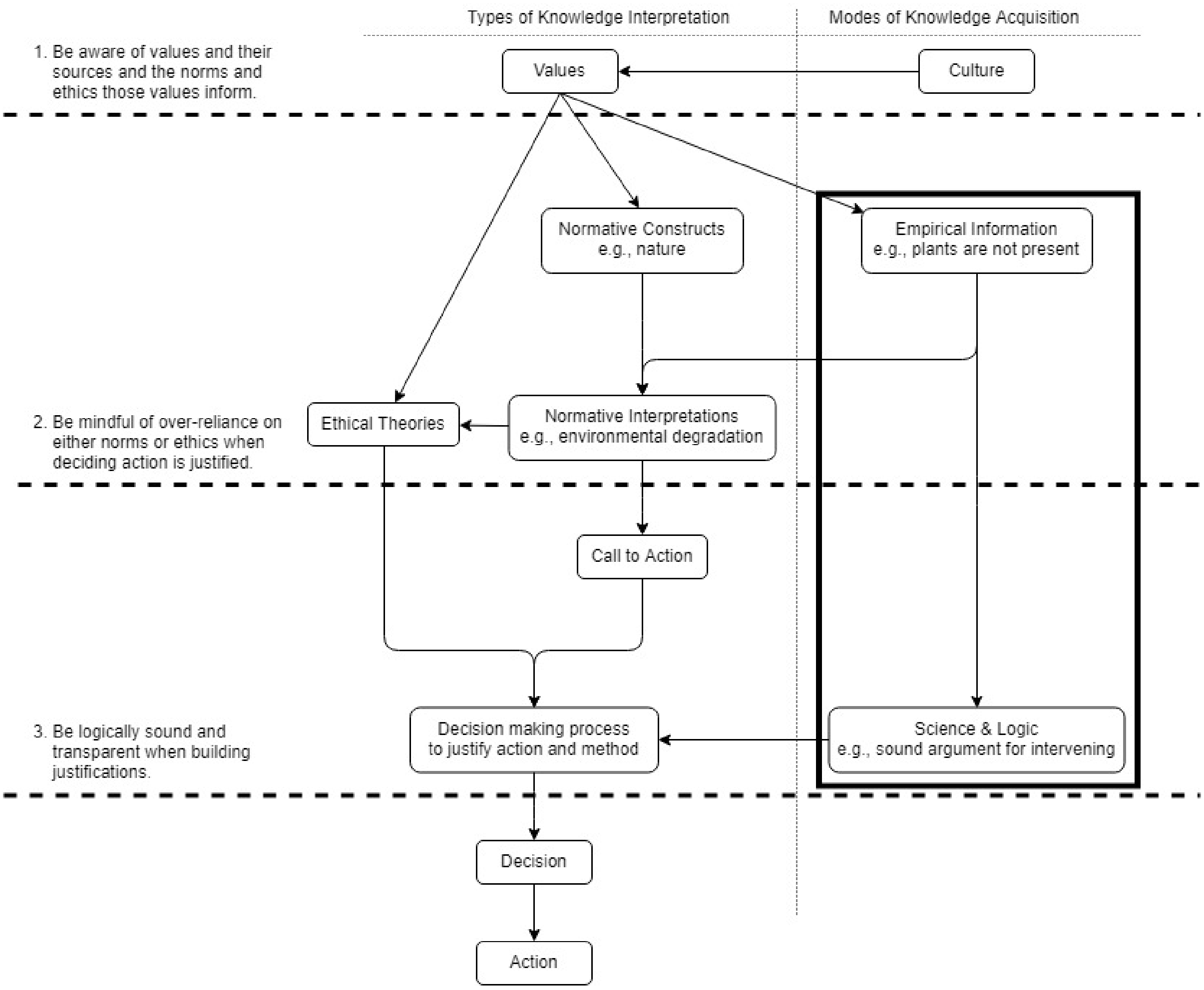

Figure 1. A conceptual model of conservation decision-making that defines the integral components of the decision-making process and thus increases the transparency of the role of values, norms, and ethics in conservation planning and decision-making. Informed by societal values, normative constructs are critical for interpreting available empirical information, for choosing which ethical theories to follow, and for initiating a call to action. In contrast, ethical theories (e.g., deontology, consequentialism) inform how one ought to act. Knowledge interpretations can be equated with or misconstrued as modes of knowledge acquisition, which can obfuscate ethical theories and allow the decision-making process to sacrifice rigorous scientific analysis and logical argument construction (bold rectangle and arrows, components of the decision-making process omitted when normative constructs are over-emphasised; dashed lines, checkpoints that temporarily pause decision-making flow to avoid this truncated pathway: 1, elucidates motivations and priorities of the decision maker and identifies those who may benefit from the decision-making process; 2, recommends self-reflection by the decision makers, identifies potential points of contention, and encourages stakeholder consideration and engagement; 3, ensures decisions are thoroughly developed, are not grounded on inappropriate assumptions or poor reasoning, and are informed by relevant science).

The last few years have witnessed increasing criticism of the lack of, or selective use of, scientific evidence and strong logic to support conservation policy (Treves 2009; Vucetich & Nelson 2012; Artelle et al. 2014; Bergstrom et al. 2014). Conservation programs that violate basic principles of logic or disregard scientific evidence are commonplace and often spur public, scientific, and political controversy. Recent topical examples include Canadian wildlife agencies manipulating scientific statements against grizzly bear (*Ursus arctos horribilis*) hunting to support new hunting seasons (Artelle et al. 2014) and government officials ignoring peer-reviewed evidence that badger (*Meles meles*) culling is an ineffective method for long-term reduction of bovine tuberculosis (Jenkins et al. 2010). In such cases, evidence suggests that the normative constructs, hidden assumptions, and ideological beliefs that shape social and political agendas are overly influencing the reasoning of decision makers (Heeren et al. 2017) to the extent that fundamentals of logic are circumvented.

We explored this worrying trend by examining how the overemphasis of the reason for acting (i.e., normative constructs) might be disrupting and delegitimising decision-making processes. By characterising the relationships between values, norms, empirical evidence, and ethics in decision-making (as depicted in Fig. 1), we postulated that the overemphasis of norms may generate 3 primary concerns: that the acquisition of knowledge may not be pursued, either because it is deemed unnecessary or because the normative interpretations are misconstrued as empirical evidence; that clear interpretations of and adherence to ethical theories may become obfuscated; and that arguments for intervention may be increasingly susceptible to failures in logic (Chew & Laubichler 2003). Failure to acquire proper empirical evidence to support interventions can make program evaluation difficult and justifications difficult to convey (e.g., Walsh et al. 2012; Bergstrom et al. 2014). Irrespective of the support for the underlying normative positions, universal community and scientific support can be withdrawn if there is a perception of insufficient ethical consideration or transparency (Miller et al. 2011; Robinson 2011; Ban et al. 2013; Ramp et al. 2013). More problematically, decision makers may mistakenly rely on interpretation of social norms to retroactively justify interventions, rather than articulating logical arguments supported by strong evidence and being explicit about values and assumptions.

To work through how these pitfalls manifest in contemporary conservation decision-making, we performed an ethics-based analysis of a recent topical example that attracted considerable international debate. While this example is not reflective of all conservation decisions that attract negative debate, we selected it because it clearly highlights a situation where there was a strong emphasis of normative constructs in the decision-making process. Our case study originated on Pelorus Island, Queensland, Australia, where a management plan conceived by the local council and conservation scientists was eventually abandoned after international outcry and state government intervention. We suggest that the methods proposed, and subsequently partially taken, transgressed most rational and ethical considerations and had little support despite having goals that align with a mainstream conservation agenda, namely the removal of introduced species.

To explore our case study, we employed the ethics-based tool of argument analysis, which evaluates the degree to which decision-making adheres to the rules of informal logic and adequate transparency (Hughes et al. 2010; Vucetich & Nelson 2012). This method breaks down an argument into its 2 basic components – premises and conclusions – and evaluates each premise for truth and examines the construction of the argument for valid logic (a detailed introduction to argument construction and argument analysis is available in Supporting Information). This process tests whether decisions are underpinned by arguments that are clear, consistent, and sound and sheds light on the way normative constructs intersect with values and ethical positions to shape those decisions (Vucetich & Nelson 2012). We applied argument analysis to the Pelorus Island narrative as a case study for describing the importance of moral attentiveness, for detailing strategies to earn the confidence of both scientists and lay stakeholders, and for analysing the fundamental drivers of contentious conservation decision-making. We used this process to inform a toolkit for conservation decision-making, complete with a decision-making conceptual model, checkpoints, and recommendations that we believe will help practitioners and policy makers construct robust and transparent conservation programs and prevent discord in future conservation planning.

Pelorus Island Goat Control Program

Pelorus Island lies off the coast of northern Queensland approximately 85 km north of Townsville. Dominated by littoral rainforest, the small island (~4km^{2}) belongs to a group of rare ecosystems with ≥70% closed canopy cover and within 2 km of the coast (DECC 2008; Schwartz 2016a). In July 2016, elected officials from the Hinchinbrook Shire council commenced the Pelorus Island Goat Control Program (PIGCP), designed to eradicate ß300 goats (*Capra aegagrus hircus*) from the island (Cripps 2016). The goats were introduced to the island over 200 years ago as a food source for lighthouse keepers and shipwrecked sailors. Scientific evidence justifying the need to intervene is not publicly available, but the Hinchinbrook Shire council deemed removal of the goats was necessary because their presence was purportedly linked to undesirable ecological states that cause increased runoff and soil erosion (Schwartz 2016a).

The intervention planned to trap 4 wild male dingoes (*Canis dingo*) on the Australian mainland, castrate and vaccinate them, attach GPS collars, and then introduce them to the island to predate on the goats (Cripps 2016; Schwartz 2016a). After 2 years, the dingoes would be lethally shot to prevent them from predating upon other fauna. As a precaution, however, each dingo would be implanted with lethal 1080 (sodium flouroacetate) poison capsules that would dissolve and kill them after 2 years if shooting proved too difficult (Cripps 2016; Schwartz 2016a). This program was approved by the Queensland Animal Ethics committee and was partially funded by the Australian Academy of Science (Townsville Bulletin 2016; Australian Academy of Science 2017). The PIGCP was intended as a test case and, if successful, would be expanded to other islands inhabited by goats (Schwartz 2016a). The program commenced in July 2016 with the release of 2 poison-laced dingoes.

Publicity of the intervention on *ABC Landline* prompted swift condemnation from the Royal Society for the Prevention of Cruelty to Animals (RSPCA). Likewise, the general public communicated opposition in social media posts and an online international petition that garnered nearly 200,000 signatures in protest. Positions denouncing the project cited unjustifiable consequences such as the welfare of the goats, the poisoning of the dingoes, and the potential harm to small native animals (Goldman 2016; Miles 2016; Schwartz 2016b). Responding to the public backlash, the Queensland Minister of Environment intervened to halt the program with an Interim Conservation Order on the grounds that it endangered a threatened shore bird (Goldman 2016; Miles 2016; Schwartz 2016b).

Methods

Using argument analysis, we identified the major arguments articulated by both proponents and objectors and evaluated key reasoning and justifications. We then selected a central argument articulated by proponents and examined the premises and conclusion that compose the argument. Finally, we assessed the argument for its dependency on scientific evidence and normative constructs to understand how the decision to intervene and the actions taken were justified.

Stakeholder Reason Statements

We reviewed available newspaper articles, television programs, social media posts, press releases, and communication plans published over the 7 months following the public announcement of the PIGCP in July 2016. We identified key stakeholders and collated statements made by each as pertains to the PIGCP (Table 1). We classified statements according to support or disapproval for the PIGCP and extracted reasons from these statements, which were sorted into a reason table (Table 2). The reasons provided are inferred from public statements and the PIGCP itself and are therefore not exhaustive. We assumed that primary reasons for implementing the PIGCP were publically stated, but it is possible a fundamental reason was withheld. From this table, we selected what we inferred was a central reason for supporting the implementation of the PIGCP to examine further.

Table 1. Stakeholder statements supporting and opposing the Pelorus Island Goat Control Program (PIGCP)[a] aggregated from news reports, articles, press releases, and petition websites in the 7 months following the announcement of the PIGCP.

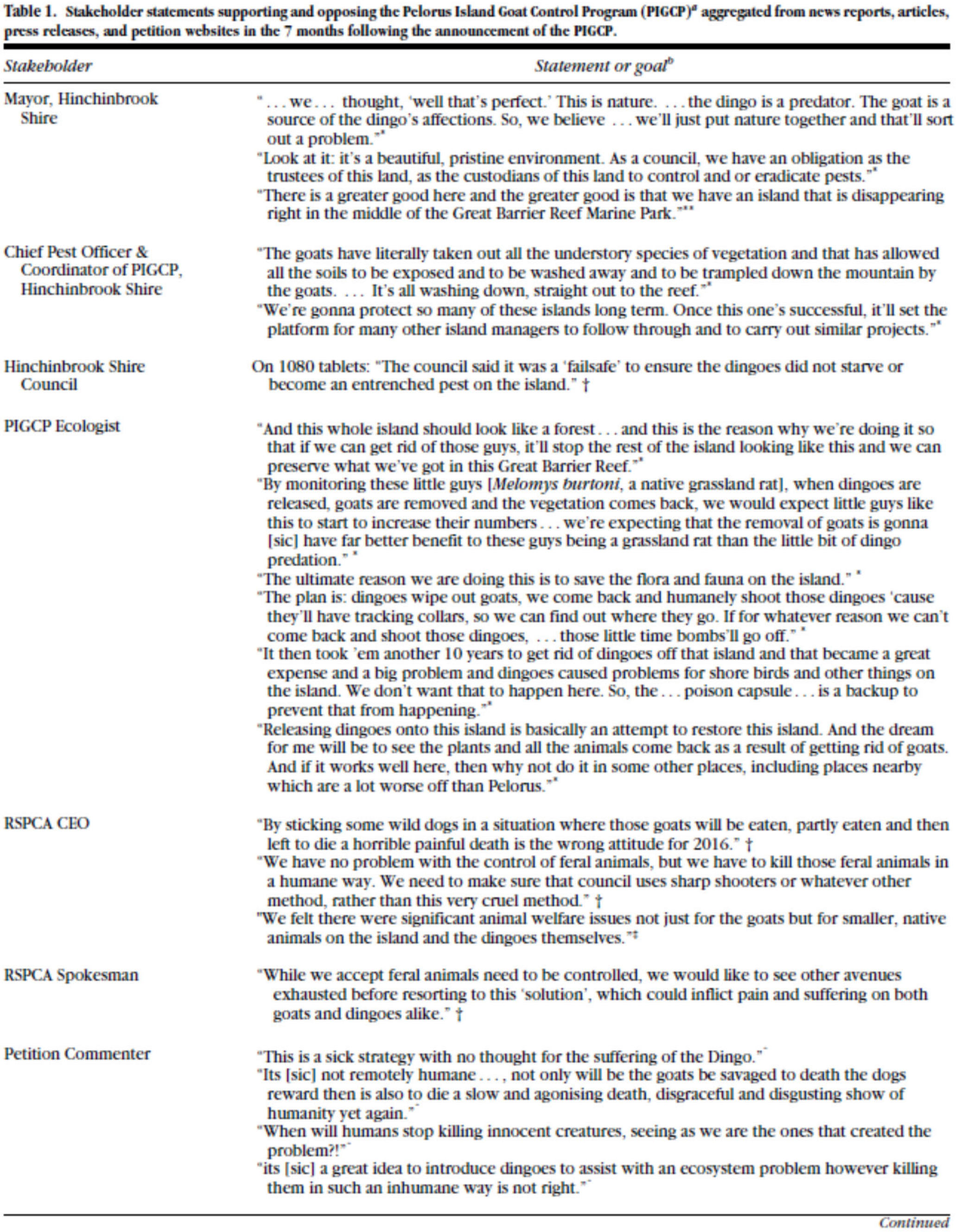

Table 1. Stakeholder statements supporting and opposing the Pelorus Island Goat Control Program (PIGCP)[a] aggregated from news reports, articles, press releases, and petition websites in the 7 months following the announcement of the PIGCP.

Stakeholder	*Statement or goal*[b]
Mayor, Hinchinbrook Shire	"... we ... thought, 'well that's perfect.' This is nature. ... the dingo is a predator. The goat is a source of the dingo's affections. So, we believe ... we'll just put nature together and that'll sort out a problem."[*] "Look at it: it's a beautiful, pristine environment. As a council, we have an obligation as the trustees of this land, as the custodians of this land to control and or eradicate pests."[*] "There is a greater good here and the greater good is that we have an island that is disappearing right in the middle of the Great Barrier Reef Marine Park."[**]
Chief Pest Officer & Coordinator of PIGCP, Hinchinbrook Shire	"The goats have literally taken out all the understory species of vegetation and that has allowed all the soils to be exposed and to be washed away and to be trampled down the mountain by the goats. ... It's all washing down, straight out to the reef."[*] "We're gonna protect so many of these islands long term. Once this one's successful, it'll set the platform for many other island managers to follow through and to carry out similar projects."[*]
Hinchinbrook Shire Council	On 1080 tablets: "The council said it was a 'failsafe' to ensure the dingoes did not starve or become an entrenched pest on the island." †
PIGCP Ecologist	"And this whole island should look like a forest ... and this is the reason why we're doing it so that if we can get rid of those guys, it'll stop the rest of the island looking like this and we can preserve what we've got in this Great Barrier Reef."[*] "By monitoring these little guys [*Melomys burtoni*, a native grassland rat], when dingoes are released, goats are removed and the vegetation comes back, we would expect little guys like this to start to increase their numbers ... we're expecting that the removal of goats is gonna [sic] have far better benefit to these guys being a grassland rat than the little bit of dingo predation." [*] "The ultimate reason we are doing this is to save the flora and fauna on the island." [*] "The plan is: dingoes wipe out goats, we come back and humanely shoot those dingoes 'cause they'll have tracking collars, so we can find out where they go. If for whatever reason we can't come back and shoot those dingoes, ... those little time bombs'll go off." [*] "It then took 'em another 10 years to get rid of dingoes off that island and that became a great expense and a big problem and dingoes caused problems for shore birds and other things on the island. We don't want that to happen here. So, the ... poison capsule ... is a backup to prevent that from happening."[*] "Releasing dingoes onto this island is basically an attempt to restore this island. And the dream for me will be to see the plants and all the animals come back as a result of getting rid of goats. And if it works well here, then why not do it in some other places, including places nearby which are a lot worse off than Pelorus."[*]
RSPCA CEO	"By sticking some wild dogs in a situation where those goats will be eaten, partly eaten and then left to die a horrible painful death is the wrong attitude for 2016." † "We have no problem with the control of feral animals, but we have to kill those feral animals in a humane way. We need to make sure that council uses sharp shooters or whatever other method, rather than this very cruel method." † "We felt there were significant animal welfare issues not just for the goats but for smaller, native animals on the island and the dingoes themselves."[‡]
RSPCA Spokesman	"While we accept feral animals need to be controlled, we would like to see other avenues exhausted before resorting to this 'solution', which could inflict pain and suffering on both goats and dingoes alike." †
Petition Commenter	"This is a sick strategy with no thought for the suffering of the Dingo."[ˆ] "Its [sic] not remotely humane ..., not only will be the goats be savaged to death the dogs reward then is also to die a slow and agonising death, disgraceful and disgusting show of humanity yet again."[ˆ] "When will humans stop killing innocent creatures, seeing as we are the ones that created the problem?!"[ˆ] "its [sic] a great idea to introduce dingoes to assist with an ecosystem problem however killing them in such an inhumane way is not right."[ˆ]

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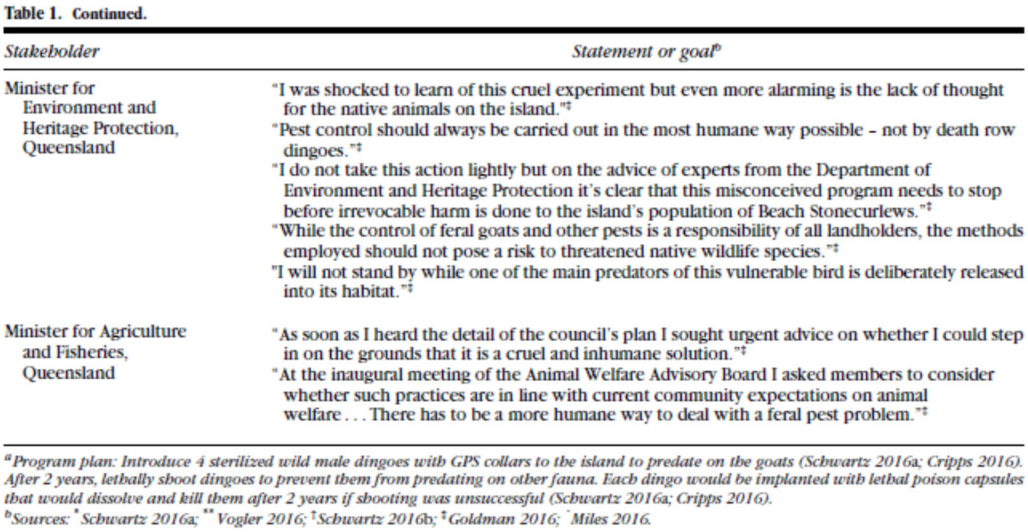

Table 1. Continued.

Stakeholder	*Statement or goal*[b]
Minister for Environment and Heritage Protection, Queensland	"I was shocked to learn of this cruel experiment but even more alarming is the lack of thought for the native animals on the island."[‡] "Pest control should always be carried out in the most humane way possible – not by death row dingoes."[‡] "I do not take this action lightly but on the advice of experts from the Department of Environment and Heritage Protection it's clear that this misconceived program needs to stop before irrevocable harm is done to the island's population of Beach Stonecurlews."[‡] "While the control of feral goats and other pests is a responsibility of all landholders, the methods employed should not pose a risk to threatened native wildlife species."[‡] "I will not stand by while one of the main predators of this vulnerable bird is deliberately released into its habitat."[‡]
Minister for Agriculture and Fisheries, Queensland	"As soon as I heard the detail of the council's plan I sought urgent advice on whether I could step in on the grounds that it is a cruel and inhumane solution."[‡] "At the inaugural meeting of the Animal Welfare Advisory Board I asked members to consider whether such practices are in line with current community expectations on animal welfare . . . There has to be a more humane way to deal with a feral pest problem."[‡]

[a] *Program plan: Introduce 4 sterilized wild male dingoes with GPS collars to the island to predate on the goats (Schwartz 2016a; Cripps 2016). After 2 years, lethally shoot dingoes to prevent them from predating on other fauna. Each dingo would be implanted with lethal poison capsules that would dissolve and kill them after 2 years if shooting was unsuccessful (Schwartz 2016a; Cripps 2016).*

[b] *Sources: [*] Schwartz 2016a; [**] Vogler 2016; [†] Schwartz 2016b; [‡] Goldman 2016; [´] Miles 2016.*

Table 2. A reason table for either supporting or rejecting the Pelorus Island Goat Control Program[a] constructed by extracting reasons from stakeholder statements in Table 1.[b]

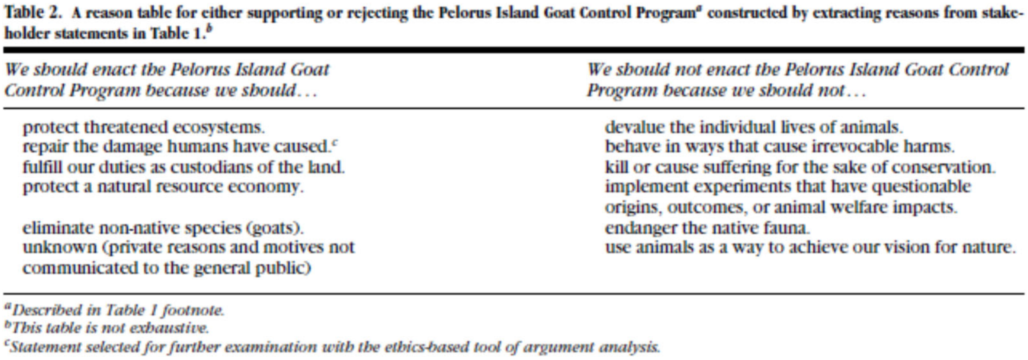

Table 2. A reason table for either supporting or rejecting the Pelorus Island Goat Control Program[a] constructed by extracting reasons from stakeholder statements in Table 1.[b]

We should enact the Pelorus Island Goat Control Program because we should . . .	*We should not enact the Pelorus Island Goat Control Program because we should not . . .*
protect threatened ecosystems.	devalue the individual lives of animals.
repair the damage humans have caused.[c]	behave in ways that cause irrevocable harms.
fulfill our duties as custodians of the land.	kill or cause suffering for the sake of conservation.
protect a natural resource economy.	implement experiments that have questionable origins, outcomes, or animal welfare impacts.
eliminate non-native species (goats).	endanger the native fauna.
unknown (private reasons and motives not communicated to the general public)	use animals as a way to achieve our vision for nature.

[a] *Described in Table 1 footnote.*

[b] *This table is not exhaustive.*

[c] *Statement selected for further examination with the ethics-based tool of argument analysis.*

The underlying motivation of conservation programs, such as the PIGCP, is to enable nature to flourish by preventing or reversing outcomes that inhibit progress. This concept largely reflects the widely accepted moral obligation to restorative justice, or repairing harm or damage we have caused. We examined the use of restorative justice as an argument supporting the implementation of the PIGCP because it invokes a sense of tragedy to nature, which can elicit a range of conservation intervention recommendations depending on the ethical theories and values held by the decision makers. To identify fundamental flaws in logic, we transformed a key inconclusive premise of the primary argument into the conclusion of a secondary argument, and a key inconclusive premise in the secondary argument into the conclusion of a tertiary argument. This created a nested set of arguments; the tertiary argument informed the truth or appropriateness of the premise in the secondary argument, which in turn informed the premise in the primary argument (Fig. 2). We added the implicit premises required to ensure logical strength and full transparency. A detailed explanation of this process is available in Supplementary Materials.

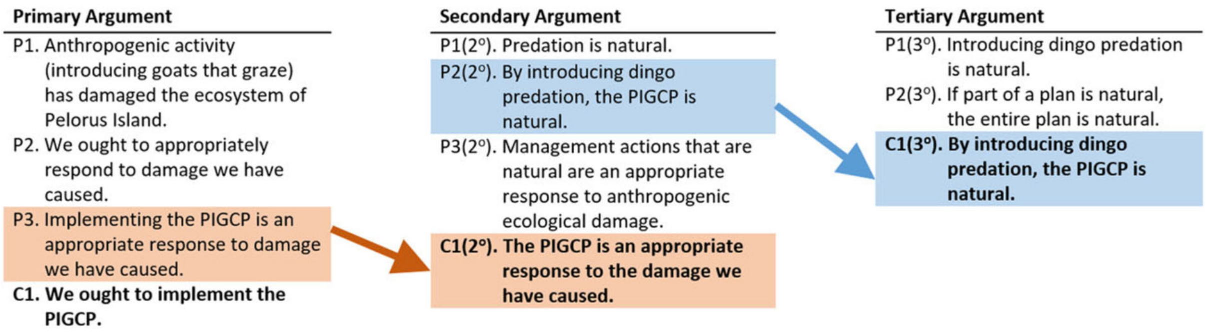

Figure 2. Example from the case study of the Pelorus Island Goat Control Program (PIGCP) of how argument analysis deconstructs a primary argument into a series of nested arguments to analyse the argument for truth and valid logic. To fully assess the soundness of the primary argument, a premise from the first argument becomes the conclusion of the secondary argument, and a premise from the secondary argument becomes the conclusion of a tertiary argument. This example is the nested argument supporting the implementation of the PIGCP.

Results

Primary Argument

The primary argument took the following general form (P, premise; C, conclusion).

P1. Anthropogenic activity (introducing goats that graze) has damaged the ecosystem of Pelorus Island.

P2. We ought to appropriately respond to damage we have caused.

P3. Implementing the PIGCP is an appropriate response to the damage we have caused.

C1. We ought to implement the PIGCP.

Premise 1 demonstrates how a normative interpretation can be presented as empirical evidence rather than informed by it (Fig. 1). First, this normative interpretation would be more defensible if grounded in scientific evidence, such as goat population estimates, vegetation indices, or erosion metrics. If scientific reports, findings, or analyses on the ecological state of Pelorus Island exist, they have not been released to the public or cited in Hinchinbrook Shire meeting minutes or biosecurity plan. A draft of the goat removal plan and communications strategy does not reference any science-based evidence of changing ecological states (Cripps 2016). Second, though this absence of evidence does not indicate evidence of absence, it does suggest that this statement overly relies on the unwavering belief in the tenets of the normative discipline of invasion biology (e.g., the mere presence of goats is evidence of harm). While the framework of invasion biology has become dominant in the last few decades, alternative scientific perspectives challenge its attempts to present empirical information as answers to questions that are based on (often anthropocentric) values and its tendencies to present values-based conclusions as empirical information (e.g., Chew & Laubichler 2003; Sagoff 2018). Ultimately the purpose of analysing the premise here is not to argue about the ecological function of goats, but rather to demonstrate the lack of scientific transparency that can occur when ardent credence in a normative discipline downplays critical analysis of normative influence and consequently equivocates normative interpretations with fact. Because this statement takes the form of a normative interpretation specific to one discipline that is not unanimously supported, P1 is inconclusive.

Premise 2 invokes the practice of restorative justice (i.e., fixing what we have broken). While not necessarily globally accepted, this premise can be justified from a variety of normative ethical frameworks. For example, repairing a harm or damage is likely to increase positive value in the world (relative to a world in which the harm is not repaired), and can thus be justified from a consequentialist perspective. From a virtue perspective, on the other hand, a commitment to right personal wrongs demonstrates virtues such as respect, honesty, and justice. Recent empirical work suggests these virtues are shared across cultural contexts (van Oudenhoven et al. 2014).

The evaluation of P3, which suggests the appropriate-ness of intervening, relies on the truth of P1, which we declared as unsubstantiated. Only when the justification for intervention in P1 is further investigated can one begin to explore whether the methods suggested in the PIGCP are scientifically robust and ethical. We were therefore able to analyse only the appropriateness of this premise under the assumption that P1 is true and could explore only the theoretical reasoning of the PIGCP method as a whole.

Secondary Argument (2^o)

The appropriateness of P3 can be evaluated by converting it into the conclusion of a new argument. The construction of this secondary argument (2^o) is informed by a line of reasoning stated by the mayor of the Hinchinbrook Shire (Schwartz 2016a).

P1(2^o). Predation is natural.

P2(2^o). By introducing dingo predation, the PIGCP is natural.

> *Mayor of Hinchinbrook Shire: "...we just thought, 'Well that's perfect.' This is nature. I mean, the dingo is a predator. The goat is a source of the dingo's affections. So, we believe that ...we'll just put nature together and that'll sort out a problem."*

P3(2°). Management interventions that are natural are appropriate responses to anthropogenic ecological damage.

C1(2°). The PIGCP is an appropriate response to the damage we have caused.

The ecological statement of P1(2°) is irrefutable, if only because it is tautological. Predation is a key component of food webs and energy transfer, trophic cascades, and life on Earth in general.

Premise 2(2°) is adapted directly from the ABC Land-line report (Schwartz 2016a), in which the mayor states that the PIGCP is nature. Such normative language evokes the age-old debate over the construct of nature. The operative definition of nature can shift considerably among various contexts of human intervention. British philosopher John Stuart Mill (1874) asserted that the frame of reference used to define nature is delineated by the perception of how humans relate to the rest of the natural world. Nature is therefore defined in 2 separate contexts: one includes human activity that puts forces of the natural world together and the other excludes human activity altogether. The definition of nature invoked by the user determines the degree to which human intervention on Pelorus Island adheres to being natural. In this premise, however, nature is also employed in what Mill (1874) calls a false third definition: "some external criterion of what we should do," which is most likely informed by a preference for either the first or second definition. The appeal to an ill-defined nature sets this argument up for a fallacy of equivocation, when an ambiguous word is used with 2 different meanings in an effort to meet a falsely derived criterion: introducing that which is nature in P2(2°) is inappropriately equivocated with nature from P1(2°). The premise also exposes a fallacy of composition, a false assumption that a quality applies to a whole because it applies to a part of that whole. Regardless of which definition of natural is applied, the argument required to support the truth of this premise – an entire action is natural if one piece of it is natural – is logically flawed.

Premise 3(2°) not only calls on Mill's (1874) third false definition of nature, but also attempts to justify an intervention method based on the degree of naturalness to which the program adheres. Management of ecosystems, however, always requires some degree of human intervention. If naturalness were a criterion of the appropriateness of an intervention, then even successful programs may not be considered appropriate. Although this particular premise would benefit from additional analysis in the context of the PIGCP, a tertiary argument is not necessary here because the evaluation of P2(2°) already nullifies the argument.

Tertiary Argument (3°)

The fallacy of composition in P2(2°) clearly demonstrates weak logic, but the fundamental flaw is revealed when the premise is converted into the conclusion of the tertiary argument.

P1(3°). Introducing dingo predation is natural.
P2(3°). If part of a plan is natural, the entire plan is natural.
C1(3°). By introducing dingo predation, the PIGCP is natural.

Premise 2(3°) identifies the source of the fallacy of composition by suggesting that if part of something is X (e.g., if part of a birthday cake is eggs), the whole thing must then be X (then the whole cake is eggs). The tertiary argument is therefore not a sound argument.

Notably, when another component of the PIGCP that many may consider not nature is substituted into an alternative argument structure (A3°), the subsequent conclusion contradicts the naturalness of the PIGCP.

P1(A3º). Embedding 1080 capsules into dingoes is not nature.
P2(A3º). If part of a plan is not nature, the entire plan is not nature.
C1(A3º). By embedding 1080 capsules into dingoes, the PIGCP is not nature.

Within these parameters of the definition of nature, the fallacy of composition in the tertiary argument supports the conclusion that the PIGCP is both nature and not nature. This, in turn, violates Aristotle's law of non-contradiction, which states, "it is impossible to hold the same thing to be and not to be" (Gottlieb 2015).This violation of the law of non-contradiction demonstrates one way that the fallacy of composition nullifies the soundness of an argument in its entirety.

Argument Analysis Conclusions

The premises and conclusions construct 1 large set of nested arguments (Fig. 2), and because the tertiary argument informing the secondary and primary arguments is not sound, we concluded that the argument as a whole is not sound. Arguments are only as strong as their weakest premise, and even if our conclusion for one or more premises is refuted, sufficient uncertainties are present to warrant the examined reason (we should repair harm or damage we have caused) as insufficient justification for the implementation of the PIGCP.

Discussion

The PIGCP is an example of conservation decision-making that falls afoul of 3 primary concerns that result from the overemphasis of normative constructs. Using argument analysis, we highlighted a misrepresentation of normative interpretations as fact in the absence of empirical evidence and pinpointed the weak logical construction of the entire argument. We further suggest that overreliance on norms obfuscated appropriate interpretations of and adherence to ethical theories that are pivotal in helping to justify interventions. While much of the public debate centred on the manner of the proposed actions, implicit in that outcry and the consequent cancellation of the project are the 3 underlining problems that we highlight.

In light of increasing debate on the merits of different conservation programs and actions, such as habitat restoration and climate change mitigation, we have attempted to highlight why it is that conservation arguments can sometimes be susceptible to these types of failures. Although part of the answer may be because of a general lack of education in ethics among scientists and managers (Saltz et al. 2019), we suggest that a persuasive alternative answer lies in the overreliance on normative constructs (Callicott et al. 1999; Chew & Laubichler 2003). At the heart of conservation, practitioners develop policy to act in response to ecological scenarios that have unfolded contrary to normative definitions, expectations, or images of nature. This response mechanism is shaped by the desire to conserve in the face of perceived tragedy. Discussed at great lengths in the humanities, the concept of tragedy intrinsically shapes the way we perceive the world around us (Golden 1976), yet its role in conservation receives little attention. Adapting Aristotle’s definition of *tragedy* as a mimicry (i.e., dramatic performance) that elicits pity and fear from the audience (Golden 1976), we define *tragedy* in the context of conservation as an ecological narrative in which nature is affected by humankind.

Tragedy can manifest at an individual, species, population, or ecosystem level. Species extinction is perceived as a fundamental tragedy that conservationists strive to prevent, as are habitat loss, pollution, the impacts of climate change, and many other repercussions of anthropogenic change. With the goal of enabling nature to flourish, conservation seeks to mitigate or reverse tragic outcomes that alter nature. Though normative language assists with communicating narratives through linguistic representation, the socially constructed interpretation of words like *tragedy, nature*, and *pest* can become overinflated when invoked in scientific discourse (Chew & Laubichler 2003). When utilised, empirical science can help unravel the nature of tragedies to provide factual context and allow for quantifiable objectives to be established. But normative constructs like *tragedy* are framed by values (Manfredo et al. 2017), and together with ethical theories are used to inform effective and logical decisions required to meet those objectives (Fig. 1). The challenge is to be cognisant of the roles of norms and ethical theories in the decision-making process: disregard for strongly held normative positions or the overemphasis of only 1 specific ethical philosophy may override social acceptability, such as when the unwillingness of national governments to act on climate change provokes strong condemnation from the public. Meanwhile, overemphasising normative constructs can risk clouding the adherence to moral ethical theories and as we have shown, can impede critical thought and transparency, and permit unsuccessful or unethical interventions, or both.

Inattention to the power of norms and ethics has been implicated in the immediate response to eliminate species whose ranges have expanded through human-assisted dispersal. Considered alien and invasive, the mere presence of goats out of range conflicts with normative expectations of nature for both conservationists and laypeople alike. The power of anecdotes and norms can supersede scientific evidence and entrench perceptions that the presence of goats is intrinsically wrong, requiring control or removal under the mandate of invasion biology (Sutherland et al. 2004; Larson 2005). Inherent in this view is the tragedy of globalisation: although migrants can become integral components of modern ecosystems individually or collectively (Carroll 2011; Schlaepfer et al. 2011), their fate is nevertheless sealed by their tragic nomenclature (Simberloff 2012; Chew 2015). In these cases, empirical information is not always presented as the foundation of a normative position, and instead the sense of tragedy triggered by the mere existence of wild goats out of range can incur further harms by inhibiting the adoption of morally attentive ethical theories, impeding logic, and incentivising reliance on normative interpretations in place of evidence (Larson 2005).

We suggest that a key reason for the numerous uncertainties of both truth and appropriateness imbedded in a key justification for the PIGCP lies in the tragedy invoked by the program proponents: introduced species do not represent nature (i.e., the nature they value). The drive to intervene, empowered by the normative constructs of tragedy, nature, and invasive, overshadowed a critical analysis of the values, norms, and ethics driving the program; outweighed the imperative to be transparent, both in science and values; and obscured the ability of program proponents and animal ethics and funding bodies to consider the consequences of their ethical theories, such as the welfare trade-offs of the dingoes, goats, and other resident species. Moreover, the provision of a scientific and logical justification that the goats have deleterious impacts would not be sufficient to mend the examined arguments because failures in truth and violations of Aristotelian logic are committed throughout. The role of goats as actors in this global conservation tragedy creates distance between ethical discourse and conservation action (Caughley & Sinclair 1994), whereby the power of tragedy subverts ethical engagement, scientific integrity, welfare considerations, strong logic to support decisions, and transparency of norms and assumptions. Seeking to address what the council perceived to be an ecological tragedy, they inadvertently created a plan that would exacerbate the tragedy on Pelorus Island.

Our conceptual model of conservation decision-making (Fig. 1) clearly defines the interrelated inputs that direct the decision-making process. The model highlights that when normative constructs are overly emphasised, normative interpretations can be misconstrued as empirical information and the use of science and logic in the decision-making process can become weak or omitted altogether. To combat these fundamental errors, we provide 3 checkpoints in the model that strategically pause the decision-making flow. First, decision makers must be aware of values and their sources, as well as the normative constructs and ethical theories that those values inform. This checkpoint elucidates the motivations and priorities of the decision maker, and identifies those that may benefit from the decision-making process. Second, be mindful of overreliance on either normative constructs or ethics when deciding action is justified. Not only does this checkpoint recommend self-reflection by the decision makers, it can also identify potential points of contention and therefore encourage stakeholder consideration and engagement. Third, be logically sound and transparent when building justifications. This last checkpoint ensures that decisions are thoroughly developed, are not grounded on inappropriate assumptions or poor reasoning, and are informed by relevant science. Implementation of this checkpoint requires better training in critical thinking in the conservation sciences. Equipping conservation decision makers with tools such as argument analysis would improve recognition of values, norms, and ethical theories, improve moral attentiveness, and increase the effectiveness of conservation decision-making.

As demonstrated by this PIGCP case study, the scientific discourse around conservation decision-making process is often misconstrued as independent of the ethical frameworks and social norms that inform conservation decisions. To lay the groundwork for integrating ethics into mainstream conservation, we recommend 5 fundamental attributes of improved conservation decision-making: clarity, transparency, scientific integrity, adaptiveness, and compassion. Clarity requires that decision makers are explicit; they should clearly identify norms and values driving decision-making and use sound logic (Vucetich & Nelson 2012). Transparency ensures information, such as assumptions, motivations, scientific evidence, and methods (Dubois et al. 2017), is shared. Upholding scientific integrity informs decision-making with scientific evidence; ensures normative interpretations are not misinterpreted; establishes clear benchmarks for success and thresholds for expected outcomes (Biggs & Rogers 2003); aids in the design of methods that are appropriate for achieving, monitoring, and evaluating success; and can lead to reassessment of the call to action following intervention (i.e., does the intervention need to continue?) (Dubois et al. 2017). Adaptiveness requires an open mind when engaging with stakeholders and their positions and the ability to manage wildlife in a way that appeals to a range of moral perspectives and values (van Eeden et al. 2017). Adopting the practice of stakeholder engagement informs a thorough evaluation of the values, outcomes, welfare, and trade-offs for a wide array of stakeholders and assures that benefits are maximised and harms are minimised. Lastly, having compassion means that decision makers will consider the consequences of conservation intervention on sentient individuals and evaluate whether harm is justified or is a product of overrelying on normative positions (Ramp et al. 2013).

Our intention in analysing the justification for the PIGCP was to demonstrate the importance of harmonising normative constructs, ethics, and logical argument construction so that conservation decision makers can design better and more successful conservation programs. We hope the adoption of this toolkit will help clarify the role of normative constructs, diminish existing contentions in conservation decision-making, and improve the success of conservation objectives in the 21st century.

Supplementary Materials

Introduction to Argument Analysis

Ethical arguments contain at least one descriptive premise that can be evaluated as true or false (e.g., humans are sentient beings) and one ethical premise (e.g., we ought to treat sentient beings with respect) that can be evaluated as appropriate or inappropriate (Vucetich & Nelson 2012). Applying argument analysis to these kinds of ethical premises can help us determine whether the arguments behind any decision are ethically justified, or in other words, that they follow and support the way in which virtuous humans ought to act (Vucetich & Nelson 2012).

The basic structure of any argument follows the format “we should do X because Y,” in which “X’ is the behaviour (i.e., conclusion) and “Y” is the reason supporting this decision (Hughes et al. 2010). Using stakeholder statements and other sources of information, construction of a reason table can help clarify the reasons supporting the conclusion of each stakeholder (Vucetich & Nelson 2012). Any of these reasons can be evaluated with argument analysis.

All arguments consist of a set of premises (P) that support a specific conclusion (C). For example:

P1. Boston is in Massachusetts.
P2. Massachusetts is in the United States.
C1. Boston is in the United States.

An argument is considered sound if all premises are true and the premises follow strong logic (Hughes et al. 2010). In other words, the true premises need to actually support the conclusion. If any premise is not true (or appropriate) or the logic of the premises does not support the conclusion, then the argument is deemed not sound based on the given reason (i.e., set of premises). Consider the following arguments:

P1. Dublin is in Ireland.
P2. Ireland is located in the Pacific Ocean.
C1. Dublin is therefore located in the Pacific Ocean.

This argument adheres to proper logic, but the argument is not sound because P2 is not true (Ireland is in the Atlantic Ocean).

P1. Both rabbits and kangaroos are mammals.
P2. Kangaroos are herbivores.
C1. Therefore, rabbits are herbivores.

In this argument, each premise is independently true but the composition of the argument (i.e., logic) is weak. Even though both species are mammals, it would be incorrect to conclude that one is an herbivore just because the other is also an herbivore. This argument is therefore not sound because it does not follow strong logic. This, however, does not mean that the conclusion is incorrect – rabbits are in fact herbivores – it only means that the conclusion is not supported by the given reason (Vucetich & Nelson 2012). It is obvious that a different set of premises that is true and follows strong logic (e.g., rabbits only eat plants) can appropriately support the conclusion.

The strength of the logic in an argument relies on the assumptions that are not necessarily stated in the premises. The insertion of an implied premise (P1(b) below) into the argument can correct for failures in logic such as the one above.

P1(a). Both rabbits and kangaroos are mammals.
P1(b). If two animals are both mammals, they also have the same diet.

P2. Kangaroos are herbivores.
C1. Therefore, rabbits are herbivores.

The insertion of P1(b) compensates for the weakness in logic and the analysis can now focus on the independent assessment of the premises in a structurally strong argument (Vucetich & Nelson 2012). By removing the issue of weak logic, the faultiness of this argument shifts to the truth of the individual premises. If the premise(s) inserted to correct the logic is not true or appropriate, then the logic must be weak (Vucetich & Nelson 2012). In this argument, P1(b) is not true, thereby rendering the argument not sound. This insertion increased transparency, thereby clarifying where the argument errs. Inserting premises can be controversial; people can claim that they did not say what was inserted on their behalf. Regardless, the inserted premise is necessary and has to be implied in order for the logic to be strong enough to reach the original given conclusion. The process of evaluating the soundness by building a set of premises for a given reason, assessing the argument's flow of logic, and determining the truth of the premises can be applied to any argument.

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Chapter 4. Emboldening human-wildlife coexistence through moral inclusion and One Health

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Abstract

Sharing space with nature outside of protected areas is vital to effectively conserve biodiversity. Sharing, however, is not easy or simple; human-wildlife conflicts (HWCs) arise when competing stakeholder interests (human and nonhuman) are not easily reconcilable. The recognition of the complexity of HWCs between human and nonhuman stakeholders has led to a surge in research on shared landscapes, framing coexistence as a more positive-leaning and solution-orientated response to HWC. However, the entrenched coupling of HWC and coexistence reinforces an engrained human-nature dualism and downplays the importance of multispecies landscapes. We suggest two prerequisites, moral inclusion and a holistic approach, will help evolve practices and systems for the sharing of food production environments into those that prioritise the needs of all stakeholders of shared landscapes. Cohabitation, a morally inclusive and holistic approach to coexistence, captures the entanglement of socio-ecological relationships between stakeholders in a way that promotes multispecies landscapes where all needs are considered. One Health, which posits that the health outcomes of humans, animals, and the environment are inextricably related, provides a suitable framework for exploring the level of engagement with the principles of cohabitation. Within this review, we gauge

the current level of holistic contextualisation of multispecies landscapes in the HWC and coexistence literature and then explore how moral expansiveness and One Health together may incentivise humans to share space and embolden a coexistence landscape that fosters empathy for all its inhabitants.

Introduction

There is growing consensus within the conservation community that sharing space with nature outside of protected areas is vital to effectively conserve biodiversity (Kremen 2015; Kamal et al. 2015; Grass et al. 2019). Sharing, however, is not easy or simple; complex challenges arise when competing stakeholder interests (human and nonhuman) are not considered reconcilable (Nyhus 2016; Pooley et al. 2017). Moreover, the balance of decision-making is often biased towards human life and livelihood, instigating the systemic and continual decline of landscapes that provide for wildlife. For example, beef production currently drives forest and woodland conversion across the globe, with few successful policy initiatives in place to incentivise the prioritisation, or consideration, of nonhuman needs (Menezes et al. 2021). Coexistence in this context translates to tolerance of the presence of wildlife in production landscapes to the extent that doing so does not sacrifice production (Nyhus 2016); a breach of the limits of tolerance often warrants a response that protects human objectives at the expense of wildlife. In this way, coexistence reflects a narrative based on human-wildlife conflict (HWC) (Inskip and Zimmermann 2009, Nyhus 2016), reinforcing widely accepted practices of ongoing and sustained exploitation of the biosphere driven by systemic and rapid land conversion rates (Hansen et al. 2013), government-supported predator control programs (Creel & Rotella 2010; Kerley et al. 2018), and strongly held cultural basis for the subjugation of nature in western societies (Plumwood 1993; Wallach et al. 2020). Although non-lethal mechanisms to mitigate HWCs have been developed to counter these and other challenges (van Eeden et al. 2018b), for the most part these efforts continue to reside within the paradigm of human exceptionalism: the same goals are maintained with human needs first, but softer methods for achieving them are sought. Here we ask how practices and systems for the sharing of production environments can evolve to prioritise the needs of all stakeholders of shared landscapes. If we level the playing field by being morally inclusive of wildlife in production considerations and decision-making, how can coexistence support resilient food production and producers while embracing a multispecies society that recognises shared equity?

To begin with it is important to consider how coexistence has been positioned as conflict between stakeholders. Conflict between humans and wildlife occurs when the needs and behaviours of humans interfere with the lives of wildlife, or when the needs and behaviours of wildlife interfere with the lives and livelihoods of humans (Madden 2004). This framing of conflict is key to understanding the complexity of interactions between inhabitants of shared landscapes because it recognises that HWCs not only involve direct interactions, but also include the events, decisions, and behaviours that lead up to and follow the direct interaction itself. For example, in production landscapes, HWCs are commonly recognised as predation by carnivores on livestock, as competition for grazing resources between livestock and wildlife, or as wildlife consumption of crops intended for human consumption and market (Nyhus 2016). Each of these scenarios, however, cannot be reduced to an isolated event that is initiated by wildlife; HWCs on production landscapes are largely associated with systemic issues, such as habitat loss (Chartier et al. 2011), prey availability (Patterson et al. 2004), human and livestock proximity to protected areas (Palmeira et al. 2008; Inskip & Zimmermann 2009b), and economic and food security

(Inskip & Zimmermann 2009b; Nyirenda et al. 2018), issues that are often human-derived. HWCs are therefore materialisations of human actions that have negative impacts on wildlife, and yet wildlife are commonly described as the antagonists. As a result, HWCs may provoke further HWCs in the form of retaliatory and/or pre-emptive persecution of wild animals (Inskip & Zimmermann 2009b; Thorn et al. 2012; van Eeden et al. 2018b). In this way, HWCs ultimately reflect dynamic interactions encompassed within a holistic system, shaped by the historical narratives of engagement among stakeholders.

The recognition of the complexity of interactions between human and nonhuman stakeholders has led to a surge in research on shared landscapes (Frank 2016; Nyhus 2016), reframing coexistence as a more positive-leaning and solution-orientated response to HWC. Conventional solutions to HWCs can validly seek to reduce tension by excluding wildlife from the system, but many of these solutions reinforce a human-nature dualism that fuels conflict (Plumwood 1993; Wallach et al. 2020). Rather than direct removal of wildlife through killing and/or permanent exclusion, positive solutions utilise long-term strategies and tools that aim to reduce spatio-temporal overlap between humans and wildlife, such as shepherding and temporary deterrents, to allow wildlife to persist and encourage tolerance of their presence (Nyhus 2016; Foxlights 2021; Landmark Foundation 2021a). This reframing, however, is not easy and challenges persist around how to, or what it means to, coexist (Knox et al. 2020; Pooley et al. 2020). Indeed, an entrenched coupling of HWC and coexistence downplays the importance of multispecies landscapes; landscapes that are grounded through the complex network of interactions among stakeholders. In contrast, by examining coexistence within a holistic framework that reflects the entanglement of socio-ecological relationships between stakeholders where all needs are considered, the challenge of promoting coexistence in production environments may be explicitly addressed. That is not to say that all needs may always be met, but rather that by downgrading conflict, it may be possible to elevate negotiation.

Two important steps are necessary to employ this approach in production environments. The first and essential step is for decision makers to extend moral inclusion to wildlife. Here we refer to moral inclusion as an individual's assessment of whether someone or something is morally significant and is therefore worthy of ethical consideration and fair treatment (Opotow 1990). Contrastingly, the current paradigm of human exceptionalism in coexistence, whereby the needs of humans are elevated above those of nature, casts a narrow net of moral inclusion, often excluding nonhuman entities from moral consideration (Opotow 1990; Plumwood 1993; Wallach et al. 2020). The second step is to adopt a suitable holistic framework to conduct negotiations. As a transdisciplinary intellectual platform that contextualises systems by the inextricable health relationships between humans, animals, and the environment, the One Health framework is well suited to support advancement in multi-species coexistence (FAO 2021a). Within this review, therefore, our intent is to gauge the current level of holistic contextualisation of multispecies landscapes in the HWC and coexistence literature and then explore how moral expansiveness and One Health together may incentivise humans to share space and embolden a coexistence landscape that fosters empathy for all its inhabitants.

From conflict to cohabitation

While HWCs occur in landscapes across the urban to rural spectrum (Redpath et al. 2013), here we focus on HWC and coexistence in the context of non-urbanised production landscapes, given the critical importance of food production landscapes for the survival of humans and wildlife alike (Bedunah & Angerer 2012). While coexistence is offered as a desirable “end goal” for these landscapes by some, it is seldom defined (Knox et al. 2020). This lack of specificity has yielded disparate visions of coexistence and inconsistent interpretations of (mostly implicit or undefined) benchmarks for success. This is problematic because programs with undefined goals or expectations can struggle to measure success or gain stakeholder support (Knox et al. 2020). Further, if aspirations for these landscapes do not explicitly outline objectives for wildlife persistence, then it seems unlikely that the moral inclusion of wildlife is being factored into decision-making.

One explanation for this discipline-wide inconsistency is that coexistence is undoubtedly context-specific: one widely adopted definition may not suit all shared landscape contexts. Instead, coexistence research often positions coexistence as a solution to, or positive orientation towards, HWC, whereby the needs of humans and wildlife are negotiated to the extent that both parties can exist on the same landscape (Frank 2016; Nyhus 2016). But coexistence, in this sense, is merely co-occurrence of humans and wildlife sans immediate risk of harm, which fails to capture the complexity of shared landscapes, continues to reinforce a human-nature dichotomy, and inhibits the adoption of a widely-accepted expectations of success (Harihar et al. 2013; Boonman-Berson et al. 2016; Frank 2016).

As an alternative framing of coexistence, cohabitation has been adopted to better capture the entanglement of human and nonhuman lived experiences that shape the eco-evolutionary trajectories they share (Boonman-Berson et al. 2016). As a morally inclusive approach to coexistence, cohabitation values the knowledge imparted by indigenous and local practices that recognise animism, spirituality, and connection to country that are so often rejected or misappropriated by western culture, challenging the colonial narrative of human exceptionalism that is entrenched in dominant coexistence paradigms (Plumwood 1993; Nadasdy 2005; Fix et al. 2019; Wallach et al. 2020; Toncheva & Fletcher 2021; Trisos et al. 2021). For example, cohabitation between humans and bears in a small mountain village in Bulgaria is underpinned by local ecological knowledge and the residents' dissolution of the human-nature dualism (Toncheva & Fletcher 2021; Toncheva et al. 2021). Humans view bears as legitimate inhabitants of the region and treat overlap with bears as an expected part of their lives; humans call on Bulgarian folklore for information on bear behaviour and personalities and for guidance on healing practices following bear encounters. Both bears and humans seek to understand and respond appropriately to the signs and signals left by one another to minimise conflict (Toncheva & Fletcher 2021; Toncheva et al. 2021). Engaging with entanglement in this way is significant because information derived from attentiveness to the ways inhabitants co-shape environments can meaningfully contribute to positive coexistence outcomes.

When the needs and lives of the bears in Bulgaria are integrated into the way in which humans conduct their own lives, the bears become moral subjects whose sentience, sapience, and autonomy are properly affirmed (Plumwood 1993; Wallach et al. 2020). As moral subjects, their needs and behaviours are explored more broadly and considered morally relevant, allowing a deeper examination of entanglement and a more equitable evaluation of the way in which they co-shape the landscape. Indeed, if wildlife are not positioned as moral subjects within the narrative of coexistence, how can they be envisaged as part of an equitable socio-ecological system? The embodiment of cohabitation is predicated on moral inclusion; to create a socio-ecological landscape where the entanglement of stakeholders of shared landscapes is fully revealed and the needs of stakeholders are met equitably, wildlife must be recognised as worthy of attentiveness (Boonman-Berson et al. 2016; Toncheva & Fletcher 2021).

Supporting coexistence with One Health

Framing coexistence as cohabitation provides an opportunity to inject an existing framework predicated on entanglement, such as One Health, into coexistence research. The One Health framework is built upon three health spheres – humans, animals, and environment – and posits that the health outcomes of each are inextricably connected (Fig. 1) (Zinsstag et al. 2011; FAO 2021a). A One Health approach informs the development of comprehensive transdisciplinary investigatory design and research to solve global health challenges, encouraging a broader contextualisation of health outcomes (FAO 2021a; Gruetzmacher et al. 2021). One Health is well known for driving transdisciplinary investigations into zoonotic disease transmission, which have identified links between increased animal-human contact to food insecurity and habitat loss (Brock et al. 2019; Friant et al. 2020), but the framework is also applied within the context of health challenges in other fields such as veterinary and comparative medicine, wildlife conservation, and environmental toxicology (Dantas-Torres et al. 2012; Buttke et al. 2015; Randhawa et al. 2015; Backer & Miller 2016; Gruetzmacher et al. 2021). Ultimately, One Health works within the statutes that all three health spheres thrive best when mutually supported and that sustainable and healthy solutions are those that support all stakeholders of the system (Zinsstag et al. 2011; Gibbs 2014; FAO 2021a; Gruetzmacher et al. 2021).

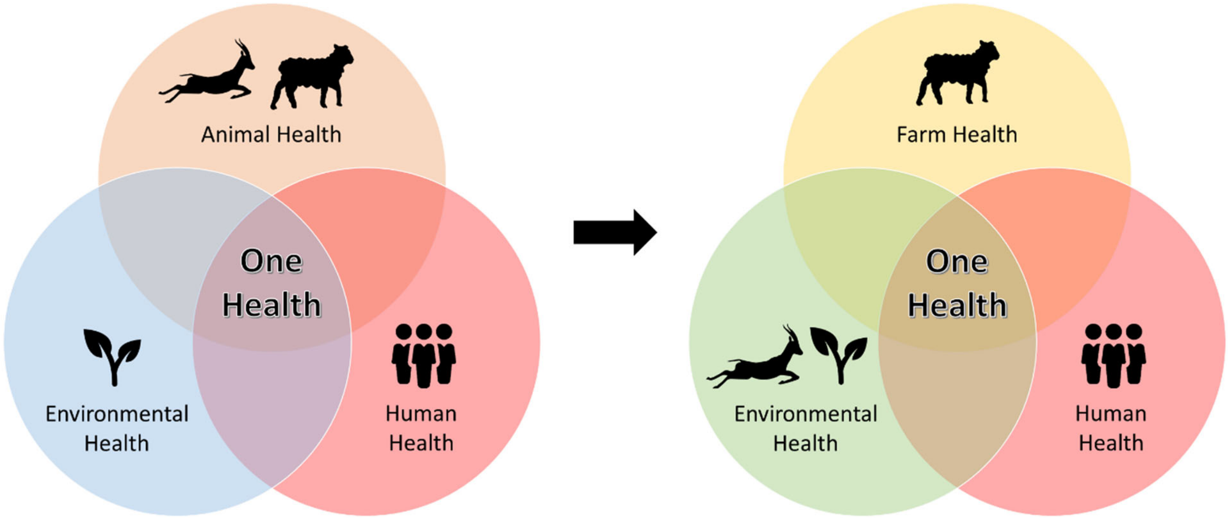

Figure 1. The One Health framework posits that human, animal, and environmental health are all inextricably related. The framework has been altered for the purpose of this study to better reflect food production systems; the animal health sphere was replaced with farm health and wildlife and livestock were redistributed to environmental and farm health, respectively. Images: Flaticon.com

Common One Health challenges often focus on issues where health is intersectional across stakeholders and it therefore well suited to advancing coexistence research and practice. Through stakeholder analysis and transdisciplinary research, the framework can reimagine shared landscapes as networks of interdependent relationships amongst the environment and its inhabitants (FAO 2021a). In this way, One Health can help identify the failings in a production system that pertain to the intricate relationships embedded within it. There is merit in this approach because it not only serves as a tool to help conceptualise shared landscapes, but more importantly, it also enables problem solving by clearly pinpointing the missing elements of entanglement that may be critical to embodying coexistence, in stark contrast to conflict and co-occurrence.

A One Health analysis of coexistence in production landscapes

The underlying principles of One Health are not novel to issues of coexistence, but holistic attentiveness to them is only infrequently acknowledged. We therefore set out to examine the current level of engagement with One Health within production landscapes by exploring the HWC and coexistence literature and quantifying the implications for different health spheres raised throughout. Analysis of this kind is useful for gauging the level of complexity ascribed to coexistence, for identifying biases towards favoured spheres and gaps in knowledge, and for highlighting positive outcomes of sharing space. Remaining attentive to the value orientations of moral exclusion and human exceptionalism on one hand, and to the value orientations that favour moral inclusion and cohabitation on the other, we use this analysis to discuss opportunities for embracing a multispecies society on shared landscapes that recognises shared equity between its inhabitants.

To do this we amassed all recent literature on actionable coexistence or mitigation of HWC, searching peer-reviewed literature on Web of Science (all databases) using a combination of the following search terms: human-wildlife conflict, coexistence, carnivores, predators, wildlife, farming, agriculture, cropping, livestock, deterrents, mitigation, protection, and repellents. The search terms were strategically chosen to maximise search returns, but certain terms, such as herbivores and pests, were not included because they returned many unrelated papers. We refined the search to include only those articles that were published between January 2009 and July 2019, printed in the English language, and matched the Web of Science filters of “research areas” and “categories” that are relevant to the field of HWC and coexistence (e.g., Web of Science category of “history” and research area of “meteorology” were excluded from the search). This initial search returned 1,014 records.

We screened all titles and abstracts of the refined search results for relevance, duplicates, and exclusion criteria; articles were eliminated if they reported on experiments that used only captive animals, were not *in situ* studies (e.g., risk predictions/modelling drivers of conflict, reviews), caused long-term physical impact to wildlife which did not reflect coexistence (e.g., detusking, shock collars), only evaluated tolerance or compensation (because they often do not disclose the modifications in interactions with wildlife that pre-empted these measures), or did not adhere to the principle of sharing space (e.g., large-scale exclusion fencing, translocation). Articles that modelled risk were included if they also had an *in situ* component. Additionally, we only included articles that featured conflict with terrestrial mammals. Snowball and citation searches of final records and identified literature reviews yielded an additional 90 records, which were also screened for exclusion criteria. Altogether, 88 articles were included for analysis (see Supplementary Materials).

Coding for One Health spheres

We first modified the One Health spheres into human health (HH), farm health (FH), and environmental health (EH) to better address the unique composition of stakeholder interests in production landscapes (Fig. 1). We reassigned wild animals to EH and domesticated animals to FH to reflect the context in which their interests and functions are most relevant. We used an inductive coding approach to assess each article for the outcomes or impacts of sharing space that were mentioned or considered in either the introduction, discussion, or both (Thomas 2006; Thomas & Harden 2008). This process created an organic code library that was expanded when a new type of outcome was mentioned. Articles were coded for presence rather than instance; for example, an article may mention livestock depredation on multiple occasions but was only coded for this once. Codes were not separated according to whether impacts were positive or negative (e.g., decreased income and increased income were both coded as “economics”); instead, we aimed to quantify the acknowledgment of possible downstream outcomes that would be considered under a One Health model. Each code was assigned to a single sphere of our adapted model of One Health (e.g., economics was nested within HH, livestock productivity was nested within FH, and wildlife conservation was nested within EH). For each article, we calculated the total number of unique codes stratified by sphere. For instance, an article coded for wildlife conservation, livestock depredation, economics, and opportunity costs, would have 1 code within EH, 1 code within FH, and 2 codes within HH. To shed light on the attentiveness to the three spheres in the literature, we divided the articles into five code groups (0-code, 1-code, 2-code, 3-code, and 4+ code) within each sphere based on their stratified code counts. In the abovementioned example, the article would be included in the 1-code group for EH, 1-code group for FH, and the 2-code group for HH; likewise, an article that referenced 1 code within EH, 5 codes within FH, and 3 codes within HH would be included in the 1-code group for EH, 4+ code group for FH, and 3-code group for HH. For each sphere we then calculated the proportion of articles included in each code group.

We examined the prevalence of each code throughout the literature by calculating the total number of articles that referenced each code. To gain a clearer understanding of how each code was distributed across the literature, we then stratified the article count for each code by the code group to which each article belonged. For example, wildlife welfare, a code nested within EH, was coded in 21 articles total; 2 of those articles were in the 1-code group for EH, 1 was in the 2-code group, 5 were in the 3-code group, and 13 were in the 4+ code group, indicating that wildlife welfare was somewhat prevalent in the literature but predominantly mentioned in more diverse articles. Lastly, of the articles that referenced all three spheres at least once, we calculated the frequency of co-occurrence of all combinations of three codes from different spheres to identify the codes that most overlapped in the literature and, conversely, those that did not.

One Health spheres of influence in coexistence

Overall, the vast majority of the 88 articles (91%) on coexistence and HWC in production landscapes referenced at least one code from each of the three One Health spheres. Just seven articles contained codes from only two spheres and only one article referred to only one sphere. The majority of articles contained only one or two codes from each of the three spheres (Fig. 2), which predominantly referred to direct or tangible impacts of HWC (Fig. 3). Notably, minimal attentiveness to One Health was revealed through the low frequency of 3 and 4+ code articles across all three spheres (Fig. 2). Only 19% of articles referenced three EH codes, 15% referenced three FH codes, and 13% referenced three HH codes. Similar results for articles in the 4+ code groups were found across all three spheres.

Although each sphere was represented by a unique number of codes (EH: 8, FH: 9, and HH: 6), a clear trend in the frequency of codes emerged across all three spheres (Fig. 3). Each sphere was predominantly represented in the literature through a narrow set of 1-3 highly prevalent codes, which were referenced by articles across all non-zero code groups. The remaining codes in each sphere were less frequently mentioned in the literature and were most often only discussed in articles that included 4 or more codes from the respective sphere.

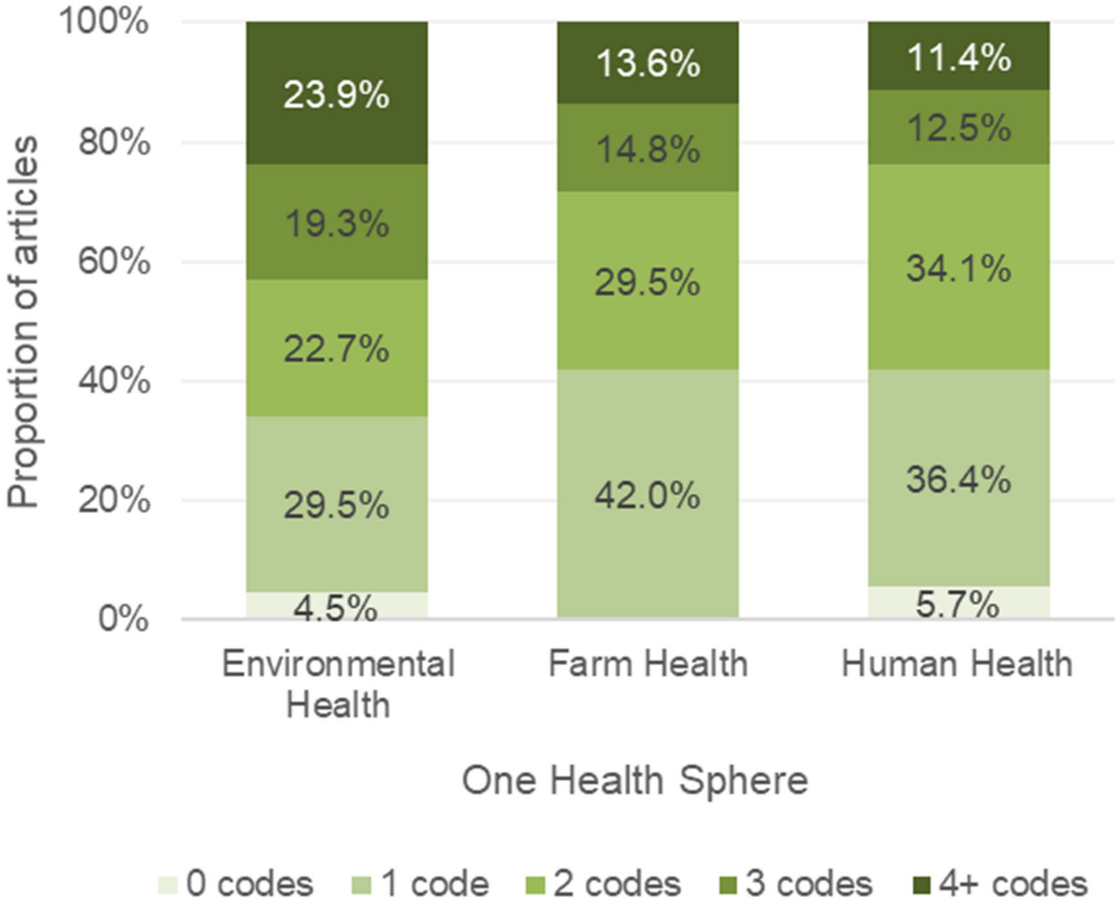

Figure 2. Percentage of total articles (n=88) in the five code count groups – 0, 1, 2, 3, or 4+ codes – within each of the three One Health spheres.

Analysis of the One Health spheres revealed that co-occurrence of codes within articles was largely restricted to the most prevalent codes from each sphere (Fig. 4). While 432 possible three-way code combinations occurred 1050 times in the 88 articles (an average of 2.4 occurrences per combination), only six (1.4%) of those 432 possible combinations, which occurred in more than 20 articles each, accounted for 185 (17.6%) of all combination occurrences in the literature (an average of 30.8 occurrences per combination). Fourteen (3.2%) of the 432 possible combinations that were present in anywhere between 10 and 20 articles each, and accounted for 175 (16.7%) of all combination occurrences (12.5 occurrences per combination). Meanwhile, 162 out of 432 possible combinations (37.5%) were present in fewer

330 than 10 articles each (3.4 occurrences per combination), 115 of which (26.6%) only occurred in one. Nearly one-third of all possible code combinations (135, 31.3%) were absent from the literature entirely.

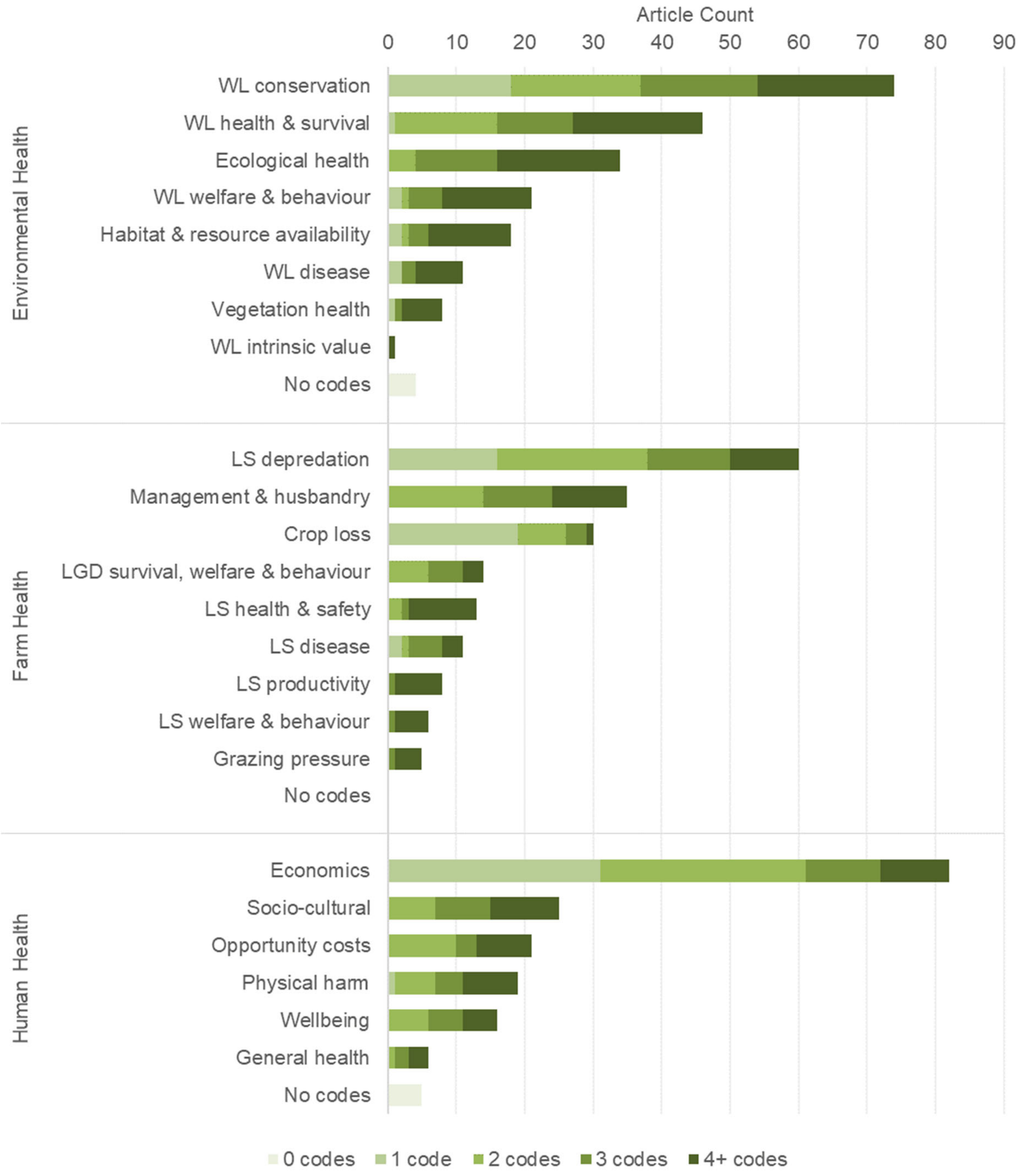

Figure 3. The prevalence of a code throughout the literature was evaluated by 335 calculating the total number of articles that contained the code. Total article counts were stratified by the code group to which each article belonged for the respective sphere. WL = wildlife, LS = livestock, LGD = livestock guardian dog.

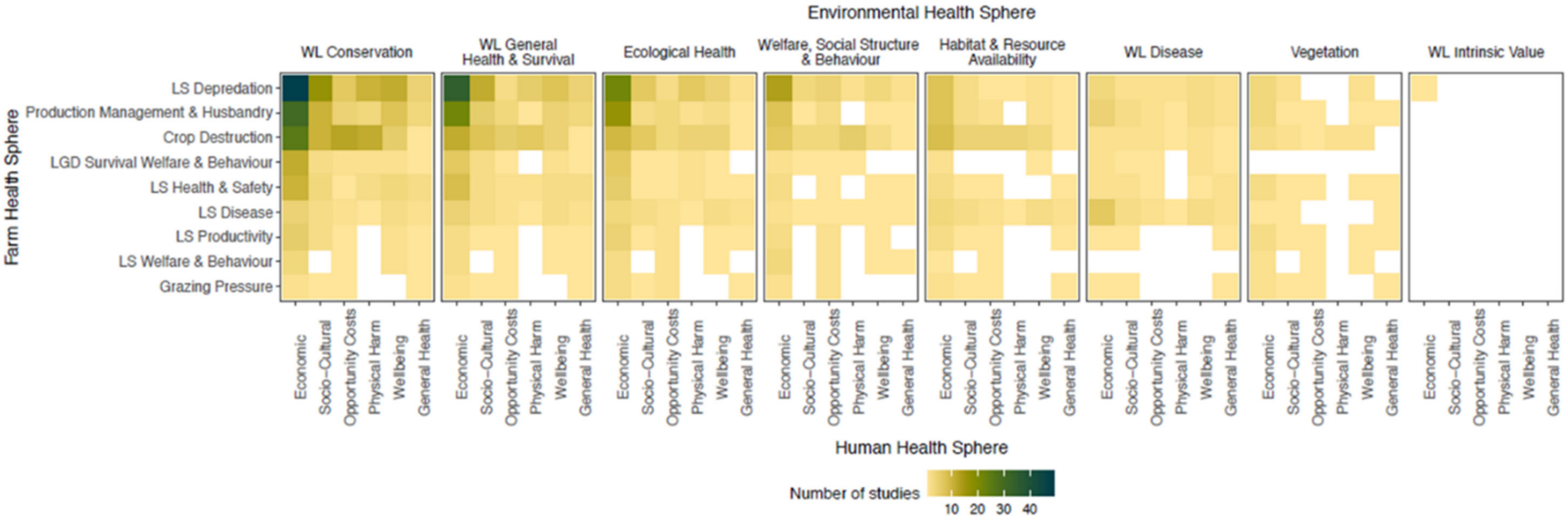

Figure 4. Three-way tile plot indicates the frequency of articles that reference each possible combination of 3 codes across the three One Health spheres. Articles that did not contain at least one code for each sphere (8 out of 88) were not included in the
340 analysis. White tiles indicate zero instances of co-occurrence across the remaining 80 articles. WL = wildlife, LS = livestock, LGD = livestock guardian dog.

One Health analysis reveals knowledge gaps

Our analysis of the recent HWC and coexistence literature reveals a clear deficiency in attentiveness to interactions among stakeholders in production landscapes. Unsurprisingly, indirect and relational effects of shared systems were mentioned less frequently than immediate or direct effects, and there were few articles that covered more than one code in each of the three spheres or even multiple codes within a sphere. The frequency of code combinations was greatly skewed towards those combinations that included frequent codes; combinations that included less frequent codes were largely absent. This trend was evident from strong clustering of code overlap (blue and green) and the frequent absence of co-occurring codes (white and yellow) (Fig. 4). These findings suggest a narrowness in the HWC and coexistence narratives, albeit with some encouraging attention to intersectionality among One Health spheres.

In many ways this was to be expected, as the dominant narrative of conflict positions certain metrics, and therefore codes, above others. Consequently, codes representing the key interests of humans, farm production, and the environment, such as crop loss or species conservation, are more frequently referenced. The pressing nature of these codes, however, should not preclude the importance of, or even acknowledgement of, outcomes that are outside the normative rhetoric of conflict, such as vegetation growth, livestock productivity, and human wellbeing. Indeed, many of these outcomes are critical indicators of resilience and sustained functioning of shared landscapes and reveal the benefits of cohabitation (Jadhav & Barua 2012; Prowse et al. 2015; Keesing et al. 2018).

Our analysis was constrained by codes that were present in the literature (Thomas 2006; Thomas & Harden 2008), so One Health implications of coexistence that were not discussed in any of the 88 articles, such as soil health, were not included. It is important, however, to acknowledge those topics that were not considered in the literature and explore explanations for their absence because doing so can provide insight into opportunities for expanding coexistence discourse. If the dominant coexistence narrative was predicated on morally inclusive cohabitation, we would expect to find considerable engagement with metrics that are indicative of moral standing in the literature. Notably, topics that are critical for ensuring that stakeholder needs are equitably addressed in shared landscapes, such as livestock intrinsic value and wildlife autonomy, were largely absent from our analysis. Those that were present in the literature, such as wildlife intrinsic value and livestock welfare, were not dominant in the literature and were, for the most part, mentioned only in articles that better engaged with the holistic context of their research, as evidenced by the inclusion of three or more codes in a sphere.

Envisaging expansive and morally inclusive coexistence

As we have shown, the narrative of conflict can result in a narrow view of coexistence, downplaying the importance of relational interactions within other health spheres of these socio-ecological systems. What drives this and how do we overcome it? One way of exploring this is to examine the social and moral underpinnings of coexistence in production landscapes, focussing on the role that human exceptionalism and moral exclusion of animals play in fostering the human-nature dualism. Human exceptionalism, which is the positioning of humans outside of and above nature, may be implicated in limiting a more expansive view of coexistence (Opotow 1990; Wallach et al. 2020). While human exceptionalism may act to restrict coexistence objectives, it may also incentivise the adoption, without question, of conflict solutions based on mechanisms that discourage wildlife on production land, leaving little possibility for cohabitation.

Social and moral contexts of conflict

A beginning point for understanding the social context for human responses to HWC is the perception of risk. Sensitivity to conflict is driven by the perceived risk of an adverse interaction (e.g., loss of human life or livelihood), which is in turn informed by scientific evidence and social perceptions, norms, and anecdotal histories particular to the context of the interaction and place (Estévez et al. 2015). While each of these sources of information are essential for good decision-making, achieving a balance between them matters because the magnitude of perceived risk is itself a driver of HWC (Dickman 2010; Yanco et al. 2019). Predicated on objective and subjective information streams, perceived risk may outweigh actual risk and give rise to disproportionate responses (Dickman 2010). For example, negative perceptions of cheetahs on Namibian farmlands were used to justify the majority of documented cheetah captures and nearly half of their deaths over a period of 9 years, despite limited evidence of livestock depredation (Marker et al. 2003). Preventing HWCs before they occur might be viewed as win-win, but not if doing so necessitates the persecution or exclusion of wildlife where coexistence is the goal.

Understanding how HWCs and their solutions become entrenched in conservation management, and societal responses to nature more generally, is essential if coexistence is to grow as a solution to conflict. In HWC cases like the cheetahs in Namibia, culturally engrained perceptions of threat, and the normative constructs that inform them, may not be substantiated nor questioned (Yanco et al. 2019). Rather, normative constructs like pest, invasive, and nuisance (terms that describe societal values, expectations, or codes of conduct) are employed to negatively characterise species that encroach on human interests, allowing proponents to avoid consideration of the foundations of their actions (Simberloff 2012; Yanco et al. 2019). These kinds of normative constructs have been shown to override due diligence in ethical decision-making, effectively excluding wildlife from moral consideration and ultimately the landscape itself (Yanco et al. 2019). Furthermore, they exacerbate conflict between human stakeholder groups with contrasting interpretations of the issues at hand (Redpath et al. 2013).

Conflict is itself a normative construct, viewed through a lens of societal and cultural values and beliefs (Estévez et al. 2015). The subjectivity of normative approaches to HWC ultimately leads to disputes over the severity and relevance of perceived threats, and therefore disagreements over the appropriateness of responses (Redpath et al. 2013). It is within this context that HWCs often materialise as conflicts between two or more groups of humans rather than between humans and wildlife (Redpath et al. 2013). For example, Guadeloupians fiercely protect the Guadeloupe raccoon (*Procyon sp.*), which they deem their national icon, despite agricultural losses and value-laden declarations by foreign researchers that the raccoons are invasive species that “are not unique species worthy of special conservation attention“ and “deserve no special taxonomic recognition or conservation status” (Helgen et al. 2008; Nuñez et al. 2018). Here, the two human stakeholder groups clearly differ in their interpretations of the existence of, and therefore the appropriate response to, human-raccoon conflicts. But it is the implied moral evaluations embedded in the justification to eradicate racoons that directs our attention to the moral fulcrum on which the societal interpretation of conflict balances.

Underlying driver of human exceptionalism

As in the case of the Guadeloupe raccoons, the treatment of animals is underpinned by the moral status they are afforded. Referring to an individual as “not worthy” or “not deserving” of moral significance can be used to make harmful actions permissible and morally acceptable (Opotow 1990; Opotow et al. 2005). But two groups of people may differ greatly in the way they evaluate a being’s moral status; or in other words, whether they include individuals within their moral circle (Opotow 1990; Opotow et al. 2005; Laham 2009; Crimston et al. 2018). Individuals included in this conceptual space, where “moral values, rules [of justice], and consideration of fairness apply”, are deemed deserving of compassion, ethical consideration, and fair treatment (Opotow 1990; Crimston et al. 2018). Those who are cast beyond the boundaries of moral inclusion, such as the Guadeloupe raccoons to some, are relegated as “non-entities, expendable, or undeserving” (Opotow 1990). While conflicts with entities who are morally included often play out as regulated and fair negotiations, conflicts with outsiders take the form of unregulated power struggles in which harmful words and actions by the in-group are either justified or go unquestioned (Opotow 1990). Circles of moral inclusion constrict even further with increasing conflict and competition, amplifying the dichotomous relationship between those inside and outside the bounds of moral inclusion (Opotow 1990). This moral dichotomy is no more obvious than in shared landscapes, where wildlife are often cast as “conscious human antagonists” (Peterson et al. 2010), whose perceived moral failings are met with unrivalled human dominance. Despite a clear scientific consensus that attributes the influx of HWC to the resonating impacts of a growing human population on the environment, namely in the form of continued encroachment on natural space and competition over natural resources (Inskip &

Zimmermann 2009b; Nyhus 2016), wildlife are typically condemned as the perpetrators of harm.

The construction of moral circles is largely dictated by the predominant social order (Opotow 1990), and in the western world, the pervasiveness of human exceptionalism strongly positions humans as fundamentally separate from, or above, nature (Plumwood 1993). The entrenched anthropocentric sense of self elevates the needs of humans over those of other non-human beings, casting others to the outer limits of moral consideration and blindly justifying harm (Opotow 1990; Plumwood 1993). Human exceptionalism stymies moral inclusiveness of wildlife in shared landscapes, and therefore the acceptance and protection of wildlife as legitimate constituents within multispecies landscapes. Positioning wildlife outside of moral circles perpetuates conflicts and dominates western decision-making, behaviour, and conservation science and practice in general (Wallach et al. 2020).

HWC and coexistence as positive punishment

The dualism between people and nature is systemically woven into the fibres of HWC and coexistence conflict mitigation strategies, driving practices that serve to reinforce the superiority of humans over wildlife. Evidence for this can be seen in the many HWC mitigation efforts that hinge on a positive punishment model of associative learning, whereby undesirable wildlife behaviours are punished or suppressed using wildlife deterrents (Snijders et al. 2019; Fontes & Shahan 2021). Positive punishment works to decrease the frequency of an unfavourable behaviour by introducing an unfavourable stimulus (McConnell 1990; Fontes & Shahan 2021). Although it can be effective for mediating immediate situational conflict, punishment does not easily create long-lasting learned responses and does not actively encourage desired behaviours (McConnell 1990; Snijders et al. 2019; Fontes &

Shahan 2021). For example, an elephant may flee in response to crop-guarding but will likely return in the absence of this deterrent (Sitati & Walpole 2006). Further, numerous studies have noted that, instead of deterring animals from crop take, deterrents only shift the unfavourable behaviour to nearby unprotected farms (e.g., Sitati & Walpole 2006; Hill & Wallace 2012; Hsiao et al. 2013). By targeting the behaviour of wildlife rather than that of humans (Snijders et al. 2019), the positive punishment model of deterrence does not directly act upon the ultimate behaviours of interest: decreased wildlife persecution and coexistence.

By conflating coexistence attempts with positive punishment strategies for addressing HWC, there is an implicit assumption that punishment of unfavourable wildlife behaviours increases human tolerance for coexistence, subsequently decreasing harm (Lichtenfeld et al. 2015a; Gunaryadi et al. 2017). This assumption, however, struggles to maintain a coherent logic, as it constructs two degrees of separation between the target for action (i.e., wildlife behaviour) and the target for tolerance (i.e., humans). This model is predicated on the belief that tolerance should passively accrue from a decrease in wildlife nuisance behaviour (i.e., depredations, resource competition). However, the targets for associative learning in these instances are the wildlife, not humans. The act of punishing unfavourable wildlife behaviour is not only driven by, but also reinforces, human exceptionalism. Although punishment of wildlife is at times unavoidable or a necessary last-ditch effort to mitigate conflicts where all other efforts have been exhausted, over-reliance on punishment implicitly sets the precedent that wildlife behaviour is wrong and requires changing, perpetuating the notion that wildlife are antagonistic to the success of human endeavours (Creel & Rotella 2010; Peterson et al. 2010; Kerley et al. 2018). By delineating and enforcing this dichotomous logic, punishment of wildlife emboldens the continued moral exclusion of wildlife, rather than promoting coexistence. Punishment achieves little in fostering a mutual understanding between users of shared landscapes, nor does it serve to encourage positive interactions between them. While positive interactions between inhabitants of shared landscapes may be the goal of rebranding HWC as coexistence, reframing duties and responsibilities among stakeholders is a vital and necessary step towards expanding human moral circles, without which coexistence may remain steeped in the same punishment mechanisms of HWC and be limited to co-occurrence.

Morally expansive One Health as positive reinforcement

In contrast to positive punishment, positive reinforcement is a model of associative learning that encourages desired behaviours (instead of discouraging unwanted behaviours) by rewarding them with positive stimuli, fostering greater durability and duration of learned outcomes (Snijders et al. 2019; Ramirez 2020). An example of positive reinforcement in the context of coexistence is the successful rearing of livestock using wildlife-friendly grazing strategies; wildlife-friendly producers that engage in behaviours that simultaneously protect livestock and encourage the persistence of wildlife on the landscape benefit from decreased predation of livestock, successful commercially-viable food production, and increased landscape resilience (see Chapter 6, Hasselerharm et al. 2021). As we have shown through our analysis of the coexistence literature, however, there is a distinct lack of emphasis on rewards in experimental research on HWC and coexistence, indicating that a strong emphasis on positive reinforcement remains elusive in HWC and coexistence discourse. The benefit of adopting a morally expansive One Health approach to HWC and coexistence is that it explicitly recognises the intrinsic value of wildlife and the innate connections between human, animal, and environmental health, and in doing so helps to realise the systemic benefits of sharing space (e.g., Hasselerharm et al. 2021). It is thus possible to shift attention away from the positive punishment of morally-excluded wildlife towards the positive reinforcement of positive human behaviours that benefit all moral constituents of shared landscapes. One Health is well suited to highlighting positive outcomes and rewards by clarifying mutual outcomes of sharing space and by reinforcing behaviours that are beneficial to stakeholders (FAO 2021a). By reframing incentives through One Health, the complexities and distal benefits of coexistence may be fully enunciated.

Encouraging vignettes of cohabitation are beginning to emerge. The ‘Lion Guardians’ program in Kenya has been successful in redirecting Maasai cultural significance attached to killing lions – societal confirmation of bravery – to rewarding the protection of lions, achieving coexistence with lions without fines or imprisonment as punishment for killing lions (Hazzah et al. 2014). Similarly, some wildlife friendly farming initiatives in Africa have rewarded shepherds and farmers for protecting wildlife through financial and cultural benefits, all the while producing favourable ecological conditions that support those landscapes that are shared equitably between pastoralists and wildlife (McManus et al. 2015a; Savory & Butterfield 2016; Keesing et al. 2018; Hasselerharm et al. 2021). In both these examples, additional co-benefits accrued that added value over and above the resolution of a typically intractable and widespread HWC: Maasai warriors were able to locate 18 lost child herders during their participation in the program (Hazzah et al. 2014), wildlife-friendly livestock producers have been able to enhance the resilience of their production landscapes by improving vegetation biomass and forage quality, and wildlife-friendly practices have promoted health benefits by lowering the abundance of ticks, a notable vector of wildlife, human, and livestock disease (Keesing et al. 2018).

While promising examples of coexistence exist, there remains strong evidence that examples that fully span all three spheres are few and far between. This is problematic, especially if this means not attaining the optimal health and resilience necessary to withstand the pressures of rapid environmental and climatic change in production landscapes (MEA 2005; Godfray et al. 2010; Hansen et al. 2013; Waters et al. 2016; Ceballos et al. 2017). We suggest that the coupling of positive reinforcement (to incentivise sharing space with wildlife) with One Health (to document how positive behaviours bestow further benefits) is a necessary and powerful reframing of coexistence that could benefit HWC around the world. This is not to infer that positive reinforcement models should replace all positive punishment initiatives, as they operate on different temporal scales, and both could play a critical role in protecting biodiversity and human livelihoods. We do, however, suggest that conflict mitigation is not an effective mechanism for, and should be viewed as distinct from, encouraging coexistence because (i) it often prioritises transient learning mechanisms, (ii) it does not effectively target human behaviour, and (iii) it fails to adequately address the human exceptionalism that fuels conflict (i.e., the values that necessitate exclusion). Conversely, emphasising the systemic co-benefits of coexistence, framed within morally expansive One Health, may help dissolve the human-nature dualism and rehabilitate the nuanced relationships between co-inhabitants of shared landscapes.

Conclusion

Wildlife, along with humans, are not only integral to healthy landscapes but are also beings with moral standing who also have a stake in the landscape (Wallach et al. 2020). Recognition of this requirement renegotiates humans as part of the system rather than above it, shaping the way coexistence is pursued, and conflict is mitigated. This humbler view of shared systems dismantles the cognitive separation between humans and others and paves the way for morally-inclusive coexistence, built off positive reinforcement of mutual benefits and shared values.

In that light, we support reimagining coexistence as *cohabitation* viewed through a One Health lens, rather than coexistence as co-occurrence. Unlike its predecessors, cohabitation promotes the expansive moral inclusion of humans and wildlife and connects them to the landscape. Moral inclusion is critical to the success of coexistence because it defines the set of beings to whom the rules of fairness apply, codifies a willingness to share resources with those beings, and acknowledges that sacrifices may need to be made so those beings can thrive (Opotow 1990). In practice, extension of these rules to a broader moral community prompts increased engagement in pro-social and pro-environmental behaviours and interactions (Laham 2009; Goetz et al. 2010; Bratanova et al. 2012). Cohabitation enacts the fundamental components of moral inclusion through validation of wildlife “as ‘fellow inhabitants’ that actively co-shape the space in which humans and wild animals can dwell” instead of as “‘other entities’ to be acted upon by humans” (Boonman-Berson et al. 2016). This definition captures two critical components of cohabitation: (i) attention to the lived experiences of others (Boonman-Berson et al. 2016), which validates non-human sentience, sapience, and autonomy and (ii) the One Health perspective that shared systems are a product of an incalculable number of interactions between humans, wildlife, and the environment. Together, these elements reflect the entanglement of entities in shared landscapes that are examined within the context of a One Health approach.

Importantly, expansive moral inclusion would provide clarity for coexistence in production landscapes. It would clarify the entities that comprise the system, how they interact, and what their needs and goals may be. It would guide the exploration of complex reciprocal relationships, shared experiences, and the entanglement of a diverse assemblage of beings who collectively cultivate a dynamic living system. And as a precursor to One Health, moral inclusion would set the stage for identifying missing or failing elements of entanglement that, if restored, would embolden healthy and shared production landscapes. If we choose to ignore this clarity, we fail to acknowledge wildlife as legitimate constituents of shared space and therefore overlook their roles in shaping environments. Peaceful cohabitation begins with redefining coexistence in terms of relationships between cohabitants of shared landscapes. By expanding the boundaries of moral inclusion, cohabitation counters the power imbalances forged by human exceptionalism and paves a path towards dissolving the human-wildlife dichotomy and the exclusion and exploitation it encourages.

Supplementary Materials

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Part 2: Pedagogy of moral inclusion

My dissertation uses a case study approach to investigate what happens when conservation and, more specifically, coexistence on production landscape, are reframed by moral inclusivity and seeks to uncover whether mutualistic pathways improve the ethical and practical outcomes of coexistence. I pursue this in three sequential parts – barriers, pedagogy, and opportunities – that together support the argument that a holistic, morally inclusive coexistence is critical to the progress of conservation in shared landscapes.

In Part 1, I revealed that normative constructs underpinned by the position that humans are separate from nature can stifle progress in conservation through poor decision-making, public backlash, and justifications of harm. Instead, an approach that is grounded in awareness and transparency of values and objectives in conservation can lead to more ethically and scientifically rigorous conservation action. In chapter 4, I found that human exceptionalism can contribute to a more limited understanding of multispecies coexistence landscapes in the literature and that a morally inclusive approach is better suited to strongly incentivise coexistence.

Part 2 investigates a pedagogical approach to expanding circles of moral consideration to include wildlife. I substantiate the efficacy of a morally inclusive pedagogical approach to primary school science instruction and contend that education programs that affirm the value of all living beings may inspire the public to engage in morally inclusive coexistence.

Chapter 5. Compassion and moral inclusion as cornerstones for conservation education and coexistence

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Abstract

Although coexistence permeates conservation policy and action, increased public awareness has not necessarily translated into action despite concerted conservation education effort. To galvanize and focus prosocial behavior, education that extends compassion to an expansive moral circle of living beings may encourage values of inclusion that are critical for actualizing coexistence. We used a case study to examine the utility of a humane education pedagogical approach for increasing moral inclusion of various wildlife. Our study implemented a pre-test post-test design to characterize the set of species that mattered to 52 Australian primary school students and to evaluate how a humane education intervention that encourages moral expansiveness and compassion can impact who matters and why. Following the program, the number of species that mattered to students increased and students expanded their moral circles of inclusion as represented by norms of intrinsic value. Though limited to a small population of primary school students, our findings demonstrate that a humane education intervention can enhance moral inclusion, a precursor to coexistence. By successfully promoting greater compassion for non-human animals, interventions like coexistence education programs, and policies that replace negative norms with those that affirm the value of all living

beings, the public may develop deeper connections with other living beings and ultimately feel inspired to coexist with and protect earth's biodiversity.

Introduction

Coexistence as a pathway to protecting biodiversity in human-dominated landscapes permeates conservation policy and practice (Treves & Bruskotter 2014; Carter & Linnell 2016; Kremen & Merenlender 2018). The utility of coexistence as a solution to biodiversity decline, however, is complicated by ill-defined expectations and measures of success across the discipline (Knox et al. 2020; Pooley et al. 2020). Furthermore, increased public awareness of coexistence through targeted conservation education efforts and outreach has not necessarily translated into largescale adoption of coexistence behaviors (Miller 2005; Bickford et al. 2012; Thomas et al. 2019). Numerous causes for the gap between knowledge and action have been investigated (Miller 2005; Bickford et al. 2012), but one critical component of progressing from knowledge to action in general has received comparatively less research attention in the context of coexistence. Compassion, or caring for others, manifests as a visceral connectivity, compelling actions to care for and safeguard the wellbeing of others (Singer & Klimecki 2014). It incentivizes passive consumers of knowledge to act and intrinsically motivates engagement in prosocial behaviors (Leiberg et al. 2011; Weng et al. 2015). Caring, in short, bridges the gap between cognition and action (Goetz et al. 2010). In the case of coexistence, perhaps people fail to share space with wildlife not because they do not know enough, but because they do not care enough (Goralnik et al. 2012). If care is a critical motivator for galvanizing coexistence behaviors, then actualizing peaceful coexistence with wildlife requires outreach and education efforts that lay the foundations for care and remove roadblocks to caring. Primary school education (grades K-5) provides a unique opportunity for such efforts because it prioritizes instruction in both foundational learning skills and prosocial skills at a critical stage of social development (Schonert-Reichl et al. 2012; Samuels et al. 2016; Bialystok & Kukar 2018).

Learning to care is strongly prioritized in primary education, where daily lessons and interactions with classmates help students develop compassion for other people, understand moral responsibilities, and become ethically minded (Schonert-Reichl et al. 2012; Samuels et al. 2016; Bialystok & Kukar 2018). During this process of social development, children absorb cues from their social environment to begin shaping their “moral circles”, or the conceptual space that defines the set of beings that are valued intrinsically, as beings who are worthy of ethical consideration and deserving of compassion (Laham 2009; Bratanova et al. 2012). While the inclusion of specific beings in one’s moral circle can inadvertently come at the expense of the inclusion of others, research showing that moral circles that are more inclusive of the living world are predictive of pro-environmental behaviors (Bratanova et al. 2012) encourages the hypothesis that pedagogical strategies teaching children to care for other (non-human) animals as members of their moral circles can promote coexistence values.

As people navigate the difficult ethical terrain of developing and continually refining their moral circles, they often rely on normative constructs to help define and simplify criteria for inclusion (Opotow 1990). Normative constructs, like aesthetics and danger, delineate discrete categories that help generalize conclusions across numerous decision-making scenarios (Lapinski & Rimal 2005). Though generally helpful, perverse normative constructs, such as race or gender roles, can not only dominate the development of moral circles, but also restrict moral inclusivity and stymy compassion (Opotow 1990). This is readily demonstrated by the systemic, institutionalized, and overt persecution and mistreatment of minority peoples (Opotow 1990; Layton 2006; Yoshida et al. 2012). Similarly, norms promulgated by current mainstream conservation paradigms (e.g., wildlife “pests” or “invasive” species) direct that certain entities should be actively excluded from the moral circle (Wallach et al. 2019; Yanco et al. 2019). Observing and internalizing these norms, people decide with whom (both human and non-human) it is acceptable to coexist, or not.

To disrupt social norms that perpetuate ambivalence towards exclusion of wildlife, educational interventions that promote moral expansiveness alongside knowledge acquisition are needed. The pedagogical approach of humane education converges these two goals by imparting core learning objectives through the lens of compassion for all living beings, while challenging students to apply critical thinking and investigate global issues (IHE 2020). The coalescence of knowledge- and ethics-based learning at such an important developmental stage has been shown to increase compassion for, and encourage greater inclusivity towards, wildlife (e.g., Nicoll et al. 2008, Rule & Zhbanova 2014, Samuels et al. 2016). The goal of this case study was to evaluate whether a pedagogical focus on compassion and moral inclusion in a western-education primary school setting could influence the construction of students’ moral circles and, ultimately, promote wildlife coexistence values. If successful, this pedagogical approach could advance the wider goals of primary education and also facilitate the development of coexistence programs and policies that bridge the chasm between knowledge and action.

We pursued our goal in two stages: first, we quantified how many of seven different species mattered to a cohort of primary school students in Australia and identified the norms that informed their reasoning; and second, we assessed how a short humane education intervention reshaped the set of species that matter to them and, more specifically, expanded their moral circles of inclusion as represented by norms of intrinsic value.

Methods

Data collection

We recruited two fifth grade classes from a semi-rural public school in Queensland, Australia to participate in the study. The school was selected for the case study because it is a traditional western-education primary school that represents average Australian socio-educational advantage (ACARA 2018). Both classes completed a two-part pre-test survey loosely based on Laham (2009). In part one, students decided whether the lives of 7 different non-human mammals did or did not matter to them. The species included in the survey were foxes, brumbies (wild horses), possums, rabbits, dingoes, koalas, and kangaroos. The species were chosen based on variations in in characteristics including aesthetics, nativeness, and conservation status to ensure that a range of attitudes were catered for rather than preempting respondents' normative positions.

The survey asked students whether each species mattered *to them* to ensure age appropriate language. However, a species that matters to a student is not necessarily included in their moral circle because moral inclusion necessitates the attribution of intrinsic value. For example, a child may state that a wild horse matters to them because they can be tamed; this reasoning does not directly indicate that the species matters for its own sake. To track shifts in students' moral circles following the intervention therefore required assessing not just how many species mattered, but the reasons why they mattered. In part two, students were asked to justify their response for each species.

A humane education science curriculum (i.e., treatment, supplementary panel S1), which consisted of 2 hour-long and 2 half hour-long sessions taught by an external educator over two weeks, was subsequently delivered to one class (i.e., experimental group). The other class (i.e., control group) received the standard science educational curriculum instructed by their regular teacher. Four days after the final session of the treatment, both classes completed a post-test survey identical to the pre-test survey. This quasi-experimental design allowed for within- and between-subject tests, which improved validity and provided confidence in the assumption of causation for the effect of the program.

Data Analysis

We used NVIVO (QSR International Pty Ltd., 2020) to code binary responses in part one as either inclusion in or exclusion from the set of species that matter to each student and to code open-ended responses in part two for dominant normative themes. We used an inductive approach to analyze the data (Thomas 2006; Thomas & Harden 2008), which developed an organic coding library that expanded as new themes emerged (supplementary table S1). After excluding any responses that were illegible, incomplete, or misunderstood the survey questions, we created two data sets, one with all pre-test responses (i.e., unpaired) and one including only paired pre- and post-tests responses for both the control and experimental groups. All analyses were conducted in R (R Core Team 2019).

We used the unpaired data set to gain an understanding of students' baseline attitudes. We computed the proportion of inclusion responses across all seven species and the median number of species that students said mattered to them. We then identified the predominant norms used to justify responses. We used these data to construct a decision tree (Therneau & Atkinson 2019), which identified the norms that, when present, predicted whether a child excluded an animal.

Paired responses were analyzed to test the effect of the treatment. We used a Wilcoxon rank-sum test to establish baseline homogeneity across the two groups for the number of species students said mattered to them and a Wilcoxon signed rank test to assess changes in these numbers following the treatment. We also performed a McNemar’s test, which compares shifts in binary responses between pre- and post-test surveys to detect the likelihood that the changes in responses were due to the treatment.

Sign tests were used to evaluate the change in proportional representation of each norm across responses for all species following the treatment. Lastly, we constructed a decision tree for each group to examine changes in norms predictive of exclusion.

Results

Fifty-two students (26 per group) participated in this study, 52% of whom were female. Fifty-one of 52 students participated in the pre-test, which amounted to 346 complete responses across the seven species. Forty-seven of 52 students participated in the post-test. Further data cleaning yielded 310 paired survey responses across all species.

Students included a median of 5.0 species in their sets of species that matter. A pronounced majority (88.2%) of the 246 *inclusionary* pre-test responses across all seven species were justified by four predominant norms: *aesthetics* (24.4%), *intrinsic* *value* (22.4%), *threatened status* (21.5%), and *affinity* (19.9%). A slight majority (56%) of the 100 *exclusionary* pre-test responses were explained by only two norms, *perceived danger* (39%) and *nuisance* (17%), with the remaining responses justified across a range of other norms (supplementary table S2). Accordingly, a decision tree revealed that *perceived danger* and *nuisance*, as well as *knowledge* and *other*, were critical for distinguishing whether a respondent excluded a species (Fig. 1).

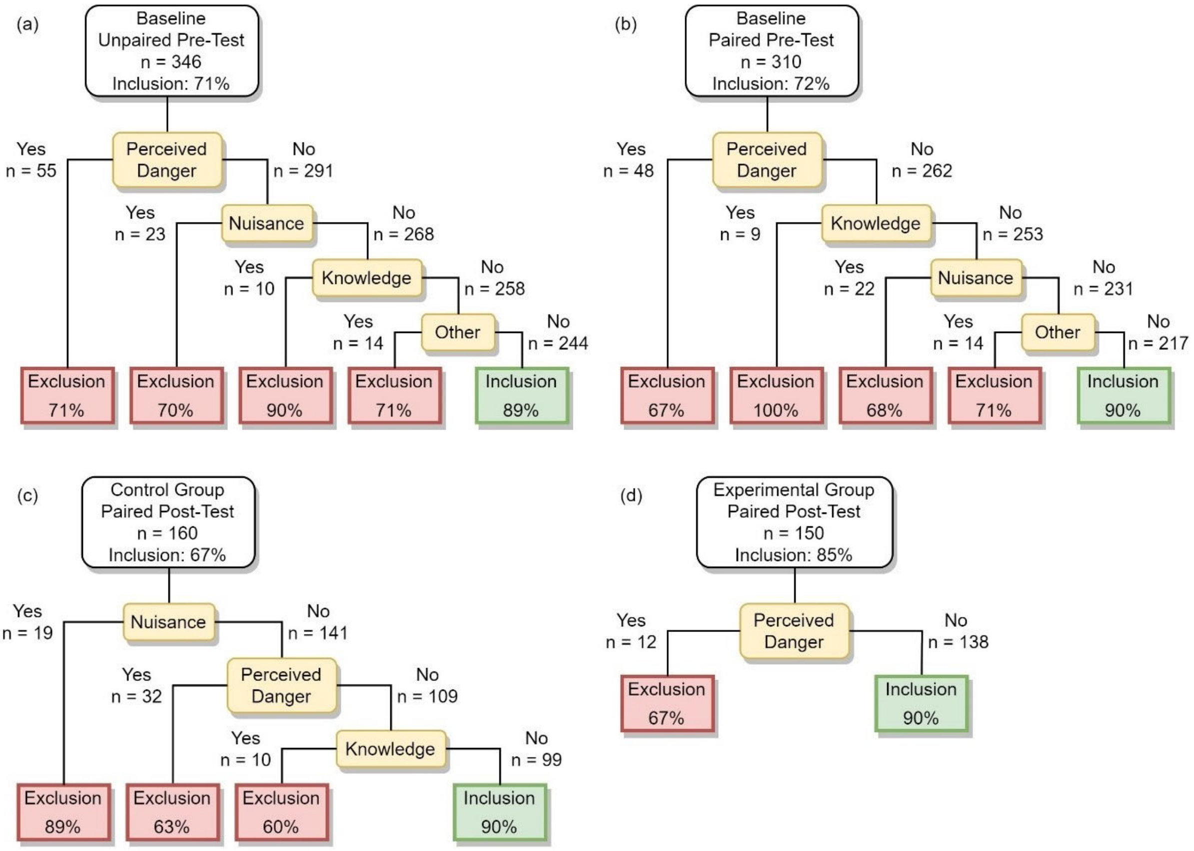
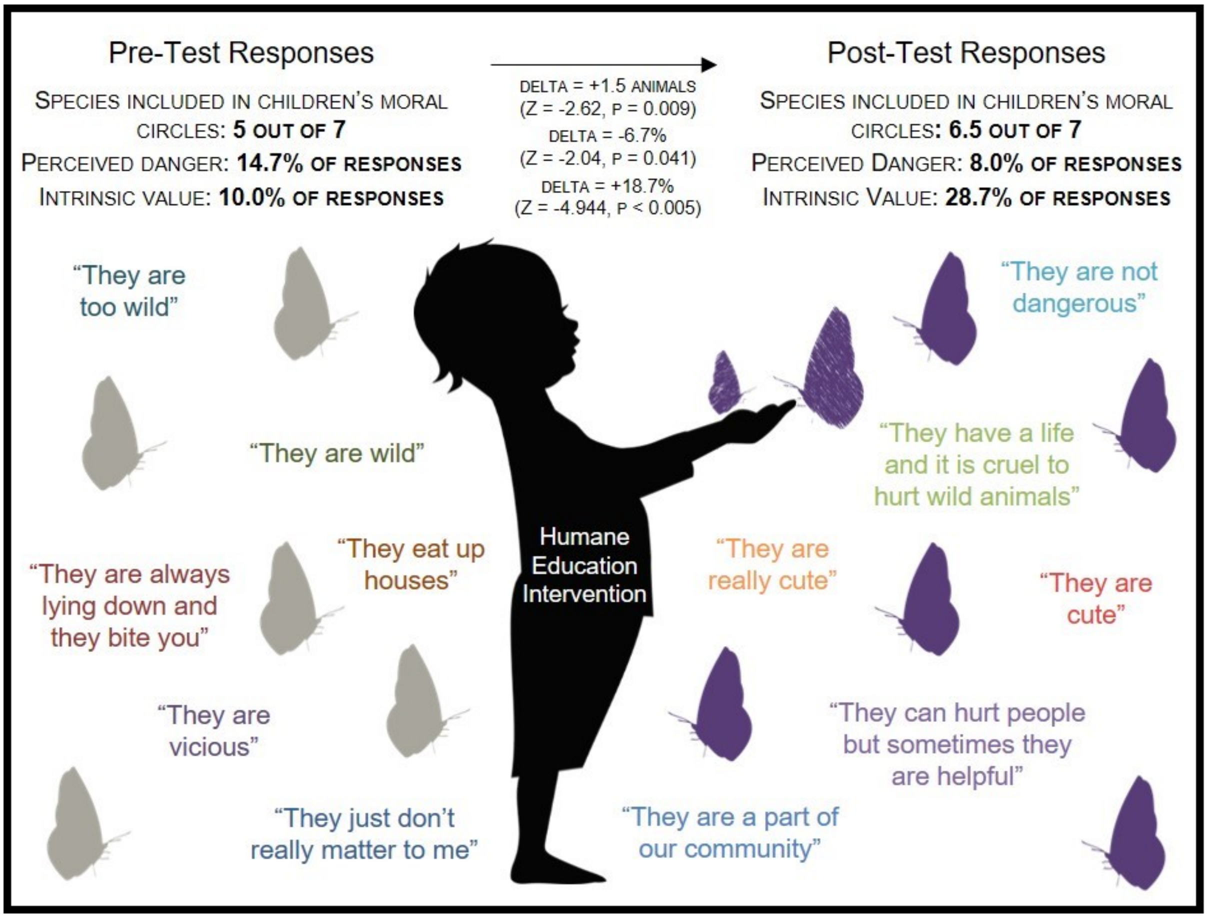


Figure 1. Decision trees identifying norms that classify species inclusion within moral circles in (a) baseline pre-test results for all responses, (b) baseline pre-test results for paired responses, and paired post-test results for the (c) control and (d) experimental groups. Yellow decision nodes indicate norms that, when present, predict that a respondent will exclude the species in question from his/her moral circle. *n* indicates the number of responses from the data set that reflect the conditions of the node split. Percentages in root nodes represent overall species inclusion. Terminal nodes specify the classification accuracy of responses in respective branch.

Paired pre-test species inclusion did not differ significantly between the two groups.

Following the treatment, the median number of species included by the experimental group increased significantly from 5 to 6.5 (Fig. 2, Z = -2.62, p = 0.009, r = 0.516), but decreased in the control group (5 to 4, Z = -0.08, p = 0.937, r = -0.307), albeit not significantly. The number of responses by individuals in the experimental group that changed from *exclusion* to *inclusion* (n = 24) was significantly greater than the number of responses that changed from *inclusion* to *exclusion* (n = 3, supplementary table S3), indicating a positive treatment effect (χ^2 = 16.333, df = 1, p < 0.005, Cohen's g = 0.389). There was no difference in the control group (χ^2 = 3.556, df = 1, p = 0.059, p < 0.005, Cohen's g = 0.222).



"They are too wild"

"They are wild"

"They are always lying down and they bite you"

"They eat up houses"

"They are vicious"

"They just don't really matter to me"

"They are not dangerous"

"They have a life and it is cruel to hurt wild animals"

"They are really cute"

"They are cute"

"They can hurt people but sometimes they are helpful"

"They are a part of our community"

Figure 2. Major findings of a short intervention that prioritised critical thinking and empathy towards living beings through humane education pedagogy. The number of butterflies indicate the median number of species included in children's moral circles in the pre-test (left, grey) and post-test (right, purple) paired survey results. Quotes extracted from paired surveys where respondents demonstrated noticeable shifts in their use of norms are highlighted by matching hues and mirrored over the mid-line. Image source: GDJ. 2015. *Child Holding Butterfly Silhouette.* Openclipart.

Post-test responses in the experimental group demonstrated considerable shifts in norms (supplementary table S2), most notably in *intrinsic value* and *perceived danger* (Fig. 2, 3). In the experimental group, the proportion of responses justified by *intrinsic value* increased from 10.0% to 28.7% (+18.7%, Z = -4.944, p < 0.001), while responses justified by *perceived danger* decreased from 14.7% to 8.0% (-6.7%, Z = -2.04, p = 0.041). Meanwhile, the proportion of control group responses justified by *intrinsic value* decreased (-6.9%, Z = -2.679, p = 0.007), while those justified by *perceived danger* increased (+6.3%, Z = -1.651, p > 0.05), albeit not significantly.

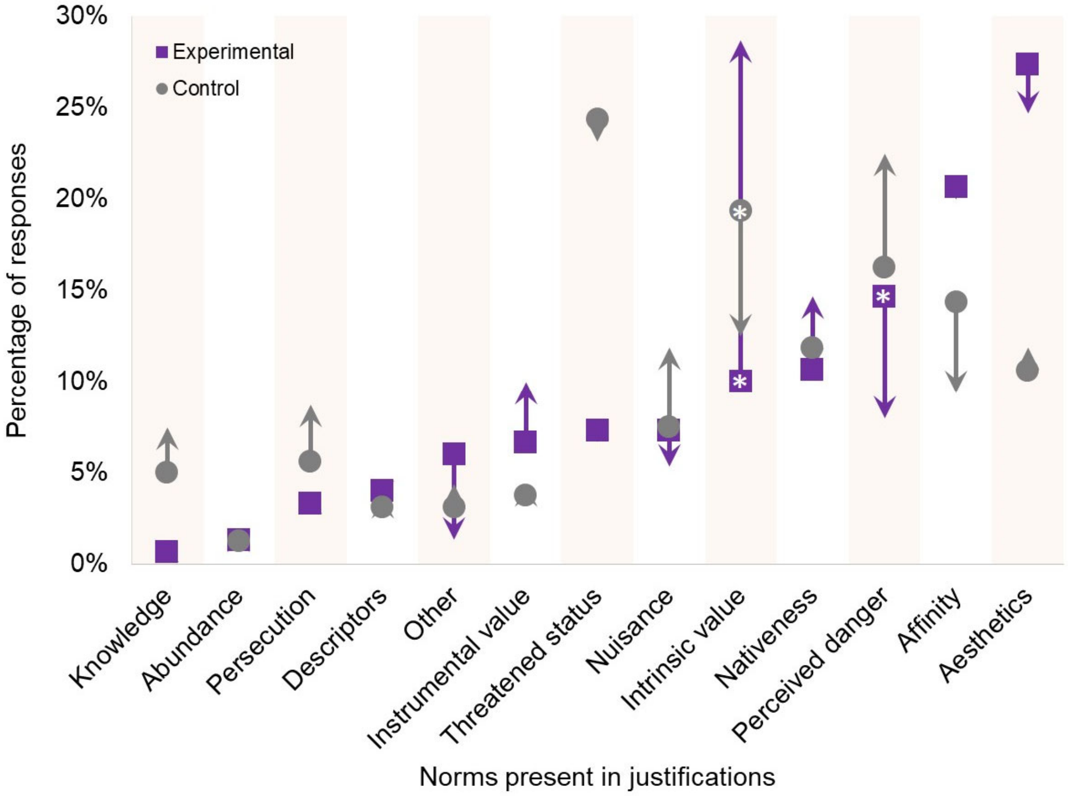


Figure 3. Proportional representation of each norm present in responses across all species. Shapes and arrow tips indicate pre-test and post-test results, respectively. Asterisks indicate significant changes (p < 0.05) between pre- and post-test results.

While a decision tree for the control group post-test responses mirrored that of the baseline pre-test survey, the decision tree for the experimental post-test responses revealed that *nuisance*, *knowledge,* and *other* were eliminated as norms influencing exclusion (Fig. 1). Only danger remained as a significant predictor.

Discussion

Here we demonstrated that students responded positively to a short intervention that prioritized critical thinking and empathy towards living beings through humane education pedagogy. Baseline data showed that the majority of the seven species already mattered to the students in this study and that inclusion and exclusion were largely justified by norms of aesthetics, intrinsic value, threatened status, affinity, perceived danger, and nuisance. Following the intervention, students in the treatment group included more species overall in their sets of species that matter to them and changed their reasoning for inclusion or exclusion. Notably, justifications of intrinsic value increased, reflecting an expansion of students' moral circles. These findings suggest that creative pedagogical strategies that combine core academic content with ethical instruction can successfully promote moral expansiveness and compassion for non-human beings in western-educated primary school students.

We directly measured shifts in the salience of norms, but our results do not necessarily indicate that students in the experimental group categorically accepted or rejected new norms following the treatment. For example, decreased expressions of *perceived danger* do not necessarily mean fear is no longer relevant, but that the motivations around fear and children's discomfort with unpredictable or "wild" animals have weakened in response to the treatment. We suggest that because fear was no longer such a salient norm, students drew more heavily upon other normative justifications, such as *intrinsic value*, to explain inclusion or exclusion.

While the post-test increase in the salience of intrinsic value indicates that students expanded their moral circles in response to the humane education treatment, the same conclusions cannot be drawn from an increase in the number of species included in the set of species that matter to them. It is fair, however, to posit that mattering is a necessary precondition for moral inclusion. In other words, a species that matters may not have intrinsic value, but if a species has intrinsic value, it surely matters. Our results support the interpretation that, even if students did not expand their moral circles to include more non-human animals, they did develop a broader sense of care for non-human animals in the classroom. This increase in the number of species that matter for reasons other than intrinsic value may prime children to expand their moral circles as their moral development continues.

To feel compassion means to care, largely for the suffering experienced by someone, or in this case some being, and to desire to relieve them from this state (Goetz et al. 2010). In this sense, feelings of compassion imply the recognition of sentience, which can be a pre-cursor to acknowledging that a being has intrinsic value, or has value purely because it exists and not just because it serves some external purpose or function (Batavia & Nelson 2017a). Students' realizations that animals are autonomous, sentient beings who have their own lived experiences and emotions (themes emphasized in the humane education curriculum) (Bekoff 2000) may explain the weaker influence of *nuisance* post-treatment in the experimental group. This finding, paired with an increase in *intrinsic value* and an overall increase in the inclusion of species, indicates that the intervention may contribute to a greater sense of compassion for non-human animals. Given that coexistence asks of humans to acknowledge the needs of other beings in shared landscapes, compassion for other beings can only vitalize human-wildlife coexistence (Ramp & Bekoff 2015).

While clear evidence indicates that pro-social and pro-environmental behaviors extend from an expansive moral circle (Goetz et al. 2010; Bratanova et al. 2012), mainstream western conservation paradigms have, perhaps inadvertently, adopted ideologies that effectively narrow moral circles. Subdisciplines such as invasion biology manifest care for ecological systems and, in many cases, the beings perceived as belonging to the system, but at the same time propagate exclusionary principles by categorizing the living world into those who belong and those who do not (Wallach et al. 2018). We recognize that moral tension does exist when the control of one species for the sake of another may be supported by strong reasoning (Batavia et al. 2020), however too often these types of decisions are made as the first steps in conservation action without proper due diligence (Dubois et al. 2017; Yanco et al. 2019). The underlying moral principles of such perspectives and ensuing programs that often kill for conservation profoundly contradict the fundamental prerequisites of conservation through coexistence: inclusivity, equity, and compassion for sentient, sapient beings. We cannot expect coexistence to succeed as a mainstream conservation paradigm if conservationists continue to signal that it is necessary to enact discriminatory and exclusionary principles to achieve conservation goals.

Likewise, primary school education can at times paradoxically pair its fundamental goal of encouraging moral expansiveness with participation in school-wide conservation programs grounded in principles of exclusion. Activities such as schoolyard “pest” trapping and statewide “Pest Invaders” science and art competitions (Predator Free NZ 2017; Furner 2019) that are prevalent in western-oriented cultures instill and reinforce negative normative constructs that dismiss the ethical obligation to extend moral consideration to certain non-human beings (Yanco et al. 2019). While neither educational institutions nor the field of conservation are singularly at fault for propagating these mixed messages, we must begin to even the playing field of moral inclusion to ensure the success of conservation by promoting compassionate coexistence.

We suggest that two key components to promoting coexistence, inclusivity and compassion towards others, are obfuscated by exclusionary education programs. Conservation and primary school educators alike can counter the negative messages conveyed by these programs and better incorporate aspects of moral development into their curriculums by using a humane education approach to promote care and moral inclusion in their curricula. Traditional teaching methods of knowledge acquisition can educate students on the importance of conservation; however, a greater synergy between conservation and humane education may better impart this message and encourage public engagement in coexistence by nurturing a critical link between knowledge and action: compassion.

As a precursor to adopting new pedagogical approaches in conservation education, however, the findings of this study are limited to primary school aged children in a western global context. We therefore recommend larger scale studies into the effectiveness of this educational paradigm on other age demographics, as well as the longevity of its impacts, and its relevance beyond the Australian cultural context. We also urge conservation educators to create innovative and inspirational material that encourages compassion and moral inclusion and to disseminate these tools to teachers and conservation practitioners alike.

It is often our youngest citizens that stimulate public engagement with global environmental challenges. Ultimately, our goal is to inspire children, who are the future of the conservation movement, to develop deeper connections with other living beings so they may inspire others to coexist with and protect earth’s biodiversity. If scientific curricula can be delivered in a way that replaces negative norms that stymy compassion with norms that affirm the value of all living beings, over time we may see an increase in pro-environmental behaviors and, ultimately, an increase in active and purposeful coexistence with wildlife.

Supplementary Materials

Supplementary panel S1. Summary of humane education curriculum.

The treatment consisted of a 3-hour humane education science program that replaced regular science lessons for two weeks. Through a series of interactive activities, the curriculum provided instruction for required fifth grade subject material while simultaneously introducing the concepts of intrinsic value, the moral circle, and sharing space with wildlife. The control group participated in the treatment following the conclusion of the study. The following outline provides a general explanation of the activities and concepts introduced in each lesson. Additional curriculum material available upon request.

Lesson 1 (1 hour)	*Objectives*	• By the end of this lesson, students should be able to: o Ask basic scientific questions that are of interest to wildlife conservation o Explain basic reasons why wildlife are important o Describe the main elements of the scientific method o Propose at least 2 kinds of information/adaptations that can be caught on camera • Students will get the opportunity to: o Connect with nature through outdoor immersion and mindfulness o Explore real-life science techniques as young scientists
	Tasks	• Introduction to wildlife conservation o Wildlife conservation ▪ Coexistence and sharing habitat o Camera trap image slideshow • Scientific method/Plan camera trap experiment o Question around sharing space and adaptations o Background knowledge o Prediction/Hypothesis o How to use Materials & methods/Experiment to test prediction o Explain results and conclusions • Set up cameras o Walk to field (animal follow the leader) o Nature Mindfulness activity • Set up cameras

Lesson 2 (30 minutes)	*Objectives*	• By the end of this lesson, students should be able to: o Give examples of 5 subjects or objects that are either inside or outside of their moral circle o Justify the way they populate their moral circle based on ideas of intrinsic value o Explain basic reasons why wildlife are important and what makes them unique (adaptations) o Award moral significance to animals for reasons beyond/despite their instrumental value or benefits to humans (or lack thereof) o Make connections between the way we label other species and the ways in which we include them in our moral circle • Students will get the opportunity to: o Think critically about the ways in which they view and morally evaluate other beings o Start investigating “icky” animals o Recognize interesting adaptations that make “icky” species unique and important
	Tasks	• Group Activity: Moral Circle story and activity o Students are presented with various objects and beings. As a class they decide whether each belong inside or outside of the moral circle • Discussion: Moral Circle o What does it mean to be inside the moral circle? Outside? o What other examples of “difficult to love” subjects do we often talk about as humans? What types of names do we call them? Should they be included in our moral universe? Why or why not? o What makes wildlife and nature important? o What makes wildlife special? Similar to/Different from us? ▪ Structural/Behavioural Adaptations and survival • Group Activity: Incredible Icky animals (Part 1) o Students read stories in groups about incredible “icky” animals
Lesson 3 (1 hour)	*Objectives*	• By the end of this lesson, students should be able to: o Give examples of 5 subjects or objects that are either inside or outside of their moral universe o Award moral significance to animals for reasons beyond/despite their instrumental value or benefits to humans (or lack thereof) o Make connections between the way we label other species and the ways in which we include them in our moral universe

		o Evaluate scientific evidence collected through their camera trap installation o Describe the basics of the scientific method o Explain how the collection of data can be used to answer scientific questions and predictions • Students will get the opportunity to: o Think critically about the ways in which they view and morally evaluate other beings o Evaluate scientific evidence collected through their camera trap installation
	Tasks	• Review Moral Circle concept • Group Activity: Incredible Icky Animal (Part 2) o Student groups complete activity sheet and present to class why their animal is special, interesting, or important • Review camera trap pictures • Review scientific method • Camera trap image analysis o Data table recording o Bar graph construction o Species index • Discuss findings – Did we prove our hypothesis?
Lesson 4 (30 minutes)	*Objectives*	• By the end of this lesson, students should be able to: o Identify the main differences between structural and functional adaptations and how they help animals survive o Demonstrate understanding of at least 2 structural and 2 functional adaptations using theatrical performance • Students will get the opportunity to: o Express their science knowledge through play o Relate to and connect with wild animals through role play
	Tasks	• Review structural vs. functional adaptations • Group game: Adaptations charades o In this activity, students will become animals! Make sure to remind them to channel their inner wild animal and try to understand their animal's feelings and needs. • Class wrap up

Supplementary table S1. Coding library of dominant normative themes present in part two of the survey results. Rather than using a prescriptive coding library, codes were generated as new themes emerged from survey responses. Responses were coded for presence rather than instance.

Code	**Definition (responses that refer to…)**	**Example**
Abundance	The number or relative amount of the species	"There are heaps of them" "There are millions"
Aesthetics	How the species looks or feels	"They are adorable, slow, soft, and huggable" "They are majestic"
Affinity	Whether a species was likeable or not, or fascination with the species, or personal experiences, emotions, or stories	"They are my favorite animal" "They remind me of my dog" "They are not interesting to me"
Descriptors	Factual observation about the species	"They are fast" "They hang in a tree"
Instrumental Value	The ecological function of the species, the ways in which they benefit humans, or a species' "purpose"	"They can be tamed" "They are important to the environment" "They give us food" "They don't do anything for us"
Intrinsic Value	The sentience, sapience, and/or autonomy of the individuals of that species or an animal's right to live or behave as itself	"They hunt to live. They are unique and we kill/hunt to live so why shouldn't they?" "They are unique and should have a will to live" "All animals should be respected"
Knowledge	The respondent's knowledge and awareness of the species	"I don't think about them much" "I know about them"
Nativeness	Endemism or whether an animal "belongs" in Australia	"They are native to Australia" "They aren't Aussie"
Nuisance	How a species impacts humans' livelihoods	"They are extremely annoying" "They can steal food from our farms" "They are a pest"
Other	Miscellaneous topics	"They're weird" "Back in the old days the policemen used them to get around" "They are grumpy grandpas"
Perceived Danger	The relative personal risk of interacting with a species	"They can kill you"

		“They try to attack you at night” “They are harmless”
Persecution	Human encroachment or harm incurred on the species	“They get hunted a lot” “They are getting killed by cars”
Threatened Status	The species’ conservation status or environmental threats to the species	“They are dying from bushfires” “They’re almost extinct” “They are not endangered”

Supplementary table S2. Counts of codes for each norm in baseline pre-test survey results, experimental group pre- and post-test survey results, and control group pre- and post-test survey results, according to whether the respondent included or excluded the species in question from their moral circle. Total column provides overall count irrespective of inclusion or exclusion. Percentages calculated as a proportion of the number of survey responses (n). Sign test for differences between pre- and post- test counts performed on total column only. *p < 0.05

	Baseline (n = 346)			Experimental (n = 150)			Control (n = 160)		
	Inclusion	Exclusion	Total	Inclusion	Exclusion	Total	Inclusion	Exclusion	Total
Abundance									
Pre	2	2	4	1	1	2	1	1	2
	(0.8%)	(2.0%)	(1.2%)	(0.9%)	(2.3%)	(1.3%)	(0.9%)	(2.2%)	(1.3%)
Post				2	0	2	1	2	3
				(1.6%)	(0.0%)	(1.3%)	(0.9%)	(3.8%)	(1.9%)
Difference				1	–1	0	0	1	1
				(0.6%)	(–2.3%)	(0.0%)	(0.1%)	(1.6%)	(0.6%)
Aesthetics									
Pre	60	1	61	40	1	41	17	0	17
	(24.4%)	(1.0%)	(17.6%)	(37.4%)	(2.3%)	(27.3%)	(14.8%)	(0.0%)	(10.6%)
Post				36	1	37	18	1	19
				(28.1%)	(4.5%)	(24.7%)	(16.8%)	(1.9%)	(11.9%)
Difference				–4	0	–4	1	1	2
				(–9.3%)	(2.2%)	(–2.6%)	(2.0%)	(1.9%)	(1.3%)
Affinity									
Pre	49	5	54	27	4	31	22	1	23
	(19.9%)	(5.0%)	(15.6%)	(25.2%)	(9.3%)	(20.7%)	(19.1%)	(2.2%)	(14.4%)

Post				26	4	30	13	2	15
				(20.3%)	(18.2%)	(20.0%)	(12.1%)	(3.8%)	(9.4%)
Difference				–1	0	–1	–9	1	–8
				(–4.9%)	(8.9%)	(–0.7%)	(–7.0%)	(1.6%)	(–5.0%)
Descriptors									
Pre	9	6	15	3	3	6	4	1	5
	(3.7%)	(6.0%)	(4.3%)	(2.8%)	(7.0%)	(4.0%)	(3.5%)	(2.2%)	(3.1%)
Post				5	0	5	5	1	6
				(3.9%)	(0.0%)	(3.3%)	(4.7%)	(1.9%)	(3.8%)
Difference				2	–3	–1	1	0	1
				(1.1%)	(–7.0%)	(–0.7%)	(1.2%)	(–0.3%)	(0.7%)
Instrumental value									
Pre	13	4	17	8	2	10	5	1	6
	(5.3%)	(4.0%)	(4.9%)	(7.5%)	(4.7%)	(6.7%)	(4.3%)	(2.2%)	(3.8%)
Post				12	3	15	3	4	7
				(9.4%)	(13.6%)	(10.0%)	(2.8%)	(7.5%)	(4.4%)
Difference				4	1	5	–2	3	1
				(1.9%)	(9.0%)	(3.3%)	(–1.5%)	(5.3%)	(0.6%)
Intrinsic value									
Pre	55	0	55	15	0	15	31	0	31
	(22.4%)	(0.0%)	(15.9%)	(14.0%)	(0.0%)	(10.0%)	(27.0%)	(0.0%)	(19.4%)
Post				43	0	43	20	0	20
				(33.6%)	(0.0%)	(28.7%)	(18.7%)	(0.0%)	(12.5%)
Difference				28	0	28*	–11	0	–11*
				(19.6%)	(0.0%)	(18.7%*)	(–8.3%)	(0.0%)	(–6.9%*)
Knowledge									
Pre	1	9	10	0	1	1	0	8	8
	(0.4%)	(9.0%)	(2.9%)	(0.0%)	(2.3%)	(0.7%)	(0.0%)	(17.8%)	(5.0%)
Post				0	2	2	4	8	12
				(0.0%)	(9.1%)	(1.3%)	(3.7%)	(15.1%)	(7.5%)
Difference				0	1	1	4	0	4
				(0.0%)	(6.8%)	(0.6%)	(3.7%)	(–2.7%)	(2.5%)
Nativeness									
Pre	30	7	37	11	5	16	17	2	19
	(12.2%)	(7.0%)	(10.7%)	(10.3%)	(11.6%)	(10.7%)	(14.8%)	(4.4%)	(11.9%)
Post				19	3	22	16	1	17
				(14.8%)	(13.6%)	(14.7%)	(15.0%)	(1.9%)	(10.6%)
Difference				8	–2	6	–1	–1	–2
				(4.6%)	(2.0%)	(4.0%)	(0.2%)	(–2.6%)	(–1.3%)
Nuisance									
Pre	7	17	24	4	7	11	3	9	12
	(2.8%)	(17.0%)	(6.9%)	(3.7%)	(16.3%)	(7.3%)	(2.6%)	(20.0%)	(7.5%)

Post				4	4	8	2	17	19
				(3.1%)	(18.2%)	(5.3%)	(1.9%)	(32.1%)	(11.9%)
Difference				0	–3	–3	–1	8	7
				(–0.6%)	(1.9%)	(–2.0%)	(–0.7%)	(12.1%)	(4.4%)
Other									
Pre	4	10	14	2	7	9	2	3	5
	(1.6%)	(10.0%)	(4.0%)	(1.9%)	(16.3%)	(6.0%)	(1.7%)	(6.7%)	(3.1%)
Post				2	0	2	4	3	7
				(1.6%)	(0.0%)	(1.3%)	(3.7%)	(5.7%)	(4.4%)
Difference				0	–7	–7	2	0	2
				(–0.3%)	(–16.3%)	(–4.7%)	(2.0%)	(–1.0%)	(1.3%)
Perceived danger									
Pre	16	39	55	9	13	22	7	19	26
	(6.5%)	(39.0%)	(15.9%)	(8.4%)	(30.2%)	(14.7%)	(6.1%)	(42.2%)	(16.3%)
Post				4	8	12	12	24	36
				(3.1%)	(36.4%)	(8.0%)	(11.2%)	(45.3%)	(22.5%)
Difference				–5	–5	–10*	5	5	10
				(–5.3%)	(6.1%)	(–6.7%*)	(5.1%)	(3.1%)	(6.2%)
Persecution									
Pre	13	4	17	3	2	5	7	2	9
	(5.3%)	(4.0%)	(4.9%)	(2.8%)	(4.7%)	(3.3%)	(6.1%)	(4.4%)	(5.6%)
Post				6	0	6	14	0	14
				(4.7%)	(0.0%)	(4.0%)	(13.1%)	(0.0%)	(8.8%)
Difference				3	–2	1	7	–2	5
				(1.9%)	(–4.7%)	(0.7%)	(7.0%)	(–4.4%)	(3.2%)
Threatened status									
Pre	53	4	57	11	0	11	37	2	39
	(21.5%)	(4.0%)	(16.5%)	(10.3%)	(0.0%)	(7.3%)	(32.2%)	(4.4%)	(24.4%)
Post				10	0	10	34	3	37
				(7.8%)	(0.0%)	(6.7%)	(31.8%)	(5.7%)	(23.1%)
Difference				–1	0	–1	–3	1	–2
				(–2.5%)	(0.0%)	(–0.6%)	(–0.4%)	(1.2%)	(–1.3%)

Supplementary table S3. McNemar’s test for species inclusion/exclusion in pre- and post-test survey responses.*$p < 0.05$

			Post-test		
			Inclusion	*Exclusion*	*Total*
Pre-test	Control	*Inclusion*	102	13	*115*
		Exclusion	5	40	*45*
		Total	*107*	*53*	*160*
			Inclusion	*Exclusion*	*Total*
	Experimental	*Inclusion*	104	3*	*107*
		Exclusion	24*	19	*43*
		Total	*128*	*22*	*150*

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Part 3: Entanglement in practice

My dissertation uses a case study approach to investigate what happens when conservation and, more specifically, coexistence on production landscape, are reframed by moral inclusivity and seeks to uncover whether mutualistic pathways improve the ethical and practical outcomes of coexistence. I pursue this in three sequential parts – barriers, pedagogy, and opportunities – that together support the argument that a holistic, morally inclusive coexistence is critical to the progress of conservation in shared landscapes.

In Part 1, I revealed that normative constructs underpinned by the position that humans are separate from nature can stifle progress in conservation through poor decision-making, public backlash, and justifications of harm. Instead, an approach that is grounded in awareness and transparency of values and objectives in conservation can lead to more ethically and scientifically rigorous conservation action. In chapter 4, I found that human exceptionalism can contribute to a more limited understanding of multispecies coexistence landscapes in the literature and that a morally inclusive approach is better suited to strongly incentivise coexistence. In Part 2, I demonstrated that moral inclusion can be effectively integrated into primary school education and that morally inclusive pedagogy inspires children to accept wildlife as legitimate constituents of shared landscapes.

Part 3 explores opportunities for conservation on coexistence landscapes when the discipline practices moral expansiveness. I present two practical examples of morally inclusive coexistence, wherein humans are entangled with the rest of nature rather than separate to it, to demonstrate the viability of this approach and its holistic contribution to conservation goals.

Chapter 6. Testing the efficacy and behavioural mechanism of a light-based non-lethal sensory deterrent on red foxes and eastern grey kangaroos

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Abstract

Growing calls for coexistence are met with several obstacles, such as unclear definitions of coexistence itself and the difficulties of encouraging long-term behaviour change, that impede the progress of peacefully sharing space. As part of the effort to renegotiate culturally engrained intolerance for wildlife and to improve willingness to share space, non-lethal wildlife deterrents have been developed and implemented globally. While many non-lethal tools have been tested for their efficacy in terms of measures of conflict, there is limited scientific inquiry into the behavioural mechanisms of such devices. This is noteworthy because many deterrents emit sensory stimuli to interfere with calculations of risk by wildlife to redirect the behavioural pathway away from “unwanted” behaviours. The lack of behavioural investigation demands urgent attention because evidence that can be used to refine non-lethal deterrent technology and therefore improve outcomes can assist in reducing emphasis on culturally normative lethal control of wildlife and help codify non-lethal practices into evidence-based policy. One light-based non-lethal tool that is gaining traction as a globally relevant predator deterrent is Foxlights, which was developed for deterring red foxes (*Vulpes vulpes*) but is also thought to deter herbivores from grazing in pastures. The purpose of this study was to acquire robust quantitative evidence on the underlying behavioural mechanism of Foxlights for the first time. We utilised a Before-After Control-Impact (BACI) design on two livestock production landscapes in Australia to evaluate the effect of Foxlights on activity rates, activity durations, and temporal activity patterns of red foxes and eastern grey kangaroos (*Macropus giganteus*). While we tested Foxlights in two contrasting contexts of persecution, anticipating greater sensitivity when wildlife associate light stimuli of farmers/hunters with higher risk, our results did not reveal any significant trends. Despite this, we strongly advocate for further application of experimental designs, like BACI designs, that account for variability in field conditions by controlling for confounding variables inherent in environmental landscapes. Best practice in research design into non-lethal methods for conflict reduction is needed to embolden efforts to change the ways in which we interact with our non-human neighbours.

Introduction

As the human population grows and habitat fragmentation accelerates, limitations on resources and space puts pressure on the lives of humans and wildlife alike (Inskip & Zimmermann 2009a; Nyhus 2016). As these pressures accelerate, the needs and behaviours of humans and wildlife can drive conflict and intolerance (Madden 2004). Problematically, anthropocentric responses to human-wildlife conflict (HWC) prioritize and preserve the needs of humans over those of wildlife, facilitating practices that eliminate or reduce wildlife from the landscape, either through exclusion or lethal measures (Inskip & Zimmermann 2009a; Thorn et al. 2012; Boonman-Berson et al. 2016). These ongoing practices threaten the conservation of wildlife globally (Ripple et al. 2014), and endanger the welfare and lives of sentient individuals (Nunny 2020). To remedy this situation, one solution proposed by conservationists is to redirect the energy spent excluding wildlife towards finding sustainable and mutualistic measures of coexisting with them (Kremen & Merenlender 2018; Pooley et al. 2020).

The definition of *coexistence* is inconsistently applied in the literature and therefore varies along a spectrum that ranges from co-occurrence but temporal avoidance to a morally-inclusive version of cohabitation that promotes mutualistic sharing (Harihar et al. 2013; Boonman-Berson et al. 2016; Carter & Linnell 2016; Knox et al. 2020). At its simplest, coexistence aims to identify solutions to human-wildlife conflicts (Nyhus 2016; Pooley et al. 2017). More holistic interpretations of coexistence, such as that of cohabitation, focus on the ways in which human and wildlife interactions co-shape the landscape (See Chapter 3, Boonman-Berson et al. 2016, Toncheva and Fletcher 2021). While still employing non-lethal mitigation techniques, cohabitation encourages behaviours, and therefore the use of tools, that curate mutual benefits and compassion for all constituents of shared landscapes. Regardless of how coexistence is envisaged and actioned, the various interpretations of coexistence agree upon the core goal of reducing HWC to protect the lives of both wildlife and humans.

Growing calls for coexistence, however, are met with several obstacles that impede on the progress of successfully sharing space (Treves & Bruskotter 2014; Dietsch et al. 2019). These include culturally engrained intolerance for wildlife, conflicting wildlife value orientations, and, more generally, a lack of consensus and clarity around where objectives lie on the spectrum of coexistence (Dietsch et al. 2019; Jordan et al. 2020; Knox et al. 2020). As part of the effort to renegotiate culturally engrained intolerance for wildlife and to improve willingness to share space, non-lethal wildlife deterrents have been developed and implemented globally. While not the only (or singularly most important) component of coexistence, practical and evidence-based non-lethal tools for conflict mitigation, especially those predicated on inclusion and understanding, are critical for paving a path toward cohabitation between humans and wildlife.

Empirical studies that exist to support the utility of non-lethal tools such as fladry, livestock guardian dogs, and night-time corralling, most often quantify the functional effectiveness of non-lethal tools by measuring success in conflict reduction (see Eklund et al. 2017, van Eeden et al. 2018), such as a reduced number of depredation events. While this approach is undoubtedly practical, it does not directly provide information on the mechanism driving behavioural change in wildlife. Oversight of the significance of behavioural data in the accumulation of evidence supporting non-lethal tools is noteworthy because the behavioural outcomes that are measured in HWC studies are not isolated events, but rather responses to complex calculations of multifaceted risk (Lima & Bednekoff 1999; Ramp et al. 2005; Fischer et al. 2017). Animals gather information about their environments through a range of sensory modalities and utilise it to calculate risk (Elmer et al. 2021); this calculation can be critical in deciding whether to engage in specific behaviours that may improve fitness, and can be costly (or fatal) if miscalculated (Lima & Dill 1990; Hebets & Papaj 2005; Ward & Mehner 2010). For example, tammar wallabies (*Macropus eugenii*) often detect predators using visual cues, but may only flee once this risk is confirmed by auditory cues obtained though conspecific foot-thumping (Blumstein et al. 2000). Such behavioural processes are not negligible in HWC mitigation research because many wildlife deterrents are designed to communicate aversive stimuli, such as predator scent, pungent taste, and loud noise, to alter calculations of risk and subsequently redirect the behavioural pathway away from “unwanted” behaviours (Ramp et al. 2011; Elmer et al. 2021). Measuring success in terms of the likelihood of an undesirable behaviour without investigating how the device alters patterns of behaviours is therefore a cursorial approach to evaluating deterrent effect. A better understanding of the behavioural mechanisms of non-lethal deterrents demands urgent attention because this kind of information can help refine a tool and its use to be more relevant for the targeted species (Coulson & Bender 2019; Elmer et al. 2021), thereby improving outcomes of non-lethal approaches to interactions with wildlife. Advancement in the efficacy of non-lethal tools ultimately contributes to the reduction of culturally normative and accepted (though often ineffective) lethal control of wildlife and helps codify non-lethal practices into science-based policy.

The use of light as a sensory mechanism for deterring wildlife is particularly suited to crepuscular and nocturnal species. One light-based tool that is gaining traction globally is Foxlights, a relatively inexpensive and novel non-lethal wildlife deterrent already in use by pastoralists seeking to protect livestock and wildlife. Equipped with 9 night-activated lights that randomly flash in three colours (red, blue, and white) (Fig. 1), Foxlights were designed to reduce predation on livestock by emitting visual cues that are thought to exploit canid neophobia through simulation of night-time human presence (i.e., a farmer on the prowl with spotlight and gun) (Foxlights 2021). While Foxlights are marketed as a predator deterrent, users of Foxlights have reported that they may also assist with deterring herbivorous species from human assets, such as ducks from rice paddies, bats from roofs, and kangaroos from grazing pasture.

Figure 1. Foxlights, a night-time non-lethal predator deterrent used worldwide.

With increasing global use of Foxlights, research into their efficacy and of other similar devices for reducing negative interactions between humans and wildlife is paramount. While the growing, but limited, number of peer-reviewed studies on the efficacy of Foxlights or similar flashing light mechanisms for deterring wildlife (e.g., Lesilau et al. 2018, Okemwa et al. 2018, Ohrens et al. 2019, Adams et al. 2020, Naha et al. 2020, Verschueren et al. 2021, Wanjira et al. 2021) investigate reductions in conflict, they do not address the behavioural mechanisms of the deterrent. To the best of our knowledge, there are no studies on Foxlights (or similar mechanisms) that evaluate changes in the behavioural ecologies of the target species, a critical element of deterrent efficacy.

The purpose of our study was to quantify changes in the spatial and temporal patterns of pasture-use by red foxes (*Vulpes vulpes*) and eastern grey kangaroos (*Macropus giganteus*) in response to the deployment of Foxlights. We designed our research to provide a robust method for acquiring quantitative evidence of the underlying behavioural mechanism of Foxlights by utilising a Before-After Control-Impact (BACI) design (Stewart-Oaten & Bence 2001). Manufacturers recommend the use of Foxlights to “keep predators at bay” and to “aid in the deterrent of night predators” (Foxlights 2021). For this to be the case, we would expect the frequency of fox activity to decline in the presence of Foxlights (i.e., they may choose to avoid the area by going elsewhere). For those animals that are not deterred entirely, it is plausible that the presence of Foxlights will nevertheless heighten their assessment of risk, resulting in a reduction in the duration of their presence (i.e., they may still frequent the area but they will do so more quickly). Based on anecdotal evidence of those who utilise Foxlights, we would expect similar responses from grey kangaroos.

Methods

Study Design and Area

Our study used a BACI design on two livestock production landscapes in Australia to evaluate changes in camera trap capture rate and duration of red foxes and grey kangaroos in response to Foxlights. In a BACI design, two independent transects are selected to monitor a response variable. One transect is randomly assigned to receive the intervention (i.e., impact transect) while the other transect remains undisturbed (i.e., control transect). Data is collected on both transects simultaneously before and after (or during) the intervention is implemented and response to the intervention is determined by the interaction between before/after and impact/control. The utility of this design lies in its ability to isolate the treatment effect from the local natural variability inherent in field trials (Stewart-Oaten & Bence 2001).

The mechanism of Foxlights is designed to mimic risk associated with human presence (i.e., potential persecution). We therefore chose to implement our study on two sites with different wildlife management histories to provide insight into how responses to Foxlights may vary with opposing wildlife control practices. Site 1, set in the Bathurst region of inland New South Wales, farms both cattle and sheep following the traditional approach to protecting livestock using a combination of shooting kangaroos and foxes and poison baiting foxes and dingoes. Site 2, in the Bundaberg region of coastal Queensland, farms only cattle. The property shares a border with a national park, but despite dingo and fox presence and a healthy kangaroo population, the farm managers do not employ any wildlife control measures within the bounds of the farm itself (the national park, however, is baited within its boundaries). Data were collected on Site 1 in 2018 and Site 2 in 2020 while both properties were experiencing drought conditions.

Study Implementation

At each site, we selected two independent transects and randomly assigned them to the Control or Impact treatments. Each roughly linear transect was equipped with 10 camera traps for detecting movement of wildlife through the landscape. We captured undisturbed wildlife activity at each transect simultaneously for 2-3 weeks (i.e., Before period). We then activated three Foxlights for two weeks on the Impact transect while maintaining the original undisturbed conditions at the Control transect (i.e., After period). The experiment concluded at the end of the 2-week After period.

To detect the movement of wildlife at each transect, we mounted 10 motion-sensing camera traps ~1 m above ground every ~50 m along a wire fence line. The fence line bordered closed canopy cover on one side and grazing pasture on the other at all sites. The Foxlights were erected ~1.5 m above ground approximately 125 m apart from one another, positioned within 10 m of the fence line in a way that ensured visibility to approaching wildlife. Assuming the maximum home range size of grey kangaroos is approximately 1 km^2 on rural landscapes (Viggers & Hearn 2005), transects at each site were >1 km apart and separated by dense vegetation to ensure independence of sampling.

This study was reviewed and approved by University of Technology Animal Care and Ethics Committee (ETH18-2124) and New South Wales National Parks & Wildlife Service (Scientific License #SL102076). Scientific License was not required in Queensland.

Data Analysis

We manually sorted camera trap images according to species. For each treatment period, we calculated the total number of events per species by camera, relativised by the number of trap nights by camera (i.e., event frequency). The detection of an animal or group of animals was considered a single event; any detections of the same species that occurred within 5 minutes of the previous detection were condensed into one event. Event duration was calculated as the duration between the first and last capture of the event. The duration of single capture events were recorded as 1 second.

All analyses were conducted in R (R Core Team 2019). We converted the data to ordinal factors and used ordinal regressions to model the effect of Foxlights on the event frequencies and durations of both foxes and kangaroos. Ordinal models were used because the data were non-normal and highly skewed; unlike other non-parametric tests such as Wilcoxon and Kruskal-Wallis, ordinal models can test the interaction amongst factors without assuming normality.

We used the ‘overlap’ package (version 0.3.2) to test for changes in temporal activity patterns by calculating the degree of overlap, as quantified using the coefficient of overlap. We estimated kernel densities, creating probability density distributions for the activity patterns of each species. We then used these density distributions to calculate the coefficient of overlap (Δ^4) between treatments for each species, which quantifies the temporal overlap of behaviour when Foxlights are off (before period) versus on (after period). We used the Δ^4 overlap statistic as it is considered the most reliable for estimating the activity patterns of species with sample sizes greater than 75 detections (Ridout & Linkie 2009). We calculated 95% confidence intervals by generating 10,000 smoothed bootstrap samples for when Foxlights were on and for when they were off. We accounted for bootstrap bias using the “Basic0” approach.

Results

We did not find a significant effect of the interaction between period and transect on red fox activity at either Site 1 or Site 2 ($p > 0.05$, Fig. 2A, 2B). We found a significant effect of the interaction between period and transect on grey kangaroo event frequency at Site 2 (df = 1, $\chi^2 = 5.24$, $p = 0.02$, Fig. 2D), but not at Site 1 ($p > 0.05$, Fig. 2C). At Site 2, kangaroo event frequency significantly increased when Foxlights were on (model estimate ± SE = 2.73 ± 1.19, Z = 2.29, $p = 0.02$).

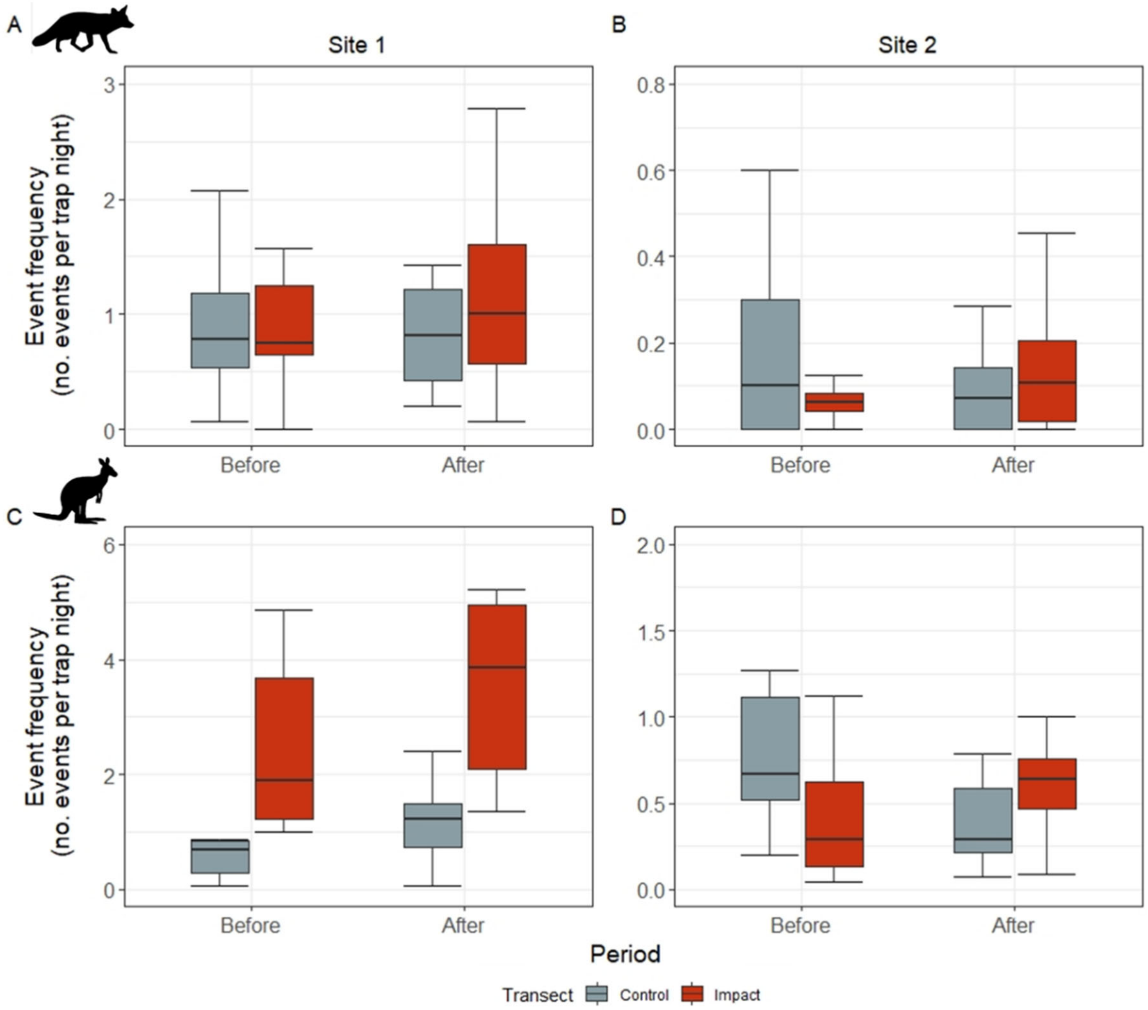

Figure 2. Event frequency by treatment before and after Foxlights were activated for red foxes at A) Site 1 and B) Site 2, and for grey kangaroos at C) Site 1 and D) Site 2.

We found a weakly significant effect of the interaction between period and transect on fox event duration at Site 1 (df = 1, $\chi^2 = 3.53$, $p = 0.06$, Fig. 3A) and no effect at Site 2 ($p > 0.05$, Fig. 3B). At Site 1, fox event duration decreased when Foxlights were on (-0.35 ± 0.19, Z = -1.88, $p = 0.06$). There was no effect of the interaction between period and transect on kangaroo event duration at either site ($p > 0.05$, Fig. 3C, 3D).

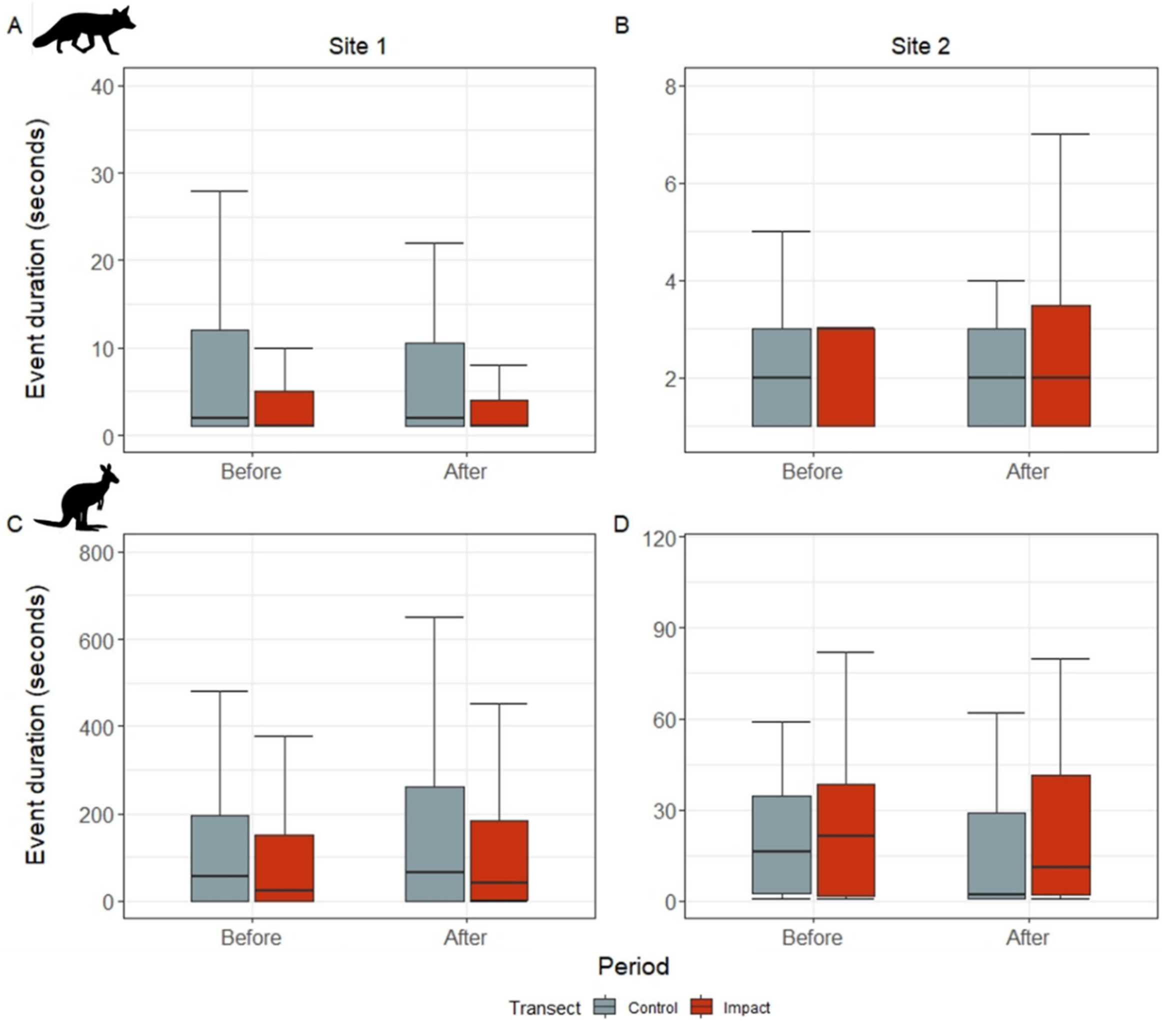

Figure 3. Event duration by treatment before and after Foxlights were activated for red foxes at A) Site 1 and B) Site 2, and for grey kangaroos at C) Site 1 and D) Site 2.

Overlap of fox activity when Foxlights were off and when Foxlights were on was high at both Site 1 (Δ^4 = 0.82, CI = 0.76-0.84, Fig. 4A) and Site 2 (Δ^4 = 0.77, CI = 0.65-0.82, Fig. 4B). Patterns in grey kangaroo activity were similarly high at both sites (Site 1: Δ^4 = 0.77, CI = 0.74-0.79; Site 2: Δ^4 = 0.62, CI = 0.60-0.65; Fig. 4C, 4D). These findings indicate that neither species notably altered their temporal activity patterns in response to the activation of the Foxlights.

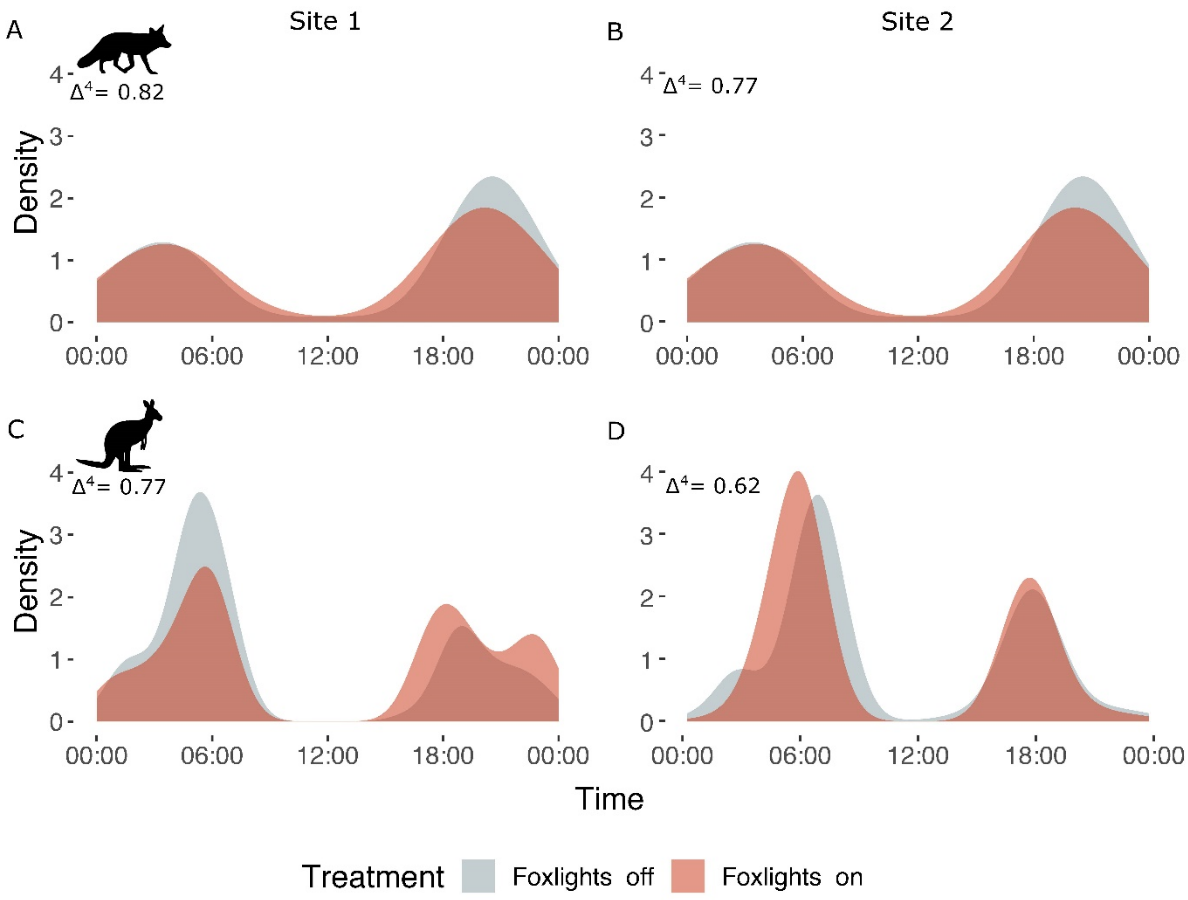

Figure 4. Overlap of activity when Foxlights were off and when Foxlights were on for red foxes at A) Site 1 and B) Site 2, and for grey kangaroos at C) Site 1, and D) Site 2.

Discussion

The effectiveness of a light emitting deterrent relies upon three factors: 1) the animal's ability to perceive the stimulus, 2) the capacity for the stimulus to induce a correct desired behaviour, and 3) maintenance of a novel stimulus (lack of habituation) (D'Angelo & van Der Ree 2015, Coulson & Bender 2019). Although we did not set out to explicitly detect whether foxes or kangaroos observe and respond to the stimulus directly, the aim of our study was to apply a robust methodology to test the underlying behavioural mechanisms of Foxlights, a light-based non-lethal wildlife deterrent. We tested for changes in behaviour in three ways. First, we tested whether the activation of Foxlights deterred the presence of foxes and kangaroos.

We then examined how the duration of their behaviour changed when they were present, followed by whether temporal patterns of activity shifted when Foxlights were on. Overall, we did not identify any major trends in changes in activity patterns in response to Foxlights.

Our analysis revealed two measures of activity that responded to Foxlights. Kangaroo event frequency increased slightly when Foxlights were on at Site 2, but not at Site 1. One explanation for this could be attributed to calculations of risk (Lima & Dill 1990; Hebets & Papaj 2005; Ward & Mehner 2010). At the time of data collection, drought conditions were progressing rapidly, threatening wildlife populations Australia-wide. While surrounding landscapes became barren, graziers at Site 2 actively managed the rotation of cattle and were able to preserve vegetation in the pastures included in this study. The impact transect at Site 2 ran perpendicular to a main road, with the closest end of the transect only ~20 m away from the roadside. Given the constraints of low vegetation availability elsewhere and the dangers of roads, the risk of starvation may have outweighed the perceived risk of active Foxlights.

Our findings indicated that fox event duration likely decreased in response to the activation of Foxlights at Site 1. While the p-value was marginally greater than the significance level used in this study (0.05), we chose to make note of this effect due to its practical implications. The additive effect of implementing a suite of tools following random intervals is believed to be critical for effective non-lethal wildlife management (Shivik & Martin 2000; Stone et al. 2017b). In practice, Foxlights are not generally implemented alone, but are instead employed in conjunction with other non-lethal tools for deterring predators, such as night-penning and human presence (Stone et al. 2017b; Lesilau et al. 2018; Ohrens et al. 2019). Although the independent effect of Foxlights may not be significant, the changes in activity duration observed in this study indicate a shift in behavioural calculations that may contribute to the overall effectiveness of the multi-faceted approach of non-lethal strategies. Experimental approaches that do not test the behavioural responses that precede predation are not able to provide insight into such possibilities.

Given the increase in attentiveness to the intrinsic value of wildlife and to the conservation value of wildlife persistence in production landscapes (Manfredo et al. 2016; Kremen & Merenlender 2018; Bruskotter et al. 2019), it is imperative to develop effective non-lethal wildlife deterrents as viable alternatives to lethal control. Moreover, strong empirical evidence is critical for supporting global efforts to increase the adoption of these strategies both in practice and in policy (Eklund et al. 2017). While our study did not reveal any major conclusions regarding the effectiveness of Foxlights, we found utility in the BACI design for rigorously investigating the efficacy of a non-lethal deterrent under field conditions.

The BACI design provides a robust method for controlling for innate differences across environmental landscapes and production management that can confound experimental results (Stewart-Oaten & Bence 2001). Animal behaviour, however, is also highly variable by nature (Palmer et al. 2017; Hertel et al. 2020; Shaw 2020), the vagaries of which may have impacted our results. For example, Foxlights are not the only stimulus present on the transects: other stimuli such as the presence of other animals or environmental conditions like weather events can impact how animals behave at a given moment (Abernathy et al. 2019; Wooster et al. 2019). Although BACI designs can control for fluctuations in environmental variability, unpredictability will always be inherent in behavioural responses and individual decision-making of wildlife to threatening stimuli (Jones & Godin 2010; Hertel et al.

2020; Shaw 2020). Future studies on sites with higher capture rates and with increased sampling periods may be able to refine this approach. Decisions to predate or graze are not unidimensional, however, best practice in research design into non-lethal methods for conflict reduction are needed to influence wildlife decision-making and to embolden efforts to change the ways in which we interact with our non-human neighbours.

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Chapter 7. Examining the suitability of wildlife-friendly farming as a holistic approach to sustainable food production using a One Health model of livestock production landscapes

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Abstract

Wildlife and people rely on the persistence of healthy and resilient landscapes to sustain them, but the environmental consequences of unsustainable food production practices are threatening the futures of food security and biodiversity conservation alike. The adoption of sustainable food production has been proposed as a vital strategy for securing the health and resilience of production landscapes, however recommendations for transforming the concept into practice is mostly limited to broad-scale strategies that are disconnected from landscape level implementation. The One Health framework, which recognises that the inextricable relationships between human, animal, and environmental health are integral to healthy systems, be an applicable strategy for evaluating the suitability of farming practices to meet sustainable food production goals. We constructed a One Health network diagram of livestock production landscapes to illustrate some of the key relationships between the stakeholders of extensive livestock production systems, which are represented by three different health spheres – farm, environmental, and human. Our network

diagram sheds light on the complexity of the interactions between spheres on production landscapes by illustrating the directions of health relationships between the spheres and by presenting a selection of key indicators of health. We used this diagram to guide a case study that investigates how One Health relationships actualise on a wildlife-friendly farm in South Africa relative to neighbouring conventional farms. Compared to conventional practices of free-roaming grazing and lethal wildlife control, many wildlife-friendly farming approaches utilise livestock herding and night-penning as a way to not only protect livestock from predators, but to also mechanically rehabilitate degraded food production landscapes. The three farms examined in our study clearly followed very different journeys through the One Health network, only to arrive at relatively similar productivity targets with respect to livestock, but vastly different measures of wellbeing in other One Health spheres. Nevertheless, the case study demonstrates the utility of our network diagram for evaluating WFF as a sustainable food production strategy using quantitative data from a practical example. Our study reveals that sustainable food production is much more than just the sum of its parts. The holistic approach of WFF, which is grounded in One Health, strives to reconnect and revitalise the fragmented relationships between those parts, creating a landscape in which all stakeholders coexist.

Introduction

Wildlife and people rely on the persistence of healthy and resilient landscapes to sustain them. However, since the beginning of the industrial revolution, many food production practices have been, and continue to be, responsible for widespread environmental degradation across the world. Practices like vegetation removal, topsoil depletion, and overgrazing by livestock have caused catastrophic wildlife decline, exacerbated anthropogenic climate change, and initiated large-scale landscape desertification (Milton et al. 1994; Godfray et al. 2010; Foley et al. 2011; Ripple et al. 2015; Díaz et al. 2019; Powers & Jetz 2019; Leclère et al. 2020). In return, food production itself has become vulnerable to these consequences, threatening long-term food security (Milton et al. 1994; Mann & Sherren 2018; Díaz et al. 2019; Leclère et al. 2020; Ortiz et al. 2021). There is, therefore, an increasing global focus by conservationists, agriculturalists, economists, and food security experts on the development of policy and practical mechanisms that promote and secure the health and resilience of production landscapes (Glamann et al. 2017; Searchinger et al. 2019; Gerten et al. 2020; Herrero et al. 2020). The adoption of sustainable food production practices that balance food provision with environmental health has been proposed as a vital strategy for meeting the demands of a growing human population and nature conservation (Godfray et al. 2010; Foley et al. 2011; Tscharntke et al. 2012).

At a policy level, efforts to entrench sustainability policy in food production have been encouraging, as global policies on sustainable futures now highlight the central role of sustainability as a clear target for simultaneously improving global food security and protecting biodiversity (UN 2017; CBD 2020). Indeed, sustainable food production has been endorsed by the United Nation’s (UN) Sustainable Development Goals (SDGs) and the Convention on Biological Diversity (CBD) post-2020 Global Biodiversity Framework as a critical operational tool (UN 2017; CBD 2020). Goal 2 (“Zero Hunger”) of the SDGs calls for the adoption of sustainable food production systems as a key mechanism for reducing global food insecurity, while Target 9 of the CBD framework asserts that sustainable agricultural ecosystems is needed to protect biodiversity on production landscapes (UN 2017; CBD 2020). Both policies also emphasise that productivity, or the total of all production outputs and inputs (ILO 2021), must be increased to ensure that production is able to meet the food demands of the global population. As complementary policies on global targets for 2030, the UN and CBD directives are explicit regarding the need for a unified approach to achieving agricultural and biodiversity health goals.

While these policies underscore the inextricable relationship between human and wildlife health and their mutual dependence on ecological health and resilience, recommendations for transforming the concept of sustainable food production into practical solutions are mostly limited to broad-scale strategies that are disconnected from landscape level implementation (e.g., Searchinger et al. 2019). To address this, adaptive farm management frameworks that adopt holistic approaches to revitalising mutually beneficial outcomes for nature and people are needed for global policy to succeed (Wittman et al. 2017). Methods for assessing the sustainability of food production practices, however, fail to accurately capture the complex webs of environmental impacts forged by food production landscapes, which are critical to understand for assessing sustainability (Halpern et al. 2019). We suggest that a One Health framework, which aptly sheds light on the interconnectedness of stakeholders of food production systems (Zinsstag et al. 2011), can be used to better understand the complexities of sustainable food production. A One Health approach may therefore be an applicable strategy for evaluating the suitability of farming practices to meet sustainable food production goals, which we explore in the context of extensive commercial livestock production.

One Health and livestock production

The One Health framework posits that the health of humans, animals, and the environment are inextricably intertwined (Fig. 1), and that systemic resilience is derived from actions that support the health and wellbeing of all three of those spheres (Zinsstag et al. 2011). Conversely, poor health outcomes stemming from one sphere can reverberate through the system and inflict poor health for others. For example, in the context of extensive livestock production, severe grazing damages plant productivity (Fedrigo et al. 2018), increases soil compaction (Byrnes et al. 2018), and decreases water infiltration (Xu et al. 2018), which all impact forage availability for livestock grazing. Food producers may then resort to persecuting wildlife to compensate for these spiralling pressures, exacerbating already fractured ecological processes (du Toit et al. 2017). In contrast, wildlife-friendly grazing strategies can support livestock production and wildlife by employing grazing methods that improve plant productivity and resilience (Hasselerharm et al. 2021) and increase the bioavailability of nitrogen (Schurch et al. 2021).

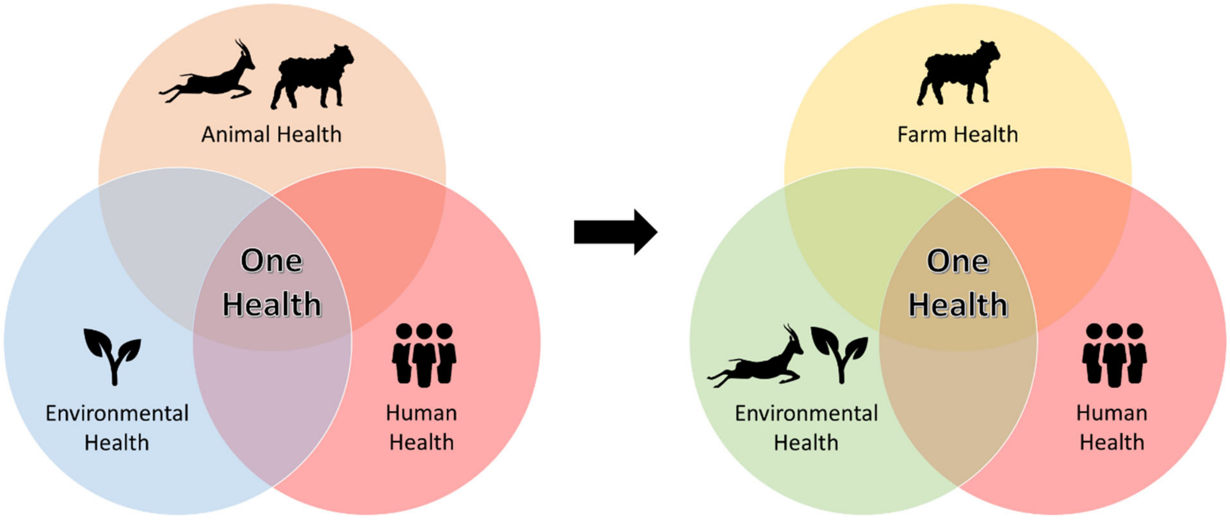


Figure 1. The One Health framework posits that human, animal, and environmental health are all inextricably related. The framework has been altered for the purpose of this study to better reflect livestock production systems; the animal health sphere was replaced with farm health and wildlife and livestock were redistributed to environmental and farm health, respectively. Images: Flaticon.com

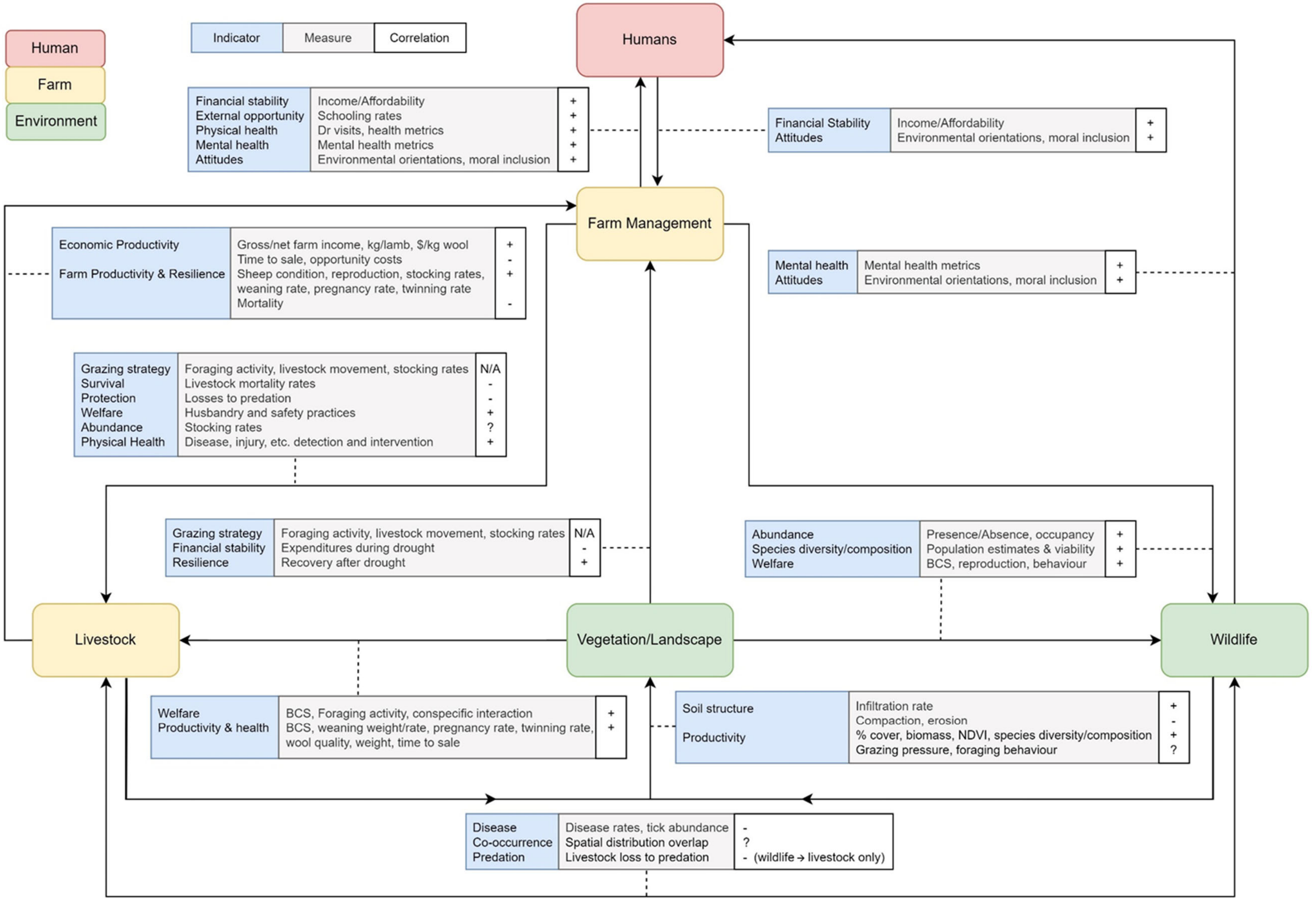
To capture and evaluate the complex and interconnected relationships that are embedded within livestock production environments, the systemic impacts of selected food production practices are best viewed as social-ecological systems

(Wittman et al. 2017). To that end, we constructed a One Health network of livestock production landscapes, integrating and relating stakeholder outcomes (that are often examined independently of one another) to highlight their interconnectedness (Fig. 2).

Our One Health network diagram reflects a selection of measures from the extensive body of research examining livestock production landscapes and strategies, including livestock health and husbandry (e.g., Lichtenfeld et al. 2015; Barnes & Hibbard 2016), farm productivity (e.g., Ferguson et al. 2013; Odadi et al. 2018), ecological processes (e.g., Schmiedel et al. 2016; Chillo et al. 2017; Crawford et al. 2019), and production landscape biodiversity conservation (e.g., Crawford et al. 2019; Schurch et al. 2021), but is not exhaustive and is just one example of how One Health can be used to evaluate sustainability food production. While the stakeholders of a One Health system are traditionally divided into the three spheres of humans, animals, and the environment, we chose to alter the stakeholders included to better reflect livestock production systems. Although wildlife and livestock are both animal groups, in a production context they serve different functional roles within the system; for example, while wildlife are critical for maintaining ecological processes, such as trophic cascades, livestock serve as the backbone of farm productivity. To accommodate this, we replaced the animal health sphere with farm health and redistributed wildlife and livestock to environmental and farm health, respectively (Fig. 1). While this process injected further complexity into the spheres, we clarified this by partitioning the environmental and farm spheres into separate stakeholders (e.g., farm health is split into farm management and livestock).

Our diagram captures some of the key relationships between spheres on production landscapes by illustrating the directions of health relationships between the spheres and by presenting a selection of key indicators of health. Each indicator represents one category of health outcome that contributes to the overall health of the downstream sphere, while acknowledging that it stems from the actions of the upstream sphere. The indicators are paired with relevant quantifiable measures and specify the direction of correlation between the measure and the health outcome for the downstream sphere. For example, both wildlife and livestock can influence the health of vegetation by altering soil structure. Soil structure can be assessed using measures such as infiltration rate, which is positively correlated with vegetation health, and erosion, which is negatively correlated with vegetation health. Although the indicators and measures we provided are not exhaustive, they clearly illustrate the abundance of interactions and variables that can alter the health of an entire system.

The versatility of this network diagram is derived from its adaptability to the world's various grazing landscapes; instead of providing over-generalised benchmarks for success, it provides guidance on how to select benchmarks that are relevant to each system. By parsing out the complexities of grazing landscapes, it can be used to identify failings in health relationships and to inform the selection of practices that can increase the resilience of the overall system. For example, the diagram clarifies the ways in which overgrazing practices that threaten the long-term health of the landscape for short-term gains can trigger a series of negative feedback loops through the system. At the same time, it provides a framework for selecting sustainable grazing strategies to improve vegetation productivity and quality, and ultimately landscape resilience. In this way, the network diagram provides a valuable tool for evaluating the performance of various landscape management strategies.



Indicator	Measure	Correlation
Financial stability	Income/Affordability	+
External opportunity	Schooling rates	+
Physical health	Dr visits, health metrics	+
Mental health	Mental health metrics	+
Attitudes	Environmental orientations, moral inclusion	+

Indicator	Measure	Correlation
Financial Stability	Income/Affordability	+
Attitudes	Environmental orientations, moral inclusion	+

Indicator	Measure	Correlation
Economic Productivity	Gross/net farm income, kg/lamb, $/kg wool	+
	Time to sale, opportunity costs	-
Farm Productivity & Resilience	Sheep condition, reproduction, stocking rates, weaning rate, pregnancy rate, twinning rate	+
	Mortality	-

Indicator	Measure	Correlation
Mental health	Mental health metrics	+
Attitudes	Environmental orientations, moral inclusion	+

Indicator	Measure	Correlation
Grazing strategy	Foraging activity, livestock movement, stocking rates	N/A
Survival	Livestock mortality rates	-
Protection	Losses to predation	-
Welfare	Husbandry and safety practices	+
Abundance	Stocking rates	?
Physical Health	Disease, injury, etc. detection and intervention	+

Indicator	Measure	Correlation
Grazing strategy	Foraging activity, livestock movement, stocking rates	N/A
Financial stability	Expenditures during drought	-
Resilience	Recovery after drought	+

Indicator	Measure	Correlation
Abundance	Presence/Absence, occupancy	+
Species diversity/composition	Population estimates & viability	+
Welfare	BCS, reproduction, behaviour	+

Indicator	Measure	Correlation
Welfare	BCS, Foraging activity, conspecific interaction	+
Productivity & health	BCS, weaning weight/rate, pregnancy rate, twinning rate, wool quality, weight, time to sale	+

Indicator	Measure	Correlation
Soil structure	Infiltration rate	+
	Compaction, erosion	-
Productivity	% cover, biomass, NDVI, species diversity/composition	+
	Grazing pressure, foraging behaviour	?

Indicator	Measure	Correlation
Disease	Disease rates, tick abundance	-
Co-occurrence	Spatial distribution overlap	?
Predation	Livestock loss to predation	- (wildlife → livestock only)

Figure 2. A One Health network diagram of livestock production landscapes elucidates some of the key relationships between the stakeholders of the system. The diagram illustrates the directions of health relationships between the spheres and presents a selection of key indicators of health. Each indicator represents one category of health outcomes that contributes to the overall health of the downstream sphere, yet stems from the actions of the upstream sphere. The indicators are paired with relevant quantifiable measures and specify the correlation between the measure and the health outcome for the downstream sphere. Indicators and measures are not exhaustive.

Wildlife-Friendly Farming

One growing example of locally focussed farm management practices that strive for both food security and environmental health is wildlife-friendly farming (WFF). Selecting grazing strategies that are most beneficial to the landscape and its inhabitants, WFF is a holistic landscape-scale approach to sustainable food production that considers the health of all stakeholders to be integral to landscape resilience and production outcomes (McManus et al. 2015b; Johnson & Wallach 2016; Savory & Butterfield 2016; Hasselerharm et al. 2021; Landmark Foundation 2021a; Schurch et al. 2021). WFF strategies vary based on the farming system (e.g., ecosystem, product type) that is being utilised; on rangeland landscapes, wildlife are not only protected, but are actively encouraged to roam freely to improve ecological function in the landscape (Schurch et al. 2021). To account for possible risks to livestock that accompany sharing space with wildlife, many WFF approaches utilise non-lethal livestock protection strategies, such as livestock herding, night-penning, and visual and auditory deterrents, to protect livestock from predators (McManus et al. 2015b; Stone et al. 2017a; Schurch et al. 2021). Wildlife friendly practices, however, serve a dual purpose for increasing food security; while they ensure supervision of livestock as a means to increasing production success, they also work to rehabilitate degraded food production landscapes that are critical for supporting the future demands of food production (Savory & Butterfield 2016; Crespin & Simonetti 2020; Hasselerharm et al. 2021; Landmark Foundation 2021a; Schurch et al. 2021).

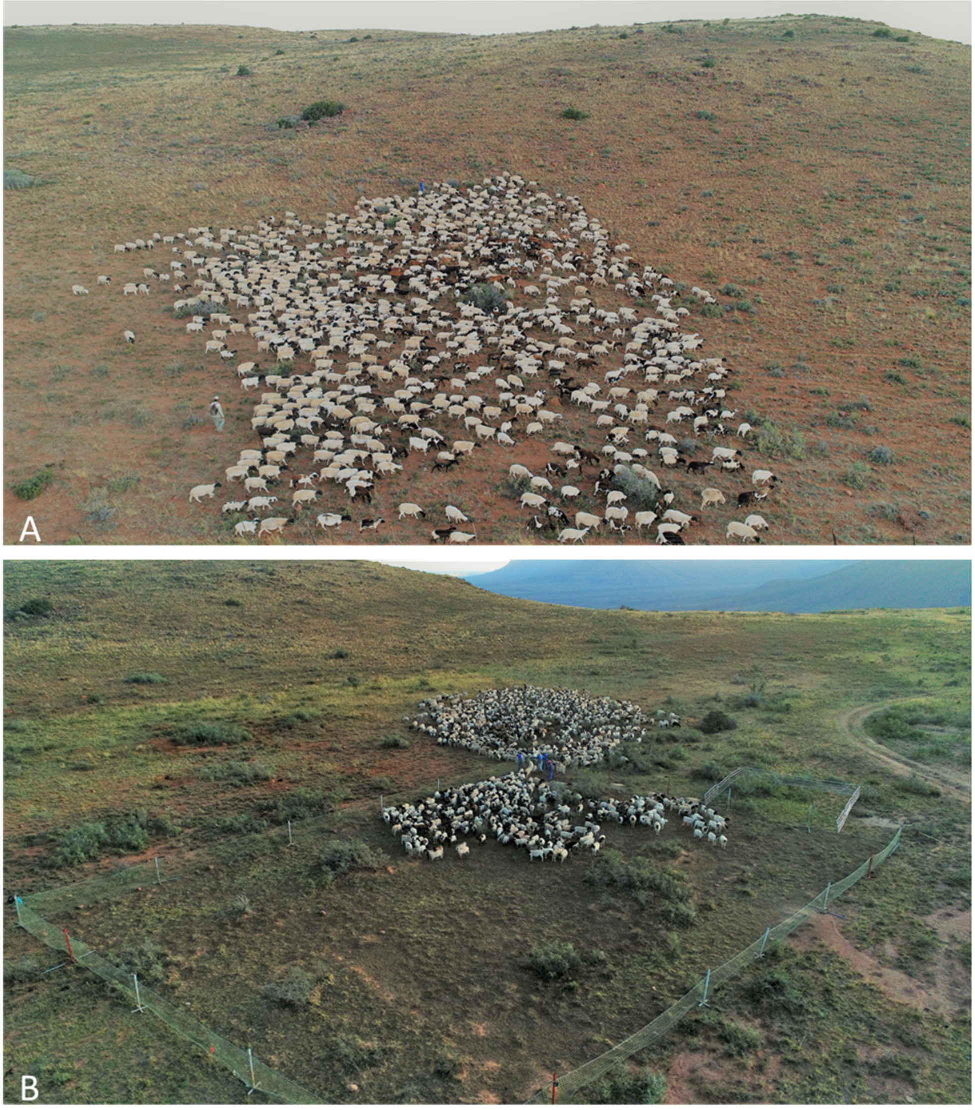


Figure 3. Livestock shepherding in the WFF context employs a high impact and short duration grazing strategy paired with night-time penning and human protection. A) Shepherding controls the density, speed, and duration of livestock grazing to repair fragmented ecological processes. B) Livestock are housed in temporary and densely packed pens for protection and to trample eroded landscapes. Images: C. Hasselerharm, 2018.

Livestock shepherding in the WFF context employs a high impact and short duration grazing strategy to repair fragmented ecological processes (Savory & Butterfield 2016; Mann & Sherren 2018; Landmark Foundation 2021a). In contrast to convention free-roaming grazing practices, which allow livestock to roam freely within large fenced areas, shepherding controls the density, speed, and duration of livestock grazing to prevent the uprooting and overgrazing of vegetation, to reduce selectivity of only palatable species, and to revitalise senescent vegetation (Fig. 3A) (Savory & Butterfield 2016; Mann & Sherren 2018). The dense herd emulates now extirpated, reduced, or restricted herds of herbivores, whose movements across landscapes trampled top soil crusts and deposited nutrients in the form of dung and urine (Savory & Butterfield 2016; Nattrass et al. 2017; McManus et al. 2018; Gordon et al. 2021a, 2021b). At night, housing of livestock in temporary and densely packed pens can accelerate this process on severely eroded areas of the landscape (Fig. 3B) (McManus et al. 2018). Together, these adaptive strategies can be modified to suit the requirements and conditions of individual production landscapes (Savory & Butterfield 2016; Mann & Sherren 2018; McManus et al. 2018). Indeed, studies across different landscapes have demonstrated that these practices can increase vegetation productivity and resilience following drought (Hasselerharm et al. 2021), improve soil hydrologic processes (Weber & Gokhale 2011), and promote nutrient cycling (Park et al. 2017). These grazing techniques can also reduce the need for harmful agricultural inputs (e.g., herbicides and pesticides) (Ferguson et al. 2013), increase productivity (Ferguson et al. 2013; Odadi et al. 2018), and generate premiums for wildlife-friendly certified products (Treves & Jones 2010; WFEN 2015; Landmark Foundation 2021b).

Putting One Health into practice: A case study

Here we present a case study to explore the utility of One Health to evaluate the performance of WFF and conventional grazing practices across different socio-ecological spheres. To populate our network diagram with data, we collected and compared quantitative data on sheep productivity and behaviour from three neighbouring farms in the Nama-Karoo region of South Africa. By selecting three farms that differ in their management practices, we used our One Health network to examine how different practices can influence other spheres within the production system. By doing so, our goal was to highlight how differences in livestock performance and management relate to downstream stakeholders and to provide insight into the viability of WFF, with regards to this case study, as a sustainable food production strategy.

Case study location

We conducted our study in the semi-arid Nama-Karoo biome of South Africa (Fig. 4). Environmental conditions often preclude profitable crop production in large regions of South Africa and instead suit livestock grazing operations. Accordingly, South Africa was ranked 13th in the world for sheep meat production (174,170 tonnes) and 9th in wool (47,039 tonnes) in 2019 (FAO 2021b). More than 69% of the country is classified as permanent pasture and meadow, much of which is dedicated to the 23.3 million sheep within its borders (FAO 2021b). At the same time, South Africa is a global biodiversity hotspot and is at extreme risk of anthropogenic biodiversity loss (Erasmus et al. 2002; Warren et al. 2013; CEPF 2021).

Relatively low in floral biodiversity and vegetation cover, the 25 million hectares of the Nama-Karoo are characterised by unpredictable rain and drought, desertification, and local extirpation of endemic ungulates (Mucina et al. 2011). The region hosts a large portion of South Africa’s small livestock industry, which replaced the migratory springbok and other ungulates over 100 years ago (Nattrass et al. 2017). Any remaining herbivorous wildlife are considered valuable for trophy hunting purposes and are generally confined to graze and browse within property fences. Apex predators have been extirpated and mesopredators are hunted or trapped to reduce depredation on livestock. Farms in this region generally employ a conventional free-roaming grazing system wherein the flock grazes in large fenced pastures (~400 ha), and rotates between pastures every few months dependent on forage availability. Government-mandated fences, originally intended to increase production efficiency, allowed for heavy and unregulated grazing to dominate this arid region for centuries. As a result, approximately 60% of the Nama-Karoo is considered to have moderate to severe degradation of soils and vegetation (Mucina et al. 2011).

We selected three livestock production properties in the Nama-Karoo. Two farms, CF1 (~18,000 ha) and CF2 (~20,000 ha), employ conventional grazing management, wherein sheep are stocked in fixed pastures for several months and wildlife are persecuted. The third farm, WFF1 (~21,000 ha), adheres to wildlife-friendly holistic grazing management, employing high density and short duration grazing regimes, livestock shepherding and night-penning, and cohabitation with wildlife. At the time of this study, CF1 was providing significant supplementary feed (1720 kg of enriched feed per week) and actively engaging in wildlife control and exclusion, CF2 was providing moderate supplementary feed (1400 kg of basic feed per week) and had temporarily ceased wildlife control in the previous year, while WFF1 was not providing supplementary feed and wildlife control ceased five years prior. All three farms were experiencing severe drought conditions.

The movement of the herd across WFF1 is guided by a 6-month grazing plan that incorporates climatic and vegetation conditions into its landscape restoration strategies; areas selected for treatment are subjected to three passes of high impact short duration grazing twice per year at most, allowing for long periods of recovery. The night-pen is relocated to eroded areas of the landscape every seven days to break up topsoil and deposit organic nutrients in degraded areas. Meat and lamb produced at this farm are sold for a premium under a fair game brand that certifies ethically raised, wildlife-friendly meat.

This study was reviewed and approved by University of Technology Animal Care and Ethics Committee (ETH18-2262).

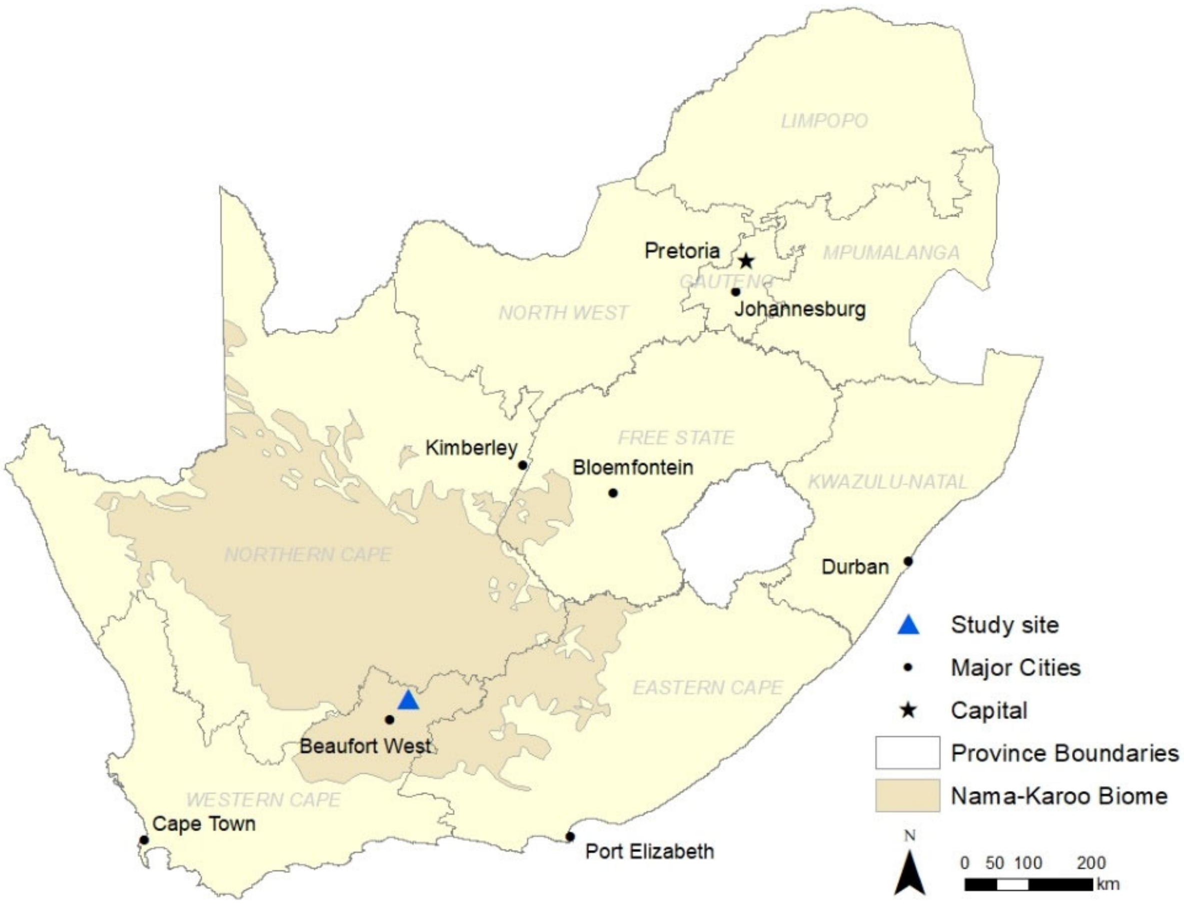


Figure 4. Study site location in the Nama-Karoo biome of South Africa.

One Health indicators

We selected three quantitative measures from our network diagram, and two farm management strategies that inform them, for analysis. We measured (i) body condition scores as an indicator of livestock health (farm sphere), (ii) shrub patch cohesion as an indicator for vegetation health (environment sphere), and (iii) foraging behaviour as both an indicator of livestock health (farm sphere) and as an indirect indicator of vegetation (environment sphere) health. We compared these metrics across farms to examine the relationships between One Health measures under different grazing and wildlife control (i.e., wildlife health) contexts. We also compared the metrics against one another by farm to identify any correlations between the metrics. We selected these three quantifiable measures because they are indicative of the goals that livestock producers aim to achieve with their selected grazing management strategies (i.e., productive livestock and mitigation of overgrazing). We then examined the One Health context and socio-ecological conditions on each farm by (i) reflecting on opportunities for employees at each farm as an indicator of human health, by (ii) discussing the impact of grazing practices on environmental health, and by (iii) describing observations during data collection that could provide further insight into livestock health.

The scoring of body condition is the livestock industry gold standard for assessing the resilience of a livestock herd. Requiring 5 seconds of manual palpation of the spine and short ribs of the sheep, body condition scoring (BCS) reflects energy stored as fat and muscle and provides an overall view of the nutritional status of the flock, independent of variables that otherwise impact weight such as wool, pregnancy, and breed (Kenyon et al. 2014). Scores range from 1 to 5, with healthy scores ranging from 2.5 to 3.5 (van Burgel et al. 2011, Kenyon et al. 2014); low BCS indicates a negative energy balance and poor health and welfare, while a high BCS can impede on normal behaviour and contribute to other welfare concerns (Verbeek et al. 2012; Kenyon et al. 2014; Beausoleil & Mellor 2017). BCS is a reliable predictor of flock and individual ewe winter survival (Morgan-Davies et al. 2008), is associated with various reproductive parameters (Kenyon et al. 2014), and is a good indicator of hunger (Verbeek et al. 2012). Though published results vary, low BCS has also been associated with increased free fatty acids and decreased leptin, insulin, cortisol, plasma glucose, and insulin-like growth factor-1 concentrations in the blood (Verbeek et al. 2012). Poor BCS in a flock can reflect poor vegetation health, which has broad economic implications for production systems. For example, lambing survival and vigour are correlated with ewe body condition score in intensive farming systems, and producers may provide supplementary feed during gestation if nutrient-rich vegetation is unavailable (Kenyon et al. 2014; Greyling 2017). However, in more extensive systems, supplementary feeding thousands of sheep spread over wide areas can be too costly, especially during drought (Mare et al. 2018).

We quantified differences in sheep grazing behaviour by calculating the event sequence length of bites and steps of sheep from each farm. An event sequence length is the count of events of one behaviour that occur consecutively before switching to a new behaviour. For example, the event sequence length of steps is five for a sheep that steps five times before taking a bite. This metric captures information on the role herbivory by sheep from each farm. Free-roaming grazing systems can allow for forage selectivity and uneven grazing distribution, which can create patterns of over-grazed palatable vegetation and under-grazed unpalatable vegetation (Milton et al. 1994; Adler et al. 2001; Savory & Butterfield 2016). Conversely, herding systems can reduce forage selectivity by restricting grazing to selected areas, obliging livestock to graze on only those plants that are available to them rather than traveling in search of preferred forage (Odadi et al. 2018). At the same, herding requires that livestock move constantly onward, limiting overgrazing on individual plants.

We used drone imagery to evaluate the distribution of vegetation by computing patch cohesion index, a measure of plant connectivity, of shrubs on all three farms (McGarigal 1995). Overgrazing can also lead to the uprooting of plants and hardening of top soil crusts, preventing water infiltration and further germination of the seed bank (Milton et al. 1994). This process can transform a once lush landscape into one of patchy, unpalatable vegetation that cannot sustain livestock production (Milton et al. 1994).

Data collection and processing

Though BCS is a subjective assessment, research on the reliability of BCS assessors has demonstrated high inter- and intra-assessor consistency when provided with intermittent calibration of technique (Phythian et al. 2012). We therefore used one trained observer to measure and record the body condition scores of a random sample of the ewes in each flock at WFF1 (n=100), CF1 (n=101), and CF2 (n=114). We used a one-way ANOVA to compare the measures of our independent observer against those of another for a random sample of scores to ensure consistency and did not find significant observer bias.

For foraging behaviour, we used a long range DSLR camera to record direct behavioural observations of random individual ewes. We recorded a total of four two-hour periods over two days at each farm, commencing three hours after dawn and three hours before dusk each day. Videography was targeted towards individuals who were actively grazing. In total, we analysed the behaviour of 157 sheep from CF1, 178 sheep from CF2, and 157 sheep from WFF1.

We used BORIS version 7.9.7 (Friard & Gamba 2016) to analyse the behaviour of each individual captured in the video footage for duration of grazing and ordered occurrence of bites and steps. A grazing period began when the individual’s head was lower than the plane of its back and was either searching for food or consuming vegetation. Grazing ceased when the individual lifted their head above the plane of their back (e.g., vigilance or running to catch up with the flock), when they walked out of the field of vision, or when a clear view was blocked (either they turned away from the camera or they were obscured by another individual). A step was recorded when a sheep raised and lowered a front leg for the purpose of movement in any direction; those that did not contribute to movement, such as to regain stability, were not included. A bite was recorded when a sheep grasped or enveloped vegetation with its mouth and used a jerking movement with its head to break forage free from the plant (Ruckstuhl et al. 2003).

We calculated the event sequence lengths for both bites and steps in each grazing period to evaluate differences in the aggregation of the two behaviours across the observation. Due to the nature of the data collection methodology, a grazing period was likely to begin and end in the middle of an event sequence. For example, if a sheep walked on camera and the first recorded event was a step, that step could actually be the third or tenth in a series, rather than the first. Similarly, the last event series could continue past the last recorded event. To avoid introducing errors in sequence length data, the first and last event sequences within a grazing bout were removed so that only event sequences with marked start and end were analysed. Grazing periods shorter than 20 seconds were also discarded for this reason.

For vegetation health, we used a quadcopter drone (Phantom 4 Pro) to capture a series of overlapping images of the landscape where grazing behaviour was recorded. The images were stitched together to create 250-600 m^2 composite images of the grazing landscape. The composite imagery was processed according to Hasselerharm et al. (2021), which classified each pixel as either shrub, grass, rock, soil, or shadow, to construct land cover maps. We then used the ‘SDMTools’ package in R (R Core Team 2019), which processes a selection of raster-based patch metrics from FRAGSTATS (McGarigal 1995), to calculate patch cohesion matrix statistics for grass and shrubs. Due to drought conditions at the time of data collection, grasses palatable to sheep were largely absent; the diet of the sheep observed in the study mainly consisted of shrubs. We therefore opted to only include patch cohesion matrix data for shrubs in this study.

Data Analysis

We first tested the effect of farm on the quantifiable metrics we selected. We tested the BCS and landscape data distributions for normality with a Shapiro-Wilk test. Though the data were non-normal, the relatively large size of the data (n=317) meant that we could still rely on ordinary least squares coefficient estimates for inference as per central limit theorem (Lumley et al. 2002). Extremely significant or non-significant p-values could be interpreted confidently, with p-values close to the critical value of 0.05 being interpreted with more caution. We therefore included model coefficients and confidence intervals in our results to aid interpretation.

We used a one-way ANOVA to test for differences in body condition between farms and negative binomial models to model the effect of farm on the mean event sequence lengths for both steps and bites. Negative binomial models were used instead of Poisson models as the data were over-dispersed. Lastly, we used a one-way ANOVA to determine if shrub patch cohesion index differed between farms. We used Tukey post hoc tests to assess pairwise differences between model estimated means.

We then tested for correlations between the metrics across farms. We plotted back-transformed model estimates and 95% CIs (geometric means) of bite sequence length by farm against those for step sequence length by farm to identify patterns between foraging behaviours. We then plotted these metrics against body condition by farm to identify patterns between foraging behaviours and body condition. Lastly, we compared patch cohesion index against step sequence length for each farm to evaluate the relationship between forage connectivity and foraging behaviour. All analyses were performed in R (R Core Team 2019).

Case study findings

We found a significant effect of farm on mean BCS (F = 19.35, df = 2, $p < 0.001$, Table 1, Fig. 5B, 5C). BCS at WFF1 (mean ± 95% CI = 2.70 ± 0.07) was significantly higher than CF1 (2.47 ± 0.09) and marginally significantly lower than CF2 (2.81 ± 0.07), although the practical significance of these findings remains questionable given healthy BCS ranges from 2.5 to 3.5.

Table 1. Model estimates of body condition scores (BCS), bite sequence length, step sequence length, ratio of bite sequence length to step sequence length (B:S), and shrub cohesion index for each of the three study sites. Asterisks indicate significant differences ($p < 0.05$) between farms.

Farm	BCS (mean ± 95% CI)	Bite sequence length (geometric mean ± 95% CI)	Step sequence length (geometric mean ± 95% CI)	B:S	Shrub cohesion index
WFF1	2.70 ± 0.07*	2.96 ± 1.03*	2.59 ± 1.03*	1.14	7.81 ± 0.13*
CF1	2.47 ± 0.09*	3.95 ± 1.04*	3.41 ± 1.05*	1.16	8.56 ± 0.43
CF2	2.81 ± 0.07*	4.66 ± 1.04*	2.15 ± 1.04*	2.17	8.19 ± 0.38

There was also a significant effect of farm on bite sequence length (df = 2, $\chi^2 = 172.71$, $p < 0.001$, Table 1, Fig. 5A, 5B) and on step sequence length (df = 2, $\chi^2 = 120.47$, $p < 0.001$, Table 1, Fig. 5A, 5C). Bite sequence length at WFF1 (geometric mean ± 95% CI = 2.96 ± 1.03) was significantly lower than at CF1 (3.95 ± 1.04); bite sequence length at CF1 was significantly lower than at CF2 (4.66 ± 1.04). Step sequence length at WFF1 (2.59 ± 1.03) was significantly higher than at CF2 (2.15 ± 1.04) and significantly lower than at CF1 (3.41 ± 1.05).

Shrub cohesion index was significantly different between farms (F = 14.01, df = 2, $p < 0.001$, Table 1, Fig. 5D), with WFF1 (7.81 ± 0.13) significantly lower than both CF1

(8.56 ± 0.43) and CF2 (8.19 ± 0.38). There was no difference in shrub cohesion index between CF1 and CF2.

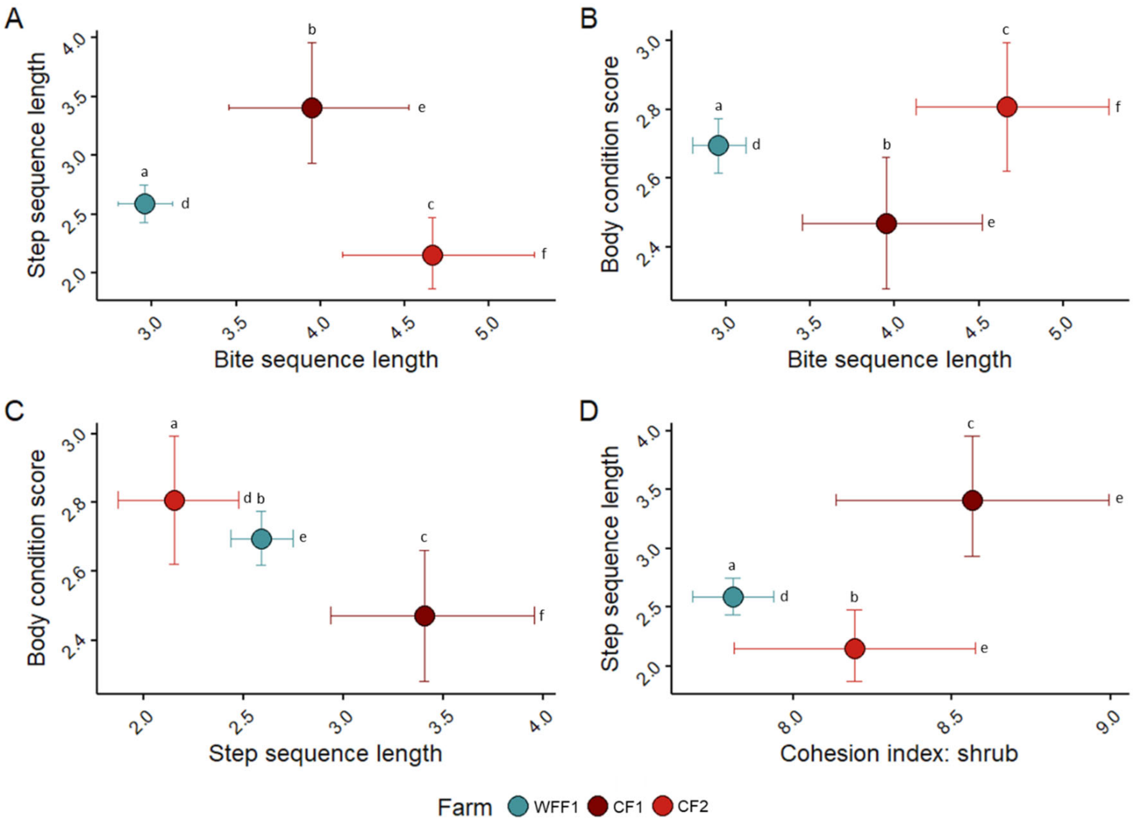


Figure 5. Comparisons between model estimates of A) bite sequence length and step sequence length by farm, B) bite sequence length and body condition score by farm, C) step sequence length and body condition score by farm, and D) patch cohesion index and step sequence lengthy by farm. Values for step sequence length and bite sequence length are geometric means and 95% CIs calculated by back-transforming model estimates and 95% CIs. Metrics with different letters are significantly different (Tukey post hoc, $p < 0.05$).

The ratio of bite sequence length to step sequence length (B:S) for WFF1 was 1.14, which was similar to CF1 (1.16) and less than CF2 (2.17). A clear relationship between bite sequence length and step sequence length across farms did not emerge (Fig. 5A). Similarly, we did not find a clear pattern between model estimates of bite sequence length and BCS by farm (Fig. 5B) or between model estimates for patch cohesion index and step sequence length by farm (Fig. 5D). There was a negative correlation between model estimates of step sequence length and BCS across farms (Fig. 5C).

Case study implications

The purpose of this case study was to demonstrate how a One Health framework can guide exploration into sustainable food production by elucidating the relationships between stakeholders in livestock production systems. To do so, we collected data on three important indicators of livestock production landscape health on three farms in a semi-arid region of South Africa that employ different farming strategies. Here we reflect on four trends that emerged from our case study comparison: 1) BCS is within acceptable range for all three farms, 2) BCS declines as step sequence length increases across all three farms, 3) bite and step sequence lengths and the B:S ratio at WFF1 provide evidence to support that shepherds are meeting the foraging behaviour targets set for their livestock, and 4) low variance among metrics from WFF1, relative to CF1 and 2, suggests improved reliability and consistency in shepherding as a production practice. Further, the application of our One Health network diagram in this case study provides a mechanism for relating livestock performance and farming strategies to wider stakeholder outcomes, enabling a holistic assessment of the viability of WFF as a sustainable food production strategy, relative to conventional farming practices.

Much of the reluctance to adopt WFF methods in the Nama-Karoo region reflects fear of livestock predation in the absence of lethal control, which can result in depredation and increased stress (Scasta et al. 2018), although perceived risk of predation is often higher than actual risk (Dickman 2010). Further concern centres on the perception that energy expenditure required by sheep during shepherding is detrimental to their productivity. This energy cost may, however, be recouped overnight during penning as livestock cannot feed and must rest. Sheep are also guided in their foraging during the day, as shepherds select new areas for them to forage in, reducing energy lost in searching for suitable forage. The body condition and behaviours we measured in our case study on Nama-Karoo sheep provide considerable insight into these concerns.

BCS is a good indicator of energy storage (Kenyon et al. 2014), and can be used to explore net effects of farming practices. In our case study we found that BCS was only marginally different between the three farms, and all were within an acceptable range for large-scale livestock production despite severe drought conditions (van Burgel et al. 2011, Kenyon et al. 2014). More specifically, livestock at WFF1 and CF2 were well within the bounds of acceptable BCS, whereas BCS scores at CF1 were considered borderline for productivity and welfare outcomes; some individual sheep were below acceptable levels.

Further, examining the relationship between energy storage and overall health (BCS) with foraging search effort (step sequence length before biting) should provide a direct indication of production conditions. Indeed, energy intake must exceed energy expenditure to maintain efficient livestock production (Moorby & Fraser 2021). In our case study, we found that BCS increased with decreasing step sequence length. Similar relationships between energy storage and foraging activity have also been found in cattle grazing systems, where increases in cattle weight gain, and therefore productivity, were explained by decreases in distance travelled and improvement in foraging efficiency (Odadi et al. 2018).

Taken together, these findings suggest that, despite concerns, there were no clear distinctions in sheep productivity between wildlife-friendly and conventional farming practices. One explanation for this outcome anecdotally supported by shepherds in this study, is that additional energetic demands from shepherding are offset by the active management of grazing activity, increasing foraging efficiency. Conversely, the energetic demands of free-roaming grazing may be difficult to control because livestock behaviour is not intensely managed in these systems. Despite criticism from the conventional farming community, WFF in this landscape was competitive in sustaining livestock condition required of commercial production.

As part of their holistic grazing management, wildlife-friendly shepherds aim to improve vegetation resilience by reducing herbivory levels at the individual plant scale, establishing low and even herbivory pressure on vegetation across farms (Savory & Butterfield 2016). By constantly walking sheep in controlled paths during the day, shepherds can ensure that sheep only take two to three bites at one plant before taking two to three steps to the next plant. Our findings suggest that this strategy is realised on WFF1, where the mean number of bites before stepping was 2.96, the mean number of steps before biting was 2.57, and the B:S ratio was 1.14. Although the B:S ratio was similar at CF1, greater mean bite and step sequence lengths suggest that both bites and steps were more aggregated at CF1 than at WFF1. The B:S ratio at CF2 was double that at WFF1 and CF1, with mean sequential bites at 4.66 and only a mean of 2.15 steps between bites, suggesting that grazing pressure on individual plants was greatest at CF2.

Across all measured metrics in the One Health spheres in our case study, livestock production by shepherding was more reliable and consistent within the sheep flock (Fig. 5). Confidence intervals for both bite and step metrics at WFF1 were notably smaller than those for CF1 and CF2, indicating greater precision of the mean and smaller variance within the sample (Smithson 2003). In the context of foraging activity, this means that the number of bites and steps were more consistent across the herd at WFF1 than at CF1 and CF2, even in a landscape with the lowest vegetation cohesion. It is plausible that this difference is being dictated by shepherds, either directly or indirectly, rather than by landscape conditions and forage availability. Overall, smaller variance in measures reflecting livestock health and production translate to greater reliability of production outcomes, an essential farming goal in volatile rangeland landscapes that experience climatic stress.

Sustainability in a One Health context

Our results revealed surprising similarities in important productivity metrics between farms, namely BCS and the relationship between BCS and step sequence length. These similarities, however, mask the broader impacts of the different grazing methods that are used to achieve production targets. Herein lies the utility of a One Health approach to livestock production sustainability: whereas a traditional farm productivity analysis may evaluate the farm’s economic output by comparing inputs to outputs, the One Health network diagram helps to visualise the ways in which different grazing strategies may affect the health of other spheres and contribute to production resilience. This provides an opportunity to explore how different grazing strategies embody sustainable food production systems to support both humans and wildlife. Here we utilise our network diagram as a guide for examining the One Health implications of the measures we evaluated at WFF1, CF1, and CF2.

At the time of this study, drought had severely impacted livestock production across the Nama-Karoo. CF1 and CF2 both provided substantial supplementary feed to their livestock to address the lack of feed available on their farms. Large-scale supplementary feeding demands additional cash input and labour, which in turn must be fulfilled either by hiring more employees or by diverting employees away from other duties such as infrastructure upkeep. Heavy machinery and fuel were also needed for mixing and distributing feed across farming landscapes. Yet despite the financial and opportunity costs of additional feed, BCS at CF1 was still only borderline acceptable for livestock performance, farm productivity, and welfare standards (Kenyon et al. 2014; Beausoleil & Mellor 2017). Likewise, at the time of the study, wool quality at CF2 was poor relative to preceding years (personal communication, February 2019).

In contrast, sheep at WFF1 did not require supplementary feeding to maintain adequate BCS during the drought. Conversely, shepherding requires constant labour input for both grazing management and livestock protection compared to conventional farming, which can affect farm economic productivity. However, unlike the costs of supplementary feeding and poor farm outputs (i.e., BCS and wool quality), labour costs of shepherding can be recouped through improved livestock performance (Odadi et al. 2018) and through the sale of products at premium prices under a “Fair Game” brand (Landmark Foundation 2021b).

The benefits of increased employment extend to the local community and the human sphere of One Health. Given pre-COVID-19 pandemic unemployment rates in South Africa were hovering around 27% (FAO 2021b), WFF1 employed a notably larger workforce of ~ 20 employees than CF1 and CF2 did (~5 workers per farm) during the period of study. The large number of WFF1 employees and their families are provided with quality housing on the property and workers’ children are required to attend school as condition of employment. Access to medical help is provided if needed, employees are monitored for unhealthy behaviours that can interfere with work, and support systems are in place to improve employee well-being. While in many cases this might appear as employer overreach, the opportunities available to the employees is reflected in high employee retention rates and anecdotal job satisfaction relative to neighbouring farms. In contrast, managers at CF1 and CF2 have struggled with employee retention and commitment.

The benefits of WFF also translate to the environmental sphere of One Health. Despite lower vegetation cohesion at WFF1 than at the conventional farms, separate research we conducted on these farms at the same time revealed that the vegetation at WFF1 responded better to rainfall following severe drought conditions compared to the vegetation at CF1 and CF2, recoupling grazing to annual rainfall cycles and vegetation growth (Hasselerharm et al. 2021). Further, retired night-pen sites at WFF1 have been found to have increased bioavailable foliar nitrogen (McManus et al. 2018). As hallmarks of vegetation resilience, vegetation recovery and nutrient availability are critical for supporting livestock production and wildlife populations, especially during restrictive climatic conditions (Thornton et al. 2009; McManus et al. 2018).

In many cases, conventional livestock practices include the lethal control and exclusion of wildlife to reduce total grazing pressure on vegetation and maximise stocking rates of livestock (Jenkins et al. 2010; Descovich et al. 2016; Nattrass et al. 2017). This practice normalises lethal actions like shooting, poisoning, and trapping of wildlife, and is often reinforced by policy initiatives that provide infrastructure and funding for baiting programs, hunting schemes, fencing, and wildlife bounties (Eason et al. 2010; Nattrass et al. 2017). Not only do these practices harm wildlife individuals and collectives, they also further interrupt the complex balance of ecological processes that sustain food production itself (Johnson et al. 2007; Letnic et al. 2012; Ripple & Beschta 2012; Johnson & Wallach 2016). Conversely, food production strategies that strive for resilience and vitality within landscapes, such as

WFF, can withstand, and even support, the presence of wild herbivores instead of persecuting or excluding them (Hasselerharm et al. 2021; Schurch et al. 2021). At the same time, wild predators are tolerated because the shepherding practices employed protect livestock from depredation, and the predators help to regulate wild herbivore populations (Stone et al. 2017a; Mkonyi et al. 2017; Schurch et al. 2021).

Both CF1 and CF2 suffered notable losses of livestock to predators during the year of this study, which could have had detrimental impacts on economic return and livestock welfare (Wallach et al. 2017; Widman et al. 2019). Livestock at these farms were also considerably more alert to and fearful of humans, including during our field surveys (sheep often fled in response to humans within 100m and a drone hovering at heights of more than 80m above ground level). Conversely, livestock at WFF1 were noticeably less stressed by human presence and drone activity, allowing researchers to approach and tolerating drone presence at 20m above ground level. Stress, whether in response to predation or to humans who are associated with unpleasant experiences, can impact livestock performance, increase disease burden, impair welfare, and reduce reproductive success (Dwyer & Bornett 2004).

The future of sustainable food production

A paradigm shift towards sustainable land use practices that revitalise, rather than sever, critical landscape processes is needed to begin rebuilding resilient landscapes that support both food production and wildlife. This requires that food production landscapes are framed as multi-faceted systems built on complex interconnected relationships between stakeholders (Wittman et al. 2017). One Health effectively contextualises relationships between independent measures within a larger socio-ecological system. Problematically, One Health is rarely communicated strongly in the coexistence literature despite clear evidence of the

One Health benefits of coexistence (see Chapter 4). For example, studies on non-lethal deterrents often report the efficacy of the tool and the direct financial and conservation implications of the findings, but pay little attention to how the findings influenced downstream processes, such as livestock welfare and human wellbeing (e.g., Otstavel et al. 2009, Scasta et al. 2017, see Chapter 4). Although some studies relay individual components of One Health relationships, holistic exploration into the broader health implications of WFF are rare.

Within our case study, the application of the One Health network diagram enabled us to expose unique relationships between seemingly disparate measures that would otherwise go unnoticed. In this way, the One Health framework provided a more holistic visualisation of our three farming systems, enabling us to reframe the focus on resilience and health across different One Health spheres. Our three farms engaged in different management practices, only to arrive at relatively similar productivity targets with respect to livestock (albeit with some notable differences in CF1). However, the farms each had vastly different wellbeing outcomes in other One Health spheres: although WFF allowed wild predators and herbivores to be present, indicators of wildlife, the environment, and human health were all notably advantageous. Given the importance of livestock production in rangeland ecosystems around the world, and increasing levels of aridification due to a rapidly warming climate (Huang et al. 2016), it is vital that we improve sustainable food production to provide both food security and environmental sustainability.

As it stands, our study does not fully address the complexities of improving and increasing sustainable food production because examples of WFF production remain rare and there are other social and political facets of livestock production that we have not addressed. However, as farmers increasingly adopt these practices, we recommend that similar One Health frameworks be utilised to support holistic assessments across different spheres. In many respects, the holistic approach of WFF is itself grounded in One Health as it strives to reconnect and revitalise the fragmented relationships among stakeholders, creating a landscape in which all can coexist.

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Chapter 8. Conclusion

Successful coexistence is prioritised within the conservation discipline as a critical contribution to conservation goals, however, challenges persist around how to actualise coexistence between morally significant beings on shared landscapes. Human exceptionalism may account for part of the challenge, which effectively demotes moral attentiveness to non-human beings. Although human exceptionalism is the primary social paradigm within Western conservation, one antidote to is to widen circles of moral inclusion, an idea which is supported by compassionate conservation (Plumwood 1993; Knutson 2013; Wallach et al. 2020). My thesis asks what happens when conservation and, more specifically, coexistence are reframed by moral inclusivity.

Guided by the morally inclusive principles of compassionate conservation, I used a case study approach to test this question in three areas that together forge a pathway towards morally inclusive coexistence: barriers, pedagogy, and opportunities. The three parts sought to identify barriers to conservation that arise when the intrinsic value and moral significance of wildlife are overlooked, to investigate a pedagogical approach to expanding circles of moral consideration to include wildlife, and to explore opportunities for conservation on coexistence landscapes when the discipline practices moral expansiveness.

How sensitive were each of the three parts to a morally inclusive reframing? As a whole, my findings suggest that a morally inclusive reframing produced more favourable outcomes for coexistence than a normative framing did in all five research chapters. In *Part 1: Barriers of human exceptionalism in conservation practice,* I revealed in chapter 3 that normative constructs underpinned by the position that humans are separate from nature can stifle progress in conservation through poor decision-making, public backlash, and justifications of harm. Instead, an approach that is grounded in awareness and transparency of values and objectives in conservation can lead to more ethically and scientifically rigorous conservation action. In chapter 4, I found that human exceptionalism can contribute to a more limited understanding of multispecies coexistence landscapes in the literature and that a morally inclusive approach is better suited to strongly incentivise coexistence. In *Part 2: Pedagogy of moral inclusion,* chapter 5 demonstrated that moral inclusion can be effectively integrated into primary school education and that, compared to science education that does not prioritise the intrinsic value of living beings, morally inclusive pedagogy inspires children to accept wildlife as legitimate constituents of shared landscapes. In *Part 3: Entanglement in practice*, I presented two practical examples of morally inclusive coexistence, wherein humans are entangled with the rest of nature rather than separate to it. In chapter 6, I applied a robust method for evaluating a coexistence tool; although the findings were limited, this case study offered a scientifically rigorous framework to support people who are championing cohabitation worldwide. Lastly, in chapter 7 I demonstrated that a morally inclusive approach to livestock production landscape management can be a viable strategy for sustainable food production because it offers holistic benefits to the numerous human and nonhuman inhabitants of shared landscapes. Together, the three parts of this dissertation uncovered a mutualistic pathway to improve the ethical and practical outcomes of coexistence.

My dissertation demonstrates how a western view of nature manifests in conservation and supports the argument that the reorientation of humans as part of nature, rather than separate to it, can enhance conservation practice. In all three parts, I was able to identify the narrative of human exceptionalism as a strong contributor to blocking progress in coexistence and demonstrate that a shift towards moral inclusion is critical to overcoming the barricade erected by human exceptionalism. This finding lends credence to the argument that moral inclusion and the reframing of societal goals towards cohabitation may be a missing link to coexistence efforts and conservation.

While the findings of my doctoral research could not possibly offer a golden key to coexistence, they can provide clarity around future opportunities for exploring and implementing cohabitation. I therefore offer six recommendations and opportunities for progress in coexistence based on the pathway toward morally inclusive coexistence that I have discussed above as well as my experience as a PhD student in a marginalised sub-discipline of conservation:

First, expect that all conservationists have values, the open acknowledgement of which should not be treated as suspect. Indeed, the role of values informing research is well founded. Given conservation is underpinned by values, it is critical to be aware of one’s own values and to be transparent about how they inform research and behaviour. Moreover, conservation must prioritise critical thinking pedagogy and encourage the utilisation of available ethical tools for evaluating the appropriateness of conservation objectives and interventions.

Second, be aware of the power of language. Language can reflect kindness or lack thereof. It can encourage acts that are harmful towards others, people and nonhuman animals, and has the power to exclude, to rationalise and justify harm, and to teach others to do the same. Language can also reinforce the rhetoric of a human-nature dichotomy, widening the relational chasm between human and nonhuman beings. Language, however, also possesses the power to uplift, support, respect, and honour others. It can inspire people to act on behalf of those human and nonhumans who are underrepresented, marginalised, or in pain and teach others to have compassion and be inclusive. Language can also foster connections between morally significant beings, narrowing the abyss that separates humans from the rest of nature. Language is a powerful tool and we must be mindful of the messages that our words can impart.

Third, a more holistic perspective of multispecies landscapes is critical for actualising positive coexistence outcomes. Coexistence is a product of the landscape in its entirety; it does not exist in a vacuum, nor does it only occur between two sets of beings (e.g., bears and humans). Morally inclusive coexistence, or cohabitation, offers a strong foundation for encouraging a more holistic interrogation of complex coexistence because it calls attention to the vast number of individuals inhabiting shared landscapes and how the relationships between them shape the landscape.

Fourth, take the time to plan for long-lasting peaceful coexistence. At the local level, coexistence should be planned in a way that respects the lives of other living beings. It takes time to understand the lives of others, their needs, and their ways of being. As I once asked someone complaining about bats toileting on his car, “did you ever consider that maybe you are parking in their bathroom?” A holistic examination of shared landscapes that integrates these aspects of the lives of wildlife into decision-making can go a long way for long-term solutions for sharing space.

Fifth, prioritise the moral inclusion of nonhuman animals in education programming. Western education systems prioritise kindness to other humans, but at the same time participate in programming that does not afford nonhuman beings the same level of treatment. Consistent messaging about how we should treat others should extend to nonhuman beings. Indeed, what message do we think people, and especially children, absorb when we justify killing cane toads with inhumane practices because they are “ugly”, “disgusting”, or “vile” in appearance? How does the logic of such a scenario inform future interactions between morally significant beings? To conserve biodiversity, we must have, and more importantly teach others to have, compassion for all living beings.

And lastly, be kind.

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