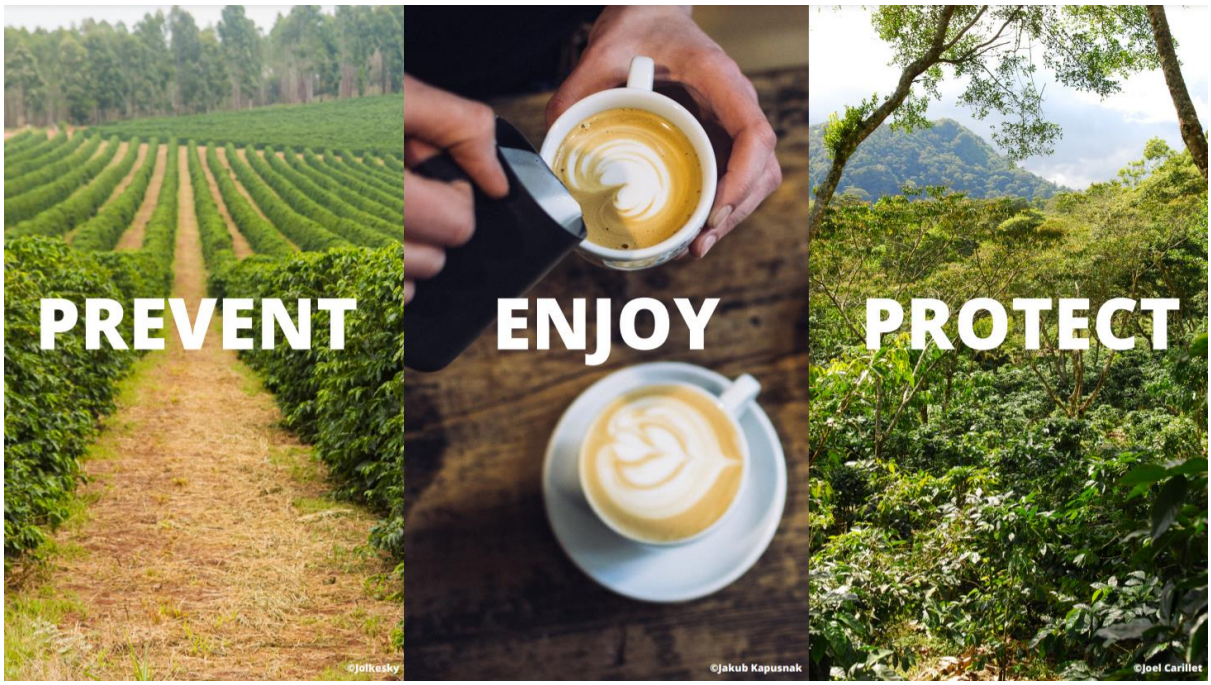
Sustainable coffee and consumer behaviour change



A thesis submitted in fulfilment of the requirements for the degree
Doctor of Philosophy

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December 2021

“Every life contains many millions of decisions…never underestimate the big importance of small things”
(Haig 2020)

Contents

Abstract

Reversing biodiversity loss is one of the most significant challenges for our global community. Our individual and collective behaviours are the primary drivers of biodiversity loss, either through direct cause-and-effect or indirectly through complex causal links. By altering behaviours that impact nature negatively, we can achieve positive change that benefits biodiversity, propels sustainable development, and produces a healthier, more equitable world. Conservation researchers and practitioners are increasingly implementing behaviour change interventions to address threats facing biodiversity. Such interventions require substantial market research to ensure their effectiveness or risk failure, wasted resources, or unintended consequences. Therefore, conservation behaviour change needs to draw on learnings from other fields while developing methods specific to biodiversity applications.

My thesis builds on the growing interdisciplinary behaviour change literature and showcases contributions to the specific case of consumer behaviour change for sustainable coffee. Specifically, I highlight: (i) the current state of sustainable coffee certification policies featuring a novel evaluation of how eleven prominent standards address critical threats to biodiversity from coffee agriculture, with discussion on opportunities to improve these policies through upstream social marketing; (ii) apply a machine learning algorithm to select variables showing the highest correlation with stated willingness to purchase environmentally friendly coffee from 1142 coffee consumers that participated in an online questionnaire, with discussion on how these insights could inform the design of a targeted behaviour change intervention to increase consumer demand for environmentally friendly coffee; and (iii) present the application of a seven-step co-design process, which showcases the value of user-centred design approaches to behaviour change interventions for biodiversity conservation, making important contributions towards the translation of consumer ideas into concrete prototypes. Together, my research contributes to advancing conservation behaviour change, emphasising reproducible methods for designing interventions to support sustainable development that benefits biodiversity and people.

Declaration

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint award of this degree.

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I acknowledge the support I have received for my research through the provision of an Australian Government Research Training Program Scholarship.

Matthew Bowie

18 July 2022

Publications arising from this thesis

Journal articles

Matthew J. Bowie, Phillip Cassey, John García-Ulloa, and Timo Dietrich., 2022. Improving sustainable coffee certification policies to help conserve biodiversity through upstream social marketing. *Manuscript in preparation*.

Matthew J. Bowie, Pia E. Lentini, Emily M. McLeod, Georgia E. Garrard, Timo Dietrich, Phillip Cassey, Sarah Bekessy, and Matthew J. Selinske., 2022. Is the public ready for environmentally friendly coffee? In review as of mid-2022 for publication in *Sustainable Production and Consumption*.

Matthew J. Bowie, Timo Dietrich, Phillip Cassey, and Diogo Veríssimo. 2020. Co-designing behavior change interventions to conserve biodiversity. Conservation Science and Practice 2:e278. https://doi.org/10.1111/csp2.278

Conference presentations

Matthew J. Bowie, John García-Ulloa, Diogo Veríssimo, Phill Cassey, Lian Pin Koh. 2018. *Can sustainability schemes really address threats to biodiversity conservation?* Presented at the 55th Annual Meeting of the Association for Tropical Biology and Conservation. 1-5 July 2018. Kuching, Sarawak, Borneo, Malaysia

Matthew J. Bowie, Phillipa Schliebs, Libby Dowling, John García-Ulloa, Diogo Veríssimo, Phill Cassey, Lian Pin Koh. 2018. *Coffee—how can we utilise sustainability schemes to support biodiversity conservation?* Presented at the 18th International Australasian Campuses Towards Sustainability Conference. 31 October–2 November 2018. Adelaide, Australia.

Matthew J. Bowie, Diogo Veríssimo, Timo Dietrich, Libby Dowling, Phillipa Schliebs, Phill Cassey, Lian Pin Koh. *Coffee—how your drug dealer can help #sustaincoffee*. Poster presented at the 6th World Social Marketing Conference. 4-5 June 2019. Edinburgh, Scotland.

Matthew J. Bowie, John García-Ulloa, Timo Dietrich, Diogo Veríssimo, Phillipa Schliebs, Libby Dowling, Lian Pin Koh, Phill Cassey. 2019. *Can sustainability schemes really address threats to biodiversity conservation?* Presented at the 29th International Congress for Conservation Biology. 21-25 July 2019, Kuala Lumpur, Malaysia.

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Matthew J. Bowie, *Sustainable coffee and consumer behaviour change*. Presented online at Blueprints for Action – Ecology and Evolution Seminar series. March 2021. https://www.youtube.com/watch?v=H43yBotdzDw&t=1s

Matthew J. Bowie, *Sustainable coffee and consumer behaviour change*. Presented online for the 2021 3-Minute thesis competition https://vimeo.com/575686606

Matthew J. Bowie, Pia E. Lentini, Emily M. McLeod, Georgia E. Garrard, Timo Dietrich, Phillip Cassey, Sarah Bekessy, and Matthew J. Selinske., 2021. *Is the public ready for biodiversity-friendly coffee?* Presented online for the Conservation Marketing Conference. 27-30 October 2021.

Acknowledgements

They say it takes a community to raise a child. I would not have made it through this PhD of mine without the wonderful support of countless people who have helped me. Thank you to everyone who has supported me through those challenging years, celebrated all the small wins with me along with way, or simply said some kind words when talking with me. Never underestimate how far a few genuine kind words will go.

To my supervisor team. Phill, thank you for joining my supervisor panel before I realised the ship was sinking and then for becoming my rescue supervisor, you have helped me take ownership of my PhD and stuck with me through to the end. Timo, thank you for bringing the energy, positive reinforcement, and fresh perspective all the time, you have taught me a lot about bringing the best out of people and enjoyment from projects. Lian Pin, thank you for taking me on as a PhD student with crazy ideas in the first place and for the opportunities to meet many people, you showed me the deep end and I learned how to swim. Special thanks to Steve Delean and Jeremy Austin for being supportive postgrad coordinators who helped when I needed it most. I also acknowledge the support I have received for my research through the F J Sandoz Research Scholarship.

To my amazing collaborators. Thank you to Diogo Veríssimo for responding to my email that would have come out of the blue in 2017. Your mentorship and conversations in those early days helped me shift my research focus to behaviour change. Thank you to Diogo, EJ Milner-Gulland, and the Interdisciplinary Centre for Conservation Science group for hosting me in 2019 and for the research project provoking conversations. A huge thank you to Sharyn Rundle-Thiele who invited me to visit the wonderful Social Marketing @ Griffith and hosted me in Brisbane after we happened to chat at a networking event. That chance encounter changed the trajectory of my research, brought Timo onto my supervisor team, and helped me bring my PhD back on track. Thank you to everyone from SM@G for all the fun times at CHANGE and WSMC 2019. Thank you to John García-Ulloa, Jaboury Ghazoul, and the Ecosystem Management group at ETH Zürich for taking me in for a month in your offices, writing retreat, and workshop on sustainable agriculture certifications. Thank you to Bambi Semroc and Niels Haak from the Sustainable Coffee Challenge and everyone else at Conservation International who helped me shape my PhD research to be at least somewhat applicable in the real world. Thank you to Phillipa Schliebs, Libby Dowling, and Ecoversity for working with me to bring my research into your work to help make the university campus more sustainable. Finally, I am thankful for the ongoing collaborations with Zoos Victoria and ICON Science. A chance encounter at ICCB 2019 has grown into multiple collaborative projects. Thank you to Emily McLeod, Pia Lentini, Matthew Selinske, Georgia Garrard, and Sarah Bekessy for letting me join your work to bring a behaviour change campaign to life that focuses on sustainable, environmentally friendly coffee. I have immensely enjoyed working with you all, even if entirely remotely via Zoom, MS Teams, and email. I look forward to seeing where

this goes. Special thank you to Emily McLeod for taking me on to work directly on the Zoos Victoria campaign through the APR.Intern program and now as a research assistant.

Thank you to my friends from SEERS Oliphant L3 who made PhD daily life so much more enjoyable: Alan, Amélie, Dillon, Molly, Ramesh, Hannah, Jarrod, Gin, Nick, Brooke, Graeme, Claire, Sreekar, Tasya, Andrew, Alicia, Aakash, Megan, Ken, Dot, Bertram, Boone, Angus, Iona, and everyone else who has been part of the group. You kept me showing up even when I felt like giving up. Thank you to Katie, Adam, Meryl, Oli, Aysegul, Steve, Talia, Jack, Sarah, and the rest of the amazing Invasion Science & Wildlife Ecology group who took me in and fed me cake and coffee every Wednesday. Jopé, Evelina, Anita, James, and the environmental crew you've treated me like family, thank you for all the good times. Finally, to all my peers and the amazing School of Biological Sciences Postgraduate Association – thank you for helping to make a more supportive and fun culture that I am sure will help many more after us.

To all my gym buddies (Rohan, Cao, and Jimmy), the futsal Bucky Ballers (Hayley, Tash, Oli, Rohan, Pat, Aimee, Tom, Tom, and Swathi), the Thursday night Badminton crew (Nikhil, Raghav, Dharmanand, Clinto, Shruti, Gayathri, Aditya, Denil, Dhanush, Alan, Subra, Sudharsan, Nick, Siva, and Sarun), and everyone who went running, bouldering, hiking, or camping with me, you all kept me sane and active over the years. To the foo-d fighters (Andy, Sai, Oli, Tash, Rohan, Rosie, Tessa, Lachlan, Cao, Mitchell, Katrina, Tom, Riley, Ryan, and Swathi) you have all been such amazing friends, I've loved our cooking days and food focused adventures. I feel very fortunate to have such amazing friends around me. Maurizio, Giuli, Claudia, and Elena – siamo una famiglia – ci manchi tanto Maurizio. To Mum, Dad, Lauran, Josh, Bindu, Asokan, and Sarun, I am so fortunate to have such a wonderful family, I would not have made it through without all those fun games nights and unwavering support.

To my wonderful wife Swathi. We've gone from dating, to engaged, to married during my PhD. You've supported me through the all the good and bad times over these past five years. Thank you for always being there to celebrate the wins with me and more importantly, helping me through what felt like endless failures and rejections. I am looking forward to the next chapter in our lives and the many adventures to come.

Thesis overview

To aid the reader, I summarise below how the chapters of my thesis connect and flow (see Figure 1.1). Coffee offers a practical link between behaviour and biodiversity. Coffee is generally bought as a single ingredient product, not as one of many ingredients in numerous products (like palm oil), making the links between consumer and producer behaviours relatively clear. Coffee producers directly impact biodiversity in the ecosystems where they grow coffee, but producers' decisions around how to grow coffee are influenced by changing consumer demands. Consequently, coffee consumer behaviour indirectly impacts biodiversity. Following this logic, it is possible to support coffee producers who grow coffee amongst biodiverse agroecosystems by changing consumers' purchasing behaviour to demand coffee grown in these ways. Through my thesis, I investigated approaches to change coffee consumer behaviour by exploring how we can co-design targeted interventions.

Although the origins for this definition are unclear (Purvis et al. 2019), sustainability is generally defined as "*meeting the needs of the present without compromising the ability of future generations to meet their own needs*" and represented by three interconnected pillars (social, economic, and environmental; Purvis et al. 2019, United Nations 2021). For the purposes of my thesis, I define sustainable coffee as "*coffee produced in ways that meets the needs of the present, supporting biodiversity and profitable producer livelihoods, without compromising the ability of future generations to meet their own needs*". By purchasing sustainable coffee, companies and consumers can support profitable livelihoods for producer communities who take actions that preserve biodiversity in the ecosystems where coffee is grown.

In chapter one I provide introductory discussion on why biodiversity needs behaviour change from consumers and why conservation behaviour change requires research and development. In this section, I also provide some background context linking coffee consumer and producer behaviours to biodiversity. This has inevitably resulted in some repetition across my thesis as chapters two, three, and four have either been published or are currently under review for publication at the time of writing.

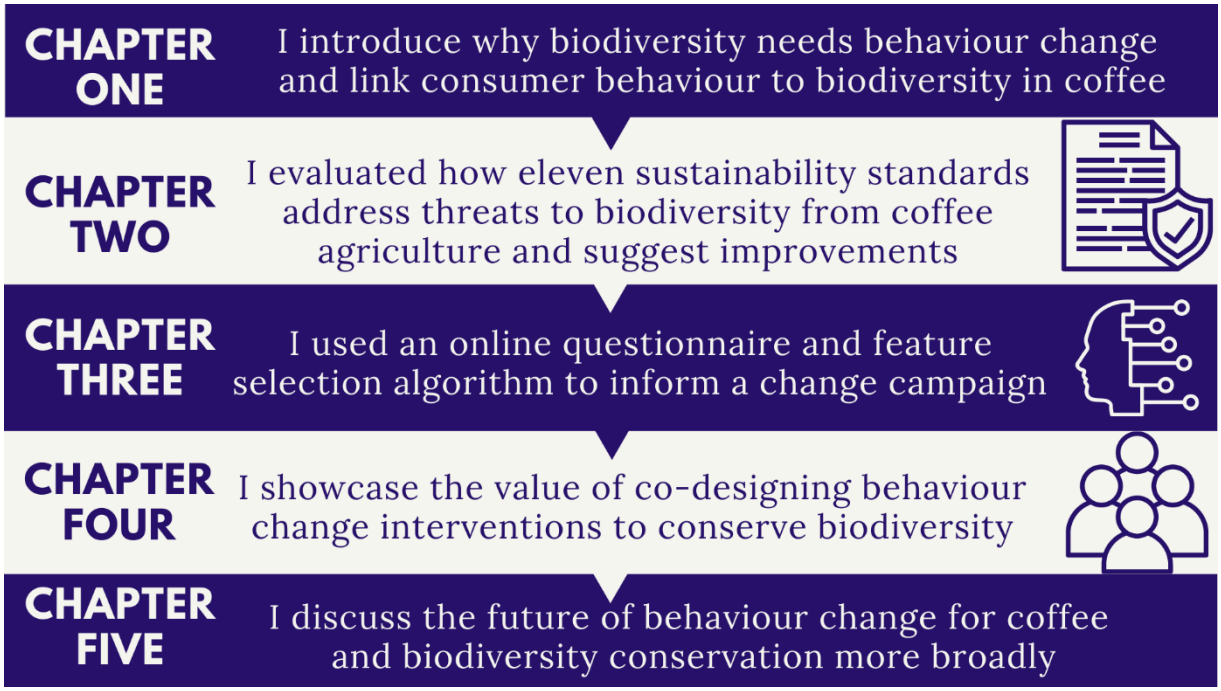

Figure 1.1. How my thesis flows and connections between chapters

In chapter two I highlight the complex world of sustainability standards with a novel evaluation of how eleven prominent standards address eight critical threats to biodiversity from coffee agriculture, encompassing thirty-four underlying threat processes. Pollution and forest habitat loss were well considered at the local scale, but many standards lacked policies to consider numerous underlying threat processes, including habitat fragmentation and conversion of agricultural land key for regional food security. I advocate for sustainable coffee standards to take landscape and regional scale approaches, which will allow tailored consideration of biodiversity needs and call for social marketers to engage with key upstream stakeholder audiences in industry, government, and not-for-profits to help enact this change.

Sustainability standards offer one path towards coffee systems that benefit biodiversity and people, connecting consumer and producer behaviour. However, one of the biggest short falls of coffee sustainability standards is that even though they have been able to certify or verify 55% of the world's coffee production, less than 25% of coffee was bought as standard-compliant in 2019 (Panhuysen and Pierrot 2020). Subsequently, many producers have been left to bear the upfront costs of becoming sustainability standard-compliant, often without receiving price premiums or priority access to markets. This reduces producers' financial capacity and motivations to continue to invest in improved sustainability practices (Global Coffee Platform 2018).

Based on my assessment in chapter two and this apparent lack of consumer demand for certified sustainable coffee, I explored two strategies for designing consumer behaviour change interventions to increase demand for sustainable coffee: (i) conventional social science survey methods and (ii) user-centred co-design.

In chapter three I used an online questionnaire to understand both coffee consumption behaviours and consumers' awareness of biodiversity and other sustainability issues across metropolitan Melbourne, in south-eastern Australia. After providing a definition of environmentally friendly coffee, I found 89% of the 1,142 respondents were willing to consume this type of coffee. While this suggests the public is ready to switch to this alternative, responses highlighted that there was limited knowledge of where to find environmentally friendly coffee, or that coffee could have negative impacts on biodiversity. I used a machine learning feature selection algorithm to identify which variables best predicted stated intention to consume environmentally friendly coffee. Despite a vibrant café culture in Melbourne, I found that 76% of respondents buy the coffee they use to make at home from supermarkets and that 57% of respondents buy instant coffee. These insights will inform the development of an upcoming behaviour change campaign, led by Zoos Victoria, but will also be important for other markets.

In chapter four I present the application of a seven-step co-design process, providing an outline and guidance for how to generate more user-centric intervention ideas and transform them into feasible prototype interventions. I applied this seven-step co-design process with coffee consumers in Adelaide, Australia to ideate and develop two prototype interventions to increase consumer demand for sustainable coffee. Through this research I outline contributions that showcase the value of user-centred design approaches to behaviour change interventions for biodiversity conservation.

In chapter five I summarise the key contributions and outcomes from my thesis. I also provide further discussion on future research avenues and practical applications of behaviour change to conserve biodiversity. I discuss the next steps needed to apply a behaviour change campaign for sustainable coffee and potential for interventions along the coffee supply chain. I further discuss where I see potential for prospective change agents to implement consumer behaviour change to help conserve biodiversity. Finally, I call for continued collaboration among communities, companies, and cultures to act—now—to reverse biodiversity loss.

Chapter 1.
Introduction

1.1. Biodiversity needs behaviour change from consumers

Every humans' individual, community, and societal behaviours impact nature whether we are aware of it or not (Bradshaw et al. 2021). Our actions can impact nature through direct cause-and-effect or indirectly through complex causal links (Schultz 2011, Wright et al. 2015). For example, direct impacts could occur from communities monitoring restoration progress (Sullivan and Molles 2016) or choosing to plant native trees, grasses, and flowers in urban areas as habitat for animals (Aronson et al. 2017) and microbiota (Mills et al. 2020) which leads to gains in local biodiversity. For complex causal links, an example could be rising affluence and shifting cultural norms in one society allowing millions of people to buy and eat more beef, indirectly causing widespread deforestation and biodiversity loss in another area due to expanding cattle farming (Godfray et al. 2018, Wiedmann et al. 2020). Fortunately—as people—we can choose to change our behaviours to increase beneficial outcomes or minimise harmful consequences for ourselves, others, and our environment (Thøgersen 2014). Sadly, since the industrial revolution, our behaviours have caused increasingly detrimental effects on our natural environment leading to massive and global biodiversity loss (Sodhi et al. 2004, Wilcove et al. 2013, Maxwell et al. 2016, Marques et al. 2019). These adverse effects rarely result from evil intentions (however, see Stoett and Omrow 2020); but are a result of everyday decisions multiplied by billions of people that operate in set systems (Schultz 2011, Thøgersen 2014, Wright et al. 2015). We each make many millions of these everyday decisions across our lifetimes for the food we eat, clothes we wear, homes we make, what we spend our time or money on, how we move about, and the people we promote to positions of power. Although the impact of these decisions may seem insignificant as we make them individually, the collective accumulation of small changes by many people can result in profound impact (Dietz et al. 2009). Consequently, by changing the behaviours that directly or indirectly harm our natural environment, we can reduce and reverse biodiversity loss (Veríssimo 2013, Amel et al. 2017, Weber 2017). Yet, identifying precisely what these behaviours are and how to change them for the better is not always obvious.

1.2. The rise of conservation behaviour change

Changing our behaviour to maintain nature is not a new idea; societies have done this throughout history to preserve their way of life (Ellen 1982, Smith and Wishnie 2000). However, in our modern global society, conservation practitioners and researchers increasingly recognise behaviour change as a valuable approach to help conserve biodiversity (Schultz 2011, Clayton et al. 2013, Wright et al. 2015, Amel et al. 2017, Bennett et al. 2017a, Reddy et al. 2017, Byerly et al. 2018, Selinske et al. 2018, Green et al. 2019, Veríssimo 2019). Such conservation interventions require substantial market research to ensure effectiveness or risk failure, wasted resources, or unintended consequences (Douglas and Winkel 2014, Lim et al. 2017, Veríssimo et al. 2020). Therefore, conservation practitioners and researchers need to draw on learnings from other fields while developing methods specific to biodiversity.

Behavioural sciences have developed substantially over the last century, frequently applied to improve social and public health, education, or financial outcomes (see Michie et al. 2011, and Davis et al. 2015 for a review and further discussion). From behavioural economics (Brown 2009, Martin and Martin 2009), to social marketing (Kotler and Zaltman 1971, French et al. 2010, Lee and Kotler 2011), or public health and clinical psychology (Rothschild 1999, Saunders et al. 2006, Michie et al. 2011), multiple disciplines of research and practice have developed various approaches to change people's behaviour for the better. While there have been some environmental applications to issues including climate change (McKenzie-Mohr et al. 2011) and recycling (Clayton et al. 2013), there have been far fewer explicit examples for biodiversity conservation (Cowling 2014, Reddy et al. 2017, Sterling et al. 2017, Selinske et al. 2018). Hereafter, I refer to behaviour change primarily applied to biodiversity as 'conservation behaviour change'. Although we know a lot about changing people's behaviour in certain circumstances (Michie and Johnston 2012), conservation researchers and practitioners need to translate that knowledge and test applications to reduce and reverse biodiversity loss (Wright et al. 2015).

For many people it may now seem straightforward that quitting tobacco smoking will benefit your health (OECD and World Health Organization 2020), or that good hand hygiene limits the spread of infectious diseases (Jumaa 2005). However, it can be harder to know what actions will lead to positive biodiversity outcomes (Veríssimo

2019). A mix of conscious and non-conscious cues, behavioural levers, social norms, and environmental situation influence our decisions, so that we can actively choose or unwittingly be influenced to behave in specific ways (see Gallagher 2017, Eyal 2019, and Wood 2019 for detailed discussion). Social and public health behaviour change interventions often focus on short-to-medium-term benefits that directly affect the individual making the change or their immediate family (French et al. 2010, Lee and Kotler 2011). Similarly, the finance and business sectors' interventions often leverage direct benefits to individuals (Brown 2009, Martin and Martin 2009). A key challenge for conservation behaviour change is that the people who will need to change their behaviours won't always directly benefit, as benefits usually accrue indirectly through complex causal links for the people changing their behaviour (Schultz 2011, Wright et al. 2015, Meijers et al. 2019, Veríssimo 2019). Further, biodiversity benefits are often only realised after several years or decades and at landscape to regional scales (Veríssimo et al. 2017). So, conservation behaviour change will need to shift communities, companies, and cultures to achieve the scale of change required to reverse global biodiversity loss. Implementers of interventions will need to find ways to work with—and for—the people they seek to serve to create the changes needed to meet sustainability and biodiversity targets (Doughty et al. 2021). With ecosystems already collapsing and countless species edging towards extinction, the nature we all depend on is at the precipice (Wilcove et al. 2013, Bergstrom et al. 2021). So, there is a pressing need to improve our understanding of what behaviours are currently of concern, or will become issues in the future, as well as how to nudge, budge, and shove these behaviours towards more beneficial paths (Cowling 2014, Oliver 2015, Clayton et al. 2017, Reddy et al. 2017, Selinske et al. 2020b).

At present, agriculture occupies half of the world's habitable land (Ritchie and Roser 2020). Most globalised food systems have devastated biodiversity, but sustainable food systems have the potential to nurture nature and human health (Willett et al. 2019, Farmery et al. 2021). For most producers, decisions around what and how to grow, farm, harvest, or manage is influenced, either directly or indirectly, by consumer demands. So, there is great potential to shift consumer demands in ways that will support the transition towards more sustainable food systems. My thesis builds on the growing interdisciplinary behaviour change literature with contributions to the case of consumer behaviour change for sustainable coffee.

1.3. Coffee communities, café culture, and coffee companies

Coffee is something that almost everyone can relate to. Coffee has deeply rooted and connected cultures for centuries; from the stories of Sufi Baba Budan smuggling the first seven seeds out of the powerful Ottoman Empire to grow coffee in southern India, to stories told by baristas of the coffee communities who grow the beans that fuel café culture around the world today. Originating from tropical and southern Africa or tropical Asia, there are over one hundred and twenty known species within the *Coffea* genus (Hamon et al. 2017). However, the two species Arabica (*Coffea arabica*) and Robusta (*Coffea canephora*), account for almost all of the coffee we consume (International Coffee Organisation 2021). In 2020, Arabica accounted for approximately 60% of global coffee production and Robusta 40% (International Coffee Organisation 2021).

Coffee is traditionally grown as shrubs or small trees in shaded agroecosystems or near-wild coffee forests, providing habitat and protection for considerable biodiversity (see Figure 1.2; Perfecto and Snelling 1995, Perfecto et al. 1996, Wunderle and Latta 1996, Greenberg et al. 1997, Moguel and Toledo 1999, Mas and Dietsch 2004, Hundera et al. 2013, Tadesse et al. 2014, Buechley et al. 2015). Today, coffee is grown in some of the most biodiverse regions of our world, with a spatial footprint of approximately 100,000 km^2 (Killeen and Harper 2016), on an estimated 12.5 million coffee farms (Enveritas 2018), supporting millions of coffee farming families and their communities (Philpott et al. 2008, Tscharntke et al. 2015). From 1990 to 2020 annual global coffee production increased from approximately 5.6 to 10 billion kilograms (International Coffee Organisation 2020). However, the coffee sector predicts global demand will more than double between 2015 and 2050 (Killeen and Harper 2016). At the same time, climatic predictions suggest that approximately 60% of the area that will be suitable to grow coffee in 2050 was covered by natural forest in 2010 (Killeen and Harper 2016). This increasing demand along with a changing climate will require coffee production areas to expand, intensify, or shift (Jha et al. 2014, Killeen and Harper 2016). If not managed carefully, these changes will likely have substantially negative consequences for biodiversity (Philpott et al. 2008, Tejeda-Cruz et al. 2010, Tscharntke et al. 2015, Nesper et al. 2017). However, many coffee companies and consumers seem unwilling to pay for the human and biodiversity costs of coffee, knowingly or unknowingly, pushing producers to use less or un-sustainable practices (Sachs et al. 2019, Panhuysen and Pierrot 2020). Consequently, coffee producers are

left to bear most of the burden, risks, and challenges to sustain coffee production (Philpott et al. 2008, Bunn et al. 2015, Tscharntke et al. 2015, Killeen and Harper 2016, Samper et al. 2017, Sachs et al. 2019, Conservation International 2021).

Although traditional methods are still employed in many areas, coffee production is increasingly shifting towards ecologically simpler systems (Guingato et al. 2008, Baker 2014, Jha et al. 2014, Nesper et al. 2019). These simpler production systems can consist of coffee plants grown under a canopy of a few shade tree species (which are often non-native), or, on highly mechanised farms as monocultures consisting of regimented rows of coffee plants grown in full sun (see Figure 1.2; Jha et al. 2014, Nesper et al. 2019). Coffee grown in these conditions, without a complex forest structure, supports far less biodiversity than coffee grown in diverse agroecosystems or near-wild coffee forests (Bhagwat et al. 2008, Tadesse et al. 2014, Buechley et al. 2015, Nesper et al. 2017, Zewdie et al. 2022). Without the nutrient and hydrological cycles or biological control agents of a functional forest ecosystem, these simpler coffee production systems require the artificial input of fertilisers, irrigation, and pesticides (Rice and Ward 1996). If not managed carefully, these fertilisers and pesticides, along with other processing by-products, can run off into surrounding habitats and cause further detrimental impacts (Murthy and Naidu 2012).

Importantly, the broader landscape context and land-use history of individual sites strongly influences the potential net loss or gain in biodiversity when transitioning any area to coffee, or intensifying production (Chazdon et al. 2016, Martin et al. 2020, Zewdie et al. 2022). Essentially, coffee agroecosystems developed from tropical forest ecosystems support higher biodiversity than coffee agroecosystems developed from open land, but still correspond to a degradation of forests and loss of biodiversity. Whereas development of coffee agroecosystems from open land rehabilitates formerly forested areas and leads to biodiversity gains (see Figure 1.2 and Martin et al. 2020 for further discussion). There is a non-linear relationship between productivity and profitability among these systems (Zewdie et al. 2022), but coffee can be profitably produced and benefit biodiversity (Bhagwat et al. 2008, Jose 2009, Hernandez-Aguilera et al. 2019, Iverson et al. 2019, Sachs et al. 2019, Martin et al. 2020).

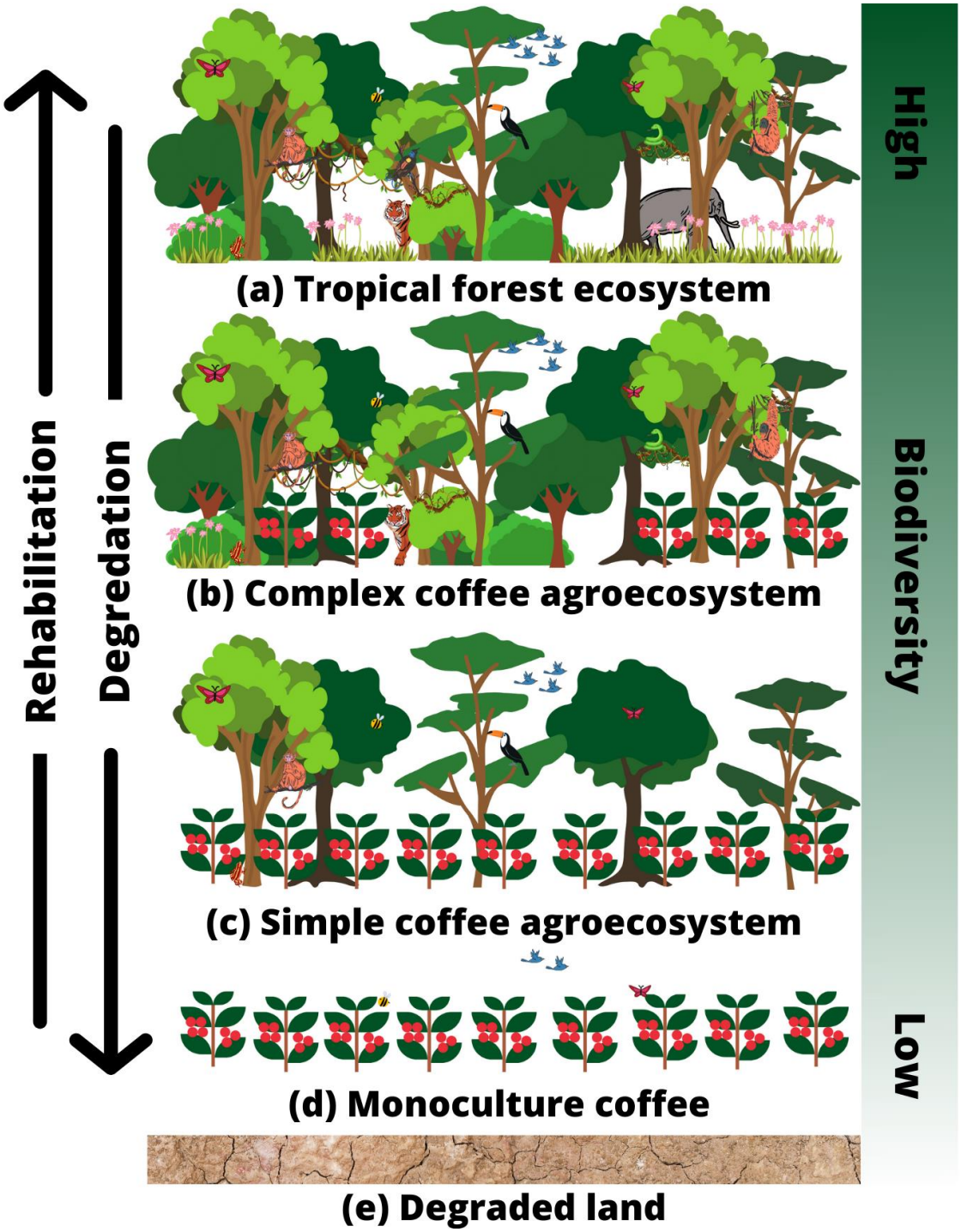

Figure 1.2. Conceptual spectrum of coffee production systems adapted from (Martin et al. 2020). (a) Tropical forest ecosystem supporting maximal biodiversity. (b) Complex coffee agroecosystem supporting high biodiversity. (c) Simple coffee agroecosystem supporting moderate biodiversity. (d) Monoculture coffee supporting low biodiversity. (e) Degraded land supporting minimal biodiversity. Coffee agroecosystems (b and c) developed from monocultures (d), or degraded land (e) rehabilitates formerly forested areas, leading to gains in biodiversity. Whereas development of complex coffee agroecosystems (b) from tropical forest ecosystems (a), simplification of coffee agroecosystems (from b to c), or conversion of coffee agroecosystems (b or c) to monocultures (d) degrades these ecosystems, leading to a reduction in biodiversity.

Changing consumer demands and external market forces can influence producers' decisions for how they grow coffee and, in turn, impact biodiversity (Hernandez-Aguilera et al. 2019, Iverson et al. 2019, Sachs et al. 2019, Panhuysen and Pierrot 2020). Therefore, it is possible to support farming families and communities that improve or maintain their practices to grow coffee amongst diverse agroecosystems by changing consumers' behaviour to demand coffee grown in these ways (Sachs et al. 2019, Bowie et al. 2020, Vogt 2020, Conservation International 2021, Garrett et al. 2021). Sustainability standards offer one path towards coffee systems that benefit biodiversity and people, connecting consumer and producer behaviour. Yet, even after operating for decades in some regions, there is a limited evidence base for positive synergistic biodiversity conservation and livelihood outcomes (Garrett et al. 2021). In chapter two, I explore the current state of sustainability standards and discuss opportunities to improve future standards that could begin to place the challenge of addressing coffee's most urgent issues more equitably across the value chain.

To be successful at influencing consumer behaviour, sustainability standards and associated logos need to have good brand recognition and be perceived as trustworthy (Yiridoe et al. 2005, Pickett-Baker and Ozaki 2008, Delmas and Burbano 2011, Chen and Chang 2013, Darian et al. 2015, Lee and Bateman 2021). However, there is confusion around many of these sustainability logos regarding recognition and what they stand for (Brécard 2014, Grunert et al. 2014, Williams et al. 2021). Consequently, even highly motivated conscious consumers can find it challenging to know where and how to find coffee that benefits biodiversity and the people who grow it (Kolk 2013, Takahashi et al. 2018, Williams et al. 2021). This may help explain why less than 25% of the coffee produced globally in 2018/19 was bought as standard-compliant, even though 55% of the coffee produced globally was compliant with at least one sustainability standard (Panhuysen and Pierrot 2020). This lack of consumer demand severely limits benefits for standard-compliant producers, reducing their financial capacity and motivation to continue investing in improved sustainability practices (Global Coffee Platform 2018, Panhuysen and Pierrot 2020). Despite these challenges, shifting consumers' purchasing behaviour to demand coffee that is grown amongst biodiverse agroecosystems and supports profitable livelihoods will be required to ensure sustainability of the coffee industry into the future (Sachs et al. 2019, Panhuysen and Pierrot 2020).

Consumer demands and trends in coffee consumption behaviour have gone through several ‘waves’ (Manzo 2014, Fischer et al. 2021). The industry characterises ‘first wave’ coffee as mass-produced, cost-effective, and convenient (Manzo 2014). This coffee is typically sold as ground or instant coffee at grocery stores or supermarkets with little information regarding where the beans were grown or by whom (Fischer et al. 2021). ‘Second wave’ coffee saw the arrival of coffee chain stores such as Starbucks, as well as a broader range of coffee drink types (e.g., flavour additives, alternative milk products), and a nascent awareness that coffee could be an agent for positive change (e.g., fair trade or organic coffee from a specific country or region; Hartmann 2011, Manzo 2014). ‘Third wave’ coffee brought with it independent coffee shops and roasters and is what many consumers would think of as today’s café culture. These cafés and roasters are willing to invest extra effort into developing direct trade relationships with coffee producers from specific regions or communities that grow high-quality beans (Hartmann 2011, Manzo 2014, Fischer et al. 2021). The third wave saw coffee become more of a luxury product and an experience, viewed with the same lens as fine wine (Hartmann 2011, Manzo 2014, Carvalho et al. 2015, Fischer et al. 2021). Australia has the highest market penetration of third wave coffee, and supported approximately 125 specialty cafés per million people in 2016 (Samper et al. 2017). Today, new waves are brewing as stakeholders within the coffee industry place even greater emphasis on equity and sustainability, including addressing biodiversity concerns (Panhuysen and Pierrot 2020, Conservation International 2021). As such, there is great potential for coffee industry stakeholders to embrace “environmentally friendly” coffee, which is produced and traded in a way that ensures fair and profitable producer livelihoods, sustainable production practices, and the protection of habitat for biodiversity.

In chapter three I used an online questionnaire to understand both coffee consumption behaviours and consumers’ awareness of biodiversity and other sustainability issues across metropolitan Melbourne, Australia. In chapter four I present the application of a seven-step co-design process, providing an outline and guidance for how to generate more user-centric intervention ideas and transform them into feasible prototype interventions. I applied this seven-step co-design process with coffee consumers in Adelaide, Australia to ideate and develop two prototype interventions to increase consumer demand for sustainable coffee.

Statement of Authorship

Title of Paper	Improving sustainable coffee certification policies to help conserve biodiversity through upstream social marketing
Publication Status	☐ Published ☐ Accepted for Publication ☑ Submitted for Publication ☐ Unpublished and Unsubmitted work written in manuscript style
Publication Details	Matthew J. Bowie, Phillip Cassey, John García-Ulloa, and Timo Dietrich. Improving sustainable coffee certification policies to help conserve biodiversity through upstream social marketing, *IN REVIEW*

Principal Author

Name of Principal Author (Candidate)	Matthew Jared Bowie		
Contribution to the Paper	Conceptualization, Methodology, Formal analysis, Investigation, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization, Project administration, Funding acquisition		
Overall percentage (%)	90%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	5th November 2021

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

I. the candidate's stated contribution to the publication is accurate (as detailed above);

II. permission is granted for the candidate in include the publication in the thesis; and

III. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

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Signature		Date	5th November 2021

Acknowledgements

M.B. and P.C. acknowledge the Kaurna people as the original custodians of the Adelaide Plains and T.D. acknowledges the Yugambeh, Yugarabul, Yuggera, Jagera and Turrbal peoples as the original custodians of the lands where they conducted this work from. We extend our acknowledgement to the traditional owners and custodians of all unceded lands where coffee is now grown. The ideas presented here developed over five years thanks to discussions and support from Lian Pin Koh; Director of the Centre for Nature-based Climate Solutions at the National University of Singapore, Jaboury Ghazoul and the Ecosystem Management group at ETH Zürich, through conversations with Bambi Semroc and Niels Haak at Conservation International's Sustainable Coffee Challenge, and through presenting preliminary results at the 55th Annual Meeting of the Association for Tropical Biology and Conservation in Kuching, Malaysia (2018) and the 29th International Congress for Conservation Biology in Kuala Lumpur, Malaysia (2019). Thank you to Amanda D. Rodewald; Director of Conservation Science at the Cornell Lab of Ornithology, for providing comments on an earlier version of this manuscript that helped improve this publication.

Funding

M.B. received financial support to complete a PhD from the Frederick James Sandoz Scholarship, a grant from the School of Biological Sciences Postgraduate Association for a graphical abstract from Animate Your Science, alongside financial support from the University of Adelaide Global Learning Travel Grant and Research Travel Scholarship to attend an agroforestry certification workshop in Switzerland and present preliminary results at two conferences in Malaysia.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Chapter 2.

Improving sustainable coffee certification policies to help conserve biodiversity through upstream social marketing

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2.1. Abstract

Upstream social marketing can help address environmental problems to drive important policy change, but examples are limited. The purpose of this study is to apply an upstream social marketing lens to critically reflect upon and discuss potential policy changes for sustainable coffee standards to better serve biodiversity. We used programme theory evaluation to assess, ex-ante, the extent to which eleven prominent standards include policies to address eight critical threats to biodiversity (encompassing thirty-four underlying threat processes) and, if so, the extent to which key decision guidelines and methodologies are provided. We found pollution and forest habitat loss were well considered at the local scale. However, many standards lacked policies to consider numerous underlying threat processes, including habitat fragmentation and conversion of agricultural land key for regional food security. We applied a novel framework to highlight the complex world of sustainable coffee policies and provide suggestions to improve these. Our findings deliver important upstream social marketing considerations and recommendations that can be applied to improve

sustainability outcomes within the coffee industry. Our analysis, and most sustainability standards, did not include non-producer actors (such as processors, traders, roasters, and end consumers) who should be involved in future work. We advocate for sustainable coffee standards to take landscape and regional scale approaches, which will allow tailored consideration of biodiversity needs. We call for social marketers to engage with key upstream stakeholder audiences in industry, government, and not-for-profits to help enact this change. Future standards could begin to place the challenge of addressing coffee's most urgent issues more equitably by incorporating the voices, perspectives, and participation of producers, processors, traders, roasters, retailers, and end consumers.

2.2. Introduction

2.2.1. Upstream social marketing is underdeveloped

Upstream social marketing is an important approach in building effective social marketing solutions. However, there is considerable ambiguity around what upstream social marketing is and how it can be applied (Gordon 2013, Newton et al. 2016). The term 'upstream social marketing' was first coined in 1993 as a criticism of social marketers' tendency to focus behaviour change interventions on 'downstream' consumers without considering how the potential for these consumers to change their behaviour could be moderated or influenced by 'upstream' actors like policymakers (Wallack et al. 1993). Since then, upstream social marketing has featured in several publications to advance our understanding (e.g., Hastings 2007, Kotler and Lee 2011, Wymer 2011, Gordon 2013), but ambiguity about its scope and application remain (Newton et al. 2016, Kennedy et al. 2018, Akbar et al. 2021). The few practical applications of upstream social marketing have shown how harnessing social listening can help understand community preferences and attitudes towards shark management policies and the policymaking process (Mehmet and Simmons 2019), or community biases and underlying reasonings towards climate and energy policy (Mehmet et al. 2021). Further applications have focussed on advocating for change at the upstream actor and organisation level which includes key decision makers in an industry, government, or not-for-profit sector and thinking of these as a key target audience for social marketing solutions (Gordon 2013, Kennedy et al. 2018, Rundle-Thiele et al. 2021). However, clear applications of upstream social marketing remain

under researched and further investigation into the potential benefits of this approach to make positive change in society is required (Akbar et al. 2021, Cook et al. 2021).

Two important gaps in our upstream social marketing investigation that warrant attention are: 1) how social marketers can engage with upstream decision makers at the industry, government, and not-for-profit sector level to serve people and planet and 2) the need for a clear conceptual distinction between upstream social marketing and policy making. In this study, we aim to: (a) provide a framework which social marketers can adapt to assess the potential for environmental policies to support biodiversity and (b) show how this framework can be defined and applied with voluntary certifications and corporate-based verification policies within the sustainable coffee sector. We provide further discussion on how upstream social marketing can better serve biodiversity and the people who depend upon it. However, more research and practical applications are needed before the social marketing community can clearly define the bounds of upstream approaches.

2.2.2. Sustainability standards act as upstream policies

We live in an increasingly interconnected, globalised, and telecoupled world (Liu et al. 2015, Marques et al. 2019). For some communities, this can mean goods and services from around the world become affordable or available in any season. For other communities, this can mean deforestation, development, or cultural change. From Colombian coffee to Scottish salmon, demand for agricultural and wildlife products from high-income and emerging economies is driving socio-economic and environmental change across geographically disconnected communities (Carrasco et al. 2017, Marques et al. 2019). Expansion and intensification of agriculture through the conversion of forests and grasslands are significant drivers of our current global biodiversity crisis (Sodhi et al. 2004, Norris 2008, Bond and Parr 2010, Sodhi et al. 2010, Wilcove et al. 2013). These changes present challenges for biodiversity conservation, but also new opportunities. Various voluntary certifications and private verification policies (hereafter sustainability standards) now exist for major agricultural and wildlife products. These sustainability standards aim to promote sustainable production with the promise of higher selling prices or priority access to markets for producers who abide by their policies and practices (Glasbergen 2018, Thorlakson et al. 2018). By purchasing sustainable products, consumers support profitable

livelihoods for the producers taking action to conserve biodiversity. In this way, sustainability standards act as upstream policies, leveraging our telecoupled world for sustainable social, economic, and environmental development (Haak 2013, Tscharntke et al. 2015, Carrasco et al. 2017).

Although many industries now use sustainability standards, coffee is a pioneer in this space (Haak 2013, Tscharntke et al. 2015). Internal industry efforts and persistent external pressures have coffee on track to become the world's first globally sustainable crop (Conservation International 2021). So, what sets coffee apart, and why does this industry need sustainability standards? Put simply—coffee is lucrative. Valued at US$200-250 billion, the coffee industry supports livelihoods for untold millions of smallholder farmers, along with their families and communities (Pendergrast 1999, Gresser and Tickell 2002, Samper et al. 2017, Sachs et al. 2019). Yet, coffee-producing countries claim less than 10% of that US$200-250 billion (individual farming families even less), while bearing most of the burden, risks, and challenges to sustain coffee production under a changing climate (Bunn et al. 2015, Samper et al. 2017, Sachs et al. 2019, Conservation International 2021). From 1990 to 2020 annual global coffee production increased from approximately 5.6 to 10 billion kilograms (International Coffee Organisation 2020). Production will need to increase further still as the sector predicts global coffee demand will double or even triple between 2015 and 2050 (Killeen and Harper 2016). This demand is expected to come as flourishing consumer markets in China, India, and other traditionally-tea-drinking societies cultivate their passion for coffee, while countries including Ethiopia and Nigeria are expected to experience massive population growth (Killeen and Harper 2016, Roser 2019). Despite all these figures of growth, it remains uncertain how much forest, grassland, or other social-ecological production systems coffee agriculture has converted or will convert to meet demand (Baker 2014, Bunn et al. 2015, Killeen and Harper 2016, Panhuysen and Pierrot 2018). What is certain is that coffee is grown in some of the world’s most biodiverse regions (Philpott et al. 2008, Tscharntke et al. 2015). Forest clearing and pruning are common practice to increase coffee production; threatening biodiversity as coffee agriculture continues to expand and intensify (Philpott et al. 2008, Tejeda-Cruz et al. 2010, Tscharntke et al. 2015). Yet, coffee can be profitably produced and minimise impacts on—or even benefit—biodiversity (Bhagwat et al. 2008, Jose 2009, Hernandez-Aguilera et al. 2019, Iverson et al. 2019,

Martin et al. 2020). Sustainability standards offer one path towards that goal, but can these policies actually help coffee conserve biodiversity?

Sustainability standards act as upstream policies which aim to reconcile environmental degradation and rising socio-economic inequalities, through a set of rules and practices, to guide sustainable development. However, sustainability is a difficult concept to define. What's more, there are concerns that important policies underlying some standards are being stifled, diluted, or removed entirely as upstream policymakers update or generalise stadards to fit various producer and consumer markets (Jha et al. 2014, Craves 2020). Furthermore, although 55% of global coffee production was standard-compliant in 2018/19, less than 25% of coffee was bought as standard-compliant (Panhuysen and Pierrot 2020), severely limiting benefits for standard-compliant producers. So, the efficacy of these standards to deliver positive real-world change remains debated (Jha et al. 2014, Tayleur et al. 2017, Tayleur et al. 2018, Hernandez-Aguilera et al. 2019, Rainforest Alliance 2020b, Smithsonian's National Zoo & Conservation Biology Institute 2020, Conservation International 2021). Studies report variable results from a biodiversity perspective after implementing sustainability standards on coffee farms, from positive to neutral, or even negative outcomes (Tejeda-Cruz et al. 2010, Jha et al. 2014, Buechley et al. 2015, Aerts et al. 2017, DeFries et al. 2017, Iverson et al. 2019, Martin et al. 2020). Ultimately, it remains unclear which threats to biodiversity sustainability standards' policies address.

Here we aim to assess the extent to which eleven prominent sustainability standards include policies to address eight critical threats to biodiversity from coffee agriculture, encompassing thirty-four underlying threat processes (see Figure 2.1 and Supplementary Material 2.1). Our study outlines opportunities for key upstream decision makers to improve future standards to help the coffee industry work towards environmental sustainability. Through this case study we explore how upstream social marketers can engage with environmental policy to drive positive change.

Figure 2.1. We assessed the extent to which thirty-four underlying threat processes (across eight threats to biodiversity from coffee agriculture) were included in sustainability standard policies and, if so, the extent to which key decision guidelines and methodologies were provided. These threats range from forest habitat loss to increasing population pressure arising from the development and intensification of coffee agriculture. See Supplementary Material 2.1 for a detailed explanation of these threats, their underlying threat processes, and how we defined these for each evaluation criteria.

2.3. Methods

2.3.1. Scoring sustainability standards

We defined a framework to focus on eight critical threats to biodiversity, encompassing thirty-four underlying threat processes relevant to coffee agriculture (Figure 2.1, see Supplementary Material 2.1 for details). It is essential to note that the location, intensity, and scale of coffee development influence these underlying threat processes. Consequently, individual producer's decisions and their collective decisions across landscapes and regions, influence the relative significance of these threats. One of the co-authors initially developed this framework to evaluate certification policies for oil-palm agriculture (unpublished methods; García-Ulloa 2016), which we have adapted and refined here for coffee agriculture. We used programme theory evaluation to assess, ex-ante, the extent to which eleven prominent

standards include policies to address the thirty-four underlying threat processes and, if so, the extent to which these policies are operationalised (e.g., provision of key decision guidelines and methodologies). Programme theory evaluation is a commonly used policy analysis tool to evaluate whether goals, needs, tools, and outcomes connect logically (Crabbé and Leroy 2008). However, we excluded goals as they differ widely among standards from biodiversity conservation to human rights.

We collated the official documentation for eleven prominent standards (see Supplementary Material 2.2; Australian Certified Organic (ACO), Baseline Common Code (4C; GCP), Bird Friendly (Smithsonian Migratory Bird Centre), C.A.F.E Practices (Starbucks), Enveritas' Sustainability Standards for Coffee Producers, Fairtrade International, International Federation of Organic Agricultural Movements (IFOAM), Nespresso's AAA Sustainable Quality Program, Principles & Practices for Sustainable Green Coffee Production (SAI Platform), Rainforest Alliance, and UTZ Certified). Next, we systematically read through this documentation, assigning any policy, regulation, or guidance material to all relevant underlying threat processes. Finally, we assessed the extent to which this collated information included relevant policies for each underlying threat process's different aspects. To guide our assessment, we defined three hierarchically comprehensive evaluation criteria (EC):

EC.1. Does the standard include policies to consider this threat process? If so,

EC.2. Are decision guidelines provided to address this threat process? if so,

EC.3. Are there supporting guidance materials and methodologies for informed decision-making to address this threat process?

We defined specific requirements for these three evaluation criteria for all underlying threat processes (see Supplementary Material 2.1 for details). For each standard and all threat processes, we scored each of the three evaluation criteria as either *included, partially included,* or *not or only minimally included*. Importantly, the score for EC1 set the maximum possible score for EC2, which in turn set the maximum possible score for EC3 (i.e., If EC1 scored *'partially included'*, EC2 cannot be scored *'included'*, or if EC1 scored *'included'*, but EC2 scored *'not or only minimally included'*, EC3 could only be scored *'not or only minimally included'*). To help the reader understand our programme theory evaluation methods, we provide an example assessment from one

standard (UTZ), for one underlying threat process—*increase in biodiversity exploitation and wildlife conflicts* (see Supplementary Material 2.3).

Importantly, our programme theory evaluation methodology does not include any measure of compliance with sustainability standards on the ground. Therefore, the results presented here do not quantify the degree to which producers fulfil standards or if the provision of and compliance with policies will result in the desired outcome. Furthermore, this evaluation only considers what sustainability standards require of producers, but not of all other potential non-producer actors. See discussion section.

2.3.2. Statistical and graphical computing

We conducted statistical analyses using the R (v.4.0.2) software environment for statistical and graphical computing (R Core Team 2020). We conducted contingency-type frequency tests to assess and visualise the independence of threats and underlying threat processes in the graphical package 'vcd' for visualising categorical data (Friendly and Institute 2000, Zeileis et al. 2007, Meyer et al. 2013). Pearson residuals, relative within each evaluation criteria, were calculated for EC2 and EC3 after (i) excluding underlying processes that scored *not or only minimally included* in EC1 or EC2, respectively; and (ii) excluding any threat or underlying threat process which no standard *included* policies for in EC1 or EC2, respectively. We determined the extent to which sustainability standards consider threats to biodiversity by calculating the percent of standards which included policies for to each of the thirty-four underlying threat processes, for each evaluation criteria.

2.4. Results

2.4.1. Standards focused on pollution and forests at a local scale

Of the eight threats assessed, we found more sustainability standards included policies that considered *pollution* and the underlying processes within *forest habitat loss* than any other threat (Figure 2.2 and Table 2.1). Within *forest habitat loss*, we found that at the local scale (i.e., within the boundaries of individual farms or farm groups) 73-91% of standards included policies that considered and specifically protected against the conversion of primary, riparian, secondary, and rare forests or

forests that support species of high conservation priority (Table 2.2). Conversely, we found fewer sustainability standards included policies that considered the underlying processes within *forest fragmentation* than any other threat (Figure 2.2 and Table 2.1).

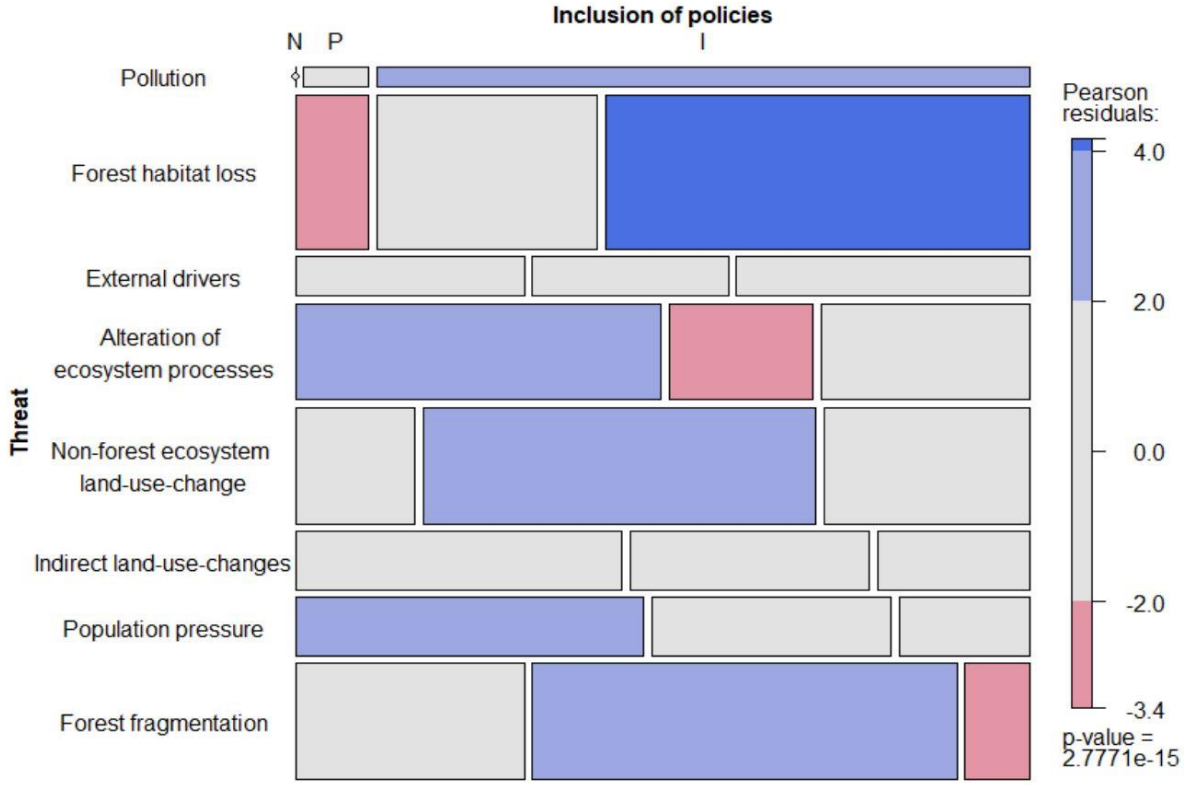

Figure. 2.2. Mosaic plot for evaluation criteria one (*do sustainability standards consider this threat?*) showing deviation in conditional independence between the eight threats (*pollution*, *forest habitat loss*, *external drivers*, *alteration of ecosystem processes*, *non-forest ecosystem land-use-change*, *indirect land-use-changes*, *increasing population pressure*, *forest fragmentation*) and inclusion of policies (*included* = **I**, *partially included* = **P**, *not or only minimally included* = **N**) across eleven sustainability standards. Mosaics are constructed so that the size of each cell (box) is proportional to the observed cell frequency for each threat-score pair. The 'height' of threat-cells is proportional to the number of underlying processes contained within them (i.e., there is one process within *pollution*, but eight within *forest habitat loss*, see Table 2.1 and Supplementary Material 2.1 for details). Cells are coloured following standard Pearson residual-based shading (Zeileis et al. 2007) to reflect each cell's contribution to the Chi-square statistic. Blue residuals indicate there are more scores in that cell for that threat than would be expected, with dark blue indicating a Pearson residual of 4 or greater, light blue a Pearson residual between 2 and 3.99. Red residuals indicate there are fewer scores in that cell for that threat than would be expected, with light red indicating a Pearson residual between -2 and -3.99, no threat scored a Pearson residual of -4 or less, which would be indicated by dark red.

Table 2.1. The overall extent to which sustainability standards address eight key threats to biodiversity from coffee agriculture. Threats are ranked based on the percent of underlying threat processes that were included in policies across all eleven standards for evaluation criteria one. The length of green bars is proportional to 100%. Pearson residuals, relative within each evaluation criteria, were calculated for criteria two and criteria three after (i) excluding underlying process which scored not or only minimally included in criteria one or criteria two, respectively; and (ii) excluding any threat or underlying process which no standard included policies for in criteria one or criteria two, respectively. Positive blue Pearson residuals indicate there are more included scores for that threat than would be expected, with dark blue indicating a Pearson residual of 4 or greater, light blue a Pearson residual between 2 and 3.99. Negative red Pearson residuals indicate there are fewer included scores for that threat than would be expected, with light red indicating a Pearson residual between -2 and -3.99. No threat scored a Pearson residual of -4 or less, which would be indicated by dark red.

	Criteria 1		Criteria 2		Criteria 3	
Threat Name	**Percent included**	**Pearson residuals**	**Percent included**	**Pearson residuals**	**Percent included**	**Pearson residuals**
Pollution	91%	3.298	64%	1.972	27%	1.254
Forest habitat loss	59%	4.165	28%	1.053	11%	0.739
External drivers	41%	0.607	32%	1.116	4%	-0.392
Alteration of ecosystems processes	29%	-0.556	22%	2.019	2%	-1.083
Non-forest ecosystem land-use-changes	29%	-0.651	14%	-1.226	3%	-1.01
Indirect land-use-changes	21%	-1.213	12%	0.339	3%	-0.189
Increasing population pressure	18%	-1.514	6%	-1.409	6%	0.894
Forest fragmentation	9%	-3.419	0%	-2.984	0%	0

For the five other threats we assessed, trends across sustainability standards were less consistent (Figure 2.2 and Table 2.1). Positively though, we found over 50% of standards included policies that considered six underlying threat processes (of nineteen) within these five threats (Table 2.2). These six threat processes included: i) alteration of soil and nutrient dynamics (82%); ii) introduction of invasive species, pests and disease (73%); iii) conversion of areas used for traditional agriculture or forestry systems (64%); iv) conversion of non-forest areas that support species of high conservation priority (64%); v) alteration of hydrological processes (64%); and vi) conversion of wetland ecosystems (55%, see Table 2.2).

2.4.2. There are consistent gaps across sustainability standards

We found none of the eleven standards included policies that considered thirteen of the thirty-four underlying threat processes (Table 2.2). Additionally, only four or fewer standards (≤36% of eleven) included policies that considered seven of the underlying threat processes (Table 2.2).

Although *forest habitat loss* was well considered overall, none of the eleven standards included policies that considered coffee's contribution to forest loss in the landscape or at any regional scale, even though seven standards (64%) included policies that considered overall forest loss within individual farms (Table 2.2). Furthermore, within *forest fragmentation,* no standard included policies to consider increased edge effects, fragmentation of large and continuous forest areas, or reduction in ecosystem connectivity at the regional level. Only three or fewer standards (≤27% of eleven) included policies to mitigate against reduction in forest connectivity in the landscape, loss of habitat heterogeneity in the landscape, or increased patch size effects (Table 2.2). Similarly, no standard included policies to consider coffee's impacts on biodiversity through fragmentation of non-forest ecosystems or loss of non-forest ecosystems at the landscape to regional scale (Table 2.2).

Investigating *external drivers*, we found only one standard included policy to consider the increase in vulnerability to global climate change, which when addressed should empower producers to effectively consider the long-term synergistic effects of coffee development and climate change on biodiversity (Table 2.2). Alongside *alteration of ecosystem processes*, no standard incorporated policies to manage threats to

biodiversity arising from coffee agriculture altering local or regional climate regulation processes, natural disturbance regimes, or other ecological processes like pollination (Table 2.2).

Finally, focusing on the social-ecological threats from coffee agriculture, we found that no standard included policies to consider avoiding the conversion of key agricultural land for food security at the regional scale or of land where other commodity products of high demand are grown (Table 2.2). Conversion on these areas for coffee production may result in their displacement to undisturbed areas inside or outside the region. Furthermore, no standard included policy for consideration of potential impacts on biodiversity from the development of transport infrastructure and only one standard contained policy to consider effects from potential rapid increases in human populations for managing coffee production (Table 2.2).

2.4.3. Standards need more guidance to practically address threats

For all underlying threat processes, and in turn all eight threats, the percent of standards that included relevant policies noticeably decreased between evaluation criteria one and three (Table 2.2 and Table 2.1). For example, ten of eleven standards (91%) included policies that considered the threat of *pollution* by requiring producers to manage and reduce impacts in the landscape resulting from the pollution of soil, air, and water (criteria 1). Yet, only three (27%) provided clear methodological guidance (criteria 3) to identify and measure potential pollutants, as well as harmful pollution levels, originating from operations within coffee farms (Table 2.2). So, although most standards may consider the various threats to biodiversity (criteria 1), fewer provided practical decision guidelines for producers to address these threats (criteria 2), and in general, standards do not provide supporting guidance for informed decision-making to address these threats (criteria 3). See Supplementary Material 2.4 for the full extent of proportional scores for all underlying threat processes and evaluation criteria.

Table 2.2. Gaps across sustainability standards that show how individual underlying threat processes contribute towards differences among eight key threats to biodiversity. Threats are ranked in the same order as Table 2.1, with underlying threat processes ranked within threats based on the percent of eleven standards that included relevant policies for evaluation criteria one. The length of green bars is proportional to 100%. Pearson residuals are relative within each evaluation criteria, but for criteria two and criteria three were calculated after (i) excluding underlying process which scored not or only minimally included in criteria one or criteria two, respectively; and (ii) excluding any threat or underlying process which no standard included policies for in criteria one or criteria two, respectively. Positive blue Pearson residuals indicate there are more included scores for that threat process than would be expected, with dark blue indicating a Pearson residual of 4 or greater, light blue a Pearson residual between 2 and 3.99. Negative red Pearson residuals indicate there are fewer included scores for that threat process than would be expected, with light red indicating a Pearson residual between -2 and -3.99, no threat scored a Pearson residual of -4 or less, which would be indicated by dark red. Note: we defined *pollution* as a separate threat but with only a single underlying threat process, so shows the same pattern as Table 2.1 and Pearson residuals become zero. Similarly, when only a single underlying process remains within a threat at criteria 2 or criteria 3, all Pearson residuals become zero.

Underlying threat processes	Criteria 1		Criteria 2		Criteria 3	
	Percent included	Pearson residuals	Percent included	Pearson residuals	Percent included	Pearson residuals
Pollution						
Increase in pollution of soils, air and waterbodies	91%	0	64%	0	27%	0
Forest habitat loss						
Conversion of primary forests	91%	1.373	73%	1.878	18%	0.099
Conversion of riparian forests	91%	1.373	36%	-0.082	27%	1.002
Conversion of forest areas that support species of high conservation priority	82%	0.981	27%	-0.572	18%	0.234
Conversion of secondary forests	73%	0.588	36%	-0.082	18%	0.234
Conversion of rare or threatened forest habitats or ecosystems	73%	0.588	27%	-0.572	9%	-0.425
Forest loss within plantations	64%	0.196	27%	-0.572	0%	-1.235
Contribution to forest loss in the landscape	0%	-2.55	0%	0	0%	0
Contribution to forest loss at the regional level	0%	-2.55	0%	0	0%	0
External drivers						
Introduction of invasive species, pests and diseases	73%	1.65	64%	0.824	9%	0
Increase in vulnerability to global climate change	9%	-1.65	0%	-1.366	0%	0

Alteration of ecosystems processes						
Alteration of soil and nutrient dynamics	82%	3.242	73%	0.816	9%	0.759
Alteration of hydrological processes	64%	2.124	36%	-0.816	0%	-0.724
Alteration of local and regional climate regulation processes	0%	-1.789	0%	0	0%	0
Alteration of natural disturbance regimes	0%	-1.789	0%	0	0%	0
Alteration of ecological processes	0%	-1.789	0%	0	0%	0
Non-forest ecosystem land-use-changes						
Conversion of non-forest areas that support species of high conservation priority	64%	2.154	27%	0.5	0%	-0.73
Conversion of wetland ecosystems	55%	1.592	27%	0.5	9%	0.639
Conversion of rare or threatened non-forest ecosystems or habitats	36%	0.468	9%	-0.833	9%	0.516
Conversion of natural savannah and shrubland ecosystems	18%	-0.656	18%	-0.167	0%	-0.577
Non-forest ecosystems loss at landscape and regional level	0%	-1.78	0%	0	0%	0
Fragmentation of non-forest ecosystems	0%	-1.78	0%	0	0%	0

Indirect land-use-changes						
Conversion of areas used for traditional agriculture or forestry systems	64%	3.055	36%	0	9%	0
Conversion of key agricultural land for food security at the regional scale	0%	-1.528	0%	0	0%	0
Conversion of land where commodity products of high demand are grown	0%	-1.528	0%	0	0%	0
Increasing population pressure						
Increase in biodiversity exploitation and wildlife conflicts	46%	2.121	18%	0.621	18%	0
Rapid increase in human population	9%	-0.707	0%	-0.84	0%	0
Increase of impacts from the development of transportation infrastructure	0%	-1.414	0%	0	0%	0
Forest fragmentation						
Reduction of forest connectivity in the landscape	27%	2	0%	0	0%	0
Loss of habitat heterogeneity in the landscape	18%	1	0%	0	0%	0
Increase in patch size effects	9%	0	0%	0	0%	0
Increase in edge effects	0%	-1	0%	0	0%	0
Fragmentation of large and continuous forest areas	0%	-1	0%	0	0%	0
Reduction of ecosystem connectivity at the regional level	0%	-1	0%	0	0%	0

2.5. Discussion

This paper addresses an important gap in upstream social marketing, demonstrating how social marketers can engage with upstream decision makers at the industry, government, and not-for-profit sector level to serve people and planet. In this study, we defined and applied a framework to assess the extent to which eleven prominent coffee sustainability standards include policies, guidelines, and methodologies to address eight critical threats to biodiversity. Our findings can help guide upstream actors within the coffee industry, not-for-profit sector, and policymakers to improve future sustainability standards. This paper makes important contributions to further the sustainable coffee movement while also providing critical discussion on how upstream social marketing can be applied to better serve biodiversity and the people who depend upon it. These contributions are discussed next.

2.5.1. Upstream social marketing should serve biodiversity and people

Through this case study we have shown how upstream social marketing can help inform environmental policy change to conserve biodiversity in the coffee sector. Our research adds to the limited practical applications of upstream social marketing for environmental issues (Kennedy et al. 2018, Mehmet and Simmons 2019, Mehmet et al. 2021). We defined a framework to assess the extent to which voluntary certifications and corporate-based verifications included policies to address eight critical threats to biodiversity (encompassing thirty-four underlying threat processes) and the extent to which key decision guidelines and methodologies are provided to help inform decision-making to address threat processes. Social marketers could modify and use our framework to assess how policies in different contexts address environmental threats to support biodiversity and people's livelihoods. Indeed, one of the co-authors has applied a version of this framework to assess sustainable palm oil certifications (unpublished data; García-Ulloa 2016). We discuss how our insights can be used to help guide upstream actors within the coffee industry to improve sustainable coffee policies (sections 4.2 and 4.3). However, further critical investigation into how social marketers engage with decision makers within and among different industry, government, and not-for-profit sectors is still needed to develop the field and to better serve people and planet (Gordon 2013, Newton et al.

2016, Kennedy et al. 2018). Importantly, the authors feel the distinction should be made clear between upstream social marketing and policy making. Upstream social marketing should promote many potential solutions with key decision makers, that can involve voluntary solutions (e.g., sustainability certifications, financial incentives, new training programs, etc.), and may also result in new or improved policies or laws (Gordon 2013). However, social marketers should not act as policymakers. Further practical applications of upstream social marketing are needed to help define these boundaries more clearly and to improve social marketing theory and practice to achieve more meaningful change beyond the downstream level (Akbar et al. 2021).

2.5.2. The current state of coffee sustainability standards

By assessing sustainability standard's underlying policies, we revealed that most standards included policies that could help producers consider the threats arising from pollution and forest habitat loss at the local scale (within individual farms). However, we found many standards did not include policies to consider numerous underlying threat processes from habitat fragmentation and threats operating at landscape to regional scales. These shortcomings may explain some of the variability among individual farm-level responses from positive to neutral, or even negative outcomes after implementing standards' policies and procedures (Tejeda-Cruz et al. 2010, DeFries et al. 2017). We know that little land remains in our world, which exists solely for nature, and that protection of fragmented ecosystems alone does not safeguard biodiversity (Laurance et al. 2002, Lindenmayer and Franklin 2002, Ellis et al. 2010). Other studies have shown how the broader landscape context and specific land-use history have significantly influenced biodiversity outcomes in agroecosystems, including coffee, after implementing sustainability standards (Ghazoul et al. 2009, Tejeda-Cruz et al. 2010, Nesper et al. 2017, Martin et al. 2020). For coffee to truly become sustainable, the industry needs to minimise or remove the barriers hindering human-nature coexistence within its social-ecological production systems (Crespin and Simonetti 2020). Social marketers can engage with decision makers within the coffee industry by assessing sustainability policies, like we have here, but could also work with other upstream actors in government and not-for-profit sectors to explore and promote further potential solutions. Further research into a variety of approaches

would help develop upstream social marketing theory and practice to better serve people and planet (Gordon 2013, Newton et al. 2016, Kennedy et al. 2018).

2.5.3. Opportunities to improve coffee sustainability standards

Sustainability standards cannot offer a single static set of decision guidelines to meet the vast range of socio-economic, political, legal, and biophysical contexts for coffee producers around the world. One-size-fits-all policies are unlikely to work, and we cannot expect every smallholder farming family to address all threats all the time (König et al. 2020). To better address biodiversity threats that operate at scales beyond individual farms, we advocate for future standards to include well developed landscape and regional scale policies that allow tailored consideration of biodiversity. We envisage future sustainability standards could include policies and guidelines to direct regional upstream actors to identify, clearly define, and subsequently consider regionally specific to landscape-specific biodiversity issues. To achieve this, future standards will need to be accommodating, with multiple locally appropriate decision guidelines, to account for what is achievable under given geopolitical and economic situations. These future standards could then help guide regional upstream actors to partner with various local organisations, governments, or not-for-profits (which can provide detailed and tailored guidance), to help empower smallholders and relevant non-producer actors to make informed decisions that minimise impacts on—or even benefit—biodiversity. Social marketers could function as an important stakeholder group here to help facilitate partnerships, programs, and tailored communication approaches. Future standards will also require transparent, accurate, and affordable methods to measure change and compliance with consistent objective monitoring. Enveritas, one of the sustainability standards we evaluated here, offers free verification for producers at the landscape scale through the use of big geospatial data, machine learning, and on-the-ground observations (Enveritas 2020). Innovative upstream solutions like this can help sustainability standards move beyond individual farm-based policies, supporting change beyond downstream actors to shift communities, landscapes, and regions.

2.5.4. Study limitations and future research agenda

Both our analysis and most sustainability standards did not include non-producer actors (such as processors, traders, roasters, or end consumers) who are directly or indirectly involved in undermining biodiversity conservation. Future research should include each of these stakeholders to help provide insights and considerations from different viewpoints to inform multiple potential solutions which may also result in new or improved voluntary sustainability policies or laws (Gordon 2013). Future sustainability standards could also begin to place the challenge of addressing coffee's most urgent issues more equitably by incorporating a wider range of insights from producers to processors, traders, roasters, retailers, and end consumers. As a first step, future revisions of standards should include more voices, perspectives, and participation of smallholder coffee producers and their non-producer partners. This could be achieved through methods such as co-design, which has been previously used with coffee consumers to prototype consumer behaviour change interventions (Bowie et al. 2020). However, sustainable coffee standards and future upstream social marketing research will need to consider the potential for producers to change their behaviour and how upstream actors like policymakers can genuinely influence change. Many of the gravest challenges to smallholder coffee producers and biodiversity are posed by political strife, conflict, economic instability, and systemic inequalities. Under these circumstances, conserving biodiversity constitutes a low priority for many smallholder farming families and their communities (Stonich 2020). Although excluded from our analyses, these external challenges greatly complicate the potential efficacy of upstream approaches like sustainability standards. Still, future standards that use a landscape approach could begin to facilitate transformation by incorporating a wider range of insights and coordinating across the sector (sensu Verburg et al. 2019).

One of the biggest shortcomings of coffee sustainability standards is that this upstream behaviour change tool has been able to certify so much coffee production, but that relatively little coffee is sold under these standards (Panhuysen and Pierrot 2020). So, producers are left to bear the costs of sustainability without receiving promised price premiums or priority access to markets. This reduces producers' financial capacity and motivations to continue investing in improved sustainability practices (Global Coffee Platform 2018, Panhuysen and Pierrot 2020). The coffee sector as a whole needs to

support and reinvest in producer communities and their standard-compliant smallholders over consecutive years by ensuring price-premiums are paid and by integrating with other approaches like carbon payments or direct-trade relationships (Jha et al. 2014, Hernandez-Aguilera et al. 2018, Hernandez-Aguilera et al. 2019, Iverson et al. 2019, Panhuysen and Pierrot 2020). The upstream actors that develop, certify, and monitor sustainability standards could help achieve this by working with roasters, retailers, marketers, influencers, and researchers to increase demand for their standard-compliant coffee (Bowie et al. 2020, Panhuysen and Pierrot 2020). Increasingly, roasters and retailers are developing internal sustainable sourcing programs, but these face transparency, accountability, and credibility challenges (MacGregor et al. 2017, Panhuysen and Pierrot 2018). Innovations like these offer alternate solutions for coffee producers to achieve profitable livelihoods whilst reducing impacts on biodiversity. By engaging with various actors, upstream social marketers can help inform multiple potential solutions to address these and other socio-environmental issues.

2.6. Conclusions

We know coffee production will continue expanding, intensifying, and moving into new regions to meet growing demand. Upstream social marketing can provide important insights and considerations for improving sustainability policies to better conserve biodiversity without necessitating mandatory laws. Social marketers should help key decision makers improve many different sustainability solutions by incorporating insights from various actors. To help the coffee sector progress towards environmental sustainability, future standards should incorporate various producer and non-producer voices, focus on landscape to regional perspectives, include policies that consider more threats to biodiversity, and provide adequate guidelines and methodologies for each actor to address those threats. Although sustainability standards are imperfect, we urge all stakeholders to continue implementing and improving solutions to address coffee's most urgent issues and sustain production into the future.

Statement of Authorship

Title of Paper	Is the public ready for environmentally friendly coffee?
Publication Status	☐ Published ☐ Accepted for Publication ☑ Submitted for Publication ☐ Unpublished and Unsubmitted work written in manuscript style
Publication Details	Matthew J. Bowie, Pia E. Lentini, Emily M. McLeod, Georgia E. Garrard, Timo Dietrich, Phillip Cassey, Sarah Bekessy, and Matthew J. Selinske. Is the public ready for environmentally friendly coffee? *IN REVIEW*

Principal Author

Name of Principal Author (Candidate)	Matthew Jared Bowie		
Contribution to the Paper	Conceptualization, Methodology, Formal analysis, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization, Project administration		
Overall percentage (%)	85%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	5th November 2021

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

I. the candidate's stated contribution to the publication is accurate (as detailed above);

II. permission is granted for the candidate in include the publication in the thesis; and

III. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

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Contribution to the Paper	Conceptualization, Methodology, Investigation, Writing - Review & Editing, Project administration, Funding acquisition		
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Signature		Date	26th November 2021

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Signature		Date	26th November 2021

Acknowledgements

This research was conducted on the unceded lands of the Woi wurrung, Wathaurong and Boon wurrung language groups of the eastern Kulin Nations. M.B. and P.C. acknowledge the Kaurna people as the original custodians of the Adelaide plains, and T.D. acknowledges the Yugambeh, Yugarabul, Yuggera, Jagera and Turrbal peoples as the original custodians of the lands where they conducted this work from. We extend our acknowledgement to the traditional owners and custodians of all unceded lands where coffee is now grown. Thank you to Darcie Carruthers, Ben Sanders, and Peter Lancaster for their contributions to the development of the questionnaire. The Design and Social Context College Human Ethics Advisory Network (DSC CHEAN), as a sub-committee of the RMIT Human Research Ethics Committee (HREC) approved the collection of questionnaire data and the conduct of the project, approval number CHEAN A 21948-01/19.

Funding

The questionnaire was funded by Zoos Victoria and research supported through ARC Linkage Grant LP190100453.

M.B. received financial support to complete a PhD from the Frederick James Sandoz Scholarship.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Chapter 3.

Is the public ready for environmentally friendly coffee?

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3.1. Abstract

Coffee is grown in a variety of ways and along a spectrum of intensities, from diverse agroecosystems supporting considerable biodiversity at one end, to monoculture systems supporting little biodiversity at the other. Consumer demands and external market forces can influence producers' decisions about which coffee systems they adopt and, in turn, how they impact biodiversity. Behaviour change interventions that promote environmentally friendly purchasing can shift consumer demands, but these interventions should be evidence-based and guided by research to ensure their effectiveness. We used an online questionnaire to understand coffee consumption behaviours and awareness of biodiversity and other sustainability issues amongst coffee consumers in Melbourne, one of Australia's largest cities and a global hotspot for coffee culture and sector innovation. After providing a definition of environmentally friendly coffee, we found 89% of the 1,142 respondents were willing to consume this type of coffee. While this suggests the public is ready to switch to this alternative, responses highlighted that there was limited knowledge of where to find environmentally friendly coffee, or that coffee could have negative impacts on biodiversity. Using a recursive feature elimination algorithm, we found that consumers' previous purchasing behaviours and values correlated most strongly with stated

willingness to consume environmentally friendly coffee. Specifically, willingness to consume environmentally friendly coffee was highest in respondents who had higher environmental concern and placed greater importance on sustainability or ethical certifications of food products. Despite a vibrant café culture, we found that 57% of respondents buy instant coffee for home consumption, while 30% buy pods, 25% buy ground coffee and 22% buy whole beans. Furthermore, we found that 76% of respondents buy the coffee they use to make at home from supermarkets, while 26% buy from specialty coffee stores and 13% from coffee chain stores. We discuss how these insights could be used to inform targeted behaviour change interventions to increase consumer demand for environmentally friendly coffee. Our research highlights how understanding a target audience's previous behaviours and values can prove to be more valuable than demographic factors when designing interventions. These insights will inform the development of an upcoming behaviour change campaign, led by Zoos Victoria, but will also be important for other markets promoting environmentally friendly coffee as well.

3.2. Introduction

3.2.1. Coffee and biodiversity

Coffee is grown in some of the world's most biodiverse areas, and its production has direct impacts on regional ecosystems (Philpott et al. 2008, Tscharntke et al. 2015). Coffee currently supports countless farming families and communities (Philpott et al. 2008, Tscharntke et al. 2015) with a spatial footprint of approximately 100,000 km^2 (Killeen and Harper 2016) across an estimated 12.5 million coffee farms (Enveritas 2018). Global coffee demand is predicted to double or even triple by 2050 (Killeen and Harper 2016; compared to 2015 demand figures), and this increasing demand, along with a changing climate, will require coffee production areas to expand, intensify, or shift (Jha et al. 2014, Killeen and Harper 2016). However, approximately 60% of the area that will be climatically suitable to grow coffee in 2050 is currently covered by natural forest (Killeen and Harper 2016). Forest clearing and pruning are already commonly used to increase coffee production, but if not managed carefully are likely to have substantial negative consequences for biodiversity (Philpott et al. 2008, Tejeda-Cruz et al. 2010, Tscharntke et al. 2015, Nesper et al. 2017). Yet coffee can be produced profitably while minimising impacts on, or even benefitting, biodiversity

(Bhagwat et al. 2008, Jose 2009, Hernandez-Aguilera et al. 2019, Iverson et al. 2019, Martin et al. 2020).

Traditionally, coffee was grown as one stratum of near-intact forests or complex coffee agroecosystems, an approach that supports considerable biodiversity (see Figure 3.1; Wunderle and Latta 1996, Greenberg et al. 1997, Moguel and Toledo 1999, Hundera et al. 2013, Buechley et al. 2015). Although traditional methods are still employed in some areas, coffee production is increasingly shifting towards ecologically simpler systems (Guingato et al. 2008, Baker 2014, Jha et al. 2014, Nesper et al. 2019). These simpler production systems can consist of coffee plants grown under a canopy of a few shade tree species (which are often non-native) or on highly mechanised farms as monocultures consisting of regimented rows of coffee plants grown in full sun (Jha et al. 2014, Nesper et al. 2019). Coffee grown in these conditions supports far less biodiversity than coffee grown in complex coffee agroecosystems or near-intact coffee forests (see Figure 3.1; Perfecto and Snelling 1995, Bhagwat et al. 2008, Tadesse et al. 2014, Buechley et al. 2015, Nesper et al. 2017).

The broader landscape context and land-use history of individual sites can strongly influence the potential net loss of—or gain in—biodiversity when transitioning any area to coffee production (see Figure 3.1 and Martin et al. 2020 for further discussion). Consumer demands and external market forces can influence producers' decisions in how they grow coffee and, in turn, impact biodiversity (Mas and Dietsch 2004, Hernandez-Aguilera et al. 2019, Iverson et al. 2019, Sachs et al. 2019, Panhuysen and Pierrot 2020). Therefore, it is possible to support farming families and communities that grow coffee amongst diverse agroecosystems or near-intact forests by changing consumers' behaviour to increase demand for coffee grown in these ways (Sachs et al. 2019, Bowie et al. 2020, Vogt 2020, Conservation International 2021, Garrett et al. 2021).

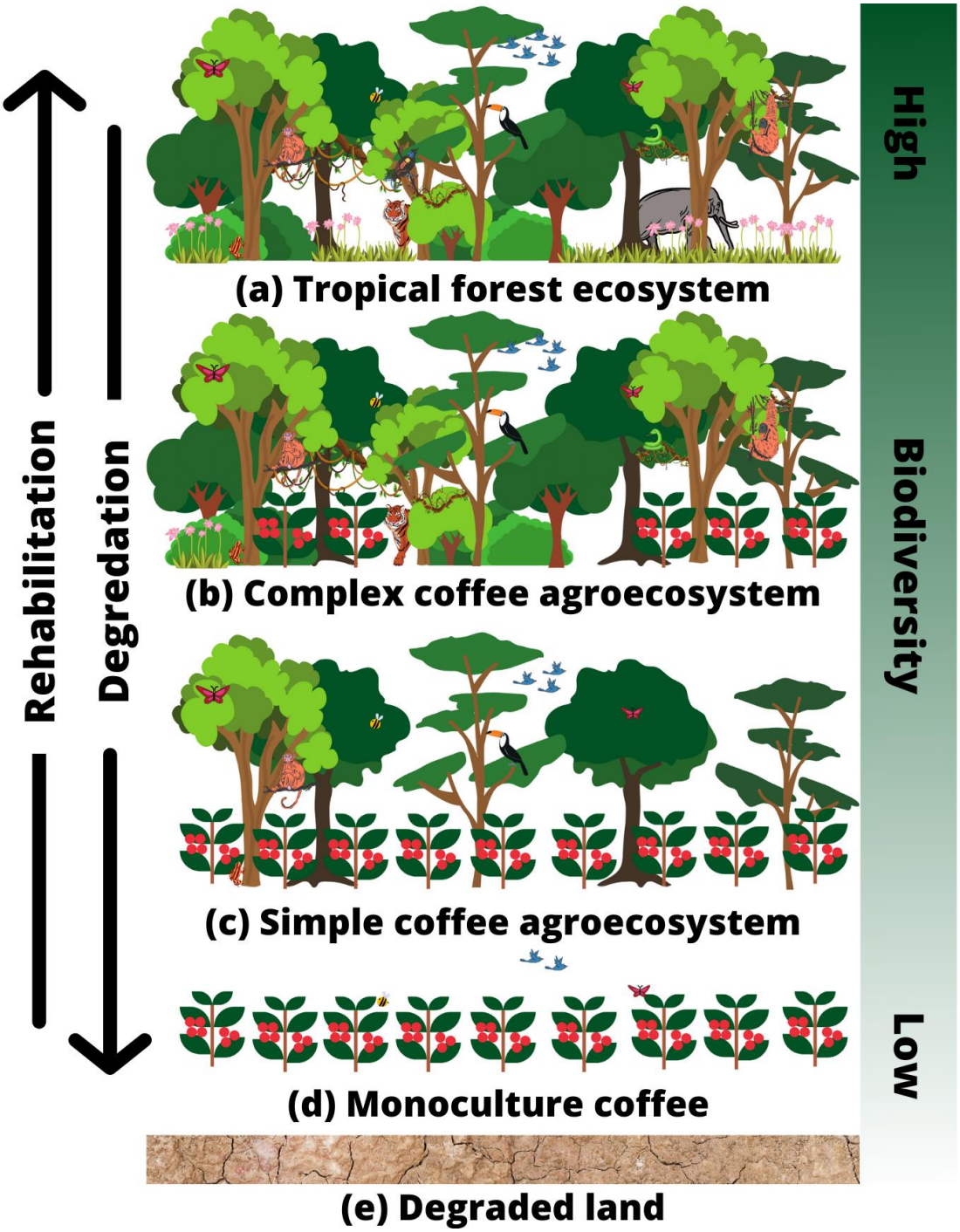

Figure 3.1. Conceptual spectrum of coffee production systems adapted from (Martin et al. 2020). (a) Tropical forest ecosystem supporting maximal biodiversity. (b) Complex coffee agroecosystem supporting high biodiversity. (c) Simple coffee agroecosystem supporting moderate biodiversity. (d) Monoculture coffee supporting low biodiversity. (e) Degraded land supporting minimal biodiversity. Coffee agroecosystems (b and c) developed from monocultures (d), or degraded land (e) rehabilitates formerly forested areas, leading to gains in biodiversity. Whereas development of complex coffee agroecosystems (b) from tropical forest ecosystems (a), simplification of coffee agroecosystems (from b to c), or conversion of coffee agroecosystems (b or c) to monocultures (d) degrades these ecosystems, leading to a reduction in biodiversity.

3.2.2. Coffee and consumer behaviour

Coffee consumption studies are of growing interest across multiple disciplines, including sustainability, health, and marketing (Samoggia and Riedel 2018). Several factors determine coffee purchasing and consumption decisions, including product features (e.g., sustainability labelling, country of origin, packaging, price, and type), personal preferences (e.g., taste, sensory perception, and health beliefs), socio-demographics, and where and how the product is consumed. Between 65% and 80% of coffee is consumed at-home depending on the locale's coffee culture (Samper et al. 2017, Samoggia and Riedel 2018, Panhuysen and Pierrot 2020). Consumers may be motivated to buy more 'sustainable' coffee by environmental concerns and alignment with their values or identity (Bezençon and Blili 2011), but the cost and product differentiation of sustainable coffee can be a strong moderator affecting stated purchasing intentions and realised purchasing behaviours (Bezençon and Blili 2011, Klimas and Webb 2017, Lee and Bateman 2021).

Sustainability standards and associated product labelling have become an increasingly common approach to guide consumer decisions and support sustainable production practices (i.e., certifications including Rainforest Alliance and Fairtrade, or verifications including Starbucks' C.A.F.E. Practices; Tscharntke et al. 2015, Glasbergen 2018, Thorlakson et al. 2018, Garrett and Rueda 2019, Garrett et al. 2021). To be successful at influencing consumer behaviour, these sustainability standards and associated logos need to have good brand recognition and be perceived as trustworthy (Yiridoe et al. 2005, Pickett-Baker and Ozaki 2008, Delmas and Burbano 2011, Chen and Chang 2013, Darian et al. 2015, Lee and Bateman 2021). However, there is confusion around many of these sustainability logos regarding recognition and what they stand for (Brécard 2014, Grunert et al. 2014, Williams et al. 2021). Consequently, even highly motivated conscious consumers can find it challenging to know where and how to find coffee that benefits biodiversity and the people who grow it (Kolk 2013, Takahashi et al. 2018, Williams et al. 2021). This may help explain why less than 25% of the coffee produced globally in 2018/19 was bought as standard-compliant, even though 55% of the coffee produced globally was compliant with at least one sustainability standard (Panhuysen and Pierrot 2020). This lack of consumer demand severely limits benefits for standard-compliant producers, reducing their financial capacity and motivation to continue investing in improved

sustainability practices (Global Coffee Platform 2018, Panhuysen and Pierrot 2020). Furthermore, although most sustainability standards address forest loss and pollution at the local scale, few address threats to biodiversity from coffee agriculture at broader landscape or regional scales (Bowie et al. 2021). Despite these challenges, shifting consumers' purchasing behaviour to demand coffee that is grown amongst biodiverse agroecosystems and supports profitable livelihoods is needed to ensure sustainability of the coffee industry into the future (Sachs et al. 2019, Panhuysen and Pierrot 2020).

Consumer demands and trends in coffee consumption behaviour have gone through several 'waves' (Manzo 2014, Fischer et al. 2021). The industry characterises 'first wave' coffee as mass-produced, cost-effective, and convenient (Manzo 2014). This coffee is typically sold as ground or instant coffee at grocery stores or supermarkets with little information regarding where the beans were grown or by whom (Fischer et al. 2021). 'Second wave' coffee saw the arrival of coffee chain stores such as Starbucks, as well as a broader range of coffee drink types (e.g., flavour additives, alternative milk products), and a nascent awareness that coffee could be an agent for positive change (e.g., fair trade or organic coffee from a specific country or region; Hartmann 2011, Manzo 2014). 'Third wave' coffee brought with it independent coffee shops and roasters and is what many consumers would think of as today's café culture. These cafés and roasters are willing to invest extra effort into developing direct trade relationships with coffee producers from specific regions or communities that grow high-quality beans (Hartmann 2011, Manzo 2014, Fischer et al. 2021). The third wave saw coffee become more of a luxury product and an experience, viewed with the same lens as fine wine (Hartmann 2011, Manzo 2014, Carvalho et al. 2015, Fischer et al. 2021). Australia has the highest market penetration of third wave coffee, and supported approximately 125 specialty cafés per million people in 2016 (Samper et al. 2017). Today, new waves are brewing as stakeholders within the coffee industry place even greater emphasis on equity and sustainability, including addressing biodiversity concerns (Panhuysen and Pierrot 2020, Conservation International 2021). As such, there is great potential for coffee industry stakeholders to embrace "environmentally friendly" coffee, which is produced and traded in a way that ensures fair and profitable producer livelihoods, sustainable production practices, and the protection of habitat for biodiversity.

In this project, we set out to develop a better understanding of consumers' awareness of biodiversity and other sustainability issues surrounding coffee production, using Melbourne as a case study. Specifically, this research aimed to inform the development of an upcoming behaviour change campaign, led by Zoos Victoria, to raise awareness of these issues and encourage people to purchase wildlife-friendly coffee. Specifically, this research aimed to:

1. Characterise current coffee purchasing behaviours and beliefs
2. Assess knowledge and understanding of environmentally friendly coffee
3. Identify what factors predict intention to consume environmentally friendly coffee

We aimed to demonstrate the value of psychographics in understanding consumer motivations as a potentially useful approach for other sustainable consumption contexts. The insights presented are an important step in understanding coffee consumption behaviours and informing campaigns to mainstream biodiversity-friendly coffee. Our research highlights insights important for other markets promoting environmentally friendly coffee (Williams et al. 2021).

3.3. Methods

3.3.1. Melbourne's café culture

Melbourne is the capital city of the state of Victoria, in south-eastern Australia, and is Australia's largest city by area, supporting a growing population of around five million people (Australian Bureau of Statistics 2018). Melbourne has a vibrant café culture and is home to a range of social enterprises which seek to address the environmental and social impacts of the coffee industry. For example, KeepCup have propelled the reusable cup movement globally to address the issue of single-use coffee cup waste (KeepCup 2021), while Reground help cafés and other businesses reimagine and redirect their 'waste' (including used coffee grounds) into a circular economy (Reground 2021). However, to date, there are no enterprises or initiatives which specifically target consumers interested in minimising biodiversity losses associated with coffee production. To address this, Zoos Victoria, a zoo-based conservation organisation, will in 2022 launch a community behaviour change campaign focusing

on wildlife-friendly coffee. In partnership with Genovese Coffee, this campaign aims to increase Victorians' knowledge of and concern for the way coffee is produced to shift consumer purchasing behaviour towards coffee that supports people, forests, and wildlife (Zoos Victoria 2019).

3.3.2. Questionnaire design and data collection

We developed an online questionnaire to understand both coffee consumption behaviours and consumers' awareness of biodiversity and other sustainability issues across metropolitan Melbourne (see Supplementary Material 3.1 for the complete questionnaire). Previous research on coffee (Tamaki and Batt 2011) and green consumption (Magnusson et al. 2001) informed our questionnaire design and question phrasing. The questionnaire consisted of eight sections: 1) current coffee consumption; 2) knowledge of environmentally friendly coffee; 3) knowledge of sustainability standard labels; 4) benefits of drinking environmentally friendly coffee; 5) other sustainable coffee behaviours; 6) environmental concern; 7) stated willingness to consume environmentally friendly coffee (our key response variable), and 8) demographics. After completing an initial set of questions, participants were provided with a definition of what environmentally friendly coffee production means before they progressed to the rest of the questionnaire. We used the New Ecological Paradigm Scale (15 Likert statements; hereafter NEP) as a proven psychographic measure of environmental concern (Dunlap et al. 2000) that has also previously been used to help understand shade-grown coffee purchasing behaviour (Klimas and Webb 2017). We based our key response variable (willingness to consume) on previous research on consumers' willingness to adopt ecologically-friendly food consumption behaviours (Tobler et al. 2011). Question format included Likert-scale responses, open-ended, and closed questions, which provided both qualitative and quantitative information.

We engaged a data collection agency (the Online Research Unit, hereafter the ORU) to recruit coffee consumers from across metropolitan Melbourne to complete the online questionnaire, which was hosted on the Qualtrics platform (www.qualtrics.com). The ORU were provided with quotas based on gender, age, and location to ensure a representative of the Melbourne population, and we collected 1,142 responses across February and March 2019. Before participation, the ORU asked potential participants

whether they would be willing to contribute to a coffee market research questionnaire and provided information that outlined what was involved in the study. We did not require participants to respond to questions that were sensitive in nature (e.g., political orientation, religion, income). Respondents self-determined their competence to consent but needed to state that they were fluent in English (the primary language used in Australia) and were over 18-years of age (the legal age of consent in Australia) to complete the questionnaire. We checked responses to ensure all necessary questions were answered, did not include a 'check question', but did use open-ended questions to help with quality assurance (Wardropper et al. 2021).

3.3.3. Statistical computing and visualisation

We conducted data visualisation and statistical analyses using the R software environment for statistical computing, version 4.0.2 (R Core Team 2020).

3.3.3.1. Current coffee behaviour & knowledge

We explored variables describing current consumption behaviour as well as knowledge of impacts of coffee production on biodiversity using R. The 'ggplot2' (Wickham 2016) and 'ggmosaic' (Jeppson et al. 2021) packages were used to visualise the distribution of responses and stated willingness to consume environmentally friendly coffee. We categorised responses to the "willingness to consume environmentally friendly coffee" questions according to the 'product adoption curve' (Rogers 2010), placing participants in one of four groups: early adopters, early majority, late majority and laggards.

3.3.3.2. Feature selection

Recursive feature elimination (RFE) is an effective feature selection algorithm to help determine which set of predictor variables (features) in a training dataset are more or most relevant in predicting the response variable (Kuhn and Johnson 2019). Random Forest-RFE analysis is essentially a decision-tree type classifier approach, whereby many decision trees are constructed from sub-sets of the data. In each of these trees the explanatory variables are 'split' at the nodes (e.g., into yes/no, or more than/less than certain values for continuous variables) in such a way that leads to the observed data (who chose which of the response to the "willingness to consume" question

categories). The final tree is a consensus tree, taking the average from across the "forest" of trees. Recursive Feature Elimination is a feature selection algorithm used to select a subset of the most relevant variables in a dataset for predicting a target variable and helps mitigate against issues of correlated variables with random forest. To determine the set of variables that best predicted stated willingness to consume environmentally friendly coffee we conducted recursive feature elimination with a random forest algorithm classification using the 'rfe' and 'rfFuncs' functions in the 'caret' package (Kuhn et al. 2020). We used 'rfFuncs' because it has a built-in mechanism for computing variable importance, and a random forest approach to reduce the risk of overfitting to training data when compared to other tools such as decision trees (Liaw and Wiener 2002, Chen et al. 2020). The original survey consisted of 52 questions, we selected 18 quantitative questions as the focus for our analysis, which related to respondent's current coffee consumption behaviour, their understanding of coffee-related issues such as sustainability and biodiversity impacts, psychographics, and demographics. We cleaned the data from these questions as follows. To confirm its reliability for measuring a single worldview of the environment in our sample, we conducted factor and reliability analyses of the 15 items making up the NEP scale (Cronbach's alpha $\alpha = 0.86$) using the package 'psych' with default 'oblimin' rotation (Revelle 2020). We then used the summed NEP score for each respondent as a singular environmental psychographic variable. For some questions that allowed multiple choice responses, such as ethnicity or where coffee was bought, we converted each response option into a binary variable. We removed any of these resulting binary variables if they contained a level with less than one percent of responses, as we deemed this would be insufficient variation to inform the RFE. As a result, gender was reduced to a binary variable (female/male), removing five respondents. Postcodes were reclassified into one of five regions of metropolitan Melbourne (inner, west, north, east, and southeast). Finally, we removed variables with incomplete data. The resulting input dataset consisted of 1,137 responses for each of 43 candidate predictor variables (see Table 3.1) and one key response variable (stated willingness to consume environmentally friendly coffee). The data were randomly partitioned into training (80%) and test (20%) datasets, and we used repeated ten-fold cross-validation with five repeats to improve the performance of feature selection. We set the function to test all possible combinations of candidate predictor variables, which were retained or discarded based on the resulting model

accuracy and reliability. Accuracy (A) is calculated as: A = (TP + TN) / (TP + TN + FP + FN), where TP is the rate of true positives, TN the rate of true negatives, FP the rate of false positives, and FN the rate of false negatives. Reliability is based on Cohen's Kappa, κ, with a score from 0 – 1 (poor ≤ 0.20; fair = 0.21–0.40; moderate = 0.41–0.60; good = 0.61–0.80; very good = 0.81–1.00; Chen et al. 2020).

Data visualisation was also carried out using R. The 'ggplot2' (Wickham 2016) and 'ggmosaic' (Jeppson et al. 2021) packages were used to visualise the variation among stated willingness and important predictor variables identified from the random forest RFE. Pearson residuals were calculated using the 'CrossTable' function in the 'gmodels' package (Warnes et al. 2018).

Table 3.1. Forty-three input candidate predictor variables used for random forest recursive feature elimination and their respective response levels.

Candidate predictor variables	**Response levels**
Age group	18-20, 21-30, 31-40, 41-50, 51-60, 61-70, 71+
Gender	Female, Male
Postcode (grouped into regions)	Inner, North, Western, Eastern, South-eastern, not listed
Education	Less than year 12, High school, Undergraduate degree, TAFE certificate or diploma, postgraduate diploma, postgraduate masters, postgraduate doctorate, prefer not to answer

Australian ethnicity, European ethnicity (*note that other ethnicities were options, but these were removed from RFRFE due to <1% of responses in YES category*)	Yes, No
Summed New Ecological Paradigm Scale score	Numeric (15 – 75)
Agreement with statements: "It is important to maintain biodiversity (nature)", "My coffee purchasing behaviours (including purchasing coffee at a café or for home consumption) can help maintain biodiversity (nature)"	Strongly disagree, somewhat disagree, neither agree nor disagree, somewhat agree, strongly agree
Level of awareness for statements: "Coffee production can have a negative impact on biodiversity (nature)", "There are different methods of coffee production that can cause less loss of biodiversity (nature) than other methods"	Not at all aware, somewhat aware, moderately aware, aware, highly aware
Indicate your level of agreement with each statement regarding sustainable / ethical food certifications: "Sustainability / ethical certifications on food products are important to me", "I am more likely to buy a coffee product if it has a sustainable / ethical certification logo on it than if it doesn't", "If a coffee product has a sustainable / ethical certification logo on it, it tells me that it has a smaller environmental / social impact than coffee products without the logo." "If a coffee product has a sustainable / ethical certification logo on it, it tells me that it is likely to taste better than coffee products without the logo"	Strongly disagree, somewhat disagree, neither agree nor disagree, somewhat agree, strongly agree

On average, how many cups of coffee do you drink per week that you make at home?	0-20, more than 20
Do you buy coffee to make at home from: supermarkets / grocery stores, specialty coffee shops / café	Yes, No
Do you buy coffee for home consumption in the form of: instant, whole beans, ground beans, pods/capsules?	Yes, No
Importance of product features on influencing decision of which coffee products to purchase for home consumption: taste, aroma, have enjoyed the product on previous occasions, familiarity with the coffee brand, type of beans (Arabica / Robusta), the look of the packaging, price, convenience, advice from salesperson / barista, advice form trusted friends / family / colleagues, brand reputation, single origin source, place of origin, organic, environmentally friendly, sustainability, fair trade	Never, rarely, sometimes, frequently, almost every time
Have you ever purchased environmentally friendly coffee for home consumption?	Yes, Unsure, No
Indicate how likely you think this statement is: “Environmentally friendly coffee is available at the supermarket you frequent the most”	Extremely unlikely, somewhat unlikely, neither likely nor unlikely, somewhat likely, extremely likely
Indicate how easy or difficult you think each statement is: “Finding environmentally friendly coffee at your supermarket / grocery store”, “Knowing if the coffee you purchase at the supermarket / grocery store is produced in an environmentally friendly way” Enc coffee find super	Extremely difficult, somewhat difficult, neither easy nor difficult, somewhat easy, extremely easy

3.4. Results

3.4.1. Distribution of responses

The 1,142 respondents from our study were roughly evenly split between female (48.9%) and male (50.6%), with 0.3% identifying as non-binary and 0.2% preferring not to answer. Respondents were spread across age groups as follows: 18-20 (1.1%), 21-30 (20.1%), 31-40 (17.3%), 41-50 (13.0%), 51-60 (18.8%), 61-70 (21.0%), and 71 or older (8.6%). A minority of the respondents stated they were either already consuming (8.1%) or were not currently (nor willing to) consume environmentally friendly coffee (11.1%), groups which we have termed the 'early adopters' and 'laggards' respectively (Figure 3.2). Most respondents stated that they would like to consume environmentally friendly coffee, and either know how to (25.0%) or don't know how to (55.7%), which we have termed the 'early majority' and 'late majority' respectively (Figure 3.2).

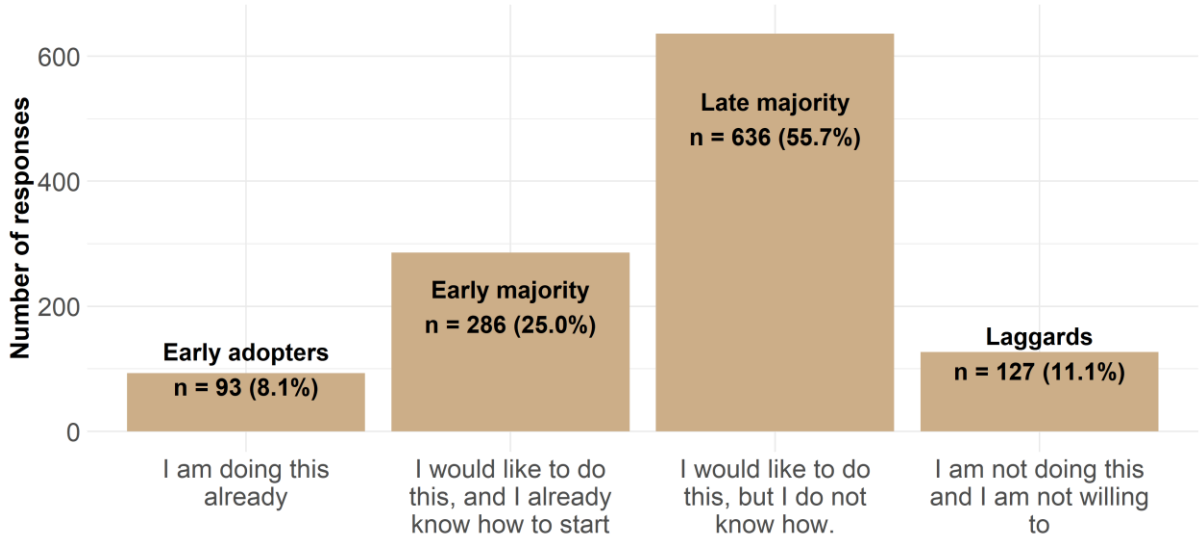

Figure 3.2. Distribution of responses across four ordinal categories of willingness to consume environmentally friendly coffee, reflecting the diffusion of innovations distribution or 'product adoption curve' (Rogers 2010).

3.4.2. Current coffee behaviour and knowledge

We found that per week and on average, respondents drink 12.8 cups of coffee that they make at home and 10 cups of coffee bought from a café or coffee shop. When asked where they bought coffee for home consumption (multiple options could be selected), the most common response was supermarkets (75.8%), followed by

speciality coffee shops or cafés (25.9%), coffee chain stores (12.6%), convenience stores or petrol stations (8.8%), and online (5.8%). When asked what type of coffee they buy to make at home (again, multiple options were allowed), the most common response was instant coffee (57.4%), followed by pods or capsules (30.0%), ground coffee (25.5%), whole beans (21.7%), and pre-brewed canned or bottled (4.4%). We found limited variation among the four categories of willingness to consume environmentally friendly coffee for these consumption behaviours (see Supplementary Material 3.2).

Focusing on coffee bought for home consumption, we found that the most important factors and product features influencing purchase decisions were having previously enjoyed a coffee product, taste, and brand familiarity (approximately 75-80% of respondents started these factors frequently or almost always influenced their purchasing decision, Figure 3.3). Aroma, price, and convenience were the next most important, with approximately 55% of respondents stating these factors frequently or almost always influenced their purchase decision, followed by brand reputation (43%) and the type (36%) of coffee bean (Arabica vs. Robusta, Figure 3.3). Product features including sustainability, fair trade, being environmentally friendly, and single or place of origin were important for 22-25% of respondents (Figure 3.3). The look of the packaging, being organic, along with advice from a barista, salesperson, or from a trusted friend, family member, or colleague ranked as the least important, with less than 20% of respondents stating that these factors frequently or almost always influenced their purchasing decision (Figure 3.3).

A greater proportion of respondents who stated that they would like to consume environmentally friendly coffee and know how to start, compared to those who don't know how, noted that they found it 'extremely easy' (9.1%) or 'easy' (28%) to find environmentally friendly coffee at their supermarket or grocery store (Figure 3.4, Supplementary Material 3.3). For respondents who stated that they already consume environmentally friendly coffee, 34.4% found it 'easy' and 17.2% found it 'extremely easy' to find environmentally friendly coffee at their supermarket or grocery store (Figure 3.4).

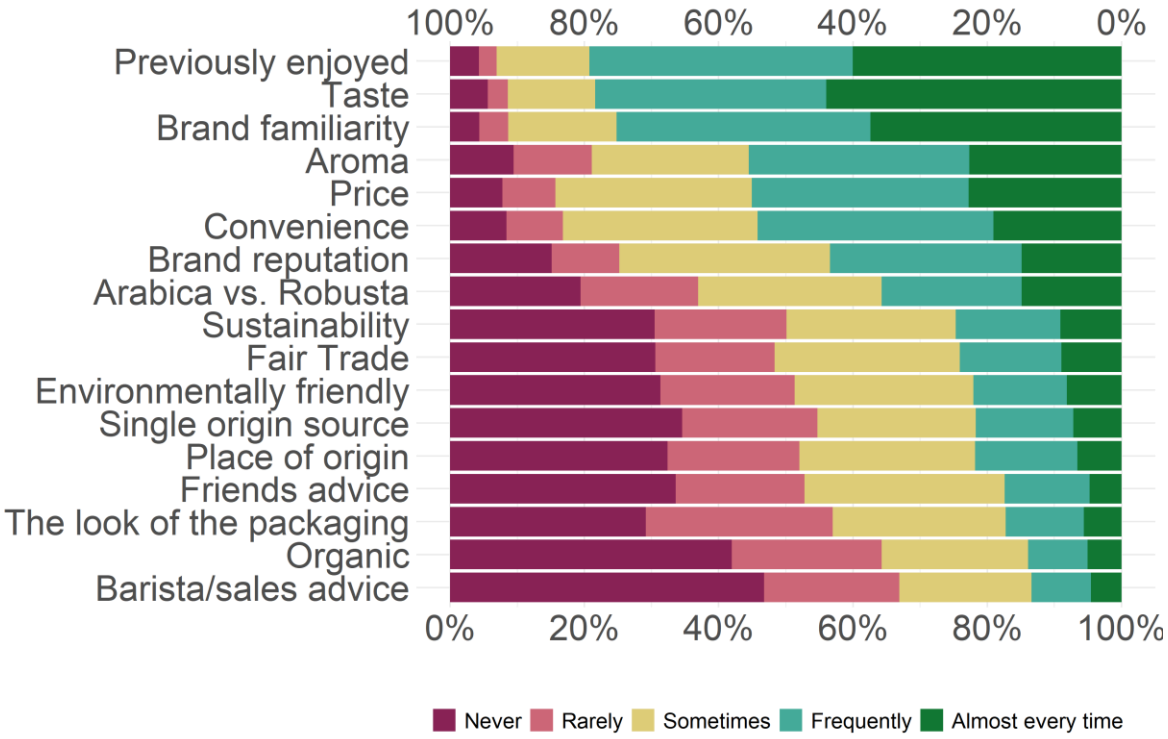

Figure 3.3. Importance of factors and product features that influence purchase decisions for which coffee products respondents bought for home consumption. Factors and product features are ranked based on the percent of 1,142 respondents who stated these frequently or almost always influenced their purchase decision.

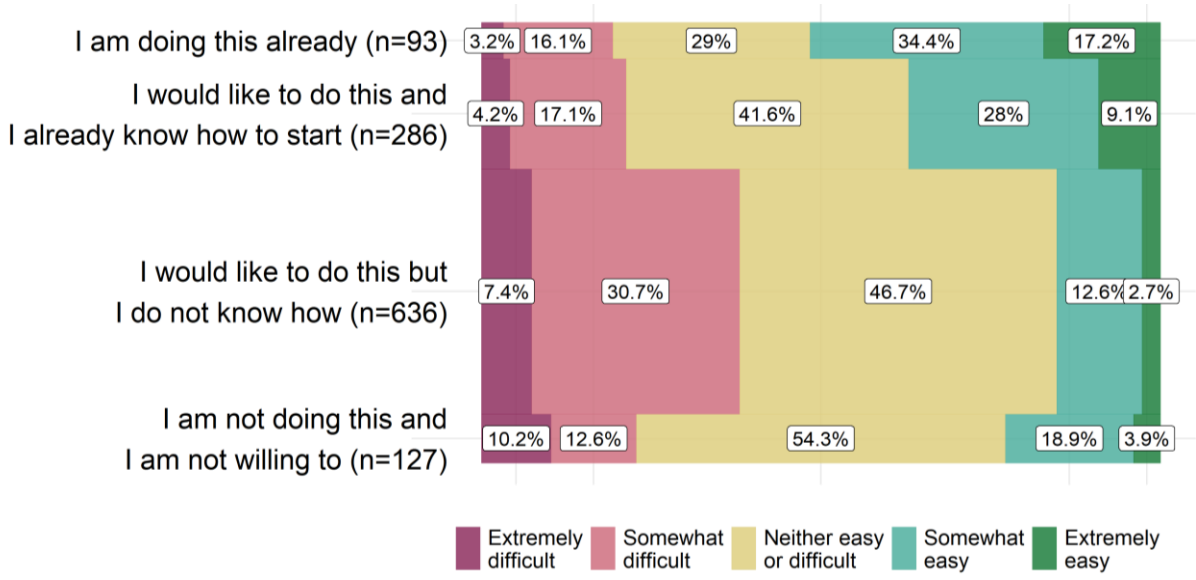

Figure 3.4. The proportion of respondents who stated that it was easy or difficult to find environmentally friendly coffee at their supermarket or grocery store. Responses are separated according to four categories of stated willingness to consume environmentally friendly coffee. Percentage labels show the proportion of responses within the four categories of stated willingness to consume environmentally friendly coffee.

We found that overall, 30% of respondents were not aware at all that coffee production could have a negative impact on biodiversity, and 38% were not aware at all that there were different methods for producing coffee that are associated with less biodiversity loss (Figure 3.5).

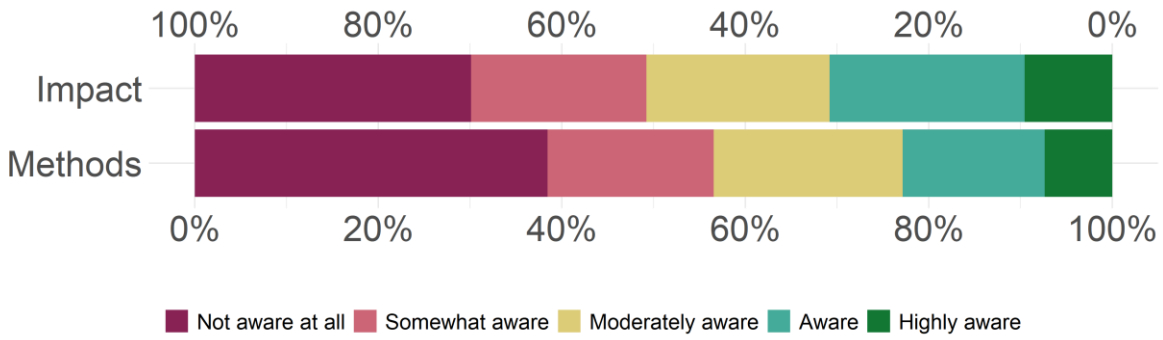

Figure 3.5. Knowledge of the negative impacts that coffee production can have on biodiversity (Impact) and awareness of the fact that there are different methods of coffee production that can cause less loss of biodiversity (Methods), n = 1,142.

3.4.3. Feature selection

The random forest recursive feature elimination algorithm selected twenty-four variables as being best for predicting stated willingness to consume environmentally friendly coffee (Supplementary Material 3.4), at which point accuracy (A) and kappa (K) are 0.62 and 0.28, respectively. However, with two or more variables, A and K reach relatively similar levels, fluctuating between 0.60 – 0.62 for A and 0.23 – 0.28 for K (Supplementary Material 3.4). We checked model performance using the 20% partitioned test data set, for which the A (0.64) and K (0.33) values were similar to the values obtained from the training data set. The RFE ranking of variables showed that whether or not respondents had previously bought environmentally friendly coffee was consistently the highest-ranked, followed by how important respondents said sustainability and ethical certifications were to them, and then the NEP scores (Supplementary Material 3.5). However, the importance of the remaining variables changed rank between RFE iterations. Due to this stochasticity, and since model accuracy and kappa reach relatively similar levels with two or more features, we discuss only the top three ranked variables below. Variable importance rankings for all other variables from an example RFE output are presented in Supplementary Material 3.5.

3.4.4. Previous purchase behaviour predicts future intention

Respondents who stated that they had previously purchased environmentally friendly coffee were more likely to state that they were already consuming environmentally friendly coffee (60.2%, Figure 3.6; Pearson residual = 10.3, Supplementary Material 3.6) or would like to and already knew how to start (26.9%, Figure 3.6; Pearson residual = 4.4, Supplementary Material 3.6). Conversely, respondents who stated that they had not previously purchased environmentally friendly coffee were more likely to state that they were not willing to consume environmentally friendly coffee (72.4%, Figure 3.6; Pearson residual = 4.3, Supplementary Material 3.6). Respondents who stated that they were 'unsure' about whether or not they had previously purchased environmentally friendly coffee were somewhat more likely to state that they would like to consume environmentally friendly coffee, but don't know how (43.7%, Figure 3.6; Pearson residual = 2.8, Supplementary Material 3.6).

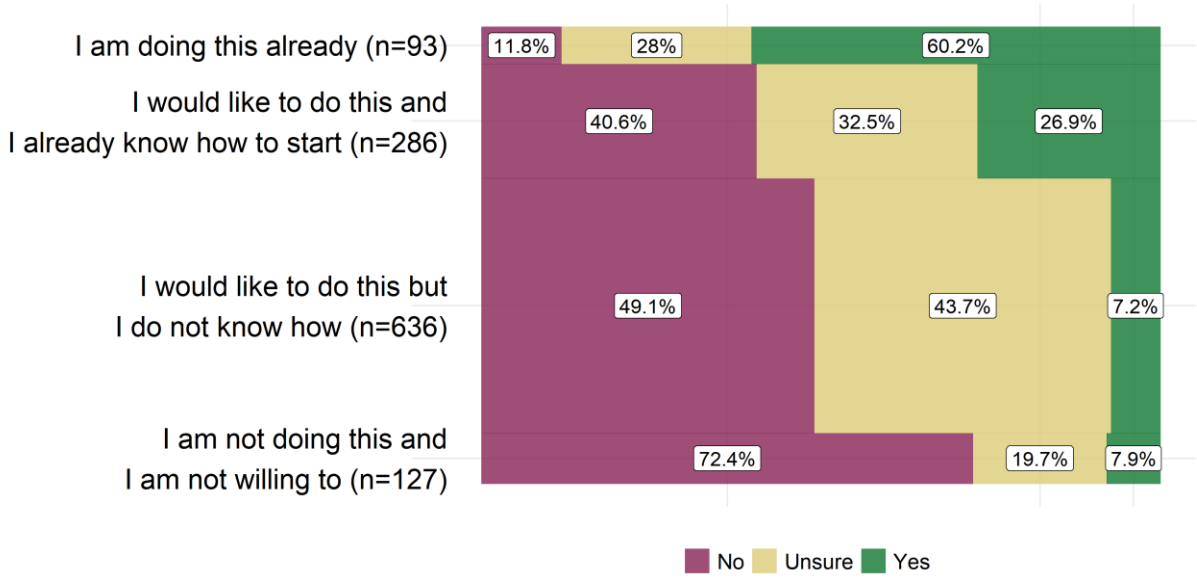

Figure 3.6. The proportion of responses (no, unsure, yes) to question "Have you ever purchased environmentally friendly coffee for home consumption?". Responses are separated according to four categories of stated willingness to consume environmentally friendly coffee. Percentage labels show the proportion of responses within the four categories of stated willingness to consume environmentally friendly coffee. Pearson residuals for deviation in conditional independence between responses shown in Supplementary Material 3.6.

3.4.5. Consumers' values are a strong predictor of future intention

A greater proportion of respondents who stated that they already consume environmentally friendly coffee, compared to those who don't, noted that they 'strongly agree' (52.7%) or 'agree' (29%) that sustainability or ethical certifications of food products were important to them (Figure 3.7, Supplementary Material 3.7). Further, proportionately fewer respondents who were willing to or already consume environmentally friendly coffee 'strongly disagreed' or 'disagreed' with these statements (<12%, Figure 3.7, Supplementary Material 3.7).

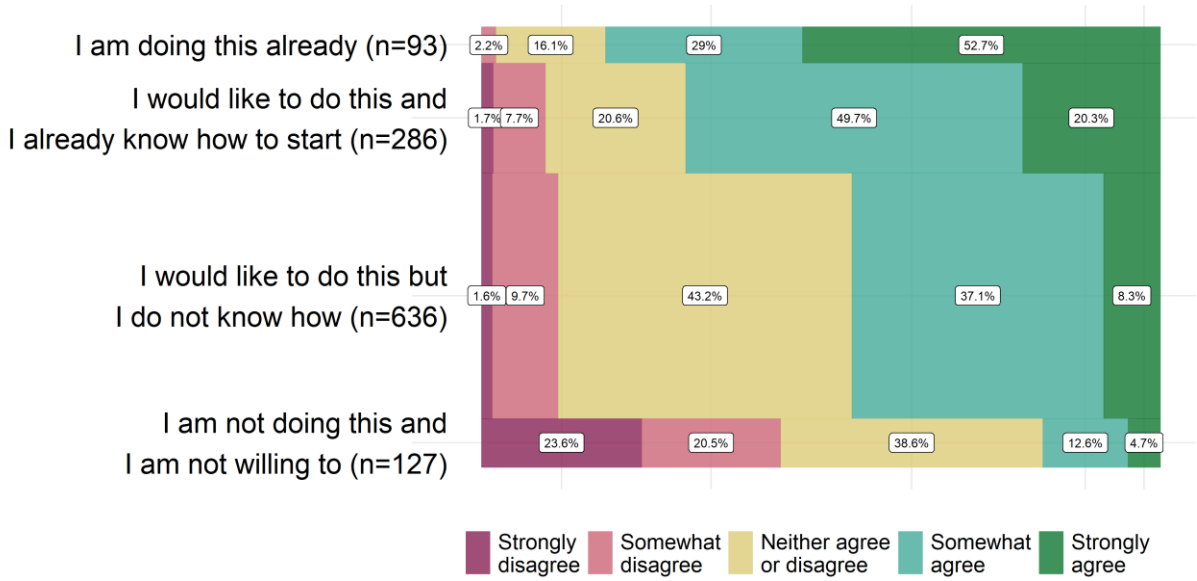

Figure 3.7. The proportion of respondents who agreed or disagreed with the statement "Sustainability / ethical certifications on food products are important to me". Responses are separated according to four categories of stated willingness to consume environmentally friendly coffee. Percentage labels show the proportion of responses within the four categories of stated willingness to consume environmentally friendly coffee. Pearson residuals for deviation in conditional independence between responses shown in Supplementary Material 3.7.

We also found a positive correlation between a higher summed NEP score and stated willingness to consume environmentally friendly coffee (Figure 3.8). Respondents who stated they already consume environmentally friendly coffee were more likely to score higher (>51 / 75) on the NEP psychographic scale compared to respondents who stated they don't and are not willing to consume environmentally friendly coffee (Figure 3.8).

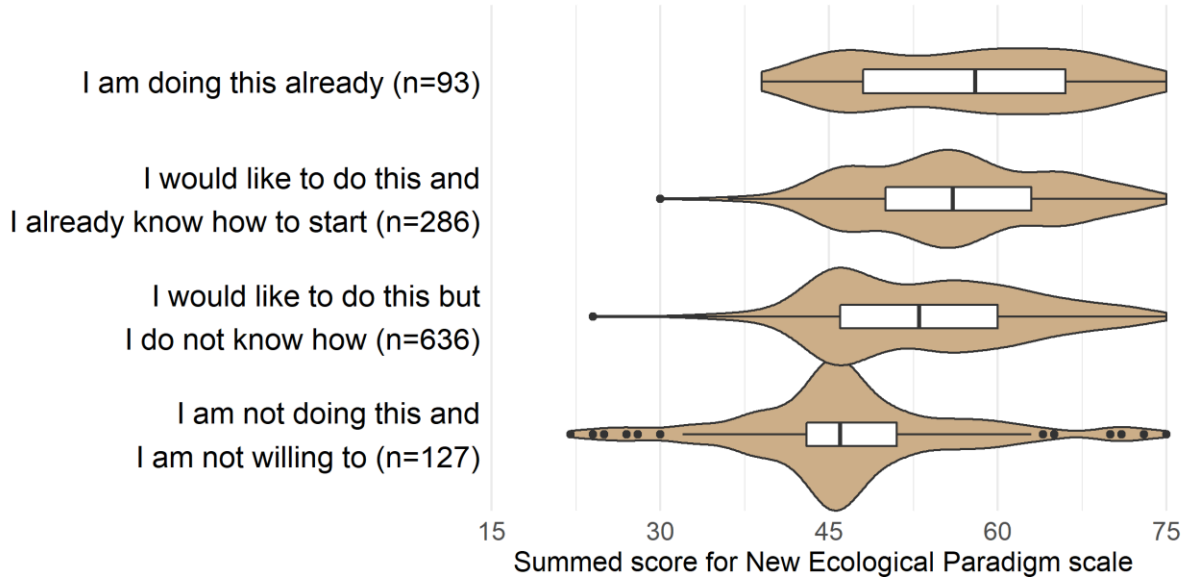

Figure 3.8. Distribution of summed score for the New Ecological Paradigm scale separated according to four categories of stated willingness to consume environmentally friendly coffee. Boxplots show the data quartiles and median summed score, while the shaded areas of the violin plots show the frequency of response scores across this distribution. Together, these plots show a positive correlation between a higher summed NEP score and stated willingness to consume environmentally friendly coffee.

3.5. Discussion

We used an online questionnaire to understand coffee consumption behaviours and consumers' awareness of biodiversity and other sustainability issues. Our findings will inform targeted behaviour change interventions to increase consumer demand for environmentally friendly coffee. This research makes important contributions to better understanding of coffee consumer behaviour, help practitioners design more effective behaviour change campaigns, and provides methodological considerations and guidance that are important for other markets promoting environmentally friendly coffee.

3.5.1. Previous behaviour and environmental values predict intentions

We found that consumers' previous purchasing behaviours and environmental values were strong predictors of willingness to consume environmentally friendly coffee. Specifically, we found that the NEP, and the importance ascribed to sustainability and ethical certifications had a positive relationship with willingness to consume

environmentally friendly coffee. This is consistent with other studies that have found the NEP to have a positive relationship with willingness to pay more for shade-grown coffee (Klimas and Webb 2017). While pro-environmental values and attitudes can predict purchase intentions (Dunlap et al. 2000, Robinson and Smith 2002), they are not necessarily reflective of actual behaviour (Willis et al. 2011, Klimas and Webb 2017). However, understanding the differences in values between groups of consumers will be important for targeting messages and interventions (Sneddon et al. 2020). We found that relatively few respondents had previously bought environmentally friendly coffee, even for those who had stated they were willing to. This may reflect low prior awareness of environmentally friendly coffee, low availability, or difficulties in finding environmentally friendly coffee where consumers normally purchase their coffee. So, while most Melbournian coffee consumers from our sample may be willing and ready for environmentally friendly coffee, interventions are needed to overcome barriers such as low availability and limited knowledge of these issues.

3.5.2. Informing behaviour change campaign design

Our sample highlights a large potential target audience of consumers who are willing to, but do not currently buy environmentally friendly coffee. Both the early majority (25%) and late majority (55%) represent large groups of consumers willing to buy environmentally friendly coffee, and who would serve as important target audiences for a behaviour change campaign, as these groups are more ready for change than laggards (11.2%). Importantly, we found differences in the real or perceived ability of these groups to find environmentally friendly coffee. Consumers who are willing and know how to start buying environmentally friendly were more likely to state it was easy to find and to have previously purchased similar products, and more likely to value sustainability or ethical certifications, compared to those who were willing but did not know how to start. However, our findings show that there are still many people who are completely unaware of the impacts of coffee on biodiversity or that there are different methods of coffee production that have lower impacts on—or even benefit—biodiversity.

The Motivation-Opportunity-Ability (MOA) framework can help explain drivers of consumer behaviour and can serve as an important framework to inform the type of interventions that should be considered to achieve behaviour change for different

market segments (see MacInnis and Jaworski 1989 and, MacInnis et al. 1991 for detailed explanation of this framework). We found that consumers in the early majority have higher motivation and ability to buy environmentally friendly coffee, and so behaviour change campaigns should focus on providing more opportunities to buy. Such campaigns could highlight the features and credentials of new environmentally friendly coffee products to connect with consumers' intrinsic motivation to support accredited products (MacInnis and Jaworski 1989, MacInnis et al. 1991). A similar approach has recently been suggested to promote bird-friendly certified coffee to bird watchers in the USA (Williams et al. 2021). Certified bird-friendly coffee became available in the USA from the late 1990s (Smithsonian Migratory Bird Center 2021), but targeted marketing towards this segment of coffee consumers who value nature and identify as bird watchers could help expand the bird-friendly coffee market more rapidly (Williams et al. 2021).

For our target audience, we found consumers in the late majority were less likely to have previously purchased environmentally friendly coffee and were less likely to state such coffee was easy to find in their supermarket or grocery store. This suggests that most consumers perceive a lack of accessible opportunities to buy environmentally friendly coffee, despite being willing to (i.e., having high motivation). Providing consumers with the understanding of where environmentally friendly coffee is available (opportunity) will help overcome a key barrier that was identified in our research. For both the early and late majority, promotion and place-based interventions could help increase opportunities to buy environmentally friendly coffee where consumers regularly buy it (Lee and Bateman 2021, Williams et al. 2021). Based on our findings, these interventions should aim to make environmentally friendly coffee more prominent and easier to find on supermarket shelves or in cafés as this is where most consumers buy their regular coffee. The use of incentives (e.g., sales promotions), taste testing events (in supermarkets and cafés), and more product options in these locations (sensu Bowie et al. 2020), could help overcome concerns around price, enjoyment, taste, and brand familiarity which consumers identified as normally influencing their coffee purchase decision.

3.5.3. Usefulness of feature selection algorithms

A common problem of high-dimensional data sets like ours is the presence of correlated predictor variables, which impact the ability for a Random Forest analysis to identify the strongest predictor variables, as the estimated importance scores of correlated variables are reciprocally decreased. We chose the Random Forest Recursive Feature Elimination method as it has been shown to be better equipped to deal with discrete multinomial response variables such as ours as well as being able to mitigate the effects of correlated predictor variables, including interactions, in high-dimensional data sets. Alternate tree-based algorithms or multinomial models do not adequately deal with this complexity without prior manipulation of the response and predictor variables that would result in a loss of explanatory power and model predictive accuracy. Whilst questionnaires like ours can be a useful for gaining consumer insights, response rates and quality can decrease with the length, timing, and frequency of surveys (Deutskens et al. 2004, Beebe et al. 2010, Sahlqvist et al. 2011). Paid panel survey companies, like the one we used in this study, can overcome some of these issues but require financial commitments. Feature selection algorithms can help identify the most important questions to ask to predict a given outcome variable, which in turn can shorten the length of surveys (Bulut 2021). Recursive feature elimination is an effective feature selection algorithm (Kuhn and Johnson 2019), and the 'caret' package provides relatively straightforward functionality to implement RFE in R (Kuhn et al. 2020). Our RFE was able to highlight the important variables that helped differentiate coffee consumers and predict their stated willingness with approximately 60% accuracy. Interestingly, several common demographic questions did not come out as important for this sample, including gender, age group, education level, and postcode. With some refinement, the selected important variables could be used to create a much shorter and cost-effective survey tool for follow-up market research or to segment target audiences.

3.5.4. Study limitations and future research agenda

Our project collected a focused sample of responses from a capital city with a dominant coffee-culture. Importantly, we have produced critical insights that can be used to inform further behaviour change interventions. Future studies which capture more diverse views from different geographic regions and demographic segments

(including non-English speakers) may help us to better understand consumers knowledge about and attitudes towards environmentally friendly coffee to inform nuanced interventions. Future studies could also make use of store reward programs or online purchasing data to help align psychographics with demographic variables that can be used to target interventions. This study was the first step in developing a behaviour change campaign to encourage Melbournians to purchase and consume environmentally friendly coffee. The next steps for this campaign will be to design and test possible messages that motivate consumers and address perceived and actual accessibility issues to environmentally friendly coffee. Zoos Victoria are building this campaign to promote wildlife-friendly coffee across the region that will leverage various channels to promote and make environmentally friendly coffee more widely available both in person and online. Future studies will be able to use the consumer insights gathered here as a baseline against which changes in consumer behaviour and knowledge can be measured during and after the campaign, to ensure robust evaluation of the desired impacts and outcomes (Mellish et al. 2019).

3.6. Conclusions

We have shown that the public is ready for environmentally friendly coffee, with 81% of our sample willing to but not currently consuming it. Our results show that despite a strong café culture in Melbourne, three quarters of people buy their coffee from the supermarket or grocery store, compared to approximately one quarter who buy from cafés. We found that although many consumers have the motivation, few respondents stated that it was easy to find this type of coffee at their supermarket or grocery store. Furthermore, over one third of respondents were not aware at all that coffee could have negative impacts on biodiversity. Based on these insights we have provided various campaign suggestions to increase the opportunities and ability for consumers to find, try, and buy environmentally friendly coffee that will be important for other markets promoting environmentally friendly coffee as well. Our study also highlights how the use of psychographics and an understanding of consumer's previous behaviours and values can be used to inform behaviour change interventions. These insights will directly inform a specific behaviour change campaign, led by Zoos Victoria, aiming to mainstream environmentally friendly coffee to support profitable producer livelihoods, sustainable production practices, and the protection of habitat for biodiversity.

Statement of Authorship

Title of Paper	Co-designing behavior change interventions to conserve biodiversity
Publication Status	☑ Published ☐ Accepted for Publication ☐ Submitted for Publication ☐ Unpublished and Unsubmitted work written in manuscript style
Publication Details	Bowie, M. J., T. Dietrich, P. Cassey, and D. Veríssimo. 2020. Co-designing behavior change interventions to conserve biodiversity. Conservation Science and Practice **2**:e278. https://doi.org/10.1111/csp2.278

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Name of Principal Author (Candidate)	Matthew Jared Bowie		
Contribution to the Paper	Conceptualization, Methodology, Formal analysis, Investigation, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization, Project administration, Funding acquisition		
Overall percentage (%)	85%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	8th September 2021

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

I. the candidate's stated contribution to the publication is accurate (as detailed above);

II. permission is granted for the candidate in include the publication in the thesis; and

III. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Timo Dietrich		
Contribution to the Paper	Conceptualization, Methodology, Investigation, Writing - Review & Editing, Supervision		
Signature		Date	8th September 2021
Name of Co-Author	Phillip Cassey		
Contribution to the Paper	Conceptualization, Resources, Writing - Review & Editing, Supervision, Funding acquisition		
Signature		Date	8th September 2021
Name of Co-Author	Diogo Veríssimo		
Contribution to the Paper	Conceptualization, Methodology, Writing - Review & Editing		
Signature		Date	8th September 2021

Acknowledgements

M.B. and P.C. acknowledge the Kaurna people as the original custodians of the Adelaide plains where this research was conducted. We extend our acknowledgement to the traditional owners and custodians of all unceded lands where coffee is now grown. The ideas presented here developed over two years thanks to discussions and support from Phillipa Schliebs, Libby Dowling, and Daniel Gregg (UofA), Bambi Semroc and Lian Pin Koh (Conservation International). Co-design workshops would not have been possible without volunteer facilitators Katherine Hill, Marina Spindel, Celeste Hill, and Swathi Edakkadan and Ecoversity. M.B. acknowledges Steve Delean for statistical support. We thank two anonymous reviewers whose constructive comments helped improve this manuscript. The collection of personal data and conduct of the project was approved by the university human research ethics committee (approval number H-2019-130).

Funding

M.B. received financial support to complete a PhD from the Frederick James Sandoz Scholarship. Ecoversity provided financial and in-kind support to provide food for participants during co-design workshops.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Chapter 4.

Co-designing behaviour change interventions to conserve biodiversity

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4.1. Abstract

Many threats to biodiversity are the result of human actions, which means that changing human behaviour can positively alter the trajectory of our current biodiversity crisis. While there is an increasing number of behaviour change interventions being implemented in biodiversity conservation, their design is rarely informed by the people they try to influence, thereby lowering the probability of success. Building successful interventions requires substantial audience research, but this can be challenging for conservation projects with perennially limited time and resources. Here, we critically discuss co-design as a useful and effective approach for gathering audience insights relatively quickly, allowing conservation practitioners to integrate end-user voices when they would otherwise be excluded from intervention design. Specifically, we present a seven-step co-design process, providing an outline and guidance for how to generate more user-centric intervention ideas and transform them into feasible prototype interventions. Further, we show how we applied this seven-step process with coffee consumers in a sustainable conservation context. This study outlines

contributions that showcase the value of user-centred design approaches to behaviour change interventions for biodiversity conservation.

4.2. Introduction

Most threats to biodiversity are directly or indirectly the result of human actions (Schultz 2011, Wright et al. 2015). This also means that changing human behaviour has the power to positively alter the trajectory of our current biodiversity crisis (Veríssimo 2013, Amel et al. 2017, Weber 2017). Whether through direct conservation action or indirectly through changes in our consumer choices, we can individually and collectively create positive impacts for our natural environment (Amel et al. 2017). Importantly, the collective accumulation of small changes by many people can result in profound impact (Dietz et al. 2009). Despite these intrinsic links, conservation is still relatively new to the behavioural sciences, with increasing calls to better integrate these and other social sciences with conservation practice (Wright et al. 2015, Bennett et al. 2017b, Reddy et al. 2017).

The past few years have seen rising interest, acceptance, and use of behaviour change disciplines such as social marketing, behavioural economics, and behavioural psychology (Daily et al. 2009, Bennett et al. 2017b, Reddy et al. 2017, Selinske et al. 2018, Veríssimo 2019). Despite some environmental applications (e.g., McKenzie-Mohr et al. 2011, Clayton et al. 2013), these disciplines have been predominantly used in social and health practice (French et al. 2010, Truong 2014), with far fewer explicit examples within conservation (for further discussion see: Clayton et al. 2013, Cowling 2014, Reddy et al. 2017, Sterling et al. 2017, Selinske et al. 2018, David et al. 2019). A challenge for applying these disciplines to conservation is that the benefits of changing behaviours to conserving biodiversity are often only realised after several years, at the scale of communities or regions, and often accrue only indirectly to the target audience through complex causal links (Veríssimo et al. 2017). Yet, while there is an increasing number of behaviour change interventions being implemented, their design is rarely informed by the people they try to influence, thereby lowering the probability of success (Aceves-Martins et al. 2016, Kubacki et al. 2017, Greenfield and Veríssimo 2019).

Building successful behaviour change interventions requires substantial audience research. This can present a challenge for many conservation practitioners who may

not be trained in or confident with the appropriate social science methods themselves (Wright et al. 2015, Bennett et al. 2017b, Robinson et al. 2019). Furthermore, the perennially limited resources and short timelines available to many conservation projects make it often impossible to implement fully-fledged consumer research studies (e.g., Veríssimo et al. 2020). To address some of these challenges, we propose co-design as a nimble approach to assist conservation practitioners create user-centred interventions in a short timeframe with limited resources. This approach will be most useful in situations where input from, and active engagement of, the target audience is important for the desired behaviour change to occur.

Here, we aim to: (a) provide critical discussion on co-design, defining the boundaries of when and where this may be more useful to biodiversity conservation; (b) present and expand upon a seven-step co-design process by suggesting how insights generated during co-design can be translated into pilot projects; and (c) show how this process can be applied with end-users in a conservation context.

4.3. An introduction to co-design

Co-design focuses on intervention design, innovating solutions that resonate with the audience you are seeking to serve. This approach empowers the target audience by involving them as contributors rather than mere recipients of behaviour change interventions, thereby facilitating successful implementation (Dietrich et al. 2017). Co-design provides practical in-depth qualitative audience insights into individuals' unique knowledge and needs, more oriented towards the design of solutions than classical social science methods (e.g., questionnaires, interviews, and focus groups; Edvardsson et al. 2013, Trischler and Charles 2019). These classical methods tend to be more descriptive of the target audience, both in demographic and psychographic terms, and in the context around which the target behaviour takes place (Veríssimo et al. 2020). Furthermore, these methods do not allow for co-creation and are often used as the basis upon which experts determine what intervention to implement (Trischler et al. 2019). Co-design focuses on the people who will be directly affected by a behaviour change intervention (Mattelmäki and Sleeswijk Visser 2011). These people may in some contexts be perfectly positioned to suggest possible solutions that are likely to have a high degree of acceptance amongst the wider target audience. Co-design participants should be empowered to contribute and feel that their experiences

and expertise are valued as this will improve their contributions to the generation of new ideas during the co-design session (Mattelmäki 2008, Sanders and Stappers 2008, Trischler et al. 2019). However, many of the people conservation practitioners work with may feel a sense of powerlessness or reduced motivation to contribute to co-design activities. This could be due to the complexity of environmental issues, an increasing disconnect between people and nature, as well as other historical or cultural reasons (Nisbet et al. 2009, Ives et al. 2017, Whitburn et al. 2020). These types of audiences are discussed in marketing and consumer behaviour literature as 'vulnerable consumers' or 'everyday citizens', which importantly is not an enduring classification of individuals, but context specific consideration that demands thoughtfulness (Baker et al. 2005). Research in healthcare service development indeed shows that not all individuals have equal capacity to contribute towards the co-design process due to varying motives for participating and prior experiences (Donetto et al. 2015, Engström and Elg 2015). It is therefore important to accommodate the unique characteristics of each target audience. Co-design can be approached with varying degrees of time invested across a number of steps with multiple strategies to engage different stakeholders (Mattelmäki and Sleeswijk Visser 2011, Donetto et al. 2015). This flexibility alongside the direct focus on potential solutions means co-design can quickly gather audience insights with limited resources.

4.4. Considerations for intervention co-design in conservation

Many behaviour change problems require proactive audience engagement and sustained uptake to be successful. Large-scale and long-term consumer research studies can provide the necessary insights, data, and engagement in these situations, yet are often not possible for conservation projects (e.g., Veríssimo et al. 2020). With this in mind, we provide guidance for how conservation practitioners apply co-design to address the challenges of conserving biodiversity. First, the project team needs to be clear about what the desired change in human behaviour is and how this will generate mutually beneficial exchanges that both biodiversity and the people enacting change positively respond to. Second, carefully consider the usefulness of user-generated ideas and insights to designing interventions. In some cases, the initial target audience may identify barriers to change that are beyond their, and the project team's control (e.g., laws, deeply entrenched cultural or religious beliefs, technological deficiencies). However, this may simply mean that the insights from co-design can be

used alongside other types of behaviour change such as law reform and technical interventions (Rothschild 1999, Veríssimo et al. 2019). Finally, it is important to recognise that co-design is used to empower the target audience as contributors to intervention design, rather than mere recipients, but outputs from co-design can be used alongside expert advice to inform intervention design.

Co-design approaches can be criticised as being too user centric, ignoring important other stakeholder contributions (Dietrich et al. 2016, Dietrich et al. 2017, Durl et al. 2017). There are limitations to what can be expected from co-design participants in terms of generating ideas for intervention solutions and these limitations have not been sufficiently discussed in co-design literature. Co-design may not be able to identify target behaviours that need to be changed and could prove challenging to implement with sensitive or illicit behaviours or those that hinge on non-conscious cues and low cognitive load decisions. Furthermore, just because users like an activity or idea doesn't mean that it is effective in producing the desired behaviour change, and vice versa. Ultimately, project teams may need to find a balance between user insights and expert judgement (e.g., evidence base, expert panels) to create behaviour change interventions that resonate with the target audience and have a high likelihood of being effective.

Previous co-design processes have not outlined how to take co-design ideas and transform them into feasible pilot projects. This paper contributes to an important gap in the literature, outlining how this can be achieved by drawing from design thinking processes (Brown 2009, Martin and Martin 2009, Tschimmel 2012) to convert intervention ideas generated though co-design one step further and define testable intervention prototypes. Table 4.1 provides an overview of a seven-step co-design process, developed with everyday citizens in mind (Dietrich et al. 2017, Trischler et al. 2019), with considerations for practitioners wanting to address the challenges of conserving biodiversity. This builds on a previous overview of the original six-step framework (Dietrich et al. 2017) completed for a transformative service research context (Hurley et al. 2018).

Table 4.1. Overview of seven-step co-design framework with considerations for biodiversity conservation

Co-design step	Description	Considerations
Steps 1-3 occur prior to the running of co-design workshops		
1. Resourcing	Identify relevant input for co-design workshops to be sourced by project team. Consider ethical implications of desired behaviour change on target audience and for those involved in co-design process. Obtain approval(s) by relevant ethical/community board/elders	Development of in-depth understanding of the issues related to the underlying topic Identification of specific themes or activities from existing behaviour change interventions to inform the development of co-design tools or activities to be used during workshops
2. Planning	Collaborate with key stakeholders. Plan next five steps, including scenarios of unexpected events that may arise during facilitation of workshops (e.g., power-dynamics, social anxiety) Note: planning and recruiting steps can be an iterative process to ensure the needs and interests of multiple stakeholders are appropriately managed to gain support for running the actual co-design activity as well as to address unexpected set-backs in recruitment of participants	Regular meetings with project team to plan recruiting, sensitising and facilitating steps Define desired outcome from co-design workshops, what/how data will be collected, managed, analysed and reported (e.g., de-identified comments, summary statistics), including reports back to the participants/target audience Network the co-design workshops and underlying topic to create awareness among relevant stakeholders and the target audience

3. **Recruiting**	Identify target group(s) who are potentially willing to, and capable of contributing new ideas that are appealing to the broader target audience	Tap strong networks between target audience and relevant stakeholders, plus project team and relevant stakeholders to identify and recruit participants
	Consider the type and tone of media, medium(s) and message(s) for recruitment to ensure appropriate for the identified target audience	Incentivise target audience (where appropriate) by making them aware of the contribution they can make through participation but carefully consider bias
	This can be an iterative process. In cases where initial recruitment strategy does not produce sufficient or appropriate participants, go back to planning an improved recruitment strategy, trying alternate media channels, medium(s) or message(s)	When appropriate, have participants publicly or privately commit (RSVP) to attending your workshop and send multiple friendly reminders. It is likely more people will sign-up than will actually show up. Expect <50% of sign-ups to show up, but be prepared for higher turnout as you won't want to turn away participants
Step 4 can occur prior to and/or during workshops while step 5 always occurs during the co-design workshop		
4. **Sensitising**	Familiarise participants with the underlying topic by allowing them to experience and test existing activities and solutions prior to co-design workshops when possible. For instances where this is not possible, use some combination of images, video, sound or short written descriptions (<50 words) of existing activities and solutions. People understand in a variety of ways so it is important to use a mix of stimuli	Integrate sensitising techniques into the co-design workshops in cases where target audience are time-poor or not accessible prior to workshops Allow participants to ‘break free’ from their everyday life to help them become aware of the specific roles they play, the changes they can make, and positive impacts they can have. Lead and show potential change but do not tell, realisation needs to be honest
5.	Welcome participants as culturally appropriate. Provide easy access to water, food, toilets or other	Use tools to reduce the dominance of the facilitator, but at the same time, avoid off-topic discussions. Finding the fine

Facilitating	facilities without the need for participants to ask facilitators for access (balancing power dynamics) Use ‘ice-breaker’ or warm-up activities and design tools to assist in developing trust, empowering participants to contribute and foster creativity and collaboration among team members. Use a range of individual and group activities (three individuals per group as a minimum when possible) Provide comfortable spaces (e.g., clean floor space or chairs and tables), design tools (butcher paper, markers, stickers, etc.) and encourage multiple modes for participants to input (e.g., writing, speaking, drawing, or designing with hands) Collect psychographic and demographic information from all participants prior to or during workshop	line between close guidance (to ensure progress and outcomes that align with the set targets) and giving voice to the users (to empower users to contribute their unique knowledge and skills) Conclude the session with a short (one minute) idea presentation from each group to ensure the content and purpose of the generated ideas are fully understood, to recognise everyone’s individual contribution, and develop a sense of accomplishment Psychographic tools (e.g., Nature Relatedness Scale) provide more insightful information on participants than or in addition to traditional demographic measures (e.g., gender, age, education, income). These insights can be used to segment teams during the actual workshop.
Steps 6 and 7 are iterative, occur after workshops are completed but can involve external input post-workshop		
6. **Reflecting**	Develop clear recommendations for behaviour change intervention design, carefully gauging feasibility of co-design ideas for your specific situation, project team capacity, target audience preferences and resource availability (resources can include relevant skill sets, time, finances, influence or networks) Define mutually beneficial value exchange propositions for change to be sustainable	Analysing gathered data with specific focus on (latent) target audience needs, experiences, and specific intervention preferences. Qualitative data provide rich insights alongside quantitative data Co-design participant insights set a starting point for new value exchange propositions that more effectively support your target audience in finding value to voluntarily change their behaviour(s)

7. **Building for Change**	Design informed behaviour change intervention prototypes based on ideation from co-design that has been critically thought through with, when possible, input from expert designers or those with experience in running behaviour change interventions Ensure behaviour change intervention is embedded with a critical and measurable evaluation process to allow the project team to track if and how change is/is not occurring, and respond if necessary This is an iterative process with reflecting on ideas from co-design participants, feasibility analyses from project team and potential secondary input from expert designers or the target audience	Co-design allows the project team to gather insights from their target audience and then use these insights, ideas, and feedback to inform the design of interventions that are more likely to effect change Design thinking processes can take the co-design ideation one step further to help define testable intervention prototypes. These prototypes then need to be tested and refined before launching a full-scale social marketing behaviour change intervention Evaluation is a critical part of all behaviour change interventions to allow the project team to understand how and why change may or may not be occurring before, during and after launching interventions

4.5. Co-design in action

Here, we present an application of the seven-step co-design process to sustainable coffee demand. Coffee agriculture can either decimate or support local biodiversity through different land-use-change and production practices (Buechley et al. 2015, Tscharntke et al. 2015, DeFries et al. 2017). The coffee industry will need to change to address the challenges of climate change, pests, and disease threatening production areas (Ovalle-Rivera et al. 2015), all while global coffee demand is predicted to more than double by 2050 (Panhuysen and Pierrot 2018, Conservation International 2021). Co-design could be successfully applied to both supply and demand side behaviour change interventions to help address these challenges. Here, we begin to explore the demand-side, as coffee is a buyer-driven globalised commodity, so changes in consumer preferences can result in shifting demands on how coffee in produced. For expanded background and rationale see Supplementary Material 4.1. Background and rationale for using co-design with coffee consumers to address biodiversity conservation. Promisingly, younger consumers increasingly appreciate information about the sustainability and ethical sourcing of their coffee (Panhuysen and Pierrot 2018). So, to better understand how co-design can work, we applied the seven-step process (Trischler et al. 2019) to generate consumer-driven ideas for interventions to change coffee consumer behaviour within a large metropolitan university in Australia. We chose this university-cohort due to the majority of coffee consumers being younger professionals. This allowed us to trial the co-design process with and audience that we anticipated to be more open towards sustainability-based behaviour change. The application of the seven steps are described below:

4.5.1. Resourcing

Resourcing for co-design workshops involved sourcing a variety of relevant intervention activities to develop activity booklets (see Supplementary Material 4.2. Co-design end-user activity booklet), used in place of activity cards as described in (Dietrich et al. 2017). Twelve intervention activities were chosen based on discussions with university coffee suppliers and other stakeholders on what had previously been attempted as well as from literature on sustainable consumerism (e.g., Sodhi 2011, Campbell-Arvai et al. 2014, Bolderdijk and Steg 2015, Dangelico and Vocalelli 2017).

While the majority of these interventions have been informed by expert-judgement, they may not be what end-users want, warranting more user-oriented focus to intervention design.

4.5.2. Planning

Planning for co-design and behaviour change with coffee consumers included discussions and relationship development with university stakeholders and representatives from coffee suppliers. This step included preparation of activity booklets, recruitment materials, room bookings, and application for ethical approval to conduct human research. Two ninety-minute co-design workshops were planned at a centrally located private room on the university campus for participant convenience. One workshop was planned during a regular lunchbreak and one immediately after standard work-hours to capture participants with varying availability.

4.5.3. Recruiting

All participants needed to be over eighteen years old, the age at which a child becomes an adult under general Australian law and were recruited from within the university population over a two-week period prior to the planned workshop. For each workshop, a separate, private, and free online registration page was created through Eventbrite (eventbrite.com.au). This registration page hosted workshop-specific information and links to relevant consent forms and participant information sheets. To simplify access to these registration pages, a shortened URL and QR-code were generated using freely available online services (bitly.com and qr-code-generator.com). In an attempt to avoid self-selection bias towards environmentally concerned consumers, the recruitment materials did not mention any terms related to environment or sustainability.

Recruitment materials consisted of A4-sized colour printed flyers, social media posts, and email announcements (see Supplementary Material 4.3. Example recruitment poster). Over the two-week recruitment period, 400 flyers were strategically placed near major lecture theatres, on notice boards, near coffee retailers, and on the inside of toilet-cubicle doors. A short social media post, including hyperlinks to recruitment pages, was shared by several university-based social media accounts on Instagram, Twitter, and Facebook, including both standard posts but also through Instagram and

Facebook *stories*. A similar fifty-word recruitment email, including hyperlinks to recruitment pages, was included in the weekly student and staff news emails sent to all university student and staff accounts. Finally, for every registration, a confirmation email was sent to the participant thanking them for registering to attend but also asking if they could invite a friend or colleague. A total of 78 registrations were recorded for two workshops, with a total of 53 participants attending workshops (68% attendance rate).

4.5.4. Sensitising and Facilitating

Sensitising—i.e., familiarising participants with underlying topic and potential solutions—was incorporated alongside facilitating into co-design workshops due to time limitations of participants who would need to take time out of their work/study schedule. All 53 co-design participants provided their informed consent to participate at the start of their workshop. To understand the profile of green-consumers, psychographics have been suggested to be more important than demographics (Larson and Farac 2019). Thus, in the first ten minutes of each workshop participants completed a psychographic and demographic questionnaire including the 21-point psychographic Nature Relatedness (NR) Scale (Nisbet et al. 2009) plus six demographic questions (age, gender, education, nationality, postcode, role at university). We chose the Nature Relatedness Scale as a psychographic with good links to sustainable product preference (Nisbet et al. 2009, Zelenski et al. 2015), but there are other psychographics that could also be used (or The Inclusion of Nature with Self (INS); Schultz 2002, e.g., The Connectedness to Nature Scale (CNS); Mayer and Frantz 2004, for further review see Tam 2013). Participants were provided a brief two-minute verbal overview of the research project before each individual was provided with an activity booklet containing twelve intervention activities (see Supplementary Material 4.2. Co-design end-user activity booklet). Participants were given 20-30 minutes to review all intervention activities and asked to comment on what they liked or disliked about them. The final page of the activity booklet asked participants to list their top and bottom three intervention activities, including why they liked or disliked them the most, with the final option to list a mix of intervention activities they would prefer to receive. During this time facilitators collected and scored NR psychographics. The mean overall NR-score for each participant was used to make groups of between three-seven individuals based on high (>3.6), neutral (3.4-3.6), or

low (<3.6) mean NR-scores. Once all participants had completed their individual activity booklets, they were asked to form into these groups. For this group activity, participants were asked to create their ultimate intervention to help sustain coffee through the university. Groups were given 20-30 minutes to create their interventions on blank sheets of Kraft paper (805 x 565 mm), with marker pens, ballpoint pens, coloured pencils, post-it notes, highlighters and use of words and drawings. At the end of this time, each group was asked to present sixty-second verbal summaries of their intervention to the entire room, which were filmed.

4.5.5. Reflecting

4.5.5.1. Psychographics and demographics

A total of 53 end-user participants commenced across two co-design workshops, however eight participants were excluded from these analyses due to incomplete responses. The remaining 45 participants were aged from 18 to 56 (mean = 25.8 years), 60% female, predominantly university students (48.9% undergraduate, 46.7% postgraduate), identifying themselves from 17 different nationalities, with representation across all five faculties of the university. Overall, participants scored moderately high on the Nature Relatedness Scale (mean = 3.94), with mean NR-perspective and NR-self greater than four out of five, while NR-experience shows a greater spread of scores (Figure 4.1; see Nisbet et al., 2009 for full explanations of these three NR descriptive labels). During workshops, facilitators used the mean overall NR-score to form groups of participants with similar mean scores. However, a limitation of this method is that participants could reach an equivalent mean overall NR-score with very different responses to individual questions (see Supplementary Material 4.4. Distribution of co-design end-user responses to Nature Relatedness Scale questions).

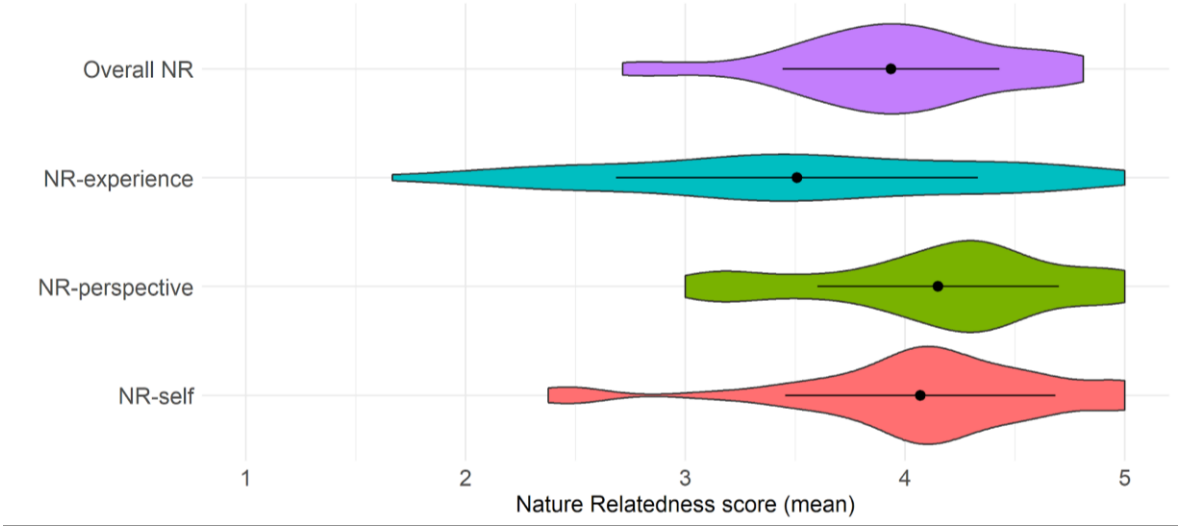


Figure 4.1. Distribution of average Nature Relatedness Scale (NR) scores, with mean and standard deviation shown respectively by the point and line within violin plots.

4.5.5.2. Individual preferences of existing intervention activities

Rankings of the twelve intervention activities showed clear preferences with four overarching categories emerging, namely and in order of preference: 1) rewards, 2) choice architecture, 3) education, and 4) norms.

Below, we expand upon these broad categories:

1) Rewards

Reward-based interventions, including *incentives* and *taste testing events*, were ranked most highly with over half of participants choosing these in their top preference (Figure 4.2). Participants indicated that rewards and positive experiences are likely to shift their purchasing choices more quickly. Illustrated by participant comments:

Incentives:

> ***EU49*** *"Who doesn't like getting their coffee cheaper? It is guaranteed that students will go for this, we love saving money, especially when it comes to coffee",*
>
> ***EU01*** *"Great idea, people like positive reinforcement via rewards"*

Taste testing events:

> ***EU09*** *"Allows people to taste coffee they wouldn't always try and learn about flavour differences. Demystifies 'sustainable' coffee",*

EU02 *"YES! One of the best ways. Would work like a trial run before properly switching to a sustainable brand, hands on experience"*

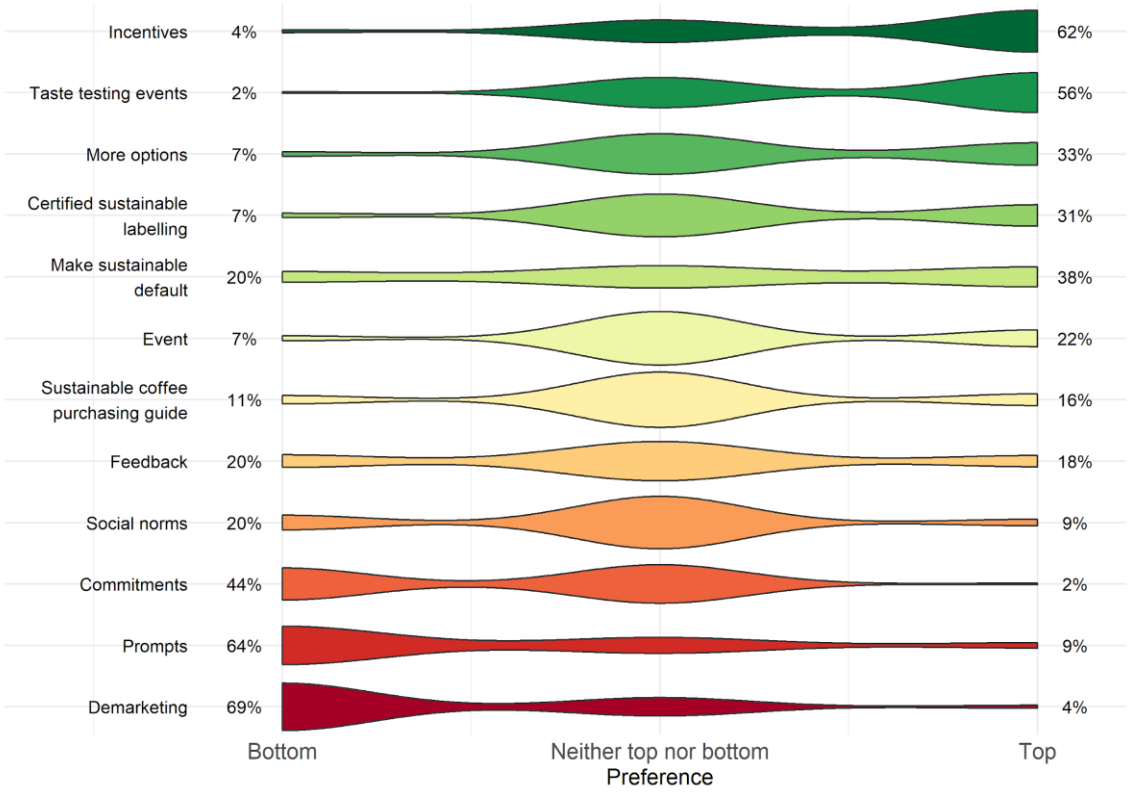


Figure 4.2. Distribution of intervention activity preferences based on the number of times each was listed within an individual's top or bottom three interventions (n = 45). Intervention activities are ranked by their mean preference, with deeper greens representing a greater proportion of top preferences while darker reds represent a greater proportion of bottom preferences, more neutral yellow colours represent no distinct preference.

2) Choice architecture

Interventions relating to choice architecture—i.e., the design and impact of how choices are presented to consumers—were the top preference for approximately a third of participants, namely *more options* and *make sustainable default*, although the latter was also placed in the bottom preference for a fifth of participants (Figure 4.2). Comments highlighted the need to retain some freedom of choice, but that too much choice was confusing. These comments also highlighted the belief that default sustainable options are likely to result in significant positive change so long as this does not remove all ability to choose from a range of options:

More options:

> ***EU19*** *"More options = more availability and a large market to choose from, gives one the freedom to experiment [but] confusing about too much to choose from.",*
>
> ***EU13*** *"More options is a really good idea but it also depends on what options they & how would they taste"*

Make sustainable default:

> ***EU51*** *"This helps the cause of sustainability significantly since everyone, irrespective of their level of awareness, is consuming sustainable coffee",*
>
> ***EU26*** *"Doesn't involve thinking, 100% participation rate! Done. Easy. Do this. Love not having to think!",*
>
> ***EU20*** *"May not be people's preference. People don't want to be told what to do"*

3) Education

Education focused interventions, including *certified sustainable labelling*, *sustainable coffee purchasing guide*, and an *event*, showed some support from participants but with no strong preferences. Participants highlighted that these education focused interventions could be paired with rewards or choice architecture focused interventions to increase their likelihood of bringing about informed changes in purchasing behaviour.

Certified sustainable labelling:

> ***EU22*** *"you know your coffee is definitely sustainable, simplifies making choices",*
>
> ***EU21*** *"Clear, simple, allows consumers to make informed choices"*
>
> *Sustainable coffee purchasing guide:*
>
> ***EU43*** *"Not likely to read, waste of paper",*
>
> ***EU17*** *"Knowing how to buy sustainably could help"*

Event:

> ***EU15*** *"Interest will be developed through events",*
>
> ***EU40*** *"Along with taste testing event, this will spread the word. Peer to peer education"*

4) Norms

Norm-based interventions, including *demarketing*, *prompts*, *commitments*, *social norms*, and *feedback*, were ranked lowest, with approximately two-thirds of participants placing *demarketing* and *prompts* in their bottom preference (Figure 4.2). Participants highlighted that negative demarketing messaging or 'annoying' reminders are unlikely to shift their coffee choices in the long-term. It also appears that some participants interpreted demarketing—i.e., any attempt to discourage consumers from buying a certain product—as an intervention that would restrict their choice. This is reflected in participant comments:

Demarketing:

> ***EU42*** *"I don't like that, because it has negative association on me. Why someone can restrict to buy? It is your personal decision. I think it is better highlight benefits of sustainable coffee.",*
>
> ***EU16*** *"I think focusing on the positives of sustainability is a better method"*

Prompts:

> ***EU04*** *"because people don't like spam and may ignore/block such messages",*
>
> ***EU12*** *"Last thing I would want is more messages on my phone"*

Furthermore, norm-based approaches were seen as unrealistic in this scenario, although positive messages could be useful in conjunction with more desirable intervention activities:

Feedback:

> ***EU35*** *"Positive optimism would really help people to come up with better ideas",*
>
> ***EU03*** *"Might be difficult to implement, especially if you use multiple cafes"*

Social norms:

> ***EU44*** *"It can encourage friends, colleagues, to increase the awareness of environment protection",*
>
> ***EU30*** *"Peer pressure is generally hard way to force people"*

Commitments:

> ***EU36*** *"Pledging for a small day to day commodity is not realistic",*
>
> ***EU08*** *"Pledges and resolutions never work"*

4.5.5.3. Group intervention design

Similarly to initial individual preferences, group interventions relied heavily on rewards, with some use of choice architecture and education focused interventions, but far fewer uses of norms (Table 4.2). Most groups used incentives and taste testing events in conjunction with education and marketing interventions around making informed choices, with multiple groups also highlighting the use of social norms in the form of celebratory endorsement. Although multiple intervention activities were initially included in the group ideation stages, all groups presented only a subset of those activities in their final pitch. There were no clear differences in terms of intervention preferences among groups consisting of participants that scored higher or lower on the Nature Relatedness Scale. Although it was noted that lower NR groups were less engaged and collaborated and communicated less with each other compared to higher NR groups. All groups presented and noted novel ideas, which primarily focused around: (i) raising awareness or education about sustainable coffee; (ii) using celebrities to create social norms; as well as (iii) other ideas around taxing, storytelling, providing experiences through exchange programs/tours or producing new products with sustainably grown coffee beans.

Table 4.3. Use of suggested intervention activities by groups within their ultimate intervention

x = Intervention activity used by groups during the creation of their ultimate intervention

Category (percent (%) of groups using category)	Intervention activity	Percent (%) of groups using intervention activity	De-identified group code (Gp #) and Nature Relatedness allocation									
			Gp 1 High	Gp 2 High	Gp 3 High	Gp 4 High	Gp 5 High	Gp 6 High	Gp 7 High	Gp 8 Neutral	Gp 9 Low	Gp 10 Low
Rewards	Incentives	90	x	x	x	x		x	x	x	x	x
(85%)	Taste testing events	80	x	x		x	x	x	x	x		x
Choice architecture	Make sustainable default	50			x	x	x		x	x		
(55%)	More options	60	x	x	x		x	x			x	
Education (43.3%)	Certified sustainable labelling	50	x		x	x		x			x	
	Event	60	x	x		x			x	x		x
	Sustainable coffee purchasing guide	20		x				x				
Norms	Feedback	20				x					x	
(16%)	Social norms	50		x		x	x	x				x
	Commitments	10		x								
	Prompts	0										
	Demarketing	0										

4.5.6. Building for change

A major gap in the Trischler et al. (2019) framework is that the final step does not provide specific or clear advice for how one should go about translating user-generated ideas and insights into actual behaviour change interventions. We decided to draw from the design thinking literature (see Brown 2009, Martin and Martin 2009, Tschimmel 2012) to convert the co-design intervention ideas one step further and define testable intervention prototypes. Drawing from the insights and ideation of end-users discussed and reflected on above, we developed two prototype interventions. Conceptualising testable prototypes is the final stage of this co-design process. Evaluation and reflection on the efficacy of these interventions will form the basis of a future follow-up study. The prototypes and their rational are outlined below:

4.5.6.1. Incentives + more options

This first prototype intervention aims to test how financial incentives influence end-user consumer choice by providing an additional sustainable option. This prototype intervention was chosen as it combines two of the most highly preferred intervention activities from the top two categories defined earlier, rewards and choice architecture (Figure 4.2, Table 4.2). More specifically, an additional sustainable coffee option will be provided in a café-setting alongside the standard coffee option, but at different prices (Figure 4.3). Before, during and after each intervention the number of coffee sales will be used to evaluate intervention success, alongside consumer surveys to gather qualitative measures for why they make their coffee choices. This experimental design is a feasible option for the project team with the available resources and stakeholder relationships developed through co-design as well as already existing sustainable coffee on the market.

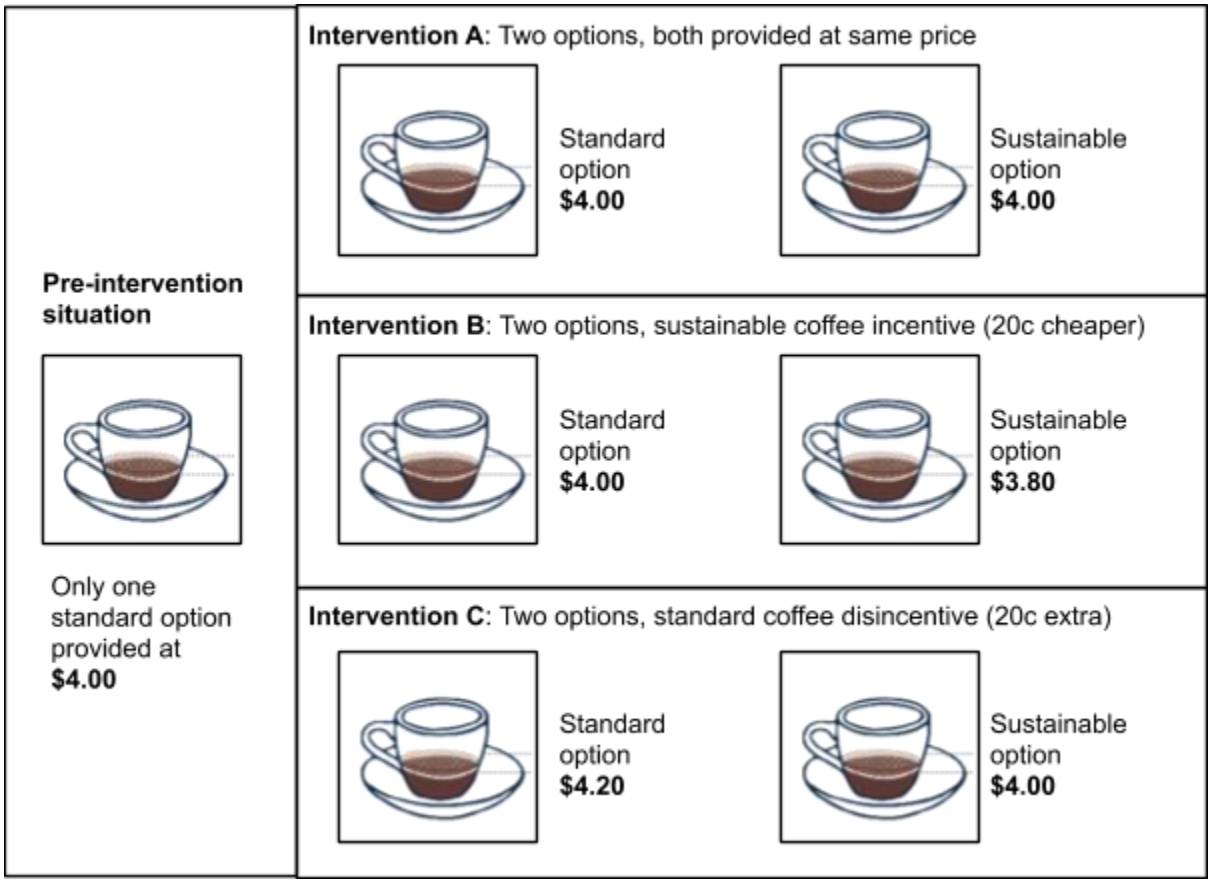


Figure 4.3. Prototype experimental design for an intervention using rewards (financial incentives) and choice architecture (more options) to test how end-user coffee consumer choice can be nudged towards sustainable options.

4.5.6.2. Default sustainable + taste testing

This second prototype intervention aims to test how default sustainable options can be implemented while engaging end-user consumers through coffee taste testing events (Figure 4.4). Again, this prototype incorporates both choice architecture and rewards with default sustainable option and taste testing events being highly preferred intervention activities (Figure 4.2, Table 4.2). Similarly to the previous prototype, sales and surveys will be used to evaluate intervention success. This experimental design is again a feasible option for the project team to implement in the university setting where there are multiple cafés and coffee vending machines on campus that could be used to test this intervention in a natural setting.

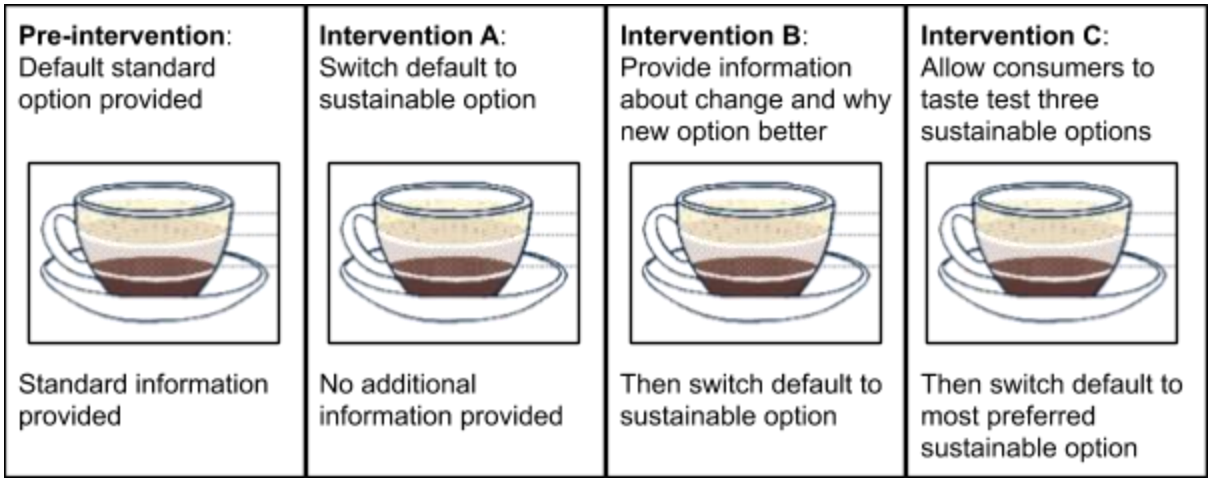


Figure 4.4. Prototype experimental design for an intervention using rewards (taste testing events) and choice architecture (default sustainable) to test how end-user coffee consumer choice can be nudged towards sustainable options. Intervention B (provide information but no taste testing) is included to evaluate the impact of prior information before change occurs, which will happen with taste testing prior to change as is intervention C.

4.5.7. Limitations and future work for this co-design application

We have shown how the seven-step co-design process has been used to generate prototype interventions from consumer-driven ideas. These two prototype interventions will be tested as part of a future study to evaluate the success of this co-design activity. However, we acknowledge that co-designing with only coffee consumers is not enough to create comprehensive interventions. Future applications of co-design should also work in consultation with wider stakeholder groups to better understand where the most impact can be made in a complex problem like sustainable coffee consumption. In our case, the project team attempted to co-design with coffee suppliers and purchasing staff but were unable to successfully bring these people together into face-to-face co-design sessions due to inaccessibility and time constraints of potential participants during recruiting. Future co-design work could overcome this by working in conjunction with traditional market research methods or by using technologies such as videoconferencing to bring together various stakeholders in a virtual co-design setting (Archibald et al. 2019), but this will no doubt bring new challenges.

4.6. The future for co-design in conservation

There is still much work that needs to be done to better understand when, where, and how co-design can be best used to help conserve biodiversity. For some conservation issues, the human behaviours that need to change will be largely driven by non-conscious, low-cognitive-load (System 1) decision making, and so may not be particularly open to introspection by co-design participants. Resultantly, co-design may be less useful at producing effective conservation interventions for these smaller, everyday decision-based behaviours. Co-design processes are also likely to struggle with illicit behaviours, so may not apply well to conservation issues driven by illegal behaviours—such as illegal wildlife trade. Conversely, there will be conservation issues largely driven by conscious, high-cognitive-load (System 2) decision making. For these issues, co-design participants could prove to be effective for generating insightful and successful conservation interventions—such as which coffee a roaster or trader buys, or how the farmer grows coffee on their farm. However, more research and real-world applications are needed to properly understand the finalities of applying co-design to conservation.

4.7. Conclusion

Changing human behaviour is complex and building successful interventions requires substantial audience research. For many conservation projects, restrictive timelines and budgets prohibit fully fledged consumer research studies. Co-design is a useful and effective approach for gathering audience insights relatively quickly, allowing end-user voices to be heard when they would otherwise be fully excluded due to perceived lack of time or resources. Specifically, the seven-step co-design process we showcase in this paper provides an outline and guidance for how to generate user-centric intervention ideas and transform them into feasible prototype interventions. Although co-design will not be applicable for every conservation program, we hope this work stimulates conservation practitioners to engage with their target audiences and include their voices in behaviour change interventions.

Chapter 5.

General discussion

Reversing biodiversity loss is one of the most significant challenges for our global community. Coffee is grown in a variety of ways in some of the world's most biodiverse areas, and its production has direct impacts on regional ecosystems (Philpott et al. 2008, Tscharntke et al. 2015). With increasing global demand and changing climatic conditions, coffee production areas will need to expand, intensify, or shift (Jha et al. 2014, Killeen and Harper 2016). Consumer demands and external market forces can influence producers' decisions about which coffee systems they adopt, and in turn, impact biodiversity. Behaviour change interventions can help shift consumer demands and guide sustainable transitions for producers. However, interventions should be evidence-based and guided by research to ensure their effectiveness.

Through my thesis I sought to understand how to change consumer behaviour to indirectly benefit biodiversity in the areas where coffee is grown. Over the previous three chapters I explored how this change could be achieved through: (i) engaging with upstream actors to improve sustainability policies; (ii) understanding downstream consumer knowledge, current behaviour, and motivations; and (iii) co-designing prototype interventions with the consumers who we seek to change. Individually, this work provides contributions to the specific case of consumer behaviour change for sustainable coffee. Collectively, my research contributes to advancing conservation behaviour change, emphasising reproducible methods for designing interventions to better serve biodiversity and the people who depend on it.

5.1. Key contributions and significance

In chapter two I provided an assessment of the policies behind coffee sustainability standards and discussed the need to engage with key upstream actors in industry, government, and not-for-profits to enact change at landscape and regional scales. This work adds to the limited practical applications of upstream social marketing for environmental issues (Kennedy et al. 2018, Mehmet and Simmons 2019, Mehmet et al. 2021), helping to improve social marketing theory and practice to achieve change

beyond the downstream level (Gordon 2013, Akbar et al. 2021). One of the key contributions from this research was showing one way in which social marketers can practically engage with upstream decision makers at the industry, government, and not-for-profit sector level to serve people and planet. I defined and provided a framework which could be adapted to assess how policies in different contexts address environmental threats to support biodiversity and people's livelihoods. Furthermore, I began to clarify the distinction between upstream social marketing and policy making. Upstream social marketing should promote many potential solutions with key decisions makers, that can involve voluntary solutions (e.g., sustainability certifications, financial incentives, new training programs, etc.), and may also result in new or improved policies or laws (Gordon 2013). However, social marketers should not act as policymakers and that distinction should not be understated. Through this research I also highlighted consistent gaps across the major sustainability standards for coffee and provided suggestions to incorporate various producer and non-producer voices, focus on landscape to regional perspectives, include policies that consider all threats to biodiversity, and provide adequate guidelines and methodologies for each actor to address those threats. These findings echo previous research advocating for sustainability standards to take a landscape scale approach (Ghazoul et al. 2009, Verburg et al. 2019). However, even the best policies cannot achieve sustainable change on their own.

Despite compliance with sustainability standards being high amongst coffee producers (Panhuysen and Pierrot 2020), the fact is that many of those producer's families or households have not experienced dramatically improved incomes or livelihoods (Bitzer and Steijn 2019, Neilson et al. 2019). When I started my PhD in 2017, coffee prices paid to many producers had already fallen below their cost of production, yet most of these people have had no option but to sell their coffee at a loss (Samper et al. 2017, International Coffee Organisation 2020). This pushed a tremendous number of people in these coffee communities below the global extreme poverty line of US$1.90 per day (International Coffee Organisation 2019, Sachs et al. 2019). Subsequently, for people living in poverty, producers becoming sustainability standard-compliant does not ensure a pathway out of poverty (Neilson et al. 2019, Sachs et al. 2019). This is not sustainable. Accordingly, any behaviour change

intervention that seeks to improve biodiversity outcomes through coffee also needs to support profitable producer livelihoods.

In chapter three I used insights from 1,142 coffee consumers to show that the public is ready for environmentally friendly coffee and how understanding a target audience's previous behaviours and values could be used to inform targeted consumer behaviour change interventions. These insights will directly inform a specific behaviour change campaign, led by Zoos Victoria in collaboration with Genovese Coffee. The campaign aims to increase the public's understanding of the issues in coffee and sell environmentally friendly coffee to support profitable livelihoods and biodiversity conservation projects in the regions where the coffee is sourced from. One of the key findings from this research was that consumers' previous purchasing behaviours and values correlated more strongly with stated willingness to consume environmentally friendly coffee than any of the common demographic variables. This supports previous research that suggested psychographics could be more important than demographics to profile green-consumers (Larson and Farac 2019). The specific findings from this research along with suggestions to increase the opportunities and ability for consumers to find, try, and buy environmentally friendly coffee will be important for other markets promoting environmentally friendly products as well. Whilst questionnaires like the one used for this research can be a useful for gaining consumer insights, response rates and quality can decrease with the length, timing, and frequency of surveys (Deutskens et al. 2004, Beebe et al. 2010, Sahlqvist et al. 2011). Therefore, I also explored how a feature selection algorithm could be used to select the most important questions to predict willingness to buy. The results showed some promise and could help create a much shorter and cost-effective survey tool for follow-up market research or to segment target audiences. However, this approach could still present a challenge for many conservation practitioners who may not be trained in or confident with the appropriate methods themselves (Wright et al. 2015, Bennett et al. 2017b, Robinson et al. 2019). Furthermore, the perennially limited resources and short timelines available to many conservation projects make it often impossible to implement fully fledged consumer research studies (e.g., Veríssimo et al. 2020).

In chapter four I presented the application of a seven-step co-design process, which showcased the value of user-centred design approaches to behaviour change interventions for biodiversity conservation, helping translate consumer ideas into

concrete prototypes. By applying this process with coffee consumers, I showed how audience insights can be gathered in a short amount of time, at minimal cost, to include end-user voices in the design of interventions when they might have otherwise been excluded due to perceived lack of time, knowledge, or resources. One of the strongest contributions from this work is the seven-step co-design outline and guidance for how to generate user-centric intervention ideas and transform them into feasible prototype interventions. This framework can be taken and applied by conservation practitioners to help engage with their target audiences and include a variety of voices in the design and prototyping of behaviour change interventions. For some conservation issues, the direct or indirect behaviours that need to change will be largely driven by non-conscious, low-cognitive-load (System 1) decision making, and so may not be particularly open to introspection by co-design participants. So, it may be the case that co-design will prove to be less useful at producing effective conservation interventions for smaller, everyday decision-based behaviours. Instead, upstream approaches could prove more effective in generating change in these scenarios by altering the context in which these everyday decisions operate. Co-design processes are also likely to struggle with illicit behaviours, so may not apply well to conservation issues driven by illegal behaviours—such as those within the illegal wildlife trade which is a major area of work for conservation behaviour change. Nevertheless, there will be conservation issues largely driven by conscious, high-cognitive-load (System 2) decision making. For these issues, co-design participants could prove to be effective for generating insightful and successful conservation interventions—such as which coffee a roaster or trader buys, or how the farmer grows coffee on their farm. There is still much research and practical applications needed to help understand when, where, and how consumer behaviour change can be best used to generate positive change.

5.2. Future research directions for sustainable coffee and consumer behaviour change

Building on from chapter two, the next steps for improving sustainability standards could involve implementing behaviour change interventions with certification policy makers to design more equitable policies with producers, traders, roasters, retailers, and consumers. This would undoubtedly be a large undertaking, that would likely take several iterations before more equitable voluntary policies are achieved. Indeed, a

similar process has been tried before, such as during the merger of Rainforest Alliance and UTZ between 2018-2020 (Rainforest Alliance 2020a). In a statement about the merger Alex Morgan, chief markets officer at the Rainforest Alliance, said *"This ambitious and innovative certification program is part of the Rainforest Alliance's strategy of collaboration with farmers, companies, implementing partners, and third-party auditors, as well as other NGOs, governments, and consumers"* (Rainforest Alliance 2020a). This is a promising development for one of the major sustainability standards in the coffee industry. Yet, we will need to wait several years before the results will show if these actions result in synergistic biodiversity and livelihood outcomes. The issue of selling standard-compliant coffee to provide continued financial incentive and motivation for standard-compliant producers will be a key challenge for many years. Future research could explore success and failure stories in sustainability transitions to understand what helped people change towards being more sustainable, what barriers hindered success, and how some kept success going through inevitable challenging times. These insights could be used for interventions to help others successfully make and maintain their sustainability transitions.

At the end of chapter four, I presented two prototype interventions. These prototype interventions appeared feasible for the project team to implement and evaluate. However, when the time came to take these next steps, our situation changed. The onset and continued challenges of COVID-19 meant that implementing these interventions was no longer feasible due to social restrictions that closed cafés and kept consumers at home, where we could not test and iterate interventions with them. Nevertheless, the insights from chapter four, along with those from chapter three, could be used to inform future consumer research design and behaviour change interventions. This future research could include the testing of different message frames, price points, duration, and modes for reaching and engaging consumers online and in person. To increase demand for a sustainable coffee product, future studies could test the difference between message frames that focus on: (i) the benefits to improved producer livelihoods and worker conditions; (ii) improved production practices that reduce deforestation and loss of biodiversity; or (iii) the unique flavour profiles of coffee grown under the complex structure of diverse coffee agroecosystems. This research will be particularly important when targeting behaviour change interventions as different groups of people may respond more strongly to one

of these messages than another. Alternatively, this research could find minimal significant difference in the response of consumers to these messages. There is still much work that needs to be done, but my research has added in a small way to help the sustainable coffee movement.

So where to from here for the sustainable coffee movement? Between the producer and the consumer, there can be many people who handle coffee, adding and taking value at every stage (Sachs et al. 2019). Imagine the journey of a single coffee bean (sensu Williams 2021). A coffee bean is grown and picked (often by hand), fermented, dried, then taken some distance to be sold to a local 'middleman'. This middleman would likely sell the coffee bean to at least one more intermediary, before the bean was taken to a port (and sold) to an exporter/trader. The coffee bean would then be packed into a shipping create, loaded onto a boat, to be taken to other side of the world. At the destination port, the coffee bean would be unloaded and taken to, or sold to, a roaster. The roaster may potentially mix this coffee bean with other beans from around the world to create a blend or keep beans separated to highlight the unique flavour profile of their single origin. The beans would then be roasted, (ground), packed into small bags or containers, before being (i) sold directly to the end-customer, or (ii) sold to a retailer (e.g., supermarket) before being bought by the end-consumer. Eventually though the coffee will be brewed, perhaps mixed with milk/mylk and other additives, to make a cup of coffee. Finally, the coffee bean has made its long journey and will hopefully be enjoyed.

In the above value chain, coffee producers generally only take a tiny fraction (perhaps 1-2% at best) of the final retail price of coffee (Samper et al. 2017, Sachs et al. 2019). Biodiversity conservation and sustainable development targets cannot be achieved without profitable producer livelihoods. This follows my definition for sustainable coffee as "*coffee produced in ways that meets the needs of the present, supporting biodiversity and profitable producer livelihoods, without compromising the ability of future generations to meet their own needs*". Subsequently, the coffee industry will need to mainstream sustainable coffee to the mass market, not just niche and specialty markets, before coffee can become the world's first globally sustainable agricultural product. Sachs et al. 2019 suggest two key strategies that "*provide ambitious yet achievable pathways for making coffee truly sustainable"*. These two key strategies are: (i) the establishment of a *"Global Coffee Fund"* to finance, in part, the

implementation of national coffee sustainability plans (which each coffee producer country will need to develop), and (ii) for coffee-producing countries to capture a greater proportion of coffee's retail price by helping producers *"change their business models towards greater participation in sales to consumers"* (Sachs et al. 2019). The latter presents tremendous opportunities for consumer and producer behaviour change interventions to assist in improving the social, economic, and environmental outcomes for coffee producer communities. Such interventions should aim to help coffee producer communities and countries capture a greater fraction of the final retail price of coffee to support their sustainability transitions. There are many opportunities along the coffee value chain for entrepreneurial producers, given a supportive and favourable circumstance (see Sachs et al. 2019, and Panhuysen and Pierrot 2020 for extensive discisson on many of these opportunities and challenges). Here I present a conceptual value chain with suggestions for where behaviour change interventions could focus to help producers overcome challenges to capture a greater fraction of the final retail price of their coffee (see Figure 5.1).

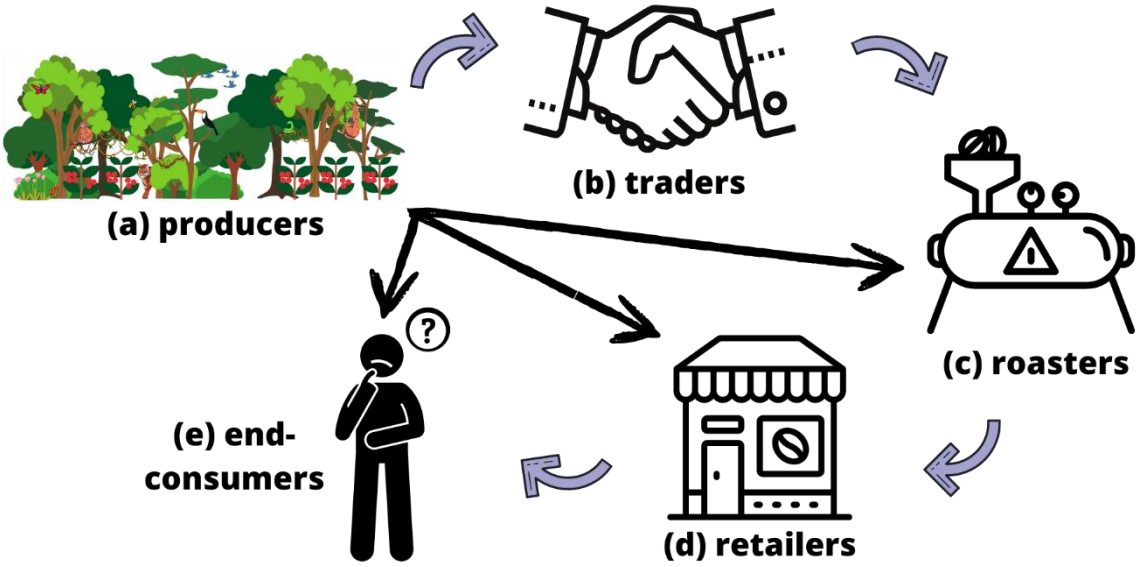


Figure 5.1. Conceptual coffee value chain. (a) Producers grow, harvest, ferment, and dry coffee to sell as green coffee beans. (b) Traders buy and sell green coffee beans. (c) Roasters buy green coffee beans to roast and sell as roasted coffee. (d) Retailers buy and sell roasted coffee. (e) End-consumers buy, brew, and enjoy roasted coffee. Curved arrows show a typical coffee value chain from (a) producers to (e) end-consumers. Straight arrows show alternate value chains that should allow producers to capture a larger fraction of the final retail price of their coffee and may include intermediary producer associations or co-operatives. Behaviour change interventions could be applied with (b) traders, (c) roasters, (d) retailers, or (e) end-consumers to increase understanding, value, and demand for sustainably produced coffee. Interventions could also be applied with producers to help establish new value chains that allow them to capture more value from their coffee to fund and maintain their sustainability transition to grow coffee amongst complex coffee agroecosystems. This may involve increasing capacity to roast or retail their coffee more directly to consumers or creation of cooperatives to vertically integrate with roasters or retailers in consumer countries (see Sachs et al. 2019, and Panhuysen and Pierrot 2020 for further elaboration on opportunities like these).

5.3. Opportunities for consumer behaviour change research and practice to help conserve biodiversity in other food systems

The opportunities and challenges of sustainable agroforestry are not unique to coffee. There are several commodity products that, like coffee, can be produced amongst complex agroforestry systems that support high biodiversity (see Figure 1.2), but can also be produced using less environmentally friendly practices. Cacao, cardamon, rubber, and vanilla are examples of agricultural products that have the potential to support profitable producer livelihoods and reduce or reverse biodiversity loss.

Cacao trees (*Theobroma cacao*, L.) are grown for their fruit with seeds that are used to produce chocolate. Much like coffee, globally increasing demand for chocolate has resulted in expanded and intensified cacao agriculture, leading to simplification of complex cacao agroecosystems, fragmentation and loss of forests, resulting in biodiversity loss (Clough et al. 2009, Ruf et al. 2015). Specialty cacao provides an average price 95% higher than mass market cacao, offering more profitable livelihoods for producers and improved financial capacity to maintain or improve biodiversity outcomes in the ecosystems where specialty cacao is grown (Cadby and Araki 2021). However, the specialty cacao market currently only accounts for approximately 5% of all cacao sales (Fine Chocolate Industry Association 2021).

Cardamom (*Elettaria cardamomum*) is one of the most expensive spices in the world, supporting profitable producer livelihoods (Reyes et al. 2010). In the East Usambara Mountains of Tanzania, cardamom cultivation has caused forest clearance and biodiversity loss (Newmark 2002). More sustainable cardamon production practices exist, and can be profitable, but the industry faces challenges to improve biodiversity without compromising livelihood outcomes (Reyes et al. 2010, Bullock et al. 2014).

The global spatial footprint of natural rubber (*Hevea brasiliensis*) plantations nearly doubled from 55,000 km^2 in 1983 to nearly 100,000 km^2 in 2012, with most expansion in Southeast Asia and southwest China (Warren-Thomas et al. 2015). Rubber agroforestry can maintain biodiversity and support producer livelihoods, but some attempts to create sustainable rubber supply chains have resulted in restricted land access for communities, instead of providing additional income, and so limiting sustainable development outcomes (Otten et al. 2020).

Between 1953 and 2014, Madagascar lost 44% of its natural forest cover (Vieilledent et al. 2018), threatening much of the island's unique biodiversity. A rapid rise in vanilla (*Vanilla planifolia*) prices in 2016 resulted in an expansion of vanilla agroforestry in north-eastern Madagascar (Hänke et al. 2018). In 2017, 70% of vanilla agroforest ecosystems had been developed from open-land, representing rehabilitation of formerly forested areas and gains in biodiversity (see Figure 1.2 and Hänke et al. 2018). Still, 30% of vanilla agroforests in the region had been developed by clearing the understory and thinning of remaining forests, presumably resulting in biodiversity losses (Hänke et al. 2018, Martin et al. 2020).

Behaviour change interventions have the potential to help support sustainability transitions within each of the above examples. Sustainability standards have been used to varying degrees for each of these and other agroforestry supply chains, most commonly resulting in either improved livelihood or improved biodiversity outcomes, but rarely both (Garrett et al. 2021). However, as I have explored through my thesis for coffee, these sustainability standards offer only path to connect consumer and producer behaviours and should be used in conjunction with other approaches. Specialty and other niche offerings present small but growing markets for sustainably produced agroforestry products (Cadby and Araki 2021). Consumer behaviour change interventions could be used to help increase demand and expand these markets to provide the financial capacity needed for producer communities to be able to maintain or improve production practices. However, mainstreaming sustainability for the mass markets of these and other products will be a key challenge for agroforestry to live up to its promises for improved biodiversity and livelihood outcomes. There are limits to what can be expected of behaviour change interventions. The harsh reality is that the broader contexts in which producers make decisions means that, even if producers wish they had other options, many may be compelled to clear forests to survive. Some of the gravest challenges for many smallholder producers, and conservation of biodiversity more broadly, are posed by political conflict and revolution, economic instability, and systemic inequities (see Stonich 2020 for an exploration and portrayal of these challenges from Honduran producer's perspectives). Currently, many countries are experiencing major political and economic struggles, likely exacerbated by the COVID-19 pandemic. Under these circumstances, conserving biodiversity represents a lower priority for many people struggling to keep their families safe.

Much of my thesis until this point has focused on improving outcomes for biodiversity in the tropical regions of our world (coffee, cacao, cardamon, rubber, and vanilla are all primarily grown in the tropics). However, from a global perspective, consumer behaviour change could, indirectly or directly, benefit biodiversity in any ecosystem (Biasini et al. 2021). At present, agriculture occupies half of the world’s habitable land (Ritchie and Roser 2020). Most current food systems have devastated biodiversity, but sustainable food systems have the potential to nurture nature and human health (Willett et al. 2019, Farmery et al. 2021). So, should behaviour change interventions be used to nudge millions of consumers towards more sustainable diets? Such a

mission may raise ethical dilemmas if poorly implemented but could reverse biodiversity loss and address the climate crisis, whilst improving morbidity and mortality outcomes for millions of people (Willett et al. 2019). Importantly, sustainable diets should provide food security, be culturally acceptable, practically accessible, and economically affordable (Burlingame and Dernini 2012).

The EAT-Lancet Commission quantitatively defined a healthy and sustainable reference diet that *"largely consists of vegetables, fruits, whole grains, legumes, nuts, and unsaturated oils, includes a low to moderate amount of seafood and poultry, and includes no or a low quantity of red meat, processed meat, added sugar, refined grains, and starchy vegetables"* (Willett et al. 2019). This reference diet allows for local adaptation to food cultures and cuisines and should be able to provide for a global population of ten billion people by 2050 if rapidly adopted (Willett et al. 2019). However, this will require drastically reduced red meat consumption for many people. This is due to the fact that beef, lamb, and mutton production currently use significantly more land per gram and calorie compared to poultry, pork, or plant-based alternatives (see Ritchie and Roser 2020 for detailed exploration of the environmental impacts of food production). Global rising affluence and shifting cultural norms have resulted in millions of people eating more red meat, indirectly causing widespread deforestation and biodiversity loss where beef, lamb, and mutton production systems have developed (Godfray et al. 2018, Wiedmann et al. 2020). Consumer behaviour change interventions could help slow and reverse demand for beef, lamb, and mutton products to help people transition to more sustainable diets (Godfray et al. 2018, Selinske et al. 2020a). However, the dietary behaviour change literature suggests barriers such as culture, cost, and entrenched taste preferences will strongly moderate efforts to change diets (Biasini et al. 2021). Subsequently, future red meat production systems should still aim to ease pressure on the ecosystems they operate in. Jigsaw Farms is an intensive sheep and beef farm in south-eastern Australia where planted forest and shrublands offset nearly half of the farm's emissions from 2000-2014 (Doran-Browne et al. 2018), whilst also supporting at least some biodiversity (Jigsaw Farms 2021). As people transition to more sustainable diets, plant-based food systems will need to expand their spatial footprint to meet global demand. However, as these foods only occupy a fraction of land of red meat per gram and calorie (Ritchie and Roser 2020) the overall impact will be a reduction in the spatial footprint of food production systems

and net gain in area freed up for non-production systems (Willett et al. 2019). This will allow for the rewilding of lost forests, shrublands, grasslands, as well as freshwater and oceanic ecosystems, resulting in global biodiversity gains (Willett et al. 2019, Farmery et al. 2021). I see great potential for consumer behaviour change interventions to help this transition, but such interventions should be used alongside other strategies, such as upstream policy reforms, to ensure a fair and equitable transitions that support producer livelihoods as food systems shift.

5.4. Consumer behaviour change has its limits

Changing consumer behaviour is complex. Through my thesis I have explored the potential benefits and challenges for applying consumer behaviour change to improve biodiversity and livelihood outcomes through coffee. There is still much work that needs to be done to better understand how, where, and when consumer behaviour change can be best used to help conserve biodiversity. However, there are limits to the degree of change that can be expected from consumer behaviour focused campaigns. Such campaigns should always be viewed as one of several solutions to help achieve a desired change. Governments around the world have adopted 'Nudge Units' or similar agencies to help incorporate behavioural insights into public health, urban development, or to reduce unemployment, among many other public policies (Benartzi et al. 2017, Hummel and Maedche 2019, DellaVigna and Linos 2020, Baggio et al. 2021). This type of behaviourally informed policymaking has the potential to change not only individual behaviour, but also upstream actors and whole organisations (Ewert 2020). Learning to live sustainably is worth the cost and effort at the societal level. However, conservation behaviour change will need to use a variety of upstream, midstream, and downstream approaches to address the key challenges of shifting communities, companies, and cultures. With this collaborative approach, change could rapidly accrue from the indirect benefits of changing people's behaviour, over several years, and at landscape to regional scales. Although consumer behaviour change will not be applicable for every biodiversity conservation project, I advocate for conservation practitioners and researchers to continue engaging and designing solutions with the people they seek to serve to benefit both people and planet.

5.5. The rise and future of conservation behaviour change

There are instances of behaviour change principles explicitly used to conserve biodiversity as early as the 1940s with the launch of the Forest Fire Prevention Campaign in the United States of America (Butler et al. 2007), "*Only You Can Prevent Wildfires – Smokey Bear*". The campaign continues today, aiming to prevent wildfires that can devastate forests and biodiversity (The Ad Council 2021). Since 1988, Rare (an environmental NGO; https://rare.org/) has used behaviour change approaches in over one-hundred of their *Pride* campaigns to alter various stakeholder behaviours for species conservation (Butler et al. 2007, Jenks et al. 2010, Veríssimo 2019). However, a concerted effort to further the use and development of behaviour change strategies—such as social marketing—to conserve biodiversity has only come in recent years (Veríssimo and McKinley 2016). In 2014, the Conservation Marketing & Engagement Working Group formed within the Society for Conservation Biology (www.consmark.org). 2016 marked the beginning of the Oxford Martin Programme on Illegal Wildlife Trade (www.oxfordmartin.ox.ac.uk/illegal-wildlife-trade/), and separately, a publicly available Wildlife Consumer Behaviour Change Toolkit (changewildlifeconsumers.org). Both of these initiatives have helped stimulate a growing community of conservation practitioners, NGOs, government agencies, academics, researchers, marketers and practitioners using behavioural science to combat threats to biodiversity from the illegal wildlife trade (Veríssimo 2019). WWF's 2017 Fuller Symposium focused exclusively on "*The Science of Influencing Behaviour*" (worldwildlife.org/pages/the-nature-of-change), bringing together experts from various fields to stimulate the integration of behavioural disciplines into conservation practice. Encouraging this style of cross-/inter-disciplinary collaboration amongst conservation researchers and practitioners with behaviour change experts from other fields should help rapidly integrate decades of learnings into the biodiversity context (Wright et al. 2015, Bennett et al. 2017a, Bennett et al. 2017b). In 2019, *Social Marketing Quarterly*—the longest-running social marketing journal—ran a special issue dedicated to using this behaviour change strategy (i.e., social marketing) focused on environmental issues (Veríssimo 2019). The collaborative publications found: (i) a lack of behavioural training that cannot meet increasing demands from conservation practitioners (Robinson et al. 2019), (ii) promising approaches to increase favourable conservation outcome efficiencies (Metcalf et al. 2019), (iii) substantial gaps between

best and current practice when designing illegal wildlife demand reduction campaigns (Greenfield and Veríssimo 2019), (iv) co-designing with community members produced a positively received campaign to reduce dog attacks on koalas in Queensland, Australia (David et al. 2019), and (v) robust evidence and applications to rapidly integrate behavioural science into global conservation campaigns (Green et al. 2019). In a small way, my thesis has built on this growing collaborative community of behavioural research and practice to help conserve biodiversity.

I am hopeful that when looking back, 2020-2021 will mark a turning point in how our globally interconnected and telecoupled societies view and value nature. Our individually unique but shared experiences of lockdowns, social separation, and slowdown in daily life allowed many people to reconnect with nature (Baillie 2020, Chaudhury and Banerjee 2020, Rousseau and Deschacht 2020). Communities, companies, and cultures have shown they can change where and how they work (Reeves et al. 2020), view infrastructure (Bakare et al. 2020, Creel et al. 2020, D'Adamo and Rosa 2020), and urban green spaces (Naomi 2020, Rousseau and Deschacht 2020). Of course, not all changes have been positive or lasting, but some will become enduring (Reeves et al. 2020). Behaviour change is a useful tool that should be used in conjunction with other approaches to help people create a healthier, happier, and more equitable world for themselves, their communities, companies, and cultures. Conservation researchers and practitioners are now well positioned to make the most of these new opportunities for biodiversity and sustainable development. Eventually, all the coffee we consume will be sustainable if we choose to make it so.

Supplementary Materials

A. Supplementary Material 2.1. A framework of eight key threats to biodiversity from coffee agriculture broken down into a total of thirty-four underlying processes.

For each underlying threat process we provide and define the specific requirements to satisfy each of the three evaluation criteria:

EC.1. Does the standard require producers to consider this process (at the appropriate spatial and temporal scales) within its conceptual or decision framework?

EC.2. Does the standard provide decision guidelines (e.g., thresholds, safeguards, regulations) to address this process?

EC.3. Does the standard provide sufficient supporting guidance (e.g., definitions, mapping protocols, data sources, impact assessments) for producers to account for and make informed decisions when addressing this process?

Threat to biodiversity	**Underlying process**	**Evaluation criterion**			
		EC1		**EC2**	**EC3**
		Assessment description	**Spatial and temporal scale**	**Key decision guidelines**	**Key methodological elements**
Direct land-use change: Habitat loss in forest ecosystems	Type of ecosystem or habitat converted: primary forest	We evaluate to what extent sustainability tools and initiatives require coffee producers to avoid the conversion of primary forests when selecting a location and deciding on the scale and	Spatial scale: N / A. The spatial and temporal aspects of forest loss are	Explicit provisions against the conversion of primary forests by coffee development.	Methodological guidance to identify primary forests (e.g., definitions, methods).

		design of their coffee operations. Natural vegetation can sustain the majority of naturally occurring species in a region or landscape. Tropical primary forests, in particular, host the highest number of species worldwide among terrestrial ecosystems. Their conversion to coffee plantations can result in the local and global extinction of species that can't survive in disturbed or converted habitats. Thus, primary forests have been identified as irreplaceable and are of high conservation priority.	evaluated separately. Temporal scale: N/A. The spatial and temporal aspects of forest loss are evaluated separately. Decision stage: Selection of location / Plantation design.		
	Type of ecosystem or habitat converted: secondary forest	We evaluate to what extent sustainability tools and initiatives require coffee producers to avoid the conversion of secondary forests when selecting a location and deciding on the scale and design of their coffee operations. Natural vegetation can sustain the majority of naturally occurring species in a region or	Spatial scale: N / A. The spatial and temporal aspects of forest loss are evaluated separately. Temporal scale:	Explicit provisions against the conversion of secondary forests by coffee development.	Methodological guidance to identify secondary forests (e.g., definitions, methods).

		landscape. Their conversion to coffee plantations can result in the local and global extinction of species that can't survive in disturbed or converted habitats. Thus, secondary forests are of high conservation priority.	N/A. The spatial and temporal aspects of forest loss are evaluated separately. Decision stage: Selection of location / Plantation design.		
	Type of ecosystem or habitat converted: riparian forest	We evaluate to what extent sustainability tools and initiatives require coffee producers to avoid the conversion of riparian forests when selecting a location and deciding on the scale and design of their coffee operations. Natural vegetation can sustain the majority of naturally occurring species in a region or landscape as well as provide ecosystem services. Riparian forests, in particular, maintain water quality, reduce flood risk, and prevent soil erosion while also	Spatial scale: N / A. The spatial and temporal aspects of forest loss are evaluated separately. Temporal scale: N/A. The spatial and temporal aspects of forest loss are	Explicit provisions against the conversion of riparian forests by coffee development.	Methodological guidance to identify riparian forests (e.g., definitions, buffer areas).

		providing habitat for forest-dependent species. Their conversion can result in a loss of these services. Thus, riparian forests have been identified as irreplaceable and are of high conservation priority.	evaluated separately. Decision stage: Selection of location / Plantation design.		
	Type of ecosystem or habitat converted: rare or threatened forest habitats or ecosystems	We evaluate to what extent sustainability tools and initiatives require coffee producers to avoid the conversion of rare or threatened forest habitats or ecosystems when selecting a location and deciding on the scale and design of their coffee operations. This criterion examines whether sustainability tools and initiatives prioritise the conservation of forest habitats or ecosystems that are rare, which have unique species composition or are highly threatened. The rarity of a forest habitat or ecosystem must be assessed taking into account the regional context, considering factors such as	Spatial scale: N / A. The spatial and temporal aspects of forest loss are evaluated separately. Temporal scale: N/A. The spatial and temporal aspects of forest loss are evaluated separately. Decision stage:	Explicit provisions against the conversion of rare or threatened forest habitats and ecosystems by coffee development.	Methodological guidance to identify rare or threatened forest habitats and ecosystems (e.g., definitions, maps). Methodological guidance to assess the rarity, uniqueness and threat level of forest habitats and ecosystems.

		size, species composition, the original extent of the habitat/ecosystem in the region as well as projections of future changes in the total area.	Selection of location / Plantation design.		
	Type of ecosystem or habitat converted: forest areas that support species of high conservation priority	We evaluate to what extent sustainability tools and initiatives require coffee producers to avoid the conversion of forest areas that support species of high conservation priority when selecting a location and deciding on the scale and design of their coffee operations. This criterion examines whether sustainability tools and initiatives prioritise the conservation of forest areas that are important for the survival of i) endangered species (as identified by global and national species red lists), ii) species listed under the CITES convention, iii) locally rare or uncommon species, iv) areas used temporarily by resident or migratory, in particular during	Spatial scale: N / A. The spatial and temporal aspects of forest loss are evaluated separately. Temporal scale: N/A. The spatial and temporal aspects of forest loss are evaluated separately. Decision stage: Selection of location / Plantation design.	Explicit provisions against the conversion of forest areas that support species of high conservation priority by coffee development.	Methodological guidance to identify forest areas that support species of high conservation priority (e.g., definitions, maps).

		droughts or extreme weather events, etc.			
	Spatial and temporal scale: Forest loss within plantations	We evaluate to what extent sustainability tools and initiatives require coffee producers to consider total forest loss within plantations when selecting a location and deciding on the scale and design of their coffee operations. Total forest loss is hereby considered as the conversion of any type of forest habitat, including primary, secondary, young regenerating, logged, riparian, and rare forest habitats. This aspect applies to both concessions and plantations established in privately owned lands.	Spatial scale: Plantation. Temporal scale: short to medium term Decision stage: Selection of location / Plantation design.	Guidelines to support adequate site selection of prospective plantations based on potential forest losses on site Guidelines to prioritise conservation of forest habitats within developing plantations Guidelines on how to interpret results of impact assessment of total forest loss within plantations and how to make decisions based on those results	An adequate conceptual framework to define forests habitats, which includes primary, secondary, young regenerating, logged, riparian, and rare forest habitats Guidance to identify forest habitats in potential and developing plantation sites Assessments to identify possible negative impacts to forest habitats within the plantation from prospective coffee development
	Spatial and temporal scale:	We evaluate to what extent sustainability tools and initiatives in the coffee industry require producers to	Spatial scale: Landscape.	Guidelines to support adequate site selection and design of prospective	A clear and operational definition of landscape in conservation terms.

	Contribution to forest loss in the landscape	consider forest loss in the landscape, and their potential contribution to this process, when selecting a location and deciding on the scale and design of their coffee operations. Important elements to take into account when addressing this process include the total forest area remaining in the landscape, temporal aspects of forest loss in the landscape (e.g., current and past deforestation patterns, future deforestation projections), and historic and future developments of other industries such as timber or mining in the landscape. Forest loss is hereby considered as the conversion of any type of forest habitat, including primary, secondary, young regenerating, logged, riparian, and rare forest habitats. This aspect applies to both concessions and plantations established in privately owned lands.	Temporal scale: short to medium term Decision stage: Selection of location / Plantation design.	plantations based on potential contribution to forest loss at the landscape level Guidelines to support decision making processes across the broad range of land-use change patterns (e.g., high- vs. low-deforestation rates, high- vs. low-agricultural encroachment) and the varying degrees of human disturbance (e.g., high forest-cover landscapes vs. low forest-cover landscapes) found in current and future coffee-producing landscapes.	Methodological guidance to identify forest habitats at the landscape scale and prioritise their conservation. Methodological guidance to identify the degree of forest cover in the landscape Methodological guidance to identify and analyse past and future land-use change patterns in the landscape, and to measure the contribution of a producer's coffee operations to those trends
	Spatial and temporal scale:	We evaluate to what extent sustainability tools and initiatives in the coffee	Spatial scale:	Guidelines to support adequate site selection and design	Technical guidance to define regional boundaries in

	Contribution to forest loss at the regional level	industry require producers to consider for forest loss at the regional level, and their potential contribution to this process, when selecting a location and deciding on the scale and design of their coffee operations. Important elements at the regional level to consider when addressing this process include the total forest area remaining, temporal aspects of forest loss (e.g., current and past deforestation patterns, future deforestation projections), and developments of other industries such as timber or mining. Forest loss is hereby considered as the conversion of any type of forest habitat, including primary, secondary, young regenerating, logged, riparian, and rare forest habitats. This aspect applies to both concessions and plantations established in privately owned lands.	Region. Temporal scale: short to medium term Decision stage: Selection of location / Plantation design.	of prospective plantations based on potential contribution to forest loss at the regional scale Guidelines to support decision making processes across the broad range of land-use change patterns (e.g., high- vs. low-habitat conversion rates, with high- vs. low-agricultural encroachment), and the varying degrees of human disturbance (e.g., regions with high- vs. low forest cover) found in current and future coffee-producing regions.	assessments Methodological guidance to identify the degree of forest cover at the regional scale Methodological guidance to identify and analyse past and future land-use change patterns at the regional scale, and to measure the contribution of a producer's coffee operations to those trends Methodological guidance to assess and account for drivers of deforestation at the regional scale including both planned (e.g., potential development of other large-scale industries) and unplanned deforestation (e.g., small-scale agricultural

					encroachment) Methodological guidance to identify the potential contribution of coffee operations to forest loss at the regional scale based on the information derived from the four points above.
Direct land-use change: Fragmentation of forest ecosystems	Landscape composition and configuration: Increase in patch size effects	We evaluate to what extent sustainability tools and initiatives in the coffee industry require producers to consider patch size effects of forest areas in the landscape when selecting a location and designing their coffee plantations. Patch size effects comprise all processes that can negatively impact biodiversity as patch size decreases (e.g., fewer favourable conditions for specialist species, smaller and less resilient populations, etc.). Although these effects operate at the patch level, they exacerbate the impacts of total habitat loss in the	Spatial scale: Landscape. Temporal scale: medium to long term Decision stage: Selection of location / Plantation design.	Guidelines to prioritise the conservation of forest patches according to their size, habitat quality and the landscape context (i.e. small patches may be of high conservation priority in highly modified landscapes). Guidelines to address patch size effects across forested areas in the landscape.	Ecologically-sound guidance to map and identify forest patches accounting for habitat quality. Guidance to assess the conservation importance in the landscape of individual patches according to their size. Guidance to estimate the degree of forest cover remaining in the landscape.

		landscape and result in higher species losses at this scale. As such, landscapes with large patches are more likely to retain high levels of biodiversity. However, in highly modified landscapes small patches may be important, and sometimes the only remaining option for conservation. Thus, patch size effects need to be considered in the landscape context.			
	Landscape composition and configuration: Increase in edge effects	We evaluate to what extent sustainability tools and initiatives in the coffee industry require producers to consider and mitigate edge effects of forest areas in the landscape when selecting a location and designing their coffee plantations. In this evaluation, edge effects are defined as changes in biological and physical conditions that occur at the boundaries between forests (primary or secondary) and the coffee plantation. Although these effects operate at the patch scale, can have pronounced impacts at the	Spatial scale: Landscape. Temporal scale: medium to long term Decision stage: Selection of location / Plantation design / Operational phase.	Guidelines to maintain/enhance buffer areas around forest patches within and in the surroundings of coffee plantations. Guidance to contribute to the mitigation of edge effects at the landscape level when such effects are highly pronounced (e.g., highly fragmented landscapes with a	Ecologically-sound guidance to define the extent of edge effects within a forest patch Guidance to estimate the extent of edge effects on remaining forests in the landscape

		landscape level, in particular on highly fragmented landscapes with a large number of small or complex-shaped forest patches. Such landscapes show reduced availability of 'core' forest area, an i.e. area unaffected by edge effects. This not only reduces habitat available for particular species groups (e.g., forest specialists) but also increases the area affected by altered ecosystem processes linked to these effects.		large number of small forest patches).	
	Landscape composition and configuration: Loss of habitat heterogeneity in the landscape	We evaluate to what extent sustainability tools and initiatives in the coffee industry require producers to consider the loss of habitat heterogeneity in the landscape when selecting a location and designing their coffee plantations. Loss of habitat heterogeneity refers to processes that range from the reduction of natural ecosystem diversity in the landscape (e.g., in natural mosaic landscapes), to the loss of forest habitat types (as	Spatial scale: Landscape. Temporal scale: medium to long term Decision stage: Selection of location / Plantation design /	Guidelines to maintain/enhance environmental gradients within areas managed for conservation (e.g., set aside areas). Guidance to maintain/restore a range of natural occurring land-use and habitat types in the landscape, with different land-use	Guidance to map and identify environmental gradients in the landscape. Guidance to map and identify different types of forest habitats in the landscape.

		defined by topographic, soil, disturbance regimes, etc., e.g., depletion of "terra firme" forests, while conserving flooding forest only). The maintenance of natural habitat heterogeneity in the landscape is important because different species require different environmental conditions for survival and permanence. Hence capturing environmental gradients within areas managed for conservation that resemble the natural mix of environmental conditions as closely as possible is likely to benefit the native species suite in the landscape.	Operational phase.	intensities between them.	
	Landscape composition and configuration: Reduction of forest connectivity in the landscape	We evaluate to what extent sustainability tools and initiatives in the coffee industry require producers to consider reduced connectivity in the landscape, and their potential contribution to this process, when selecting a location and deciding on the scale and design of their coffee operations. Connectivity is hereby defined	Spatial scale: Landscape. Temporal scale: medium to long term Decision stage:	Adequate site selection and plantation design guidelines to prioritise the conservation of habitats that are important to maintain forest connectivity in the landscape	Ecologically-sound guidance to assess forest connectivity that accounts for dispersal abilities, habitat preference, and dispersal behaviour. Methodological guidance for the adequate habitat

		as a property of the entire landscape and refers to both structural and functional connectivity.	Selection of location / Plantation design / Operational phase.	Guidelines to maintain/enhance forest connectivity in the landscape through adequate plantation design.	definition and identification of important elements in the landscape to maintain connectivity
	Regional aspects: Fragmentation of large and continuous forest areas	We evaluate to what extent sustainability tools and initiatives in the coffee industry require producers to avoid the conversion and fragmentation of large and continuous forest areas at the regional level when selecting a location and designing their coffee operations. Large and continuous forest areas are defined here as areas larger than 1000 km2 (i.e. larger than a single landscape as defined in this evaluation) with a continuous forest cover.	Spatial scale: Region. Temporal scale: short to long term Decision stage: Selection of location / Plantation design.	Safeguards to prevent the conversion and fragmentation of large and continuous forest areas.	Guidance to map and identify large and continuous forest areas.
	Regional aspects: Reduction of ecosystem connectivity at the	We evaluate to what extent sustainability tools and initiatives in the coffee industry require producers to consider the connectivity of forest ecosystems at the regional scale, and their potential contribution to its decrease at this scale, when	Spatial scale: Region. Temporal scale: medium to long term	Adequate site selection and plantation design guidelines to prioritise the conservation of areas in the landscape that are important to maintain	Methodological guidance for the adequate identification of important areas to maintain connectivity at the regional level.

	regional level	selecting a location and deciding on the scale and design of their coffee operations. Connectivity of forest ecosystems is here defined as the connectedness of different forested areas within a region. High ecosystem connectivity at the regional scale can maintain important ecological, evolutionary and biogeographic dynamics that are important for the long-term persistence of species. This is of particular importance when considering the synergistic effect of habitat loss and fragmentation, with global processes like climate change, which is likely to alter environmental patterns at regional and global scales rapidly. Under these conditions, species survival will, therefore, rely upon their capacity to respond to these changes through large-distance dispersal across human-modified landscapes and the maintenance of ecological and evolutionary	Decision stage: Selection of location / Plantation design / Operational phase.	forest connectivity at the regional scale	Methodological guidance to assess connectivity at the regional level that accounts for ecological, evolutionary and biogeographic dynamics.

		refugia. Also, maintaining connectivity at broad scales is particularly important for large-body species that require considerable areas for their survival.			
Direct land-use changes: Non-forest ecosystems	Conversion of wetland ecosystems	We evaluate to what extent sustainability tools and initiatives require coffee producers to avoid the conversion of wetland ecosystems when selecting a location and deciding on the scale and design of their coffee operations. Wetland ecosystems are crucial in the maintenance of ecosystem services such as climate regulation, or hydrological regulation and water provision. Also, these ecosystems provide temporary or permanent habitat to several species that possess specific living requirements.	Spatial scale: N / A. The spatial and temporal aspects of habitat loss are evaluated separately. Temporal scale: N/A. The spatial and temporal aspects of habitat loss are evaluated separately. Decision stage: Selection of location / Plantation design.	Explicit provisions against the conversion of wetland ecosystems by coffee development.	Methodological guidance to identify wetland ecosystems (e.g., definitions).

	Conversion of natural savannah and shrubland ecosystems	We evaluate to what extent sustainability tools and initiatives require coffee producers to avoid the conversion of natural savannahs and shrubland ecosystems when selecting a location and deciding on the scale and design of their coffee operations. Although with lower biodiversity levels than those found in tropical forests, tropical natural savannahs and shrubland ecosystems are important habitats for a large number of species. These ecosystems are increasingly under pressure with the advent of carbon-based land-use planning initiatives, that is redirecting agricultural and industrial expansion to areas of low carbon content in biomass and soils.	Spatial scale: N / A. The spatial and temporal aspects of habitat loss are evaluated separately. Temporal scale: N/A. The spatial and temporal aspects of habitat loss are evaluated separately. Decision stage: Selection of location / Plantation design.	Explicit provisions against the conversion of natural savannahs and shrubland ecosystems by coffee development.	Methodological guidance to identify natural savannahs and shrubland ecosystems (e.g., definitions).
	Conversion of rare or threatened non-forest	We evaluate to what extent sustainability tools and initiatives require coffee producers to avoid the conversion of rare or	Spatial scale: N / A. The spatial and temporal aspects of	Explicit provisions against the conversion of rare or threatened non-forest habitats and	Methodological guidance to identify rare or threatened non-forest habitats and ecosystems (e.g.,

	ecosystems or habitats	threatened non-forest habitats or ecosystems when selecting a location and deciding on the scale and design of their coffee operations. This criterion examines whether prioritises the conservation of non-forest habitats or ecosystems that are rare, which have unique species composition or are highly threatened. The rarity of a habitat or ecosystem must be assessed taking into account the regional context, considering factors such as size, species composition, the original extent of that habitat or ecosystem in the region as well as projections of future changes in the total area.	habitat loss are evaluated separately. Temporal scale: N/A. The spatial and temporal aspects of habitat loss are evaluated separately. Decision stage: Selection of location / Plantation design.	ecosystems by coffee development.	definitions, maps). Methodological guidance to assess the rarity, uniqueness and threat level of non-forest habitats and ecosystems.
	Conversion of areas that support species of high conservation priority	We evaluate to what extent sustainability tools and initiatives require coffee producers to avoid the conversion of non-forest areas that support species of high conservation priority when selecting a location and deciding on the scale and design of their coffee operations. This criterion	Spatial scale: N / A. The spatial and temporal aspects of habitat loss are evaluated separately. Temporal scale:	Explicit provisions against the conversion of non-forest areas that support species of high conservation priority by coffee development.	Methodological guidance to identify non-forest areas that support species of high conservation (e.g., definitions, maps).

		examines whether sustainability tools and initiatives prioritise the conservation of non-forest areas that are important for the survival of i) endangered species (as identified by global and national species red lists), ii) species listed under the CITES convention, iii) locally rare or uncommon species, as well as iv) areas used temporarily by resident or migratory, in particular during droughts or extreme weather events, etc.	N/A. The spatial and temporal aspects of habitat loss are evaluated separately. Decision stage: Selection of location / Plantation design.		
	Habitat loss at the landscape and regional level (non-forest ecosystems)	We evaluate to what extent sustainability tools and initiatives in the coffee industry require producers to consider the loss of naturally occurring non-forest habitats at the landscape and regional scales, including their potential contribution to these processes, when selecting a location and deciding on the scale and design of their coffee operations. Important elements to take into account when addressing this process include the total area of non-	Spatial scale: Landscape / Region. Temporal scale: short to medium term Decision stage: Selection of location / Plantation design.	Guidelines to support adequate site selection and design of prospective plantations based on potential contribution to non-forest habitat loss at the landscape and regional scales. Guidelines to support decision making processes across the broad range of land-use change patterns	A clear and operational definition of landscape in conservation terms, as well as clear guidance to define regional boundaries in assessments. Methodological guidance to identify natural non-forest habitats at the landscape or regional scales and prioritise

		forest habitats remaining at the landscape and regional scale, temporal scale aspects of habitat loss at those scales (e.g., current and past habitat conversion patterns, future conversion projections), and historic and future developments of other industries such as timber or mining. Loss of non-forest habitats is hereby considered as the conversion of any type of natural occurring non-forest habitats, which includes grasslands, shrublands, mangroves, wetlands, etc. This process applies to both concessions and plantations established in privately owned lands.		(e.g., high- vs. low-habitat conversion rates, with high- vs. low-agricultural encroachment), and the varying degrees of human disturbance (e.g., severely modified landscapes vs. highly undisturbed landscapes) found in current and future coffee-producing landscapes and regions.	their conservation. Methodological guidance to identify the degree of habitat cover remaining at the landscape or region scales. Methodological guidance to identify and analyse past and future land-use change patterns at the landscape and regional scales, and guidance to measure the contribution of producers' coffee operations to those trends. Methodological guidance to assess and account for drivers of habitat loss in a landscape or region, which includes drivers of both planned (e.g., potential development of other large-scale

					industries) and unplanned habitat conversion (e.g., small-scale agricultural encroachment). Methodological guidance to identify the potential contribution of coffee operations to habitat loss at the landscape or regional scales, based on the information derived from the four points above.
	Fragmentation of non-forest ecosystems	We evaluate to what extent sustainability tools and initiatives in the coffee industry require producers to consider and mitigate fragmentation impacts on non-forest habitats at the landscape and regional scales when selecting a location and deciding on the scale and design of their coffee operations. Non-forest habitats are hereby defined as any type of natural-occurring non-forest habitats in a	Spatial scale: Landscape / Region. Temporal scale: medium to long term Decision stage: Selection of location / Plantation design /	Guidelines to support adequate site selection and design of prospective plantations based on potential contribution to the fragmentation of non-forest habitats at the landscape and regional scales. Guidelines to prioritise the conservation of areas of non-forest habitats	A clear and operational definition of landscape in conservation terms, as well as clear guidance to define regional boundaries in assessments. Methodological guidance to identify areas with natural non-forest habitats at the landscape or regional scales and prioritise their conservation,

		landscape or region, which includes grasslands, shrublands, mangroves, wetlands, etc. Important elements to take into account when addressing the fragmentation of these habitats include patch size, edge and matrix effects, as well as a reduction in the connectivity of non-forest habitats.	Operational phase.	according to their size, quality, and connectedness, taking into account the landscape and regional context (i.e. small areas may be of high conservation priority in highly modified landscapes).	according to attributes like patch size, the occurrence of edge effects, and connectedness in the landscape. Methodological guidance to identify the potential contribution of coffee fragmentation at the landscape or regional scales, based on the information derived from the points above.
Indirect land-use changes	Conversion of areas used for traditional agriculture or forestry systems	We evaluate to what extent sustainability tools and initiatives in the coffee industry require producers to avoid impacts, such as conversion or restricted access to lands where local communities practice traditional land-uses that are critical for their livelihoods (e.g., shifting cultivation, subsistence farming, and forests used for harvesting construction material). Impacts on these areas may	Spatial scale: Landscape. Temporal scale: short to medium term Decision stage: Selection of location / Plantation design.	Guidelines to support adequate site selection and design of prospective plantations that prevent impacts (e.g., conversion, restricted access) on important areas for traditional land-uses of local communities.	Methodological guidance to identify areas where local communities practice traditional land-uses (e.g., shifting cultivation, subsistence farming, the harvest of forest materials).

		result in the displacement of traditional land-uses to undisturbed areas in the landscape or region.			
	Conversion of key agricultural land for food security at the regional scale	We evaluate to what extent sustainability tools and initiatives in the coffee industry require producers to avoid conversion on important agricultural land for food production at the regional scale when selecting a location and deciding on the scale and design of their coffee operations. Important agricultural land for food production is hereby defined as areas that are key for the production of any food that constitutes a dominant portion of the standard diet of local communities in a landscape or region (e.g., staple foods such as rice, maize or cassava, or other food items such as meat). Conversion on these areas may result in the displacement of agricultural land-uses to undisturbed areas inside and outside the region.	Spatial scale: Region. Temporal scale: short to medium term Decision stage: Selection of location / Plantation design.	Guidelines to support adequate site selection and design of prospective plantations that prevent the conversion of key areas for food security at the regional scale.	Methodological guidance to identify key areas for food security at the regional scale, assess the risk of displacement and prioritise their protection accordingly.

	Conversion of land where commodity products of high demand are grown	We evaluate to what extent sustainability tools and initiatives in the coffee industry require producers to consider when selecting a location and deciding on the scale and design of their coffee operations, avoiding the conversion of agricultural or forestry land where products of high international or national demand are grown (e.g., commodity crops, timber plantations).	Spatial scale: Landscape / Region. Temporal scale: short to medium term Decision stage: Selection of location / Plantation design.	Guidelines to support adequate site selection and design of prospective plantations that prevent the conversion of important areas for high-demand products.	Methodological guidance to identify areas where high-demand products are grown, understand the impact of conversion of such areas in market demand and assess the risk of displacement. Methodological guidance to account for historic and future land-use trajectories of agricultural or forestry industries.
Indirect population pressures	Rapid increase in human population (e.g., through labour in-migration)	We evaluate to what extent sustainability tools and initiatives in the coffee industry require producers to consider and mitigate impacts resulting from potential rapid population changes due to labour in-migration when selecting a location and deciding on the scale and design of their coffee operations. Migrant communities and rapid labour inflow can potentially result in	Spatial scale: Landscape. Temporal scale: short to long term Decision stage: Selection of location / Plantation	Guidelines to support adequate site selection and design of prospective plantations that consider and anticipate potential impacts from population inflows connected to coffee development.	Methodological guidance to identify potential impacts from population inflows connected to coffee development.

		higher impacts on the environment due to higher demand of natural resources such as material construction, land for food production, or food resources (e.g., fish, bush meat, etc.).	design / Operational phase.		
	Increase of impacts from the development of transportation infrastructure	We evaluate to what extent sustainability tools and initiatives in the coffee industry require producers to consider and mitigate impacts resulting from the development of infrastructure to support production activities when selecting a location and deciding on the scale and design of their coffee operations. The development of infrastructure to support production activities, and in particular, roads, can result in further impacts such as habitat loss, fragmentation, and increase in biodiversity exploitation, because it facilitates legal and illegal land colonization, land speculation, deforestation, fires, and overhunting.	Spatial scale: Landscape / Region. Temporal scale: short to long term Decision stage: Selection of location / Plantation design / Operational phase.	Guidelines to support adequate site selection and design of prospective plantations that consider and anticipate potential impacts (e.g., habitat loss, fragmentation, etc.) from the development of transportation infrastructure associated with coffee operations.	Methodological guidance to identify and quantify potential impacts (e.g., habitat loss, fragmentation, etc.) from the development of transportation infrastructure associated with coffee operations.

	Increase in biodiversity exploitation and wildlife conflicts	We evaluate to what extent sustainability tools and initiatives in the coffee industry require producers to anticipate how their development may exacerbate biodiversity exploitation pressures or wildlife-human conflicts when selecting a location and deciding on the scale and design of their coffee operations. Addressing this process implies, i) to adequately select and design plantations in regions with a high risk of unsustainable biodiversity exploitation (e.g., overhunting, poaching), ii) to anticipate how changes in the landscape may result in wildlife conflicts (e.g., insufficient resource and habitat availability in the landscape, or lack of adequate corridors or other landscape elements to facilitate species mobility), and iii) to create management plans to mitigate these processes.	Spatial scale: Landscape. Temporal scale: short to long term Decision stage: Selection of location / Plantation design / Operational phase.	Guidelines to support adequate site selection and design of prospective plantations that anticipate and mitigate potential impacts related to unsustainable biodiversity exploitation (e.g., overhunting, poaching) and wildlife conflict (e.g., insufficient resource and habitat availability in the landscape), which may be exacerbated by coffee development Guidelines to protect and minimise the exploitation of flora and fauna during coffee production and processing (e.g., prohibitions on hunting and collection of forest products,	Identification of species vulnerable to biodiversity exploitation and wildlife conflicts. Identification of areas where sustainable biodiversity exploitation can be permitted (e.g., for customary uses) Methodological guidance to identify and quantify potential impacts related to unsustainable biodiversity exploitation (e.g., overhunting, poaching) and wildlife conflict (e.g., insufficient resource and habitat availability in the landscape), which may be exacerbated by coffee development.

				restrictions on the use of animals for processing of coffee, proper training, management and signage of restricted areas/species).	
Alteration of ecosystems processes	Alteration of soil and nutrient dynamics	We evaluate to what extent sustainability tools and initiatives in the coffee industry require producers to consider and address their potential contribution to negative alterations to soil integrity and nutrient dynamics within the plantation and its immediate surroundings when selecting a location and deciding on the scale and design of their coffee operations. Important aspects to understand the effects of the establishment of coffee plantations in soil integrity and nutrient dynamics include soil formation, erosion, sedimentation, subsidence, acidification, and redistribution of soil carbon and nutrients (e.g., through leaching and runoff). Please note that this process excludes protection of	Spatial scale: Plantation / Landscape. Temporal scale: short to long term Decision stage: Selection of location / Plantation design / Operational phase.	Guidelines to support adequate site selection of prospective plantations that considers the potential contribution to negative effects such as erosion, sedimentation, subsidence, acidification, and redistribution of soil carbon and nutrients (e.g., through leaching and runoff). Guidelines to support adequate plantation design to reduce potential negative effects such as erosion, sedimentation,	Guidance for the identification of fragile and vulnerable soil types. Guidance to model changes to soil dynamics in the landscape resulting from coffee development, through processes like erosion, sedimentation, subsidence, acidification, and redistribution of soil carbon and nutrients (e.g., through leaching and runoff). Guidance to assess erosion, sedimentation, runoff and leaching risks in

		organic soils (e.g., peatlands), as well as the management of waste and pollution (e.g., pesticide and fertilizer application), as these aspects are considered elsewhere.		subsidence, acidification, and redistribution of soil carbon and nutrients (e.g., through leaching and runoff).	the landscape from coffee operations. Guidance should include analysis of synergistic effects on soils from both coffee and other land uses in the area.
	Alteration of hydrological processes	We evaluate to what extent sustainability tools and initiatives in the coffee industry require producers to consider and address their potential contribution to negative alterations to hydrological processes in the landscape when selecting a location and deciding on the scale and design of their coffee operations. Hydrological processes refer to water regulation and supply dynamics, i.e. the amount, timing and quality of water stored in and flowing through and out of the landscape. Important elements to understand the effects of the establishment of coffee plantations in hydrological processes include changes in water storage, water	Spatial scale: Landscape. Temporal scale: short to long term Decision stage: Selection of location / Plantation design / Operational phase.	Guidelines to support adequate site selection of prospective plantations that considers the potential contribution to alteration of hydrological processes in the landscape Guidelines to support adequate plantation design to reduce potential negative effects on hydrological processes in the landscape Identification and protection of specific	Guidance to model and identify impacts to hydrological processes in the landscape resulting from coffee operations due to changes in water storage, water infiltration, water yield, and water quality. Guidance should include analysis of synergistic effects on these processes from both coffee and other land uses in the area.

		infiltration, water yield, and water quality, as well as the synergistic effects of coffee cultivation with other land-uses present in the landscape.		habitats and areas important for the maintenance of hydrological processes (e.g., seasonally flooded forests, wetlands).	
	Alteration of local and regional climate regulation processes	We evaluate to what extent sustainability tools and initiatives in the coffee industry require producers to account for their potential contribution to negative alterations to biogeochemical and biophysical processes that regulate local and regional climate when selecting a location and deciding on the scale and design of their coffee operations. Important elements to understand the effects of the establishment of coffee plantations in processes regulating local and regional climates include changes in energy and radiation fluxes, land surface reflectance (albedo), water regulation mechanisms and leaf area index, which directly impact landscape-level	Spatial scale: Landscape / Region. Temporal scale: short to long term Decision stage: Selection of location / Plantation design.	Guidelines to support adequate site selection of prospective plantations that considers the potential contribution to alteration of processes regulating local and regional climates. Guidelines to support adequate plantation design to reduce potential negative effects on processes regulating local and regional climates.	Guidance to model and identify potential climatic impacts (e.g., landscape-level evapotranspiration, rainfall patterns, the intensity and duration of extreme seasonal events) in the landscape from coffee operations due to changes in energy and radiation fluxes, land surface reflectance (albedo), water regulation mechanisms and leaf area index. Guidance should include analysis of synergistic effects on the climate from both coffee and other land uses in the landscape.

		evapotranspiration, rainfall patterns, as well as the intensity and duration of extreme seasonal events.			
	Alteration of natural disturbance regimes	We evaluate to what extent sustainability tools and initiatives in the coffee industry require producers to consider and mitigate their potential contribution to negative alterations of natural disturbance regimes at the landscape and regional levels when selecting a location and deciding on the scale and design of their coffee operations. Disturbances are hereby defined as episodic events that result in sustain disruption of an ecosystem's structure and function, generally with effects that last for an extended time. For this evaluation, we considered only physical disturbances (i.e. fire, flood, drought, landslides). Anthropogenic disturbances (e.g., chemical pollution, drainage of wetlands) and biogenic disturbances (e.g., colonization by herbivorous	Spatial scale: Landscape / Region. Temporal scale: short to long term Decision stage: Selection of location / Plantation design / Operational phase.	Guidelines to support adequate site selection of prospective plantations that considers the vulnerability of ecosystems to negative alterations of disturbance regimes at the landscape and regional levels (e.g., guidelines to avoid development in high-risk wildfire-prone areas). Guidelines to support adequate site selection of prospective plantations that considers the contribution of coffee development to an increase in the risk of	Methodological guidance to model and identify disturbance regimes in the landscape, as well as the potential impact of coffee operations in these regimes. Guidance should include analysis of synergistic effects on disturbance regimes from both coffee and other land uses in the area. Methodological guidance to identify areas where coffee development can increase the risk of and vulnerability to disturbance events (e.g., planting in steep slopes, seasonally flooded areas, fire-prone areas).

		insects, the spread of invasive species) are considered elsewhere (e.g., drainage of wetlands is considered within alteration of hydrological processes). Alteration to disturbance regimes refers to the increase or decrease of the frequency, timing, and intensity of disturbance events in the landscape.		and vulnerability to negative alterations of disturbance regimes at the landscape and regional levels (e.g., avoid high-risk wildfire-prone areas). Guidelines to support adequate plantation design and management to reduce potential negative effects on natural disturbance regimes at the landscape and regional levels (e.g., avoiding the use of fire in land preparation).	
	Alteration of ecological processes (e.g., primary productivity, habitat regeneratio	We evaluate to what extent sustainability tools and initiatives in the coffee industry require producers to consider and manage potential impacts to the ecological processes that underpin vegetation dynamics when selecting a location and	Spatial scale: Landscape. Temporal scale: short to long term	Guidelines to support adequate site selection of prospective plantations that considers the potential impacts to ecological processes that underpin	Methodological guidance to model and identify potential impacts on vegetation dynamics in the landscape from coffee operations due to changes in processes such as regeneration,

	n, pollination)	deciding on the scale and design of their coffee operations. The ecological processes hereby considered are those related to regeneration processes (e.g., seed production, seedling recruitment) and biotic interactions (e.g., pollination, seed dispersal), which determine the direction and rate of vegetation community trajectories. Addressing habitat connectivity (important for seed dispersal) is evaluated as a separate aspect of fragmentation as a mechanism of biodiversity change.	Decision stage: Selection of location / Plantation design / Operational phase.	vegetation dynamics in the landscape, in particular, regeneration, pollination, and seed dispersal. Guidelines to support adequate plantation design to reduce potential negative effects on ecological processes that underpin vegetation dynamics in the landscape, in particular, regeneration, pollination, and seed dispersal.	pollination, and seed dispersal.
Pollution	Increase in pollution of soils, air, and waterbodies	We evaluate to what extent sustainability tools and initiatives in the coffee industry require producers to manage and reduce impacts in the landscape resulting from the pollution of soil, air and water bodies. This process includes i) pollution from fertilizers and pesticides, ii) greenhouse emissions from	Spatial scale: Plantation / Landscape. Temporal scale: short to long term Decision stage:	Guidelines towards the adequate management of waste, as well as the management and control of pollutants in soil, air and water in the landscape, during the operational phase of coffee plantations. This includes the	Methodological guidance to identify and measure potential pollutants, as well as harmful pollution levels, originating from operations within the plantation.

		activities within the plantation (i.e. we do not include emissions resulting from land clearance), iii) inadequate management of effluents, iv) eutrophication of water bodies, and v) inadequate waste management.	Operational phase.	establishment of clear indicators and pollution thresholds.	
External drivers	Increase in vulnerability to global climate change	We evaluate to what extent sustainability tools and initiatives in the coffee industry consider the long-term synergistic effects of coffee development and climate change on biodiversity persistence at the landscape and regional level; and whether they provide a framework that guides producers decisions to address these effects (e.g., by avoiding the conversion of ecological refugia) when selecting a location and deciding on the scale and design of their coffee operations. Considering these effects includes i) understanding how global	Spatial scale: Landscape / Region. Temporal scale: medium to long term Decision stage: Selection of location / Plantation design.	Guidelines to support adequate site selection and design of prospective plantations that considers projected effects on local climatic patterns resulting from climate change, and the potential synergistic effects of coffee development in these processes. Guidelines that prioritise the conservation of elements in the landscape and	Methodological guidance to model and identify synergistic long-term effects from coffee development and projected climate change at the landscape and regional scales. Methodological guidance to identify elements in the landscape and regions that are important for the adaptive capacity of species and ecosystems to climate change, in particular, ecological refugia and

		climate change is expected to affect local climatic patterns, ii) understanding how coffee development can exacerbate these trends, and iii) the identification elements in the landscape and regions that are important for the adaptive capacity of species and ecosystems to climate change (e.g., potential ecological and evolutionary refugia, regional ecosystem and habitat connectivity).		regions that are important for the adaptive capacity of species and ecosystems to climate change, in particular, potential ecological and evolutionary refugia and regional ecosystem and habitat connectivity.	regional ecosystem and habitat connectivity.
	Introduction of invasive species, pests, and diseases	We evaluate to what extent sustainability tools and initiatives in the coffee industry require producers to manage and reduce impacts resulting from the introduction of invasive species, pests, and diseases.	Spatial scale: Landscape. Temporal scale: medium to long term Decision stage: Operational phase	Guidelines towards the management and reduction of impacts in the landscape resulting from the introduction of invasive species, pests, and diseases.	Methodological guidance to identify and measure potential impacts in the landscape resulting from the introduction of invasive species, pests, and diseases.

B. Supplementary Material 2.2. Official documentation for each of the eleven sustainability standards within the coffee industry assessed

Sustainability standard	Logo	Type	Proponent	Document base
Australian Certified Organic (ACO)		Voluntary Certification Standard	Australian Organic Ltd http://austorganic.com/	**1)** Australian Certified Organic Standard 2016 V.4 ACOS_2016_v4.pdf Downloaded on the 29th January 2018 from http://austorganic.com/consumers/australian-certified-organic-standard2/
Baseline Common Code (4C)		Voluntary Verification Standard	Global Coffee Platform http://www.globalcoffeeplatform.org/	**1)** BASELINE COMMON CODE 2016 GCP_Doc_01_Baseline Common Code_v2.1_en Downloaded on the 19th January from http://www.globalcoffeeplatform.org/resources/gcp-baseline-common-code
Bird Friendly		Voluntary Certification Standard	Smithsonian Migratory Bird Centre https://nationalzoo.si.edu/migratory-birds/bird-friendly-coffee	**1)** https://nationalzoo.si.edu/migratory-birds/bird-friendly-farm-criteria
C.A.F.E Practices (Starbucks)		Private Verification Standard	Starbuck Coffee Company in partnership with Conservation International	**1)** C.A.F.E. Practices Generic Scorecard January 2016 Version 3.4 Acquired via email on the 30th January 2018 from Lorena Bustos, Manager Sustainable Coffee Markets at Conservation International **2)** https://www.scsglobalservices.com/starbucks-cafe-practices
Enveritas' Sustainability Standards for	Enveritas	Voluntary Verification Standard	Enveritas. 100 Park Avenue New York City	**1)** SustainabilityStandards for Coffee Producers

Coffee Producers			New York 10017 United States of America	(Version 1.0 2017 Enveritas). Acquired via email on the 15th May 2018 from LuShuang Xu, Project manager at Enveritas
Fairtrade		Voluntary Certification Standard	Fairtrade International https://www.fairtrade.net/	**1)** Fairtrade Standard for small-scale producer organizations. V2.3 (03/04/2019) **2)** Fairtrade Standard for Small-scale Producer Organizations (03.04.2019_v2.3) Interpretation Notes **3)** Fairtrade standard for Small-Scale Producer Organizations v2.0 Requirements overview **4)** At a glance: Revised Fairtrade Standard for Small-Scale Producer Organizations **5)** Fairtrade Standard for Small –scale Producer Organizations Main Changes June 2020 **6)** Fairtrade Standard for Coffee for Small Producer Organizations and Traders Current version: 01.04.2011_v.1.4 **7)** Hazardous Materials List Version: 1.12.2016 v 1.3. All downloaded on the 30th July 2020 from https://www.fairtrade.net/standard/spo
International Federation of Organic Agricultural Movements (IFOAM)		Voluntary Certification Standard	International Federation of Organic Agricultural Movements https://www.ifoam.bio/	**1)** The IFOAM NORMS for Organic Production and Processing Version 2014 © IFOAM-Organics International, June 2017 (Edited version of the IFOAM Norms 2014) Downloaded on the 29th January 2018 from https://www.ifoam.bio/en/ifoam-standard

Nespresso's AAA Sustainable Quality Program		Private Verification Standard	Nespresso in partnership with Rainforest Alliance	**1)** TASQ™ - CORE MODULE, THE TOOL FOR THE ASSESSMENT OF SUSTAINABLE QUALITY 2016 downloaded 13 July 2020 from https://www.nestle-nespresso.com/asset-library/Documents/Nespresso-AAA-TASQ-2016.pdf
Principles & Practices for Sustainable Green Coffee Production		Voluntary Verification Standard	Sustainable Agriculture Initiative Platform Coffee Working Group	**1)** Principles & Practices for Sustainable Green Coffee Production (version 2009) Acquired via email on the 30th January 2018 from Lorena Bustos, Manager Sustainable Coffee Markets at Conservation International
Rainforest Alliance		Voluntary Certification Standard	Rainforest Alliance https://www.rainforest-alliance.org/	**1)** Rainforest Alliance Sustainable Agriculture Standard Farm Requirements June 2020 Version 1 (including affiliated annexes 1-12) Downloaded 13 July 2020 from https://www.rainforest-alliance.org/business/resource-item/2020-sustainable-agriculture-standard-farm-requirements/
UTZ Certified		Voluntary Certification Standard	UTZ https://utz.org/	**1)** UTZ Core Code Individual version 1.1 (2015) **2)** UTZ Coffee Module version 1.1 (2015) Both downloaded on the 19th January 2018 from https://utz.org/resource-library/

C. Supplementary Material 2.3. Example assessment

To help the reader understand our programme theory evaluation methods, we present here an assessment from one standard (UTZ) for one threat process (Increase in biodiversity exploitation and wildlife conflicts). The complete assessments for all standards and threat processes can be requested from the corresponding author.

Standard: UTZ

Threat: Indirect population pressures

Process: Increase in biodiversity exploitation and wildlife conflicts

Assessment description and scale (EC1):

We evaluate to what extent sustainability tools and standards in the coffee industry require producers to anticipate how their development may exacerbate biodiversity exploitation pressures or human-wildlife conflicts when selecting a location and deciding on the scale and design of their coffee operations. Addressing this process implies:

I. To adequately select and design plantations in regions with a high risk of unsustainable biodiversity exploitation (e.g., overhunting, poaching),
II. To anticipate how changes in the landscape may result in wildlife conflicts (e.g., insufficient resource and habitat availability in the landscape, or lack of adequate corridors or other landscape elements to facilitate species mobility), and
III. To create management plans to mitigate these processes.

Spatial scale: Landscape.

Temporal scale: short to long term

Decision stage: Selection of location / Plantation design / Operational phase.

Key decision guidelines (EC2):

- Guidelines to support adequate site selection and design of prospective plantations that anticipate and mitigate potential impacts related to unsustainable biodiversity exploitation (e.g., overhunting, poaching) and wildlife conflict (e.g., insufficient resource and habitat availability in the landscape), which may be exacerbated by coffee development
- Guidelines to protect and minimise the exploitation of flora and fauna during coffee production and processing (e.g., prohibitions on hunting and collection of forest products, restrictions on the use of animals for processing of coffee, proper training, management and signage of restricted areas/species).

Key methodological elements (EC3):

- Identification of species vulnerable to biodiversity exploitation and wildlife conflicts.
- Identification of areas where sustainable biodiversity exploitation can be permitted (e.g., for customary uses)
- Methodological guidance to identify and quantify potential impacts related to unsustainable biodiversity exploitation (e.g., overhunting, poaching) and

wildlife conflict (e.g., insufficient resource and habitat availability in the landscape), which may be exacerbated by coffee development.

Summary:

Evaluation Criterion EC1 - Does the initiative require producers to consider this process in their decisions?

INCLUDED. The UTZ core code protects threatened species from the second year of certification: "Threatened and endangered species in the production area are identified and protected. Hunting, trafficking, or commercial collection of such species does not occur". The code makes useful reference to local laws, IUCN red list and CITES to help identify and manage such species. There is also specific protection of animals used for the processing of coffee within the coffee module, offering added protection against their exploitation. However, there are no requirements for initial site selection to consider an increase in biodiversity exploitation and wildlife conflicts explicitly. Therefore, this process would be better addressed with guidance for site selection of future coffee developments. Nevertheless, these standards include policies to prohibit biodiversity exploitation during coffee operations.

Evaluation Criterion EC2 - Does the initiative provide decision guidelines (e.g., thresholds, safeguards, regulations, etc.) to address this process?

PARTIALLY INCLUDED. The UTZ core code explicitly prohibits the hunting, trafficking and commercial collection of threatened and endangered species, while also having specific guidelines restricting exploitation of animals for processing of coffee beans and how to phase out their use if currently used. However, there are no guidelines on how to sustainably collect wildlife products or restrictions on species not listed as endangered or threatened by the IUCN, CITES, or local authorities. There are also no guidelines on how to consider and mitigate conflicts during the site selection stage of development. Therefore, this standard only partially includes decision guidelines to address this threat process.

Evaluation Criterion EC3 - Does the initiative provide supporting guidance to inform decision making when addressing this process (e.g., forest definitions, mapping protocols, data sources, impact assessments, etc.)?

PARTIALLY INCLUDED. The UTZ core code makes useful reference to the IUCN red list, CITES, as well as national laws to help identify threatened and endangered species. Along with the proper training that is required for management and permanent workers, this shows some guidance to identify and protect these species. However, there is no guidance on how to identify and use areas for sustainable harvest and collection of wildlife species. Together, this would allow partial alleviation from potential conflicts, but until then this standard only provides partial supporting guidance materials and methodologies for informed decision-making to address this threat process.

D. Supplementary Material 2.4. Overall scores for all underlying threat processes and evaluation criteria

Threats are ranked in the same order as Table 2.2. The length of bars is proportional to 100% and represent the proportion of eleven assessed standards which included, partially included, or did not or only minimally included relevant policies, guidelines, and methodologies to address each underlying threat processes.

Underlying threat processes	Criteria 1			Criteria 2			Criteria 3		
	Included	Partially included	Not or only minimally included	Included	Partially included	Not or only minimally included	Included	Partially included	Not or only minimally included
Pollution									
Increase in pollution of soils, air and waterbodies	91%	9%	0%	64%	36%	0%	27%	64%	9%
Forest habitat loss									
Conversion of primary forests	91%	9%	0%	73%	27%	0%	18%	46%	36%
Conversion of riparian forests	91%	9%	0%	36%	55%	9%	27%	55%	18%
Conversion of forest areas that support species of high conservation priority	82%	18%	0%	27%	64%	9%	18%	36%	46%
Conversion of secondary forests	73%	27%	0%	36%	55%	9%	18%	27%	55%
Conversion of rare or threatened forest habitats or ecosystems	73%	27%	0%	27%	55%	18%	9%	36%	55%
Forest loss within plantations	64%	36%	0%	27%	55%	18%	0%	36%	64%
Contribution to forest loss in the landscape	0%	64%	36%	0%	46%	55%	0%	9%	91%
Contribution to forest loss at the regional level	0%	55%	46%	0%	36%	64%	0%	0%	100%

External drivers									
Introduction of invasive species, pests and diseases	73%	27%	0%	64%	36%	0%	9%	64%	27%
Increase in vulnerability to global climate change	9%	27%	64%	0%	36%	64%	0%	0%	100%
Alteration of ecosystems processes									
Alteration of soil and nutrient dynamics	82%	18%	0%	73%	18%	9%	9%	73%	18%
Alteration of hydrological processes	64%	36%	0%	36%	64%	0%	0%	64%	36%
Alteration of local and regional climate regulation processes	0%	9%	91%	0%	9%	91%	0%	0%	100%
Alteration of natural disturbance regimes	0%	18%	82%	0%	0%	100%	0%	0%	100%
Alteration of ecological processes	0%	18%	82%	0%	9%	91%	0%	0%	100%
Non-forest ecosystem land-use-changes									
Conversion of non-forest areas that support species of high conservation priority	64%	36%	0%	27%	46%	27%	0%	46%	55%
Conversion of wetland ecosystems	55%	46%	0%	27%	46%	27%	9%	9%	82%
Conversion of rare or threatened non-forest ecosystems or habitats	36%	64%	0%	9%	73%	18%	9%	27%	64%
Conversion of natural savannah and shrubland ecosystems	18%	82%	0%	18%	27%	55%	0%	9%	91%
Non-forest ecosystems loss at landscape and regional level	0%	46%	55%	0%	27%	73%	0%	0%	100%
Fragmentation of non-forest ecosystems	0%	55%	46%	0%	27%	73%	0%	0%	100%

Indirect land-use-changes									
Conversion of areas used for traditional agriculture or forestry systems	64%	36%	0%	36%	46%	18%	9%	18%	73%
Conversion of key agricultural land for food security at the regional scale	0%	46%	55%	0%	27%	73%	0%	0%	100%
Conversion of land where commodity products of high demand are grown	0%	18%	82%	0%	0%	100%	0%	0%	100%
Increasing population pressure									
Increase in biodiversity exploitation and wildlife conflicts	46%	55%	0%	18%	55%	27%	18%	27%	55%
Rapid increase in human population	9%	46%	46%	0%	9%	91%	0%	0%	100%
Increase of impacts from the development of transportation infrastructure	0%	0%	100%	0%	0%	100%	0%	0%	100%
Forest fragmentation									
Reduction of forest connectivity in the landscape	27%	46%	27%	0%	46%	55%	0%	0%	100%
Loss of habitat heterogeneity in the landscape	18%	82%	0%	0%	82%	18%	0%	9%	91%
Increase in patch size effects	9%	82%	9%	0%	36%	64%	0%	18%	82%
Increase in edge effects	0%	82%	18%	0%	64%	36%	0%	0%	100%
Fragmentation of large and continuous forest areas	0%	36%	64%	0%	0%	100%	0%	0%	100%
Reduction of ecosystem connectivity at the regional level	0%	27%	73%	0%	9%	91%	0%	0%	100%

E. Supplementary Material 3.1. Complete questionnaire tool used in chapter 3

INVITATION TO PARTICIPATE IN A RESEARCH PROJECT

You are invited to participate in a research project being conducted by RMIT University. Please read this sheet carefully and be confident that you understand its contents before deciding whether to participate. If you have any questions about the project, please ask one of the investigators.

PARTICIPANT INFORMATION

Project Title: Coffee consumption in Melbourne

You are invited to participate in a survey about coffee consumption. The survey will ask you questions about your own coffee consumption, your perceptions of different coffee products, sustainability attributes of coffee. You will also be prompted to answer questions related to how you feel about the environment in addition to basic demographic questions. The RMIT Human Research Ethics Committee has approved this project, see details below.

If I agree to participate, what will I be required to do?

The survey should take between 15 to 20 minutes. We do not ask for any identifying information (you do not need to give us your name and email address!). We will ask for basic, non-identifying demographic information (e.g. age and gender). The survey itself asks you to answer questions related to your consumption of coffee and types of coffee products.

What will happen to the information I provide?

Responses will be collated and stored in a spreadsheet as group data, then subjected to analyses. Results may be published in academic journals and presented at academic conferences. Only summary information will be disseminated. Again, no identifying information will be collected as part of the survey. Once we have completed our data collection and analysis, we will import the data we collect to the RMIT server where it will be stored securely for five (5) years.

This study is funded by Zoos Victoria and RMIT University. If you have any concerns about your participation in this project, which you do not wish to discuss with the researchers, then you can contact the Research Ethics Co-ordinator, Research Integrity, Governance and Systems, RMIT University, GPO Box 2476, VIC 3001. Tel: (03) 9925 2251 or email human.ethics@rmit.edu.au

Your consent to participate in this research is indicated by the completion and submission of the attached survey. Please indicate whether you agree to the following: 1. I am over 18 years of age; and 2. I agree to participate in the research project as described.

- I agree
- I decline

This survey pertains to coffee consumption. Have you had a cup of coffee in the last week?

- Yes
- No
- Unsure

Thank you for agreeing to participate in this survey. The first set of questions will ask you a few demographic questions.

Please select your post code from the drop-down menu.

- (drop down list of Melbourne postcode and an option for “My post code is not listed”)

Please indicate your age group:

- 20 of younger
- 21-30
- 31-40
- 41-50
- 51-60
- 61-70
- 71 or older

Please indicate your gender:

- Male
- Female
- Non-binary
- Prefer not to answer
- Other

The first set of questions will ask you to reflect on different aspects of your own coffee consumption.

On average, how many cups of coffee do you drink per WEEK:

- That you make at home [I don't, 1…20, more than 20]
- That you make at your workplace/school [I don't, 1…20, more than 20]
- That you buy from a coffee shop, café or restaurant [I don't, 1…20, more than 20]

From where do you purchase the coffee for your home consumption? Please tick all that apply.

▢ Supermarkets

▢ Convenience stores/petrol stations

▢ Coffee chain stores (e.g. Starbucks, Gloria Jean's)

▢ Specialty coffee shops/ cafés

▢ Online

▢ Other (please specify):

When you purchase coffee for home consumption, what form of coffee do you typically purchase? Please mark all that apply.

▢ Instant

▢ Whole bean to grind at home

▢ Ground

▢ Pre-brewed and canned and / or bottled

▢ Pods/capsules

▢ Other (please specify)

Over the past MONTH, how often did EACH of the following product attributes influence your decision of which coffee products to purchase for home consumption?

	Never	Rarely	Sometimes	Frequently	Almost every time
Taste	○	○	○	○	○
Aroma	○	○	○	○	○

Have enjoyed the product on previous occasions	○	○	○	○	○
Familiarity with the coffee brand	○	○	○	○	○
Type of beans (Arabica / Robusta)	○	○	○	○	○
The look of the packaging	○	○	○	○	○
Price	○	○	○	○	○
Convenience	○	○	○	○	○
Advice from sales person/barista	○	○	○	○	○
Advice form trusted friends/family/colleagues	○	○	○	○	○
Brand reputation	○	○	○	○	○
Single origin source	○	○	○	○	○
Place of origin	○	○	○	○	○
Organic	○	○	○	○	○
Environmentally friendly	○	○	○	○	○
Sustainability	○	○	○	○	○
Fair Trade	○	○	○	○	○

Typically, how often do visit a coffee shop, café or restaurant and drink coffee?

- Daily
- Several times per week
- Once a week
- Once a fortnight
- Once a month
- Less than once a month

When you purchase a coffee from a coffee shop, café or restaurant, how often do you go to the same café/shop/restaurant?

- Always
- Often
- Sometimes
- Rarely
- Never

Over the past WEEK, did you visit any of the following national or international coffee chains? Please mark all that apply.

- ▢ Starbucks
- ▢ Gloria Jean's
- ▢ Hudsons
- ▢ McCafé
- ▢ Other _____
- ▢ I visited none of these in the past week

Over the past WEEK, how often did EACH of the following items influence your decision of which coffee shop or café to purchase coffee from?

	Never	Rarely	Sometimes	Frequently	Almost every time
Location	○	○	○	○	○
Convenience	○	○	○	○	○

Friend/family/work colleagues' choice	○	○	○	○	○
Quality of coffee	○	○	○	○	○
Positive previous experience	○	○	○	○	○
Familiarity	○	○	○	○	○
Value for money	○	○	○	○	○
Competitive price	○	○	○	○	○
Reputation	○	○	○	○	○
Sells organic coffee	○	○	○	○	○
Sells environmentally-friendly/ sustainable coffee	○	○	○	○	○
Sells Fair Trade coffee	○	○	○	○	○

The next set of questions will ask you about your awareness and understanding of the environmental impacts of coffee.

When you think of environmentally friendly coffee, what comes to mind?

Can you please describe below some of the negative impacts that you think the production of coffee may have on the environment?

Please indicate your level of agreement for each of the following statements

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
It is important to maintain biodiversity (nature)	○	○	○	○	○
My coffee purchasing behaviours (including purchasing coffee at a café or for home consumption) can help maintain biodiversity (nature)	○	○	○	○	○

Please indicate your level of awareness for each of the following statements.

	Not aware at all	Somewhat aware	Moderately aware	Aware	Highly aware
Coffee production can have a negative impact on biodiversity (nature)	○	○	○	○	○
There are different methods of coffee production that can cause less loss of biodiversity (nature) than other methods	○	○	○	○	○

For the purpose of this next section, when we refer to environmentally-friendly coffee we'd like you to think about the cultivation/production of the coffee beans. Environmentally friendly coffee production is not associated with reusable coffee cups or other sustainable activities at the point of sale or consumption.

For the purposes of this section, environmentally-friendly coffee production:

- Is shade grown (grown under native tree species on coffee farms)
- Protects endangered species
- Does not contribute to forest loss
- Minimises water and energy use
- Prevents soil loss and protects waterways

- Properly manages waste
- Limits pesticide use in production

Do you know where to find environmentally friendly coffee?

- Yes (Please specify where:)
- No
- Unsure

Have you ever purchased environmentally friendly coffee for home consumption?

- Yes
- No
- Unsure

What, if anything, prevents you from purchasing environmentally friendly coffee for home consumption?

Have you ever purchased environmentally friendly coffee at a coffee shop or café?

- Yes
- No
- Unsure

When you purchase coffee at a coffee shop or café do you generally assume that the coffee provided is environmentally friendly or meets environmentally friendly standards?

- Yes
- No
- Unsure
- Have never thought about it

Please explain below why you assume this.

What prevents you from purchasing environmentally friendly coffee at a cafe?

Have you ever asked your barista if the coffee you purchase is environmentally friendly?

- Yes
- No

Using the 5-point scale below, please indicate how likely you think the statement is.

	Extremely unlikely	Somewhat unlikely	Neither likely nor unlikely	Somewhat likely	Extremely likely
Environmentally friendly coffee is available at the supermarket you frequent the most.	○	○	○	○	○
Environmentally friendly coffee is available at the café that you frequent the most.	○	○	○	○	○

Using the 5-point scale below, please indicate how easy or difficult you think each statement is.

	Extremely difficult	Somewhat difficult	Neither easy nor difficult	Somewhat easy	Extremely easy
Finding environmentally-friendly coffee at your supermarket/grocery store	○	○	○	○	○
Knowing if the coffee you purchase at a café or coffee shop is produced in an environmentally friendly way	○	○	○	○	○
Knowing if the coffee your purchase at the supermarket/grocery store is produced in an environmentally friendly way	○	○	○	○	○

Using the 5-point scale below, please indicate your level of agreement with each statement regarding sustainable/ethical food certifications.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Sustainability/ethical certifications on food products are important to me	○	○	○	○	○
I am more likely to buy a coffee product if it has a sustainable/ethical certification logo on it than if it doesn't	○	○	○	○	○
If a coffee product has a sustainable/ethical certification logo on it, it tells me that it has a smaller environmental/social impact than coffee products without the logo.	○	○	○	○	○
If a coffee product has a sustainable/ethical certification logo on it, it tells me that it is likely to taste better than coffee products without the logo	○	○	○	○	○

Do you recognise the Australian Certified Organic logo above?

- Yes
- No

Have you ever purchased Australian Certified Organic coffee?

- Yes
- No
- Unsure

Given what you think about the Australian Certified Organic logo please indicate the amount of agreement or disagreement you personally feel with each statement.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Australian Certified Organic certified coffee is good for wildlife	○	○	○	○	○
Australian Certified Organic certified coffee helps preserve biodiversity (nature)	○	○	○	○	○
For the most part, Australian Certified Organic coffee is premium (or high quality) coffee	○	○	○	○	○
Australian Certified Organic coffee generally tastes good	○	○	○	○	○
Australian Certified Organic coffee is sold at establishments that	○	○	○	○	○

sell high quality coffee products					
Australian Certified Organic coffee keeps promises and commitments for environmental protection	○	○	○	○	○
Australian Certified Organic coffee products' environmental claims are misleading	○	○	○	○	○
Australian Certified Organic coffee products have a reputation as being environmentally friendly	○	○	○	○	○
I look for the Australian Certified Organic logo when purchasing coffee	○	○	○	○	○

Do you recognise the Fairtrade logo above?

- Yes
- No

Have you ever purchased Fairtrade coffee?

- Yes
- No

- Unsure

Given what you think about the Fairtrade logo please indicate the amount of agreement or disagreement you personally feel with each statement.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Fairtrade certified coffee is good for wildlife	○	○	○	○	○
Fairtrade certified coffee helps preserve biodiversity (nature)	○	○	○	○	○
For the most part, Fairtrade coffee is premium (or high quality) coffee	○	○	○	○	○
Fairtrade coffee generally tastes good	○	○	○	○	○
Fairtrade coffee is sold at establishments that sell high quality coffee products	○	○	○	○	○
Fairtrade coffee keeps promises and commitments for environmental protection	○	○	○	○	○
Fairtrade coffee products' environmental claims are misleading	○	○	○	○	○
Fairtrade coffee products have a reputation as being environmentally friendly.	○	○	○	○	○
I look for the Fairtrade logo when purchasing coffee	○	○	○	○	○

Do you recognise the UTZ logo above?

- Yes
- No

Have you ever purchased UTZ coffee?

- Yes
- No
- Unsure

Given what you think about the UTZ logo please indicate the amount of agreement or disagreement you personally feel with each statement.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
UTZ certified coffee is good for wildlife	○	○	○	○	○
UTZ certified coffee helps preserve biodiversity (nature)	○	○	○	○	○
For the most part, UTZ coffee is premium (or high quality) coffee	○	○	○	○	○
UTZ coffee generally tastes good	○	○	○	○	○
UTZ coffee is sold at establishments that sell high quality coffee products	○	○	○	○	○

UTZ coffee keeps promises and commitments for environmental protection	○	○	○	○	○
UTZ coffee products' environmental claims are misleading	○	○	○	○	○
UTZ coffee products have a reputation as being environmentally friendly.	○	○	○	○	○
I look for the UTZ logo when purchasing coffee	○	○	○	○	○

Do you recognise the Rainforest Alliance logo above?

- Yes
- No

Have you ever purchased Rainforest Alliance coffee?

- Yes
- No
- Unsure

Given what you think about the Rainforest Alliance logo please indicate the amount of agreement or disagreement you personally feel with each statement.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Rainforest Alliance certified coffee is good for wildlife	○	○	○	○	○
Rainforest Alliance certified coffee helps preserve biodiversity (nature)	○	○	○	○	○
For the most part, Rainforest Alliance coffee is premium (or high quality) coffee	○	○	○	○	○
Rainforest Alliance coffee generally tastes good	○	○	○	○	○
Rainforest Alliance coffee is sold at establishments that sell high quality coffee products	○	○	○	○	○
Rainforest Alliance coffee keeps promises and commitments for environmental protection	○	○	○	○	○
Rainforest Alliance coffee products' environmental claims are misleading	○	○	○	○	○
Rainforest Alliance coffee products have a reputation as being environmentally friendly.	○	○	○	○	○

I look for the Rainforest Alliance logo when purchasing coffee	○	○	○	○	○

What are the benefits of purchasing environmentally friendly coffee at a coffee shop, café or restaurant?

What are the benefits of purchasing environmentally friendly coffee for at home consumption?

Do you use a reusable coffee cup when drinking takeaway coffee (e.g. a KeepCup or coffee mug)?

- Yes
- No

How frequently do you use your reusable coffee cup when you get a takeaway coffee?

- Always
- Most of the time
- About half the time
- Sometimes
- Never

At home, how do you usually dispose of used coffee grounds?

▢ Put them in the general rubbish

▢ Put them in the compost/worm farm

▢ Scatter them outside/in the garden

▢ Repurpose (e.g. as body scrub)

▢ Other (please specify):

▢ Don’t ever have used coffee grounds at home

In an earlier question you selected that you use pods/capsules to make coffee. At home what do you do with your used coffee pods/capsules?

- Put them in the general rubbish
- Put them in the recycling bin
- Send them off to be refilled
- Repurpose them
- Other (please specify):
- Don’t have a coffee pod machine at home

Using the 5-point scale below, please indicate how much you personally agree or disagree with each statement. Please be as accurate as possible, so our results are a realistic representation of your opinions, feelings and views.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
We are approaching the limit of the number of people the earth can support.	○	○	○	○	○
Humans have the right to modify the natural environment to suit their needs.	○	○	○	○	○
When humans interfere with nature it often produces disastrous consequences.	○	○	○	○	○
Human ingenuity will ensure that we do NOT make the earth unliveable.	○	○	○	○	○
Humans are severely abusing the environment.	○	○	○	○	○
The earth has plenty of natural resources if we just learn how to develop them.	○	○	○	○	○

Plants and animals have as much right as humans to exist.	○	○	○	○	○
The balance of nature is strong enough to cope with the impacts of modern industrial nations.	○	○	○	○	○
Despite our special abilities humans are still subject to the laws of nature.	○	○	○	○	○
The so-called 'ecological crisis' facing humankind has been greatly exaggerated.	○	○	○	○	○
The earth is like a spaceship with very limited room and resources.	○	○	○	○	○
Humans were meant to rule over the rest of nature.	○	○	○	○	○
The balance of nature is very delicate and easily upset.	○	○	○	○	○
Humans will eventually learn enough about how nature works to be able to control it.	○	○	○	○	○
If things continue on their present course, we will soon experience a major ecological catastrophe	○	○	○	○	○

Of the statements below, which best describes your current willingness to consume environmentally friendly coffee

- I am not doing this and I am not willing to
- I would like to do this, but I do not know how.
- I would like to do this, and I already know how to start
- I am doing this already

You are almost finished! The final set of questions will ask you a few questions about yourself.

With what ethnic group do you identify? If you identify with multiple please select those that apply.

▢ Australian

▢ Indigenous Australian or Torres Strait Islander

▢ New Zealander

▢ Asian

▢ Indian

▢ Middle Eastern

▢ European

▢ North American

▢ South American

▢ African

▢ Decline to answer

▢ Other, please specify

Please identify the highest qualification you have completed:

- Less than Year 12
- High school
- TAFE certificate or diploma
- Undergraduate Degree
- Postgraduate Diploma
- Postgraduate qualification- Masters

- Postgraduate qualification- Doctorate
- Other (Please specify)
- Prefer not to answer

Please indicate your gross annual household income. Please use an estimate based on the total income for all members contributing directly to your household (this information will not be shared with any other individuals):

- No Income
- $18,200 or less
- $18,201 – $37,000
- $37,001 – $80,000
- $80,001 – $180,000
- $180,001 and over
- Prefer not to answer

Please indicate your political orientation on the 10 point scale below, with 0 being left, 10 being right and 5 being the centre:

Left										Right
0	1	2	3	4	5	6	7	8	9	10

I prefer not to answer

Thank you from RMIT University and Zoos Victoria for taking the time to complete this survey.

F. Supplementary Material 3.2. Proportion of respondents overall and within each of the four consumer categories (early adopters, early majority, late majority, and laggards) for various current coffee consumption behaviour questions.

	Early adopters (n = 93)	Early majority (n = 286)	Late majority (n = 636)	Laggards (n = 127)	**All respondents (n = 1,142)**
Average number of cups of coffee respondents drink per week:					
Made at home	14.33	12.84	12.46	13.36	**12.81**

Bought from café, coffee shop, or restaurant	10.35	9.97	9.89	10.87	**10.06**
Percent within segment who buy coffee for home consumption from:					
Supermarkets	74.2%	76.2%	75.8%	76.4%	**75.8%**
Convenience stores or petrol stations	7.5%	10.1%	9.1%	5.5%	**8.8%**
Coffee chain stores	16.1%	15.7%	10.8%	11.8%	**12.6%**
Speciality coffee shops / cafés	40.9%	28.7%	23.1%	22.8%	**25.9%**
Online	7.5%	4.9%	6.4%	3.1%	**5.8%**
Percent within segment who buy coffee for home consumption in the form of:					
Instant coffee	40.9%	61.5%	58.2%	56.7%	**57.4%**
Whole beans	40.9%	23.1%	18.9%	18.9%	**21.7%**
Ground coffee	35.5%	25.5%	23.7%	26.8%	**25.5%**
Pods/capsules	22.6%	27.3%	32.5%	29.1%	**30.0%**
Pre-brewed and canned or bottled	5.4%	7.0%	3.8%	0.8%	**4.4%**

G. Supplementary Material 3.3. Pearson residuals for “Finding environmentally friendly coffee at my supermarket/grocery store is”

Pearson residuals for deviation in conditional independence between responses to the question “Finding environmentally friendly coffee at my supermarket/grocery store is” and stated willingness to consume environmentally friendly coffee (p-value = 8.271991e-20; n = 1,142). Pearson residuals greater than 2 indicate there are more responses than would be expected, while Pearson residuals less than -2 indicate there are less responses than would be expected.

Stated willingness to consume environmentally friendly coffee	**Finding environmentally friendly coffee at my supermarket/grocery store is**				
	Extremely difficult	**Somewhat difficult**	**Neither easy nor difficult**	**Somewhat easy**	**Extremely easy**
I am doing this already	*-1.257*	*-1.563*	***-2.276***	**3.436**	**4.725**
I would like to do this, and I already know how to start	*-1.565*	***-2.394***	*-0.815*	**3.522**	**2.491**
I would like to do this, but I do not know how	0.809	**3.381**	0.702	***-3.674***	***-3.123***
I am not doing this, and I am not willing to	1.613	***-2.637***	1.598	*-0.004*	*-0.794*

H. Supplementary Material 3.4. Example RFRFE output

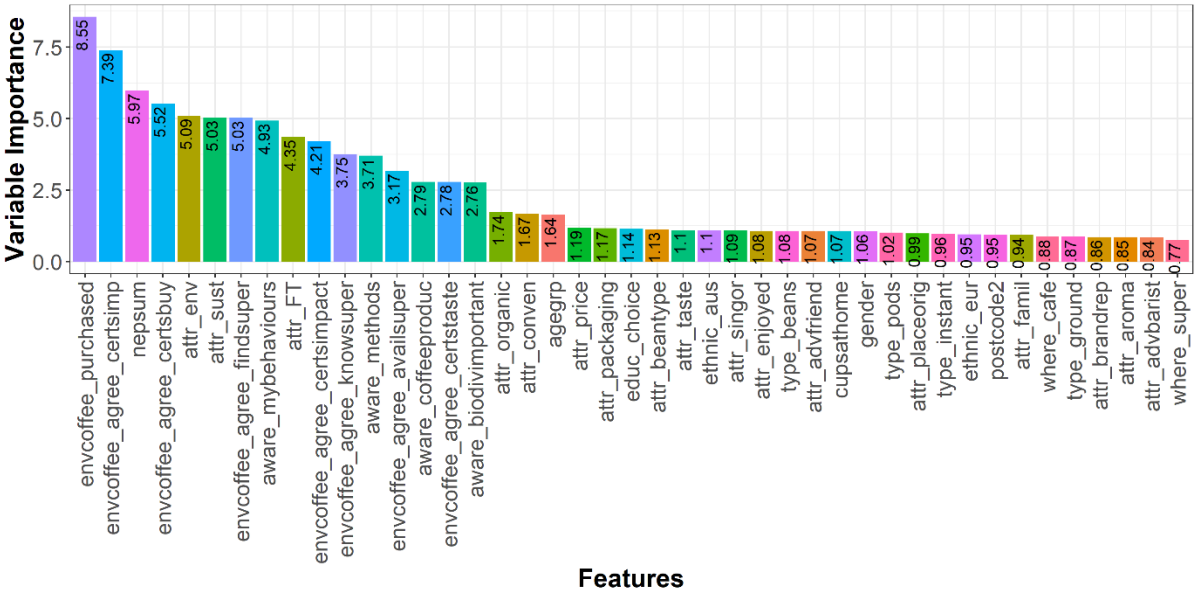
Output showing model accuracy and kappa reach a maximum level (0.6195 and 0.2753 respectively) with twenty-four features retained in the model (shown by asterisk). However, with two or more variables model accuracy only fluctuates between 0.60 – 0.62 and kappa between 0.23 – 0.28.

Number of Variables	**Accuracy**	**Kappa**	**Accuracy SD**	**Kappa SD**
1	0.5731	0.1341	0.03520	0.07372
2	0.6045	0.2369	0.03454	0.07426

3	0.6067	0.2290	0.03614	0.07625
4	0.5780	0.2183	0.04467	0.07624
5	0.5879	0.2409	0.03912	0.07582
6	0.5918	0.2458	0.04128	0.07906
7	0.5973	0.2558	0.04209	0.07795
8	0.6072	0.2708	0.04322	0.08195
9	0.5986	0.2686	0.04382	0.08235
10	0.6030	0.2721	0.04471	0.08535
11	0.6071	0.2779	0.04506	0.08526
12	0.6058	0.2705	0.04420	0.08474
13	0.6025	0.2640	0.04200	0.07787
14	0.6055	0.2665	0.04091	0.07571
15	0.6018	0.2573	0.03942	0.07138
16	0.6060	0.2671	0.04047	0.07398
17	0.6108	0.2751	0.04183	0.07747
18	0.6097	0.2673	0.03987	0.07593
19	0.6154	0.2778	0.03962	0.07668
20	0.6158	0.2739	0.03873	0.07607
21	0.6156	0.2711	0.03861	0.07565
22	0.6176	0.2746	0.03906	0.07719
23	0.6187	0.2735	0.04032	0.08019
24*	**0.6195**	**0.2753**	**0.03771**	**0.07396**
25	0.6178	0.2734	0.03708	0.07191
26	0.6156	0.2662	0.03693	0.07253

27	0.6163	0.2691	0.03822	0.07633
28	0.6174	0.2678	0.03905	0.07736
29	0.6141	0.2611	0.04039	0.07778
30	0.6119	0.2551	0.04522	0.08754
31	0.6135	0.2545	0.04539	0.09093
32	0.6137	0.2545	0.04117	0.08263
33	0.6132	0.2524	0.04147	0.08297
34	0.6132	0.2510	0.03992	0.08256
35	0.6102	0.2441	0.03725	0.07633
36	0.6122	0.2498	0.03771	0.07697
37	0.6146	0.2532	0.03677	0.07641
38	0.6141	0.2491	0.04128	0.08462
39	0.6106	0.2407	0.03916	0.08054
40	0.6128	0.2462	0.03956	0.07994
41	0.6101	0.2402	0.03914	0.07947
42	0.6088	0.2379	0.03827	0.07784
43	0.6110	0.2395	0.04036	0.08205

I. Supplementary Material 3.5. Example ranked variable importance based on random forest recursive feature elimination model.



K. Supplementary Material 3.6. Pearson residuals for “Have you ever purchased environmentally friendly coffee for home consumption?”

Pearson residuals for deviation in conditional independence between responses to the question “Have you ever purchased environmentally friendly coffee for home consumption?” and stated willingness to consume environmentally friendly coffee (p-value = 2.824863e-47; n = 1,142). Pearson residuals greater than 2 indicate there are more responses than would be expected, while Pearson residuals less than -2 indicate there are less responses than would be expected.

Stated willingness to consume environmentally friendly coffee	**Have you ever purchased environmentally friendly coffee for home consumption?**		
	No	**Unsure**	**Yes**
I am doing this already	***-4.903***	*-1.427*	**10.351**
I would like to do this, and I already know how to start	*-1.473*	*-1.234*	**4.312**
I would like to do this, but I do not know how	0.947	**2.804**	***-5.776***
I am not doing this, and I am not willing to	**4.288**	***-3.201***	***-2.403***

M. Supplementary Material 3.7. Pearson residuals for “Sustainability / ethical certifications on food products are important to me”

Pearson residuals for deviation in conditional independence between responses to the question “Sustainability / ethical certifications on food products are important to me” and stated willingness to consume environmentally friendly coffee (p-value = 5.684756e-70; n = 1,142). Pearson residuals greater than 2 indicate there are more responses than would be expected, while Pearson residuals less than -2 indicate there are less responses than would be expected.

Stated willingness to consume environmentally friendly coffee	**Sustainability / ethical certifications on food products are important to me**				
	Strongly disagree	**Somewhat disagree**	**Neither agree nor disagree**	**Somewhat agree**	**Strongly agree**
I am doing this already	*-1.914*	***-2.358***	***-3.058***	*-1.244*	**9.650**
I would like to do this, and I already know how to start	*-1.868*	*-1.142*	***-4.074***	**3.561**	**2.548**
I would like to do this, but I do not know how	***-3.009***	*-0.047*	**3.583**	0.100	***-4.103***
I am not doing this, and I am not willing to	**11.173**	**3.838**	0.712	***-4.504***	***-2.900***

N. Supplementary Material 4.1. Background and rationale for using co-design with coffee consumers to address biodiversity conservation

Coffee is a globalised commodity with profits predominantly made in ‘industrialised’ countries at the expense of social, economic, and environmental issues in coffee producing communities (Panhuysen and Pierrot 2018). Compounding this, the coffee value-chain is buyer-driven by roasters, retailers and traders who capture the majority of profits with a distinct lack of transparency, traceability or accountability (Panhuysen and Pierrot 2018). Coffee agriculture can either encroach into native vegetation and decimate the local biodiversity, or be grown amongst diverse agroforestry systems that support significant local biodiversity (Buechley et al. 2015). This latter approach is generally termed sustainable coffee when coupled with social and economic improvements (Tscharntke et al. 2015, DeFries et al. 2017). Despite challenges, the sustainable coffee movement has grown significantly in a matter of decades. The coffee industry now suggest this movement has put coffee on track to become the world’s first globally sustainable crop (Conservation International 2021). For the 2016/17 crop-year, 55% of global coffee was produced under at least one of the major sustainability certifications or verifications that exist within the industry (e.g., Fairtrade, Rainforest Alliance, Starbucks' C.A.F.E. Practices) (Tscharntke et al. 2015, DeFries et al. 2017, Panhuysen and Pierrot 2018). Yet, only 11% of all coffee was bought under those same certifications or verifications (Panhuysen and Pierrot 2018). This gap between the volume of sustainability-compliant coffee available at the producer level and the volume buyers actually purchase as ‘sustainable’ only continues to widen. This appears to be due to production shifts away from South America, where these systems were developed, to Africa and Asia, where these systems appear unable to reach the smallholder producers (Panhuysen and Pierrot 2014, 2018). Thus, there is a real divide between the expectations of producers gaining access to specialty markets or price premiums for their sustainable coffee and the reality of cost-cutting value-chains unwilling to pay for the true value of coffee.

Sustainability certifications and verifications are an important but not sufficient solution to address the social, economic, and environmental issues within the coffee industry. Sustainability certifications, provided by independent third-party bodies (e.g., Fairtrade, UTZ, or Rainforest Alliance), tend to drive support and demand for their

products by relying on brand-recognition or the intrinsic motivation of ethically and/or sustainably minded consumers. Conversely, sustainability verifications that are internal to individual brands or companies (Nespresso's AAA Sustainable Quality Program and Starbucks' C.A.F.E. Practices) are designed to ensure part or all of the coffee they buy meet a minimum set of social, economic, and environmental criteria. Promisingly, young consumers increasingly appreciate information about the sustainability and ethical sourcing of their coffee (Panhuysen and Pierrot 2018). Yet, the growth in demand for sustainable coffee by coffee roasters, retailers, traders and individual consumers has been too slow to match globally-rocketing demand for coffee overall, which is predicted to more than double by 2050 (Panhuysen and Pierrot 2018, Conservation International 2021).

To better understand how social marketing can address this issue, we applied the seven-step co-design framework (Trischler et al. 2019) to generate consumer-driven ideas for interventions to change coffee consumer behaviour within a large metropolitan university in Australia.

Activity Booklet

Gender:

Age:

THE UNIVERSITY of ADELAIDE

Role at University:

TOP AND BOTTOM THREE CAMPAIGN ITEMS

Which **THREE** campaign items do you **LIKE** the most?

Please write down the campaign name/number below with **one sentence on why you like it**

1.

2.

3.

Which **THREE** campaign items do you **DISLIKE** the most?

Please write down the campaign name/number below with **one sentence on why you DO NOT like it**

1.

2.

3.

If you can receive multiple campaign items, which items would you prefer?

Please write down the campaign names/numbers below

1

More options

You receive a greater variety of sustainable coffees to choose from.

Likes

Dislikes

2

Commitments

"I pledge to only buy my coffee from cafes that use sustainably sourced beans for the remainder of 2019"

You publicly pledge what you will do to support sustainable coffee

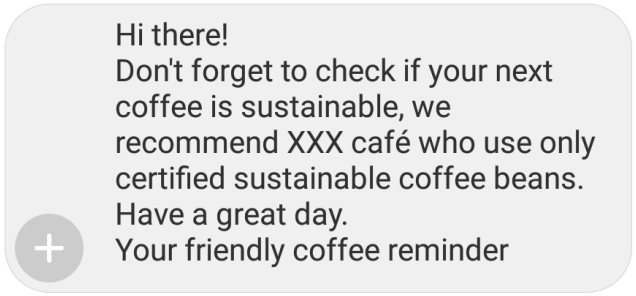
You set a realistic timeline to follow through with this commitment.

Likes

Dislikes

3

Prompts



You receive text/email messages reminding you to choose sustainable coffee for your next purchase.

Likes

Dislikes

4

Demarketing

Demarketing campaign to encourage consumers to make their own coffee and buy certified sustainable coffee.

Likes

Dislikes

5

Social Norms

80% of your colleagues are buying certified sustainable coffee. Join the movement!

You would see the above message at cafes around campus and anywhere else you drink your coffee.

Likes

Dislikes

6

Taste testing events

You have the opportunity to taste a range of certified sustainable coffees that can be purchased at university cafes or for your own supplies.

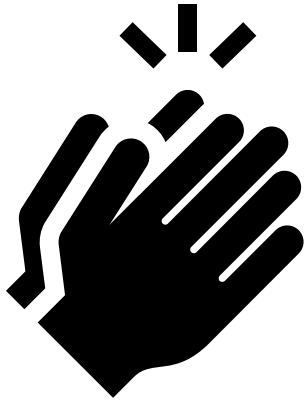
Likes

Dislikes

7

Feedback

Well done! 90% of the coffees you've bought this month were sustainable!
That's better than most coffee drinkers in Adelaide this month.



You receive feedback when you scan your rewards card with every purchase at participating cafes.

Likes

Dislikes

8

Incentives

You receive a 20c discount when you choose certified sustainable coffee over the non-sustainable alternative.

Likes

Dislikes

9

Event

You have the opportunity learn more about sustainable coffee at an event on campus.

Likes

Dislikes

10

Certified sustainable labelling

You see the above labels where you can buy certified sustainable coffee. That way you know which cafes and suppliers use sustainable beans.

Likes

Dislikes

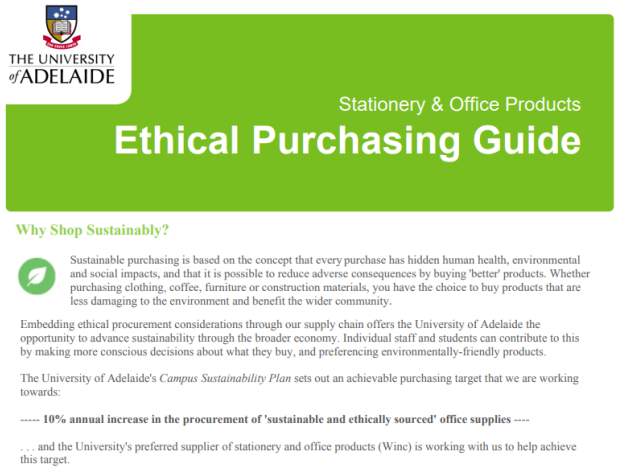
Make sustainable default

You don’t need to choose!
The default coffee choice in all stores are sustainable.

Likes

Dislikes

Sustainable coffee purchasing guide



THE UNIVERSITY of ADELAIDE

Stationery & Office Products

Ethical Purchasing Guide

Why Shop Sustainably?

Sustainable purchasing is based on the concept that every purchase has hidden human health, environmental and social impacts, and that it is possible to reduce adverse consequences by buying 'better' products. Whether purchasing clothing, coffee, furniture or construction materials, you have the choice to buy products that are less damaging to the environment and benefit the wider community.

Embedding ethical procurement considerations through our supply chain offers the University of Adelaide the opportunity to advance sustainability through the broader economy. Individual staff and students can contribute to this by making more conscious decisions about what they buy, and preferencing environmentally-friendly products.

The University of Adelaide's *Campus Sustainability Plan* sets out an achievable purchasing target that we are working towards:

----- **10% annual increase in the procurement of 'sustainable and ethically sourced' office supplies** ----

. . . and the University's preferred supplier of stationery and office products (Winc) is working with us to help achieve this target.

You receive a sustainable coffee purchasing guide, highlighting all the cafes on campus that use certified sustainable coffee, as well as what to look for and where to buy your own sustainable coffee around Adelaide.

Likes

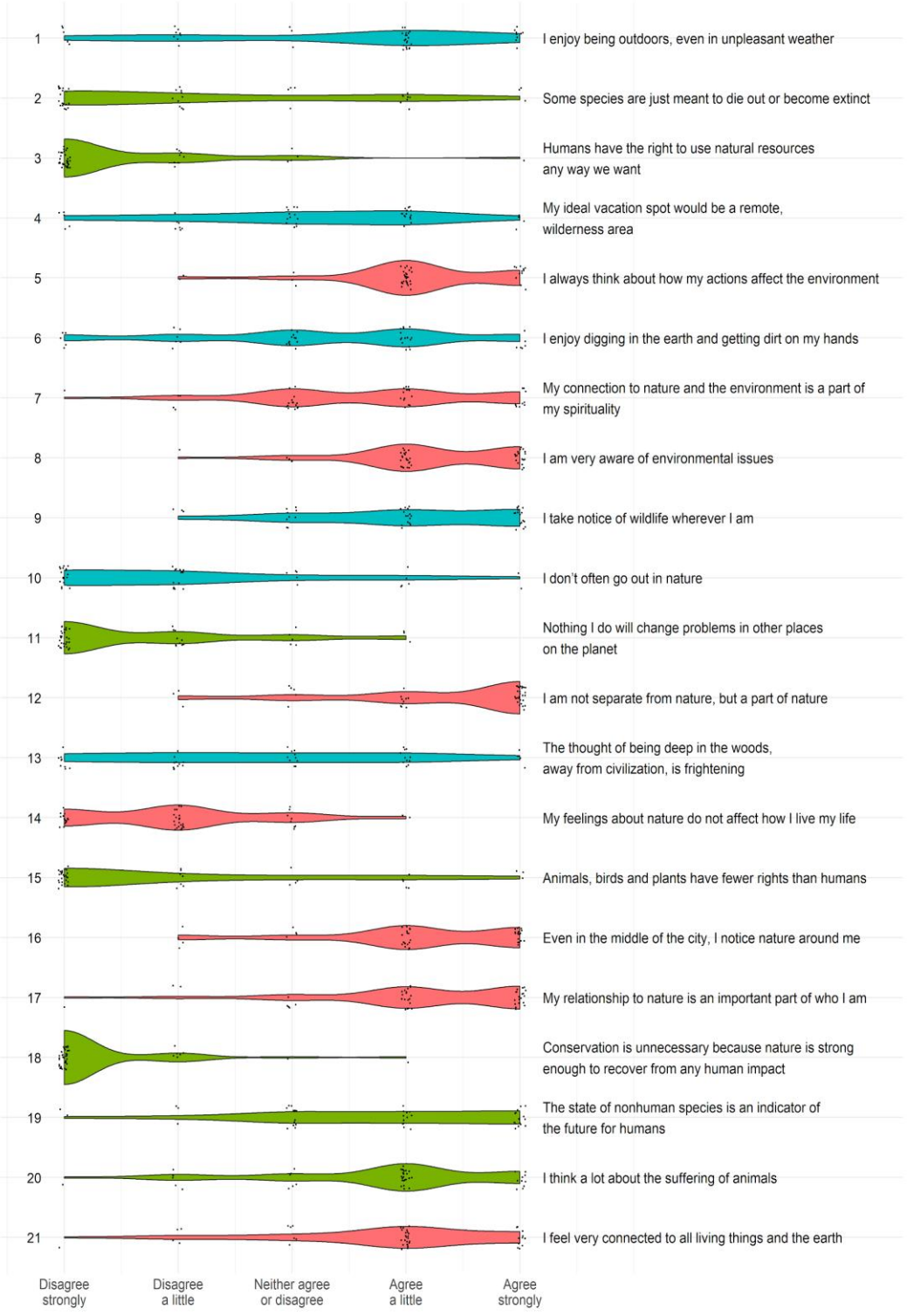
Dislikes

P. Supplementary Material 4.3. Example recruitment poster

Originally printed to full A4 size

Q. Supplementary Material 4.4. Distribution of co-design end-user responses to Nature Relatedness Scale questions

N = 45. Reverse scored items: 2, 3, 10, 11, 13, 14, 15, 18; NR-self items (pink): 5, 7, 8, 12, 14, 16, 17, 21; NR-perspective items (green): 2, 3, 11, 15, 18, 19, 20; NR-experience items (blue): 1, 4, 6, 9, 10, 13.



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