



MONASH University

**Encouraging Victorians to connect with,
and to protect, the natural environment**

Melissa Anne Hatty

BA, BSc (Hons.), MAppPsych (Health)

A thesis submitted for the degree of Doctor of Philosophy at
Monash University in 2021
Monash Sustainable Development Institute

Copyright notice

© Melissa Anne Hatty (2021-2022)

I certify that I have made all reasonable efforts to secure copyright permissions for third-party content included in this thesis and have not knowingly added copyright content to my work without the owner's permission.

Abstract

Biodiversity is being destroyed at a rate unprecedented in human history, threatening the very systems and processes upon which all species, including humans, depend. Addressing biodiversity destruction is far from simple, yet individual-level behaviour change has an important role to play. In recent years, the notion of (re)connecting people with nature as a means of involving the public in conservation has gained increased prominence in the academic literature and in government policy. Detailed understanding of connection with nature is, however, currently lacking.

This thesis sought to better understand connection with nature (CN), and its relationships with concepts of nature, time spent in nature (TIN), and nature-based pro-biodiversity behaviours (PBB) among adults living in Victoria, Australia.

Study 1 explored the dimensional structure of CN and describes the development of a self-report multidimensional instrument – the CN-12. Results revealed three dimensions of CN-Identity, CN-Experience, and CN-Philosophy. The CN-12 total and dimension scores were stable over a 12-month period and correlated positively with TIN, PBB, and with two existing multidimensional CN instruments. Preliminary analyses also suggested that different CN-12 dimensions were more strongly correlated with some PBB than other dimensions or the CN-Total score.

Study 2 considered how people understand and describe "nature" – their concepts of nature – and how such concepts relate to CN and PBB. Results revealed three concepts of nature categories: descriptive (e.g. plants, animals), normative (e.g. conservation, life), and experiential (e.g. activities in, and positive emotions about, nature), plus a complex category (two or more of the descriptive, normative, or experiential categories). CN scores (total and dimensions) were higher among participants who described nature in experiential or complex terms than those who used descriptive terms. Participants who described nature in experiential terms participated in environmental volunteering, citizen science, litter clean-ups, and community gardening more often than those who used descriptive terms. Concepts of nature moderated the relationship between CN and frequency of picking up litter.

Study 3 considered the role of time spent in nature – generally, in different types of nature, and while participating in PBB – on change in CN over a 12-month period. Results revealed that change in CN over the year was predicted by time spent in nature – generally, in

protected areas, and in urban parks – and by frequency of participating in environmental volunteering and picking up litter.

The synthesis chapter details a path analysis assessing the conceptual framework linking CN, concepts of nature, TIN, and nature-based PBB. Results suggested CN at Time 1 was the strongest predictor of CN at Time 2. Time spent in nature (generally), and participating in picking up litter predicted CN at Time 1; descriptive concepts of nature were negatively related to CN at Time 2. Time spent in nature – generally, in protected areas, and urban parks – and picking up litter were the strongest predictors of CN at Time 2.

These findings can inform government policies intended to increase CN and participation in PBB. Policies and programs should focus on fostering a sense of identity relative to nature, consider how nature is communicated, provide spaces that encourage active engagement with nature, and maximise participation in nature-based PBB.

Publications during enrolment

Hatty, M. A., Smith, L. D. G., Goodwin, D., & Mavondo, F. T. (2020). The CN-12: A brief, multidimensional connection with nature instrument. *Frontiers in Psychology*, 11(1566), 1–14. <https://doi.org/10.3389/fpsyg.2020.01566>

Hatty, M. A., Goodwin, D., Smith, L. D. G., & Mavondo, F. T. (2021). Speaking of nature: Relationships between how people think about, connect with, and act to protect nature. (accepted for publication with *Ecology & Society*)

Hatty, M. A., Mavondo, F. T., Goodwin, D., & Smith, L. D. G. (2021). Nurturing connection with nature: The role of spending time in nature and nature-based conservation behaviours. (returned for revision with *Ecosystems & People*)

Selinske, M. J., Garrard, G. E., Gregg, E. A., Kusmanoff, A. M., Kidd, L. R., Cullen, M. T., Cooper, M., Geary, W. L., **Hatty, M. A.**, Hames, F., Kneebone, S., McLeod, E. M., Ritchie, E. G., Squires, Z. E., Thomas, J., Willcock, M. A. W., Blair, S., & Bekessy, S. A. (2020). Identifying and prioritizing human behaviors that benefit biodiversity. *Conservation Science and Practice*, e249, 1–19. <https://doi.org/10.1111/csp2.249>

Thesis including published works declaration

I hereby declare that this thesis contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

This thesis includes one original paper published in a peer reviewed journal, one paper accepted for publication, and one paper returned for revision. The core theme of the thesis is understanding connection with nature and its relationship with time spent in nature, concepts of nature, and pro-biodiversity behaviours. The ideas, development, and writing up of all the papers in the thesis were the principal responsibility of myself, the student, working within the Monash Sustainable Development Institute under the supervision of Professor Liam Smith, Dr Denise Goodwin, and Professor Felix Mavondo.

The inclusion of co-authors reflects the fact that the work came from active collaboration between researchers and acknowledges input into team-based research.

In the case of Chapters 5, 6, and 7 my contribution to the work involved the following:

Thesis Chapter	Publication Title	Status	Nature and % of student contribution	Co-author name(s) Nature and % of Co-author's contribution*	Co-authors Monash student
5	The CN-12: A brief, multidimensional connection with nature instrument	Published	70%: conceptualisation, data collection and analyses, writing first draft, writing subsequent and final drafts following supervisor feedback	<ol style="list-style-type: none"> 1. Liam Smith (10%): Conceptualisation, feedback on drafts, supervision. 2. Denise Goodwin (10%): Conceptualisation, feedback on drafts, supervision. 3. Felix Mavondo (10%): Conceptualisation, feedback on drafts, supervision, statistical analyses. 	No
6	Speaking of nature: Relationships between how people think about, connect with, and act to protect nature.	Accepted for publication	70%: conceptualisation, data analyses, writing first draft, writing subsequent and final drafts following supervisor feedback	<ol style="list-style-type: none"> 1. Denise Goodwin (10%): Conceptualisation, data coding, feedback on drafts, supervision. 2. Liam Smith (10%): Conceptualisation, feedback on drafts, supervision. 3. Felix Mavondo (10%): Conceptualisation, feedback on drafts, supervision, statistical analyses. 	No
7	Nurturing connection with nature: The role of spending time in nature and nature-based conservation behaviours.	Returned for revision	70%: conceptualisation, data analyses, writing first draft, writing subsequent and final drafts following supervisor feedback	<ol style="list-style-type: none"> 1. Felix Mavondo (10%): Conceptualisation, feedback on drafts, supervision, statistical analyses. 2. Denise Goodwin (10%): Conceptualisation, feedback on drafts, supervision. 3. Liam Smith (10%): Conceptualisation, feedback on drafts, supervision. 	No

I *have* renumbered sections of submitted and accepted papers in order to generate a consistent presentation within the thesis.

Student name: Melissa Hatty

Date: 10 December 2021

Resubmit date: 20 April 2022

I hereby certify that the above declaration correctly reflects the nature and extent of the student's and co-authors' contributions to this work. In instances where I am not the responsible author I have consulted with the responsible author to agree on the respective contributions of the authors.

Main Supervisor name: Liam Smith

Date: 10 December 2021

Resubmit date: 20 April 2022

Acknowledgements

First and foremost, a very big thank you to my supervisors – Liam Smith, Denise Goodwin, and Felix Mavondo – your guidance and support on this journey have been immeasurable. A particular shout-out to Felix for sharing voluminous wisdom of stats, the publication process, and all things PhD; to Denise for gentle encouragement and a voice of reason; and to Liam for rolling with my metaphorical punches and exasperations.

Another very big thank you to Kim Lowe and Fern Hames. Your support, encouragement, light-heartedness, and humour have made this journey far smoother than it might otherwise have been. A particular thank you for helping me navigate the ins and outs of policy and state government, and for financial support of the VVN follow-up survey and first publication. Thank you also to staff at ARI and DELWP more broadly for making me feel welcome and including me in a bunch of interesting projects.

Thank you to my academic panel – Annette Bos, Rob Raven, and Sarah Bekessy – for guidance through the milestone process. To Hunter Poelsma at Monash eSolutions, for saving me much heartache when my laptop died in early 2021. And to Fatima Abdulrahman, post-grad admin demigoddess, for help with various bits of paperwork and chats about plants.

Thank you to the incredible staff at BWA for organising the GRIP orientation program – absolute genius! And a particular shout-out to Geoff Paine for documenting the GRIPster journey – how young and naïve we were back in 2018...

A very special mention and great big thank you to my fellow GRIPsters. I would not have made it this far without you. Literally.

And on a personal note, to Ben for support and patience during a tough first year. You put up with a lot and asked for very little in return – thank you. To Mum, Dad, and Brother D – thank you for love, support, understanding, and generally being such wonderful humans. To my friends and family, thank you for rolling with the general ebb and flow of a crazy workload, long periods of absence, for checking in when I needed it most, and for listening to my frustrations.

And finally, to Steve...



... my giant bundle of unconditional love. Thank you for keeping me sane.

This research was supported by an Australian Government Research Training Program (RTP) Scholarship, and part-funded by the Victorian Government Department of Environment, Land, Water and Planning (DELWP).

Contents

Tables	14
Figures	14
Abbreviations	16
Chapter 1: Introduction.....	17
The issue of biodiversity destruction.....	17
The role of human behaviour	18
Involving the public	19
Connection with nature	19
The research partnership: Victorian State Government.....	20
The current thesis	21
Theoretical and conceptual frameworks	23
Aims and objectives.....	25
Researcher position.....	26
Thesis overview	26
Chapter 2: The policy context.....	28
Global conservation policy	29
The Convention on Biological Diversity	29
Strategic Plan for Biodiversity 2011-2020 and Aichi Targets, and Post-2020 Global Biodiversity Framework.....	29
Australian conservation policy	30
Australia's Biodiversity Conservation Strategy 2010-2030 and Australia's Strategy for Nature 2019-2030.....	31
Conservation policy and human-nature relationships	32
Emerging acknowledgement of connection with nature in conservation policy .	33
Victorian conservation policy	36
Protecting Victoria's Environment – Biodiversity 2037	37
The Victorians Value Nature surveys	38
Chapter summary	38
Chapter 3: Connection with nature.....	40
Terminology and definitions	40
Themes appearing in definitions of CN	47
Theoretical and conceptual frameworks	51
Measurement of CN.....	54

Self-report questionnaires	56
Critiques of the CN construct.....	59
Understanding "nature" relative to "connection with nature"	59
CN as state or trait	61
Nurturing CN.....	63
Spending time in different types of nature	64
The quality of nature experiences	65
Nature-based pro-biodiversity behaviours.....	66
Chapter summary	68
Chapter 4: Methodological overview	69
Chapter 5: The CN-12: A brief, multidimensional connection with nature instrument (Study 1).....	73
Chapter 6: Speaking of nature: Relationships between how people think about, connect with, and act to protect nature (Study 2)	88
Chapter 7: Nurturing connection with nature: The role of spending time in nature and nature-based conservation behaviours (Study 3).....	110
Chapter 8: Conceptual framework synthesis.....	128
Method.....	128
Data screening	128
Data analysis.....	129
Results.....	130
Chapter 9: Discussion and conclusions.....	131
Objective 1: Explore and clarify dimensions of CN; develop a brief yet parsimonious self-report connection with nature instrument; investigate relationships between CN, TIN, and PBB (Study 1).....	131
CN-12 dimensions.....	133
Time in nature and CN	134
Pro-biodiversity behaviours and CN.....	135
Summary – Study 1 contribution to knowledge	136
Objective 2: Explore concepts of nature, and investigate relationships between concepts of nature and CN, and concepts of nature and nature-based PBB (Study 2)	137
Concepts of nature and CN.....	139
Concepts of nature and PBB.....	140
Concepts of nature as moderator of the CN-PBB relationship	141
Summary – Study 2 contribution to knowledge	143

Objective 3: Explore whether TIN and nature-based PBB contribute to change in CN over time (Study 3)	144
Time spent in nature predicts change in CN over a 12-month period	145
Participating in nature-based PBB predicts change in CN over a 12-month period	145
Mediation effects of time spent in nature and nature-based PBB	146
Summary – Study 3 contribution to knowledge	147
Objective 4: To test the conceptual framework.....	148
Implications for conservation policy	150
Identity relative to, and experiences of, nature.....	150
Communicating "nature"	151
Design of natural spaces.....	152
Participation in nature-based pro-biodiversity behaviours.....	155
Implications for conservation policy at the national and international levels....	155
Limitations and future research	156
Summary and conclusions.....	159
References.....	162
Appendix A.....	198
Appendix B.....	200
Appendix C.....	201
Appendix D.....	202
Appendix E.....	217

Tables

Table 1: Description of the five CN dimensions proposed by Ives et al. (2017, 2018).....	23
Table 2: Summary of connection with nature constructs and definitions, and description of CN themes identified in each construct, presented in chronological order.	42
Table 3. A sample of commonly-used self-report instruments to assess CN in adults, presented in chronological order, with CN dimensions represented.....	56
Table 4: Variances explained for key variables in the model	130
Table 5: Possible CN dimensions, captured by existing multidimensional CN instruments.	132
Table 6: Variances explained for variables in the path analysis.....	150

Figures

Figure 1: Conceptualisation of CN proposed by Ives et al. (2018, p. 2). The x-axis shows the dimensions on a continuum from internal to external connections, while the y-axis shows the analytic scale from individual- to societal-level. Reprinted with permission from the authors.	24
Figure 2: Conceptual framework for this research. Connection with nature is positioned as a central focus of the research, with time spent in nature, concepts of nature, and nature-based pro-biodiversity behaviours considered as antecedents and/or consequent to CN.....	25
Figure 3: The Inclusion Model representing human-nature relationships. Core components include connectedness, caring, and commitment. Adapted from Schultz (2002, p. 69), with permission from Springer Nature © 2002.	52
Figure 4: Conceptual framework for CN proposed by Zylstra et al. (2014, p. 125). Reprinted by permission from Springer Nature © 2014.....	53
Figure 5: The Extended Inclusion of Nature in Self scale (Martin & Czellar, 2016, p. 186). Reprinted with permission from Elsevier © 2016.	55
Figure 6: The Illustrated Inclusion of Nature in Self scale (Kleespies et al., 2021, p. 5). Reprinted with permission from the authors.....	55
Figure 7: Conceptual framework for this research.	72
Figure 8: Conceptual framework, with elements included in Study 1 highlighted.	73
Figure 9: Conceptual framework, with elements included in Study 2 highlighted.	89

Figure 10: Dendrogram of concepts of nature themes using the total sample (n = 3090). The descriptive (blue dashed line), experiential (green dotted line), and normative (red solid line) categories are highlighted.....	107
Figure 11: Dendrogram of concepts of nature themes with participants from the complex concepts of nature category excluded (n = 2425). The descriptive (blue dashed line), experiential (green dotted line), and normative (red solid line) categories are highlighted.....	108
Figure 12: Multidimensional scaling of concepts of nature themes with participants from the complex category excluded (n = 2425; Stress = 0.180, RSQ = 0.923). The three categories (descriptive, normative, experiential) are circled.....	109
Figure 13: Visual representations of the moderation effect of CN dimensions (X: CN-Identity [left], CN-Experience [right]) on frequency of picking up litter (Y) as a function of concepts of nature.....	111
Figure 14: Visual representations of the moderation effect of frequency of picking up litter (X) on CN scores (Y: CN-Total [top]; CN-Identity [bottom left]; CN-Experience [bottom right]) as a function of concepts of nature.....	112
Figure 15: Visual representations of the moderation effect of frequency of environmental volunteering (X: left) and community gardening (X: right) on CN-Experience (Y) as a function of concepts of nature.....	113
Figure 16: Conceptual framework, with elements included in Study 3 highlighted.....	114
Figure 17: Conceptual framework for this thesis showing elements included in the path analysis	128
Figure 18: Results of path analysis showing standardized regression coefficients (**p < 0.001; *p < 0.01; *p < 0.05; ^{ns} p > 0.05).....	129
Figure 19: Conceptual framework, with elements included in Study 1 highlighted.....	136
Figure 20: Multidimensional scaling of concepts of nature themes. The three categories (descriptive, normative, and experiential) are circled.	138
Figure 21: Conceptual framework, with elements included in Study 2 highlighted.....	143
Figure 22: Conceptual framework, with elements included in Study 3 highlighted.....	147
Figure 23: Entire conceptual framework for this thesis highlighting elements included in the path analysis.	148
Figure 24: Results of path analysis showing standardized regression coefficients (**p < 0.001; *p < 0.01; *p < 0.05; ^{ns} p > 0.05).....	149

Abbreviations

CN	Connection with nature
PBB	Pro-biodiversity behaviour
PEB	Pro-environmental behaviour
TIN	Time spent in nature
EID	Environmental Identity Scale
NR	Nature Relatedness Scale

Chapter 1: Introduction

The issue of biodiversity destruction

The term "biodiversity", a portmanteau of "biological" and "diversity", refers to all forms of life on Earth, including the number and variety of flora, fauna, and microorganisms, their genetic variability, habitats, ecosystems, and interconnections (Convention on Biological Diversity [CBD] Secretariat, 2000). A biodiverse natural environment provides a range of essential systems, services, and functions for life on Earth, including the provision of clean air and water, formation and maintenance of soils, regulation of climate and weather patterns, as well as provision of food, energy, and materials for a range of human uses, including clothing, construction, and medicines (World Health Organization [WHO] Regional Office for Europe, 2021; WWF, 2020). As the infrastructure for all life on Earth, biodiversity forms the very foundation upon which every species – including humans – depend (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services [IPBES], 2019).

Yet worldwide, biodiversity is being destroyed at a rate unprecedented in human history (IPBES, 2019). Human activity, particularly in the past 50 years, has substantially altered 75% of Earth's land surface, destroyed more than 85% of wetlands, and negatively impacted 66% of oceans. More than three quarters of the services provided by nature are currently in decline. Further, it has been estimated that more than one million species – 25% of those assessed – face extinction, many within decades, without significant intervention (IPBES, 2019).

It has also been estimated that 70% of the world's remaining wilderness exists in five countries, of which Australia is one (Watson et al., 2018). Yet, Australia has seen more biodiversity destroyed than any other continent (Australian Government, n.d.), and continues to have the highest rate of mammal extinctions (Woinarski et al., 2015) and one of the highest rates of deforestation in the world (Pacheco et al., 2021). One recent study reported that 19 ecosystems across Australia are collapsing and may never recover (Bergstrom et al., 2021). In Victoria, an estimated one quarter to one third of flora and fauna are threatened with extinction (Department of Environment, Land, Water and Planning [DELWP], 2020). More land clearing has occurred in Victoria than any other state in Australia, with destruction of native vegetation continuing at a rate of approximately 3,000 hectares per year (DELWP, 2017; Victorian Association of Forest Industries, 2017).

The implications of biodiversity destruction are many and varied, including threats to food security (Food and Agriculture Organization of the United Nations [FAO], 2019) and human health and wellbeing (Platto et al., 2021; World Health Organization and Convention on Biological Diversity [WHO and CBD], 2015), and limit the achievement of many of the Sustainable Development Goals (CBD Secretariat, 2018; WWF, 2020). The World Economic Forum (2020) considers biodiversity destruction among the top 10 global risks¹ in both impact and likelihood, and it has been argued that "the ability of the planet's ecosystems to sustain future generations can no longer be taken for granted" (Millennium Ecosystem Assessment [MEA], 2005, p. 5). Thus, biodiversity destruction "is not only an environmental issue but a development, economic, global security, ethical and moral one" (WWF, 2020, p. 13).

The role of human behaviour

Biodiversity destruction is a complex "wicked problem" involving a range of interacting and constantly changing factors across multiple levels of influence (Game et al., 2014). Direct drivers of biodiversity destruction include habitat loss and degradation, over-exploitation of resources, pollution, invasive species, and climate change (Bergstrom et al., 2021; WWF, 2020). Underlying these direct drivers are pressures such as systems of agriculture, forestry, and infrastructure, and indirect drivers including patterns of consumption and governance, and economic systems (WWF, 2020). These factors overwhelmingly relate to human behaviour, thus fundamental and pervasive changes in human behaviour are needed in order to slow – and indeed reverse – current patterns of biodiversity destruction (Amel et al., 2017; Buijs et al., 2012; Reddy et al., 2017; Schultz, 2011; Selinske et al., 2018).

The sheer complexity of the issue, however, means that the solutions to reducing, halting, and reversing biodiversity destruction are far from simple (Game et al., 2014).

Transformational social, structural, and system changes are needed (Amel et al., 2017; IPBES, 2019; Nielsen et al., 2021; WWF, 2020) and in this, the actions of governments, businesses and organisations are pivotal (CBD Secretariat, 2000; MEA, 2005). Yet, individual-level behaviour change also has a role to play, and may be more readily influenced than system-level change (Amel et al., 2017; Nielsen et al., 2021; O'Brien, 2015; Travers et al., 2021). Identifying which behaviours to target for change is challenging, as drivers of biodiversity destruction are often the result of many different behaviours, across

¹ "A 'global risk' is an uncertain event or condition that, if it occurs, can cause significant negative impact for several countries or industries within the next 10 years" (World Economic Forum, 2020, p. 88)

different contexts and time scales, and involving different groups of people (Bujold et al., 2020; Reddy et al., 2017; Selinske et al., 2018). Recent work, however, has identified a number of behaviours and behavioural categories that may contribute to the protection and enhancement of biodiversity, such as stewardship (e.g. volunteering, avoiding pesticides), advocacy (e.g. voting, signing petitions), and consumption (e.g. choose organic) behaviours (Barbett et al., 2020; Maynard et al., 2020; Selinske et al., 2020). Targeting these behaviours of specific benefit to biodiversity – herein referred to as pro-biodiversity behaviours (PBB) – is thus a useful place to start.

Involving the public

If biodiversity conservation efforts are to succeed, the support – and involvement – of the public is essential (Arts et al., 2018; Brulle, 2010; Fischer et al., 2012; Novacek, 2008; Phillis et al., 2013; Schwartz, 2020). While evidence suggests that there is increasing public interest in, and valuing of, biodiversity-related issues (Burivalova et al., 2018; Ipsos, 2021; WWF Australia, 2018), particularly in the context of the COVID-19 pandemic (Rousseau & Deschacht, 2020), interest does not always translate into meaningful action (Gifford, 2011; Kollmuss & Agyeman, 2002; Novacek, 2008; Uren et al., 2019).

Researchers, particularly in environmental psychology, have spent decades exploring the factors that facilitate – and inhibit – participation in behaviours that are of general benefit to the natural environment, or pro-environmental behaviours (PEB). Human behaviour is incredibly complex (Darnton, 2008) and a vast array of factors, both personal and social, influence engagement in, or avoidance of, PEB (for reviews, see Cetas & Yasué, 2017; Farrow et al., 2017; Gifford & Nilsson, 2014; Hurst et al., 2013; Klöckner, 2013). In recent years, one factor that has been implicated as an important driver of PBB/PEB is human relationships with nature, and specifically, connection with nature.

Connection with nature

The ways in which humans perceive, interact with, and relate to nature have gained increased prominence in the academic literature in recent decades. Human relationships with nature have been conceptualised using a range of terminology, including connectedness to nature (Mayer & Frantz, 2004), environmental identity (Clayton, 2003), nature relatedness (Nisbet et al., 2009), inclusion with nature (Schultz, 2002), and human-nature connection (Ives et al., 2017). Following Zylstra et al. (2014), this thesis adopts the term *connection with nature* (CN) to refer to this suite of interrelated constructs "because it

evokes the subtle yet important idea that (1) humans are already an intimate part of nature and (2) that the state imbues a sense of reciprocity and mutualism" (Zylstra et al., 2014, pp. 121–122). While CN has been defined in a variety of ways, most definitions include a relatively stable sense of personal identity encompassing relationship with the natural world that includes cognitions, emotions, and behaviours about and toward nature (Hatty et al., 2020).

It has been argued that human disconnection from nature is a driving force behind environmentally destructive behaviours (Nisbet et al., 2009; Zylstra et al., 2014), with some suggesting that CN is an important driver of, and necessary precondition for, PBB/PEB (Frantz & Mayer, 2014; Otto & Pensini, 2017; Schultz, 2002). Recent meta-analytic evidence supports this notion, with studies by Mackay and Schmitt (2019) and Whitburn, Linklater, and Abrahamse (2019) reporting moderate-to-strong positive relationships between CN and PEB. While research linking CN and PBB is comparatively sparse, some recent research suggests that people higher in CN also do more PBB (Martin et al., 2020; Prévot, Cheval, et al., 2018; Richardson, Passmore, et al., 2020). Together, this provides further evidence of the potential utility of (re)connecting people with nature as a means of encouraging greater participation in PBB/PEB among members of the public.

The research partnership: Victorian State Government

The utility of (re)connecting people with nature to foster sustainability outcomes has been recognised as a potentially useful policy lever. In 2017, the Victorian State Government Department of Environment, Land, Water and Planning (DELWP) released *Protecting Victoria's Environment – Biodiversity 2037* (DELWP, 2017), a 20-year plan to address biodiversity destruction across the state. The vision and goals of *Biodiversity 2037* reflect a move away from traditional conservation approaches to focus on prevention, early intervention and maximising the overall extent and quality of habitats and number of native species. Another novel approach is reflected in the *Victorians Value Nature* goal, which acknowledges the important role that all Victorians will play in protecting the natural environment.

Within the *Victorians Value Nature* goal are the statewide targets to have all Victorians connecting with nature, and five million Victorians acting to protect nature, by 2037. Embedded in this goal is the assumption that many Victorians have become disconnected from nature, resulting in potentially negative consequences for the environment; hence

(re)connecting Victorians with nature may facilitate an increase in behaviours that protect, support, and enhance Victoria's natural environment.

Within this context, DELWP partnered with BehaviourWorks Australia to support the Monash University Behaviour Change Graduate Research Industry Partnership (GRIP) program. The focus of this program is to address real-world problems using an applied research focus. This GRIP research, therefore, seeks to better understand the connection with nature construct with the view to informing policies to address the *Victorians Value Nature* goal of *Biodiversity 2037*.

The current thesis

For (re)connection with nature to be a useful tool in biodiversity policy and management, a thorough understanding of the CN construct is needed (Hughes et al., 2019; Restall & Conrad, 2015). Yet, such understanding is currently lacking. This thesis places CN at the centre and explores key antecedents and consequents corresponding to three broad issues in the CN literature.

First, while it is generally agreed that CN is a multidimensional construct, there is ongoing debate in the literature regarding the dimensional structure of CN; there has also been limited exploration of how different dimensions relate to constructs such as PBB/PEB (Ives et al., 2017; Restall & Conrad, 2015; Tam, 2013). Further, while more than 14 self-report instruments have been developed to measure CN, only three capture CN as a multidimensional construct (Brügger et al., 2011; Clayton, 2003; Nisbet et al., 2009). Yet, these instruments are long (21-40 items) and may not be suitable for real-world contexts where time and/or money may be limited, such as routine government data collection. In sponsoring this research, a core objective for DELWP was to develop a brief yet parsimonious multidimensional CN instrument that could be used across *Biodiversity 2037* programs.

Second, understanding of the term "nature" relative to "connection with nature" is limited. Much of the CN literature leaves "nature" undefined, and there has been little consideration of what people understand by "nature", or what aspects of nature people feel connected to (Beery & Wolf-Watz, 2014; Ives et al., 2017; Pasca et al., 2020). Yet, such an understanding has important implications for how "connection with nature" is understood and measured, as well as how CN may usefully inform biodiversity policy and management. To date, few

studies have considered how people perceive nature and the language they use to describe nature – their concepts of nature – relative to CN or to PBB/PEB.

Third, understanding of how CN develops, is maintained, and changes over time is also limited (Cleary et al., 2018; Ives et al., 2018; Zylstra et al., 2014). Time spent in contact with nature has been implicated as an important factor in the development and/or maintenance of CN (e.g. Chawla, 2020; Cleary et al., 2018), although the role of spending time in different types of nature (e.g. urban parks versus national parks) is not well understood. Further, while it is likely that the CN-PBB/PEB relationship is bidirectional (Hamlin & Richardson, 2021), research linking CN and PBB/PEB typically implies that CN is an antecedent to PBB/PEB (e.g. Mackay & Schmitt, 2019; Restall & Conrad, 2015; Richardson, Passmore, et al., 2020), with few studies exploring PBB/PEB as antecedents to CN.

It should be noted that there is a growing body of research suggesting that childhood experiences of nature are important for the development and maintenance of CN in adulthood (e.g. Chawla, 2020; Cleary et al., 2018; Kals et al., 1999; Pensini et al., 2016; Ward Thompson et al., 2008). Initiatives such as environmental education programs, school-based stewardship and gardening projects, and outdoor kinder programs (Barrable & Booth, 2020; Barthel et al., 2018; Elliot et al., 2014; Talebpour et al., 2020; Wallace, 2019) have been established with the aim of fostering CN in children (see also Chawla, 2020; Giusti et al., 2018). Yet, CN can also develop in adulthood, independent of childhood experiences (Bell et al., 2017; Cleary et al., 2018). As adults have greater agency over thoughts and behaviours that are likely to influence CN and PBB (Carr & Hughes, 2021), this research focuses specifically on adults aged 18 years and over.

In addition to relationships between CN and PBB/PEB, associations have also been reported between CN and individual traits such as agreeableness and empathic concern (Zhang, Piff, et al., 2014), altruism (Meis-Harris et al., 2019; Schultz, 2001), and mindfulness (Schutte & Malouff, 2018), and with character strengths such as curiosity (Merino et al., 2020). CN has also been linked with hedonic and eudemonic wellbeing (Capaldi et al., 2014, 2017; Pritchard et al., 2019; Richardson et al., 2021; Richardson & McEwan, 2018), with some proposing that CN is related to wellbeing via engagement with natural beauty (Richardson & McEwan, 2018; Zhang, Howell, et al., 2014), spirituality (Trigwell et al., 2014), and intrinsic values and social relational emotions (Cleary et al., 2017; Petersen et al., 2019). While not the focus of this thesis, these individual-level factors could be other potentially useful mechanisms for fostering CN and perhaps also engagement in PBB/PEB (see further elaboration in Chapter 9, page 131).

Theoretical and conceptual frameworks

In a recent review, Ives and colleagues (2017) described the CN literature as fragmented and "characterised by a plurality of disciplinary and conceptual perspectives, language, methods and research approaches" (p. 106). With a view to consolidating ideas across the literature, the authors proposed a theoretical framework describing CN relative to five distinct yet interrelated dimensions or "types": philosophical, emotional, cognitive, experiential, and material (Table 1).

Table 1: Description of the five CN dimensions proposed by Ives et al. (2017, 2018).

CN dimension	Description
Material	Consumption of goods/materials from nature (e.g., food, fibre); resource extraction and use.
Experiential	Direct interaction with natural environments (e.g., parks, forests); recreational activities in green environments.
Cognitive	Knowledge or awareness of the environment and attitudes/values towards nature; knowledge, beliefs, and attitudes in relation to nature.
Emotional	Feelings of attachment to or empathy towards nature; emotional attachments and affective responses in relation to nature.
Philosophical	Perspective or worldview on what nature is, why it matters, and how humans ought to interact with it (e.g., master, participant, steward); perspectives on humanity's relationship to the natural world.

This framework (Figure 1) describes these types of CN on a continuum from internal connections, such as worldviews about, and emotions associated with, nature (philosophical, emotional) to external connections, such as physical interaction with nature (material, experiential). These five CN dimensions are also considered relative to the scale of analysis, that is, at the individual and/or societal levels (Ives et al., 2018).

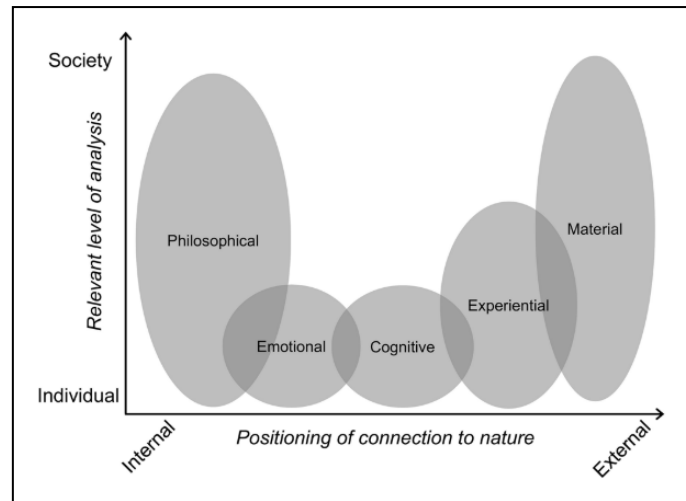


Figure 1: Conceptualisation of CN proposed by Ives et al. (2018, p. 2). The x-axis shows the dimensions on a continuum from internal to external connections, while the y-axis shows the analytic scale from individual- to societal-level. Reprinted with permission from the authors.

This theoretical framework forms the foundation of the conceptual framework for this research. This conceptual framework (Figure 2) positions CN as the central focus, as both an antecedent and consequent variable. Study 1 seeks to explore and clarify the dimensions of CN proposed in the abovementioned theoretical framework, to develop a brief yet parsimonious CN instrument, and to investigate relationships between this instrument and two constructs commonly used in CN research – time spent in nature and PBB/PEB. Study 2 considers concepts of nature relative to CN, dimensions of CN, and four nature-based PBB. Study 3 investigates change in CN over a 12-month period, with a specific focus on time spent in nature, time spent in different types of nature, and participation in nature-based PBB as predictors of CN and mediators of change in CN over time. A final synthesis chapter will assess this conceptual framework in its entirety.

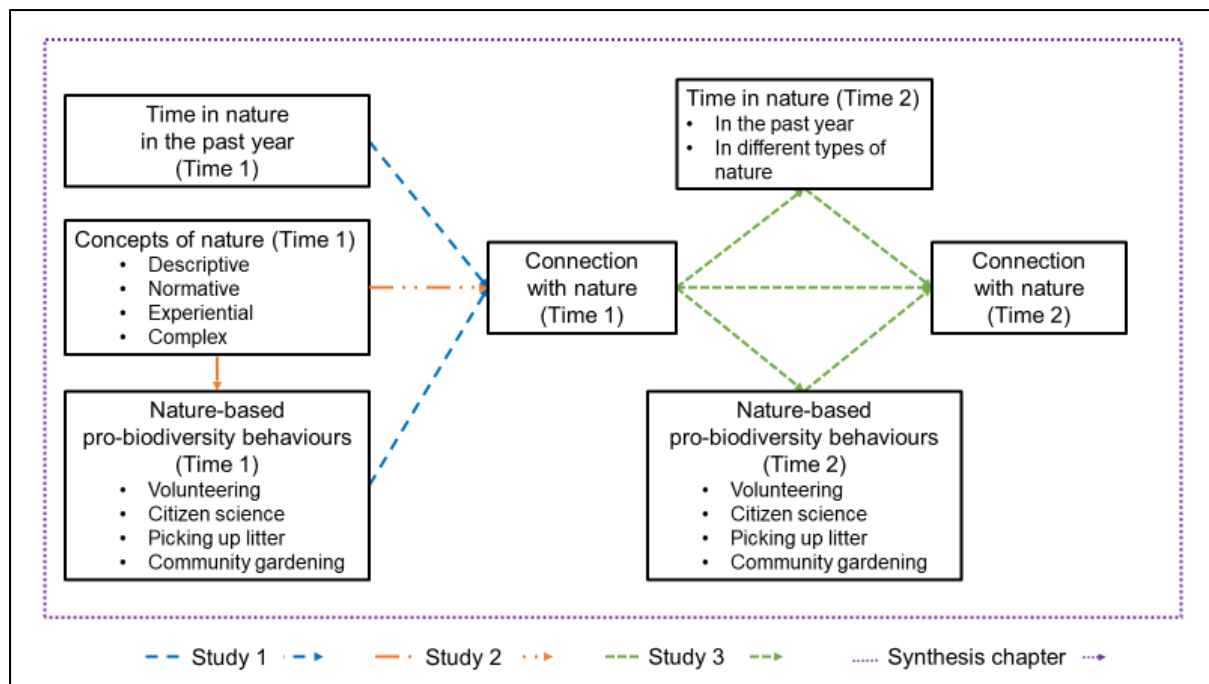


Figure 2: Conceptual framework for this research. Connection with nature is positioned as a central focus of the research, with time spent in nature, concepts of nature, and nature-based pro-biodiversity behaviours considered as antecedents and/or consequent to CN.

Aims and objectives

The overarching aim for this research is to better understand connection with nature (CN), and its relationships with concepts of nature, time spent in nature (TIN), and nature-based pro-biodiversity behaviours (PBB) among adults living in Victoria, Australia. Four objectives are proposed:

1. Explore and clarify dimensions of CN; develop a brief yet parsimonious self-report CN instrument; investigate relationships between CN, TIN, and PBB (Study 1);
2. Explore concepts of nature, and investigate relationships between concepts of nature and CN (total and dimension scores), and concepts of nature and nature-based PBB (Study 2);
3. Explore whether TIN and nature-based PBB contribute to change in CN over time (Study 3);
4. To test the overall conceptual framework (synthesis chapter).

Researcher position

The role of the researcher's own values, beliefs, and experiences on the research process is often not explicitly acknowledged in the academic literature, particularly in quantitative research. Yet, the current thesis has been influenced by my own relationship with the natural environment. I have a strong connection with nature that developed during early adulthood. I spend time noticing and actively engaging with nature every day. I believe that humans *are* nature. I espouse sustainable and minimalist lifestyle choices, and regularly participate in a range of pro-biodiversity behaviours. And, my daily experiences of nature play an important role in my own health and wellbeing. These values and beliefs drew me to this research, and will continue to influence all facets of my life, including my work, into the future.

This thesis stems from the disciplinary perspective of psychology. Using a primarily quantitative approach, this research is grounded in both a realist and a relativist ontology. Realist in that it seeks to identify a single and generalisable – albeit likely dynamic – reality of a sample of Victorians, determined by applying a scientific, hypothetico-deductive methodology. Relativist in that it recognises that understanding of the CN construct among different groups (e.g. cultural/ethnic, as discussed in Chapter 3) is limited, thus acknowledging that the results presented likely represent only one of potentially many different realities. From an epistemological perspective, this research is grounded in both constructionism and subjectivism. Constructionism in that it is assumed that people construct their understandings of, and relationships with, "nature" (CN) based on their prior experiences (contextualised meanings). Subjectivist in that it is assumed that the meaning a person ascribes to "nature" and their relationship with "nature" is based on their unique understanding and experience of the world. Thus, the overall philosophical approach is pragmatic, seeking to draw on a range of ontological and epistemological perspectives in order to generate knowledge to inform policy (see Moon & Blackman, 2014).

Thesis overview

Chapter 2 describes the policy context of human experiences of, and relationships with, nature to address biodiversity conservation issues. It considers international agreements, such as the Convention on Biological Diversity (CBD Secretariat, 2012) and the *Post-2020 Biodiversity Framework* (CBD Secretariat, 2021a) currently in development. It also considers national-level strategies (Australian Government, 2010, 2019), and Victoria's *Biodiversity 2037* (DELWP, 2017). Specifically, this chapter highlights the growing recognition within government of the CN-PBB relationship and the potential utility of (re)connecting people with

nature to address biodiversity destruction, and argues that a greater understanding of CN is needed to inform policy and programs related to *Biodiversity 2037*. Chapter 2 also introduces the *Victorians Value Nature* surveys as a key element of *Biodiversity 2037*, that form the basis of this thesis.

Chapter 3 details a narrative review of CN literature. It explores the construct of CN including theoretical origins, terminology and definitions, theoretical and conceptual frameworks, various forms of measurement, critiques of the CN construct, and discussion of how CN develops, is maintained, and may be nurtured. Chapter 3 sets the foundation for the three studies undertaken.

Chapter 4 provides a methodological overview of this research. It includes a description of the *Victorians Value Nature* surveys, sample details, as well as analytic approach.

Chapter 5 presents Study 1, the publication entitled *The CN-12: A brief, multidimensional connection with nature instrument*. This publication addresses objective 1 of this thesis. Chapter 6 includes a reflection on Study 1 and introduces concepts of nature as a potentially useful, yet under-researched construct in the CN and PBB/PEB literature. Chapter 6 concludes with Study 2, entitled *Speaking of nature: Relationships between how people think about, connect with, and act to protect nature* that addresses objective 2 of this thesis.

Chapter 7 reflects on Studies 1 and 2 and considers factors that have been associated with the development and/or maintenance of CN, including time spent in nature, in different types of nature, and participation in nature-based PBB. Chapter 7 concludes with Study 3, *Nurturing connection with nature: The role of spending time in nature and nature-based conservation behaviours* that addresses objective 3 of this thesis.

Chapter 8 brings together the different elements of the conceptual framework (Figure 2). It details methodology and results of the path analysis used to assess the conceptual framework, which are discussed in detail in Chapter 9.

Chapter 9 details an overall discussion and conclusions. It provides a reflection of the research undertaken relative to the research questions, and the contributions of the research to the field. It reflects on the theoretical and conceptual frameworks, and considers areas for future research. This chapter also includes a discussion of the relevance and utility of the findings to government policy, including the Victorians Value Nature goal of *Biodiversity 2037*.

Chapter 2: The policy context

In the context of global biodiversity destruction, policymakers are increasingly recognising that healthy and biodiverse natural environments form the very foundation of functioning human societies. Early conservation policies tended to focus on protecting and enhancing the natural environment with minimal consideration of human relationships with nature or involving the public in conservation. In recent years, conservation policy has begun to consider relationships between humans and nature as an important element of environmental planning and management (e.g. Australian Government, 2019; CBD Secretariat, 2011; DELWP, 2017). Yet, as the following discussion highlights, there remains a great deal of scope for policymakers to include nurturing of human connection with nature in policy documents to inform practice.

Over the past 50 years, shifting perceptions of relationships between humans and nature have influenced conservation science and policy (Mace, 2014). Around the mid-twentieth century, conservation focused on protected or wilderness-type areas at the exclusion of people. By the 1980's, greater awareness of detrimental impacts of human activity on species and ecosystems shifted conservation toward reducing and reversing such impacts (Mace, 2014). Such ideas were reflected in conservation policy of the late-twentieth century. The original text of the global *Convention on Biological Diversity*, for example, notes "biological diversity is being significantly reduced by certain human activities...[and] it is vital to anticipate, prevent and attack the causes of significant reduction or loss of biological diversity at source" (United Nations, 1992, p. 1). Similar recognition of the need to reverse harmful human impacts on biodiversity appear in Australian (Australian Government, 1996) and Victorian (Department of Natural Resources and Environment, 1997c) policies.

Throughout the twenty-first century, the range of biopsychosocial benefits nature provides to people has gained prominence in the academic literature. Such ideas acknowledge that humans are part of, and dependent on biodiversity, and emphasise the need for human systems that work in harmony with nature (Costanza et al., 2017; Mace, 2014). These ideas are also reflected in international policy documents, which include the vision of "living in harmony with nature" (CBD Secretariat, 2011, 2021a), and in Australian and Victorian policy documents (Australian Government, 2010; Department of Natural Resources and Environment, 1997c).

Global conservation policy

The Convention on Biological Diversity

In 1988, the United Nations Environment Programme initiated what would become the Convention on Biological Diversity (CBD), an international agreement with the objective of conserving, sustainably using, and equitably sharing biodiversity and its benefits (CBD Secretariat, 2012). The CBD was initially presented at the United Nations Conference on Environment and Development (the "Rio Earth Summit") in 1992, and had received signatures from representatives of 168 nations by mid-1993. The CBD entered into force in December 1993 (CBD Secretariat, 2021b).

The first global agreement of its kind, the CBD identifies biodiversity destruction as a global problem and outlines goals and obligations to guide international cooperation on the protection and restoration of biological diversity. The CBD text includes a number of commitments, including the development of national strategies to protect and sustainably use biological diversity, impact assessment and monitoring, increasing public awareness of the importance of conserving biological diversity, and the provision of financial resources for conservation (CBD Secretariat, 2000; United Nations, 1992).

Strategic Plan for Biodiversity 2011-2020 and Aichi Targets, and Post-2020 Global Biodiversity Framework

A revised and updated *Strategic Plan for Biodiversity 2011-2020* was adopted at the tenth *Conference of the Parties* (COP10) meeting in Japan in 2010. The *Strategic Plan* included five goals and 20 targets, known as the Aichi Targets. The goals broadly aim to increase awareness of biodiversity issues across human populations (Goal A), to reduce pressures on biodiversity (Goal B), to safeguard ecosystems (Goal C), to create equitable access to biodiversity across all human populations (Goal D), and to create greater global participation in biodiversity conservation (Goal E) (CBD Secretariat, 2011).

Building on the *Strategic Plan for Biodiversity 2011-2020*, the CBD Secretariat released the *First Draft of the Post-2020 Global Biodiversity Framework* in July 2021 (CBD Secretariat, 2021a). The draft includes a theory of change, recognising that transformational change of social, economic, and financial systems are urgently needed to stabilise and facilitate

recovery of biodiversity globally. It also includes four goals and 20 targets, with 20 action-oriented targets for 2030.

Discussion of the *First Draft* was a key agenda item of COP15 (part 1) held online between 11 and 15 October 2021. A core outcome of this meeting was the Kunming Declaration, that saw the parties commit to

Ensure the development, adoption and implementation of an effective post-2020 global biodiversity framework, that includes provision of the necessary means of implementation, in line with the Convention, and appropriate mechanisms for monitoring, reporting and review, to reverse the current loss of biodiversity and ensure that biodiversity is put on a path to recovery by 2030 at the latest, towards the full realization of the 2050 Vision of 'Living in Harmony with Nature' (CBD Secretariat, 2021c, p. 3).

Part 2 of COP15 will be held in-person in Kunming, China, between 25 April and 8 May 2022 where it is expected that the final text of the *Post-2020 Global Biodiversity Framework* will be finalised and adopted (CBD Secretariat, 2021d).

Australian conservation policy

Australia ratified the CBD in 1993 (Australian Government, 2016) and in 1996, the Australian Government released its first national biodiversity strategy, *The National Strategy for the Conservation of Australia's Biological Diversity* (Australian Government, 1996, 2010).

The *National Strategy* reflected the key elements of the initial CBD text, including the goal to "protect biological diversity and maintain ecological processes and systems" (Australian Government, 1996, p. 10). Nine principles served to guide implementation of the strategy, with a series of objectives and actions providing more detail how the strategy would be implemented. While objectives 5.1 and 5.2 aimed to increase Australians' awareness of, and involvement in, biodiversity conservation, the focus was on the provision of information and education programs. There is a single mention of connections between humans and nature among Indigenous Australians yet does not mention human relationships with nature or connection with nature for other Australians. However, given the connection with nature literature was sparse prior to the twenty-first century (Ives et al., 2017), this is perhaps unsurprising.

Australia's Biodiversity Conservation Strategy 2010-2030 and Australia's Strategy for Nature 2019-2030

In line with the global *Strategic Plan for Biodiversity 2011-2020*, the Australian government developed *Australia's Biodiversity Conservation Strategy 2010-2030* (Australian Government, 2010) to provide a national framework for biodiversity conservation over a 20-year period. Underpinned by the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), *Australia's Biodiversity Conservation Strategy 2010-2030* proposed a vision that "Australia's biodiversity is healthy and resilient to threats, and valued both in its own right and for its essential contribution to our existence" (p. 16). Three priority actions were identified: 1) engage all Australians in biodiversity conservation; 2) build ecosystem resilience; and 3) achieving measurable results.

Priority action 1, *Engaging all Australians*, identified the important role that all Australians – individuals, business, non-government organisations, and all levels of government – have in protecting and enhancing biodiversity. Specifically, this priority action aims to mainstream biodiversity such that decision-making across individual, group, and societal levels accounts for the direct and indirect impacts of the decision on biodiversity. In recognising that the term "biodiversity" is not well understood among Australians (see also Kiley et al., 2018), this priority action also emphasises that it will be necessary to improve public awareness of biodiversity and its benefits, including "a transformation in the way most Australians think about and value biodiversity" (p. 39). Further, emphasis is placed on increasing participation of the public in conservation activities.

A review of the strategy (Australian Government, 2016) highlighted a number of limitations, including a lack of adequate attention to the links between people and biodiversity, such as relationships between biodiversity, health and wellbeing, and economic outcomes. The report also noted that more effort needs to be made to improve public awareness of, and appreciation for, biodiversity and biodiversity conservation, including the health and wellbeing benefits of interacting with nature. The findings of this review informed *Australia's Strategy for Nature 2019-2030*.

The most recent biodiversity conservation strategy for Australia, *Australia's Strategy for Nature 2019-2030* (Australian Government, 2019) provides an overarching framework for other strategies across states and territories. It brings together previous strategies and related documents and provides a framework by which Australian governments will address

international commitments via the *Convention on Biological Diversity*. This strategy has three interrelated goals: 1) connect all Australians with nature; 2) care for nature in all its diversity; and 3) share and build knowledge (Australian Government, 2019).

Conservation policy and human-nature relationships

While the initial CBD text, *Strategic Plan 2011-2020 and Aichi Targets*, and Australia's *Biodiversity Conservation Strategy 2010-2030* include consideration of human relationships with nature relative to biodiversity conservation, the focus is on awareness raising with little, if any, consideration of nurturing CN to increase public support for, and engagement in, conservation. Unsurprisingly, the Australian strategy notes that "Indigenous peoples have a special connection and relationship with Australia's natural environments" (Australian Government, 2010, p. 40), noting that traditional ecological knowledge should be incorporated into conservation management. Yet, there is no acknowledgement of relationships with nature among the broader Australian population, or the role of nurturing such relationships in conservation planning and management. Around the time the global strategic plan and Australian strategy were published, a number of studies had demonstrated positive relationships between CN and PEB (see Mackay & Schmitt, 2019 and Whitburn, Linklater, & Abrahamse, 2019 for reviews) although such ideas were not yet reflected in conservation policy.

The idea of awareness raising is a common communication strategy in conservation, and is based on the assumption that people lack relevant knowledge and understanding of an issue, thus providing the missing information is presumed to change attitudes and to influence behaviour (Kidd et al., 2019; Rare and the Behavioural Insights Team [BIT], 2019; Sturgis & Allum, 2004). Yet, such ideas are overly simplistic.

Human behaviour is complex, and knowledge/awareness, and attitudes are just a few of a wide range of factors that influence behaviours such as PBB/PEB (Bamberg & Möser, 2007; Cane et al., 2012; Darnton, 2008). Thus, simply providing information in an attempt to increase knowledge/awareness or to change attitudes will inevitably neglect other factors that influence behaviour (Curtis et al., 2021). Furthermore, shifting knowledge/awareness or attitudes does not necessarily lead to behaviour change (Kollmuss & Agyeman, 2002; Rare and BIT, 2019). As biodiversity conservation necessarily involves behaviour change (Schultz, 2011; Selinske et al., 2018), any awareness raising policy or campaign must also include tangible and targeted interventions to change behaviour (e.g. Rare and BIT, 2019).

In addition, a single awareness-raising campaign is also unlikely to appeal to everyone in a population group. Individual differences such as personality, attitudes, and beliefs influence a person's relationship with the natural environment (Frantz et al., 2005; Marais-Potgieter & Thatcher, 2020; Zhang, Piff, et al., 2014), and research has highlighted a number of different types of human-nature relationships (Flint et al., 2013; Marais-Potgieter & Thatcher, 2020). Any attempt to increase awareness of biodiversity, the importance of conservation, the role of human relationships with nature, or indeed to change behaviour such as PBB/PEB should, therefore, consider the specific audience to which the message is targeted (Abraham & Denford, 2020; Flint et al., 2013; Kidd et al., 2019; Marais-Potgieter & Thatcher, 2020; Rare and BIT, 2019).

Emerging acknowledgement of connection with nature in conservation policy

Two recent documents highlight efforts to increase recognition of CN among conservation decision-makers globally. At the *Convention of the Parties* meeting in 2018, a proposal – authored by the Children and Nature Network and the International Union for Conservation of Nature Commission on Education and Communication – was circulated to participants. This proposal stated

...meaningful experiences and connection with nature are key to engendering stronger valuation, support, and action for biodiversity conservation across generations, sectors, and societies. Increased attention to the importance of public engagement and connection with nature will be important for achieving behaviour change and creating and maintaining the political will for governments to implement the Convention. While they remain critically important, efforts to increase awareness and understanding of biodiversity and its values, and of actions that can be taken, are not enough. (CBD, 2018, p. 3)

This document also detailed a series of recommendations, including the development of national policies to encourage people to (re)connect with nature through, for example, childhood and education policies, health and aged care policies, outdoor recreation, and arts and culture policies (CBD, 2018). It was also recommended that the *Post-2020 Global Biodiversity Framework*

...should recognise growing societal disconnect from nature (e.g., through rapid urbanisation and other processes) as an important indirect driver of biodiversity loss;

and it should include strategies for addressing this disconnect in order to bring about the transformations necessary to halt biodiversity loss (CBD, 2018, p. 7).

The extent to which these recommendations have, or will be, adopted by the Conference of the Parties remains to be seen.

In addition, the *Global Biodiversity Outlook 5* (CBD Secretariat, 2020) – a report on the global status of biodiversity and the actions being taken to address its destruction – briefly mentions that solutions must consider the "less tangible but highly-valued connections with nature that help to define our identities, cultures and beliefs" (p. 10). While this report is among the few international documents to explicitly note the importance of human relationships with nature in conservation, there is no further mention of CN nor discussion about policies, goals, or targets related to nurturing CN.

The current *First Draft of the Post-2020 Global Biodiversity Framework* goes a step further than previous global policies via "Target 12: Increase the area of, access to, and benefits from green and blue spaces, for human health and well-being in urban areas and other densely populated areas" (p. 7). While the "benefits" implied in this target could include contact with nature as well as CN (for reviews, see Capaldi et al., 2015; Russell et al., 2013), having access to nature does not necessarily lead to more time spent in nature, nor greater CN (e.g. Lin et al., 2014). Further, and as discussed in Chapter 7 (page 110), spending time in nature does contribute to CN but the two are different constructs (see also Richardson, 2021; Richardson, Hamlin, et al., 2021). Thus, while increasing access to nature may be a useful step in enhancing human relationships with nature, as a stand-alone target, it falls short of encouraging closer and more enduring connections with nature that are likely to facilitate positive outcomes for biodiversity conservation. More emphasis is needed on targeted interventions to enhance CN (e.g. Richardson, Dobson, et al., 2020).

The recent *Australia's Strategy for Nature 2019-2030* is the first national strategy to recognise the role of human-nature relationships and (re)connecting Australians with nature to foster conservation outcomes. Goal 1 recognises that many Australians have become disconnected from nature, and encourages all Australians to spend time in nature to foster a sense of (re)connection and to facilitate health and wellbeing outcomes associated with contact and CN. Goal 1 also recognises that enhancing Australians' knowledge and awareness of the importance biodiversity can positively impact conservation outcomes, and encourages all Australians to become active stewards of nature through activities such as volunteering, citizen science, and protecting private land via covenants or similar. Thus, this

document is the first of Australia's national biodiversity conservation strategies to consider the relationships between humans and nature.

There are, however, a number of gaps in this policy document. As with the global *First Draft of the Post-2020 Global Biodiversity Framework*, Goal 1 of the Australian policy rests on the incomplete assumption that more time spent in nature will enhance CN. Further, merely capturing time spent in nature does not account for what people *actually do* while they're spending time in nature. Spending time in nature can take many different forms and involve varying levels of attention to, and engagement with, nature (Frumkin et al., 2016). Recent evidence suggests that the quality of nature experiences is important for fostering CN (Colléony et al., 2019; Colléony, Levontin, et al., 2020), and particularly experiences that involve actively engaging with and noticing nature (Carr & Hughes, 2021; Richardson et al., 2015; Richardson, Dobson, et al., 2020) (see also Chapter 3: The quality of nature experiences, on page 65). Encouraging active engagement with nature while spending time in nature would enhance the policy position detailed in the strategy.

Another limitation of *Australia's Strategy for Nature 2019-2030* relates to the lack of concrete measures and targets. While there is a progress measure to increase "visitation rates to public nature conservation areas (land and sea)" (p. 16), this fails to capture visitation to other areas where people may experience nature, such as zoos and botanic gardens, urban parks, or beaches and waterways (Clayton & Myers, 2009; Keniger et al., 2013). Further, there is no target for measurement of CN across the Australian population. A specified target to increase CN among a given proportion of the population, or quantified increase of participation in interventions to increase CN (see Colahan & Chapple, 2019 for review) would facilitate measurable progress toward the strategy's goals.

A final shortcoming relates to how the Australian government has sought to enact these policy documents. The online resource *Australia's Nature Hub*² is intended to provide information related to *Australia's Strategy for Nature*. Yet, while a list of "actions for nature" is included, many of those flagged as addressing Goal 1 "Connected all Australians with nature" fail to specifically mention how this goal is being addressed. For example, the *National Waste Policy*³ is listed as an action for nature related to Goal 1, yet this policy makes no mention of human relationships with nature, CN, or even spending time in nature.

² <https://www.australiasnaturehub.gov.au/>

³ <https://www.australiasnaturehub.gov.au/action-inventory/national-waste-policy>

Other actions listed as addressing Goal 1, such as the *Threatened Species Strategies*⁴ and the *Environment Restoration Fund*⁵, address biodiversity conservation initiatives via on-ground actions (e.g. revegetation projects), although fail to specify actions to connect Australians with nature.

In summary, this analysis of international and Australian conservation policy highlights the cursory – albeit growing – recognition of the role human connections with nature can play in addressing biodiversity conservation outcomes. More recent policies have evolved to recognise the important role that members of the public will have in conservation efforts, as well as the value of nurturing relationships between humans and nature. Yet, significant gaps remain. Policies must move beyond awareness raising and simply providing access to nature to focus more on targeted and tangible interventions to increase CN as well as PBB/PEB. Communications and interventions should be tailored to specific audiences to maximise impact, while more concrete goals and targets related to connecting people with nature are needed.

Victorian conservation policy

In 1997, the Victorian state government Department of Natural Resources and Environment released *Victoria's Biodiversity* (Department of Natural Resources and Environment, 1997a, 1997b, 1997c). This series of three documents described Victoria's biodiversity, a strategic framework for biodiversity conservation, and actions to conserve biodiversity across the state. It acknowledged the importance of a healthy natural environment for human wellbeing and quality of life, and notes that all Victorians – individuals, groups, and organisations – have a shared responsibility for conserving biodiversity. Yet, while *Victoria's Biodiversity* includes specific actions that individuals and organisations can undertake (Department of Natural Resources and Environment, 1997c), and overall objectives and key directions for specific regions (Department of Natural Resources and Environment, 1997a), no specific goals or targets are included, nor is there a clear pathway by which the objectives and key directions could be achieved.

⁴ <https://www.australiasnaturehub.gov.au/action-inventory/threatened-species-strategy-2021-2031>

⁵ <https://www.australiasnaturehub.gov.au/action-inventory/environment-restoration-fund>

Protecting Victoria's Environment – Biodiversity 2037

In April 2017, the Victorian state government Department of Environment, Land, Water and Planning (DELWP) released *Protecting Victoria's Environment – Biodiversity 2037* (DELWP, 2017). Underpinned by the *Flora and Fauna Guarantee Act 1988*, the *Flora and Fauna Guarantee Amendment Act 2019*, as well as native vegetation clearing regulations, this document details a 20-year plan to address the ongoing decline in biodiversity across Victoria, and reflects the Victorian government's commitment to national and international biodiversity agreements described above. The 2017-2018 State budget committed \$86 million over four years plus \$20 million per year for support and implementation of *Biodiversity 2037*.

Developed over a three-year period, in consultation with members of the public, community groups, DELWP staff, and other stakeholders, *Biodiversity 2037* takes a more proactive approach to biodiversity conservation. The vision and goals of the *Biodiversity 2037* reflect a move away from traditional conservation approaches to focus on prevention, early intervention and maximising the overall extent and quality of habitats and number of native species. Another new approach is reflected in the *Victorians Value Nature* goal, which acknowledges the important role that all Victorians will play in protecting the natural environment.

Within the *Victorians Value Nature* goal are the statewide targets to have all Victorians connecting with nature, and five million Victorians acting to protect the natural environment, by 2037. As with other policies, embedded in this goal is the assumption that many Victorians have become disconnected from nature, resulting in potentially negative consequences for the environment; hence (re)connecting Victorians with nature will lead to an increase in behaviours that protect, support, and enhance biodiversity. Thus, *Biodiversity 2037* is among the few policy documents that sets an explicit target related to CN as well as PBB.

A strength of this policy is in the explicit definition of constructs. For example, connecting with nature is defined as

...time spent in nature where the person has some awareness of their surroundings. Time spent in nature could be for recreational, educational, social, health and well-being purposes, for biodiversity conservation and nature appreciation purposes, or for work. Connecting with nature can also refer to the personal values, beliefs and

meanings that underpin people's time spent in nature and the different activities they undertake. (DELWP, 2017, p. 14).

This definition reflects a more complex notion of human relationships with nature of which spending time in nature is just one component.

A number of initiatives have been undertaken to address the *Victorians Value Nature* goal of *Biodiversity 2037* (DELWP, 2021b). The online Victorian Nature Festivals in 2020⁶ and 2021⁷ were established to provide participants with opportunities to connect with, and act for, nature. The Environmental Volunteering Plan (DELWP, 2021a) outlines a strategy for supporting and expanding environmental volunteering across the state. Research has also been conducted to identify and prioritise specific behaviours of benefit to biodiversity, enabling the development of more targeted behaviour change interventions (Selinske et al., 2020, 2021). Another initiative relates to gathering reliable data about Victorians attitudes toward, and use of, the natural environment, via the *Victorians Value Nature* surveys.

The Victorians Value Nature surveys

Within the *Victorians Value Nature* goal is the enabling action to "establish reliable baselines about Victorians' awareness of biodiversity, connection with nature, and current activities to protect the natural environment" within the first five years (DELWP, 2017, p. 15). As a result, DELWP partnered with BehaviourWorks Australia to develop the *Victorians Valuing Nature Foundations Survey*. This research, reported by Meis-Harris et al. (2019), provided an initial snapshot for the *Victorians Value Nature* goal and served as a foundation for subsequent *Victorians Value Nature* surveys. The data from this survey, in conjunction with that from the *Victorians Valuing Nature Follow-up Survey*, formed the basis for this research (for further details, see Chapter 4, page 69).

Chapter summary

Biodiversity conservation policy at the international, national, and state levels has traditionally focused on protecting the natural environment with minimal consideration of human relationships with nature in conservation planning and management. In recent decades, policymakers have increasingly recognised that individual citizens, groups, and

⁶ <https://www.environment.vic.gov.au/media-releases/virtual-victoria-nature-festival-begins>

⁷ <https://www.together.vic.gov.au/victoria-nature-festival>

society more broadly have important roles to play in biodiversity conservation, although the focus on awareness raising is insufficient. More recent policies have evolved to acknowledge the importance of human relationships with nature, and in providing greater access to nature to nurture such relationships. Yet, merely providing access to natural areas does not necessarily translate into more time spent in nature, nor enhanced relationships with nature. Policies that can be translated into practice are needed, including those that facilitate and tangibly measure CN as well as PBB/PEB.

Chapter 3: Connection with nature

Connection with nature (CN) is increasingly being recognised as a potentially useful mechanism by which to engage the public in biodiversity conservation. This chapter provides a narrative review of the CN literature and sets the foundation for the three studies included in this thesis.

Terminology and definitions

The notion of human relationships with nature⁸ has become increasingly prevalent in the literature in recent decades (for reviews, see Ives et al., 2017; Restall & Conrad, 2015). Discussions of how humans perceive, relate to, and interact with nature have seen the development of a myriad of terminology and definitions, such that the literature has become "characterised by a plurality of disciplinary and conceptual perspectives, language, methods and research approaches" (Ives et al., 2017, p. 106).

Terminology used to describe human relationships with nature include connectedness to nature (Mayer & Frantz, 2004), connectivity with nature (Dutcher et al., 2007), nature relatedness (Nisbet et al., 2009), environmental identity (Clayton, 2003), ecological identity (Walton & Jones, 2018), inclusion with nature (Schultz, 2002), love and care for nature (Perkins, 2010), and emotional affinity toward nature (Kals et al., 1999). Some authors have referred to human connections with nature using broad terms such as "the environmental connectedness perspective" (Beery, 2013; Beery & Wolf-Watz, 2014), "human-nature connection" (Ives et al., 2017), and "human-nature relationships" (Braitto et al., 2017). Related terminology includes environmental attitudes, or general evaluations, favourable or unfavourable, of the natural environment and environmental protection (Collado et al., 2013; Kaiser et al., 2014; Milfont & Duckitt, 2010); the "extinction of experience" to refer to human separation and disconnection from nature (Colléony, Cohen-Seffer, et al., 2020; Pyle, 2003; Soga & Gaston, 2016, 2020), and "environmental sensitivity" as "a predisposition to take an interest in learning about the environment, feeling concern for it, and acting to conserve it, on the basis of formative experiences" (Chawla, 1998, p. 19).

⁸ Following Ives et al. (2017), this review avoids strict definitions of nature, instead adopting a broad conceptualisation that encompasses elements of the biophysical world, including ecosystems, landscapes, flora, and fauna, that may or may not include the human species.

Following Ives et al. (2017), this thesis seeks to capture the range of terminology and ideas presented in the literature – with a particular focus on the psychology literature – and adopts the term *connection with nature* (CN) "because it evokes the subtle yet important idea that (1) humans are already an intimate part of nature and (2) that the state imbues a sense of reciprocity and mutualism" (Zylstra et al., 2014, pp. 121-122). A summary of predominant CN-related constructs and definitions appear in Table 2.

Table 2: Summary of connection with nature constructs and definitions, and description of CN themes identified in each construct, presented in chronological order.

Author(s)	CN-related construct	Definition	Themes included
Kals et al. (1999)	Emotional affinity toward nature	"...a concept embracing various inclinations toward nature such as the love of nature" (p. 180). It implies a positive relationship with nature, and reflects an attitude toward nature, and is distinct from the idea of an interest in nature (the latter implies cognitive elements).	Cognitions (attitude) Emotions Relationship
Schultz (2001, 2002)	Inclusion with nature	A psychological construct encompassing cognitive, emotional, and behavioural elements; "the extent to which an individual includes nature within his/her cognitive representation of self" (p. 67), the degree of closeness, affection, or feelings of intimacy with nature, as well as commitment to engage in behaviours that protect nature. Schultz notes that these elements are themselves interconnected in that an individual's cognitive and emotional relationship with nature (e.g. beliefs about one's interdependence with nature, feelings of affection for nature) influence the extent to which they care about nature, which in turn leads to actions to protect nature.	Behaviour Cognitions Emotions Identity Relationship
Clayton (2003)	Environmental identity	A component of an individual's self-concept, encompassing "a sense of connection to some part of the nonhuman natural environment, based on history, emotional attachment, and/or similarity, that affects the ways in which we perceive and act toward the world; a belief that the environment is important to us and an important part of who we are... like a group identity, an environmental identity can vary in both definition and importance among individuals" (pp. 45-46)	Behaviour Cognitions Emotions Identity Relationship Subjective

Author(s)	CN-related construct	Definition	Themes included
Mayer & Frantz (2004)	Connectedness to nature	Connectedness to nature is described relative to an individual's emotional experience of the natural environment, the extent to which an individual views themselves as part of and in kinship with the "broader natural community" (p. 505), and includes the natural environment in their sense of personal identity	Behaviour Cognitions Emotions Identity Relationship Relatively stable
Dutcher et al. (2007)	Connectivity with nature	"Connectivity describes a perception of sameness between the self, others, and the natural world. The experience of connectivity involves dissolution of boundaries and a sense of a shared or common essence between the self, nature, and others." (p. 474) "...experiencing nature as a part of community and not just as the raw material for society. Community and connectivity involve a sense of belonging, and that sense of belonging includes not only each other but also some sense of place, one that exists on a human time scale" (p. 480).	Behaviour Cognitions Emotions (belonging) Relationship
St John & MacDonald (2007)	Ecopsychological self	A model that focuses "on the specific boundary between self and nature", based on assumptions that "(a) the boundary between the human self and nature is flexible, and (b) a sense of self that includes nature is beneficial to an individual's well-being (p. 49)	Behaviour Cognitions Relationship

Author(s)	CN-related construct	Definition	Themes included
Davis, Green & Reed (2009)	Commitment to nature	The degree to which people experience a personal relationship with nature and thus commit to engaging in behaviours that protect or enhance the relationship partner (the natural environment) and/or the relationship itself.	Behaviour Cognitions Emotions Relationship Subjective
Nisbet et al. (2009)	Nature relatedness	"...individual levels of connectedness with the natural world...the notion of a self-construal that includes the natural world. The concept of NR encompasses one's appreciation for and understanding of our interconnectedness with all other living things on the earth...It is also an understanding of the importance of all aspects of nature, even those that are not aesthetically appealing to humans (e.g., spiders and snakes). Finally, we conceive of NR as "trait- like" in that it is relatively stable over time and across situations, though not completely fixed." (p. 718)	Cognitions Identity Relationship Relatively stable
Perkins (2010)	Love and care for nature	"...deep love and caring for nature which includes a clear recognition of nature's intrinsic value as well as a personal sense of responsibility to protect it from harm" (p. 456); this definition includes feelings of awe and wonder of nature, emotional closeness and interconnectedness with nature, and responsibility and commitment toward the protection of nature.	Cognitions Emotions Relationship
Brügger, Kaiser, & Roczen (2011)	Attitude toward nature	Connection with nature is an attitude toward nature that manifests in behaviours to bond with nature. A person with a strong connection to nature is expected "to engage in all sorts of bonding activities and to appreciate nature in multiple ways" (p. 326). Attitudes toward nature are inferred from pro-environmental behaviours.	Cognitions Emotions Relationship

Author(s)	CN-related construct	Definition	Themes included
Beery (2013); Beery & Wolf-Watz (2014)	Environmental connectedness	"...the environmental connectedness perspective" is considered a broad grouping of terminology and ideas related to understanding human-nature interactions and fostering stronger relationship between humans and the natural world in order to increase environmental concern and behaviours that support environmental protection and enhancement. Thus, the environmental connectedness perspective broadly encapsulates terminology such as environmental connectedness, identity, relatedness, commitment, and affinity	Behaviour Cognitions Emotions Identity Relationship
Zylstra et al. (2014)	Connection with nature	"...a stable state of consciousness comprising symbiotic cognitive, affective, and experiential traits that reflect, through consistent attitudes and behaviors, a sustained awareness of the interrelatedness between one's self and the rest of nature" (p. 119)	Behaviour Cognitions Emotions Relationship Relatively stable Subjective
Braitto et al. (2017); Mundaca et al. (2021)	Human-nature relationship	A broad construct encompassing "the bundle of abstract worldviews, values, beliefs, attitudes and perceived norms of how humans should interact with nature, and ultimately how they should behave" (Braitto et al., 2017, p. 370) A person's "relationship and behavior toward nature [that] is guided by both their understandings and perceptions of nature (i.e., a cognitive component) and the way we feel toward nature (i.e., an affective component)." (Mundaca et al., 2021, p. 2)	Behaviour Emotions Cognitions Relationship

Author(s)	CN-related construct	Definition	Themes included
Hunt et al. (2017)	Nature connection/nature connectedness	"...nature connectedness or nature connection encompasses a person's subjective sense of their relationship with the natural world." (p. 9)	Relationship Subjective
Ives et al. (2017, 2018)	Human-nature connection	<p>Ives et al., 2017: "...an umbrella concept, encompassing a broad range of terms from different disciplines and applications...for instance connectedness with nature or nature relatedness in environmental psychology and (re-)connection to the biosphere in sustainability science." (p. 106)</p> <p>Ives et al., 2018: "...human-nature connectedness is a multifaceted concept incorporating (1) material connections such as resource extraction and use; (2) experiential connections such as recreational activities in green environments; (3) cognitive connections such as knowledge, beliefs and attitudes; (4) emotional attachments and affective responses; and (5) philosophical perspectives on humanity's relationship to the natural world. (p. 1)</p>	Behaviour Cognitions Emotions Relationship
Walton & Jones (2018)	Ecological identity	<p>"...within the context of self-environment relations, we will conceptualize identity as relatively stable socially embedded meaning attached to the self that position individuals within a web of socioecological relationships, based on shared personal characteristics, roles, and group memberships" (p. 659)</p> <p>Ecological identity is thus "...the extent and ways by which an individual views himself or herself as being a part of an integrated social and biophysical (i.e., ecological) system characterized by mutually beneficial processes and nested webs of relationships. (p. 666)</p>	Cognitions Identity Relationship Relatively stable

Themes appearing in definitions of CN

A number of themes are evident across definitions of CN, with overlap between themes also evident. These themes reflect a psychological perspective that is predominant in the CN literature (Ives et al., 2017; Restall & Conrad, 2015).

Personal and subjective

A common theme across many definitions of CN is that of subjectivity. An individual's relationship with the natural world is seen as a personal and subjective experience that is influenced by a range of factors, and is expressed in a range of different ways (Hunt et al., 2017). Clayton (2003) suggests that environmental identity is based on history and can vary in definition and importance across individuals, implying a personal and subjective nature. Similarly, Walton and Jones (2018) suggest that ecological identity reflects the ways in which an individual views themselves and their place within a larger system, implying uniqueness in each individual's perspective. For Davis, Green and Reed (2009), commitment to nature reflects a personal relationship with nature while for Nisbet et al. (2009), nature relatedness is explicitly referred to as "individual levels of connectedness" (p. 718), implying elements of individuality and subjectivity. In recognising the personal and subjective nature of CN, Zylstra and colleagues (2014, p. 126) suggest that "attempts to produce a definitive and fixed definition of CWN [connection with nature] are idealistic and may even border on arrogance". Thus, this review seeks to capture a broad sense of CN that encompasses a variety of conceptualisations and definitions.

Identity

Identity, and particularly the extent to which an individual considers nature to be part of their definition and perception of self, is another theme that frequently appears in the CN literature. Such ideas are prominent in discussions around environmental identity (Clayton, 2003) and ecological identity (Walton & Jones, 2018), yet also appear relative to connection with and to nature (Mayer & Frantz, 2004; Zylstra et al., 2014). Similarly, Schultz (2002) argues that inclusion with nature incorporates "the extent to which an individual includes nature within his/her cognitive representation of self" (p. 67), while Nisbet and colleagues (2009, p. 718) suggest that nature relatedness includes "the notion of a self-construal that includes the natural world".

In a distinct yet related manner, some authors have considered environmental identity from the perspective of role identification, such as perceptions of the self as an environmentalist or as someone who engages in behaviours that benefit the natural environment. Such conceptions are reflected in statements such as "acting environmental [*sic*] friendly is an important part of who I

am" (van der Werff et al., 2014, p. 634), "I think of myself as an environmentally-friendly consumer" (Whitmarsh & O'Neill, 2010, p. 308), and "to engage in household recycling is an important part of who I am" (Nigbur et al., 2010, p. 265). Thus, while environmental role identity does not explicitly consider nature as part of the self, the construct does overlap with CN with respect to behaviours toward the natural environment.

Relationship

Common to all CN-related constructs described in Table 2 is the idea of a relationship between humans and the natural environment. In describing connectedness to nature, Mayer and Frantz (2004, p. 505) refer to "a sense of kinship" with a "broader natural community". Similarly, Dutcher et al. (2007) discuss connectivity with nature relative to "a dissolution of boundaries and a sense of shared or common essence between the self, nature and others" (p. 474), implying relationship closeness such that little or no distinction is drawn between the individual and nature. More recently, Mundaca and colleagues (2021) argue that CN includes connectedness in the sense of "having a bond or being in touch with something" (p. 4).

A relationship between parties or objects may be expressed as behaviour. Davis and colleagues (2009) explicitly refer to commitment to nature relative to the relationship between a person and nature. The relationship is considered relative to one's willingness to put time and effort into the relationship, and to consider the relationship partner (nature) in decision-making such that the relationship can be nurtured and may continue. For Clayton (2003), environmental identity is conceptualised relative to its impact on how an individual perceives and acts toward the natural environment, while for Schultz (2002), inclusion with nature encompasses a relationship that is reflected in a sense of commitment to protecting nature.

The notion of a relationship between the self and nature is reflected in Ives and colleagues' (2018) philosophical dimension of CN, defined as "philosophical perspectives on humanity's relationship to the natural world" (p. 1) and "perspective or world view on what nature is, why it matters, and how humans ought to interact with it (e.g., master, participant, steward)" (p. 3).

Emotions

Often discussed in the CN literature is the theme of emotion, and particularly positive emotion. Some authors explicitly refer to emotional aspects of human-nature relationships, such as love of nature (Kals et al., 1999; Perkins, 2010) while for others, emotional experience is embedded within the definition. Schultz (2002) considers inclusion with nature to encompass an emotional connection with nature that reflects an individual's feelings of affection or intimacy with the natural

world. Clayton (2003) considers environmental identity relative to an emotional attachment to nature, while for Mayer and Frantz (2004), connectedness to nature includes an emotional experience of nature. In their five-dimensional model, Ives and colleagues (2018) argue that CN includes an emotional dimension, defined as "emotional attachments and affective responses" (p. 1) and "feelings of attachment to or empathy toward nature" (p. 3). For Mundaca and colleagues (2021) emotional elements of CN include empathy for, and enjoyment of, nature, as well as a bond with nature.

Cognitions

For many authors, CN includes a variety of beliefs, values, and norms about one's relationship with the natural environment. For Dutcher and colleagues (2007), connectivity with nature includes an individual's perception of the self, relative to the natural world. Nature relatedness "encompasses one's appreciation for and understanding of our interconnectedness with all other living things on the earth" (Nisbet et al., 2009, p. 718), a notion that includes a set of values and beliefs about the relationship between humans and nature. For Perkins (2010), love and care for nature encompasses beliefs about one's responsibility to care for and protect the natural world, while for Clayton (2003), environmental identity reflects a set of beliefs about the importance of nature and the way nature is perceived relative to a sense of identity. Following Dunlap et al. (2000), Bruni and colleagues (2012) consider CN in purely cognitive terms, conceptualising CN as a "primitive belief" about the extent to which a person perceives themselves to be part of, or separate from, the natural environment. For Mundaca et al. (2021), CN includes a cognitive dimension, representing knowledge, awareness, understanding, and appreciation of nature.

A cognitive dimension of CN is discussed by Ives and colleagues (2018). Defined as "cognitive connections such as knowledge, beliefs and attitudes" (p. 1) and "knowledge and awareness of the environment and attitudes/values toward nature" (p. 3), cognitive CN may also thus include knowledge and awareness of the environment and environmental issues, constructs that are often the focus of environmental education (Zylstra et al., 2014). It has been suggested that cognitive CN also overlaps with philosophical CN in that both refer to beliefs and values about how humans perceive and should interact with the natural environment (Ives et al., 2018).

Behaviour

Behaviour is also a prominent theme in the CN literature. Some authors consider CN as a motivating force for behaviour; Kals et al. (1999), for example, suggest that emotional affinity toward nature motivates behaviours that enable contact with nature. Similarly, Clayton (2003) argues that environmental identity can act as a motivating force for behaviours that in turn help to

communicate environmental identity to others. In describing inclusion with nature, Schultz (2002) identifies a behavioural component that includes commitment and motivation to act to protect nature.

CN is also seen to manifest as behaviour, such as spending time in natural environments (e.g. for leisure) or engaging in behaviours to protect or enhance nature. Davis and colleagues (2009), for example, argue that environmental commitment is reflected in behaviours that nurture the human-nature relationship, as opposed to behaviours that might damage the relationship. Zylstra and colleagues (2014) suggest that CN is a state of consciousness that becomes apparent via behaviour, particularly repeated behaviours, and a commitment to engage in behaviours that protect nature. Similarly, Mundaca et al. (2021) argue that CN comprises cognitive and emotional dimensions, with experiential or behavioural dimensions considered a product of interactions between humans and nature via the cognitive and emotional dimensions, rather than a dimension of CN *per se*.

Ives and colleagues (2018) refer to experiential CN, defined as "direct interaction with natural environments" (p.3). Experiential CN could therefore include a range of behaviours that involve direct contact with nature, including recreational activities (e.g. hiking), incidental interactions (e.g. walking through a park on the way to work), as well as purposeful conservation or science activities (e.g. tree planting, citizen science).

Clayton and colleagues (2017) suggest that experiences of nature encompass more than simply contact with nature, arguing that an experience of nature "must be seen as a process, including: (1) interactions between individuals and natural entities; (2) social and cultural context; and (3) consequences for new skills, knowledge, or behavioral changes." (p. 646). Embedded within this is a relationship between humans and the natural world, and the implication that such a relationship may change over time. If such an idea is applied to CN more broadly, it could be argued that CN generally is a dynamic and relational construct.

As highlighted by this discussion, a plurality of definitions and terminology have been used to describe CN. Across this diversity of definitions, a number of key themes are evident. Typically conceptualised as subjective and personal, CN relates to a relatively stable sense of personal identity, encompassing a relationship between the self and the natural world that includes emotions (e.g. love, empathy, appreciation) and cognitions (e.g. attitudes, beliefs, knowledge) about and toward nature, as well as behaviour (e.g. experiences in, with, or toward nature).

Theoretical and conceptual frameworks

Early theoretical work discussed relationships between humans and nature through constructs such as deep ecology and the ecological self (Bragg, 1996; Naess, 1973), and ecopsychology (Roszak, 1992). Deep ecology is an environmental philosophy perspective that rejects notions of humans existing *within* nature, instead arguing that humans *are* nature and are thus intimately entwined with and dependent upon nature (Naess, 1973). From this perspective, the ecological self encompasses not just the individual but rather "a wide, expansive or field-like sense of self, which ultimately includes all life-forms, ecosystems and the Earth itself" (Bragg, 1996, p. 95). From an ecopsychology perspective, human health and wellbeing depends on the health and wellbeing of the natural world (Roszak, 1992). Ecopsychology "seeks to heal the more fundamental alienation between the person and the natural environment" (Roszak, 1992, p. 320) by emphasising the intimate and dependent nature of human relationships with nature, and nurturing practices that foster emotional, cognitive, and spiritual connections with the natural world (Fisher, 2013).

One of the most commonly cited theories of human-nature relationships is the biophilia hypothesis, popularised by E. O. Wilson (1984) and later expanded by Kellert and Wilson (1993). The biophilia hypothesis (Wilson, 1984, 1993) proposes that humans possess an innate tendency to pay attention to, and to form relationships with, other living organisms – a product of humans evolving in and with nature over millennia. From this perspective, a person's identity is intimately tied to – and depends upon – a relationship with nature, in that nature influences "emotional, cognitive, aesthetic, and even spiritual development" (Kellert, 1993, p. 42). Building on the idea of biophilia, CN has also been described as a basic psychological need (Baxter & Pelletier, 2019; Hurly & Walker, 2019), or a tendency "to seek out certain basic types of psychosocial experiences and to feel good and thrive when those basic experiences are obtained" (Sheldon, 2011, p. 552).

More recently, CN has been conceptualised as a multidimensional construct involving thoughts, emotions, and experiences (e.g. Richardson et al., 2019; Schultz, 2002; Whitburn, Linklater, & Abrahamse, 2019). One early CN model was proposed by Schultz (2000, 2002). The *Inclusion Model*, described in Figure 3, captures cognitive, emotional, and behavioural aspects of human-nature relationships through the constructs of connectedness with nature, caring for nature, and commitment to protect nature. For Schultz, connectedness is cognitive, encompassing beliefs about one's relationship with nature and the extent to which nature is included in the cognitive representation of self. Such connectedness leads to caring for nature or an emotional experience, feelings of intimacy, and a sense of interdependence with nature. Caring, in turn, leads to behaviours to protect nature.

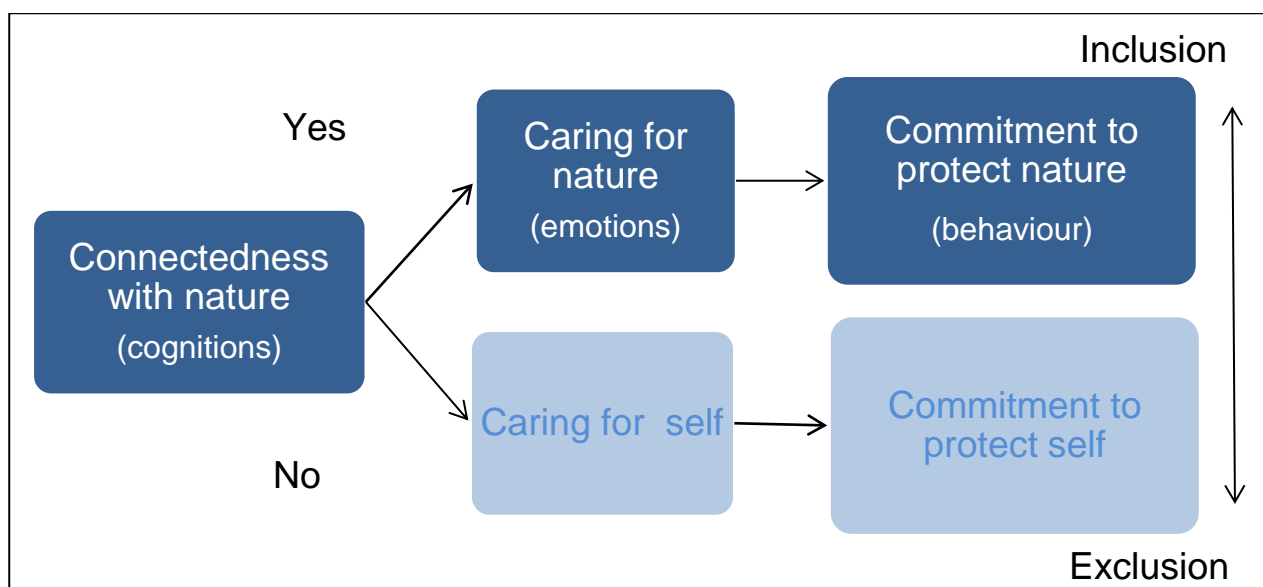


Figure 3: The Inclusion Model representing human-nature relationships. Core components include connectedness, caring, and commitment. Adapted from Schultz (2002, p. 69), with permission from Springer Nature © 2002.

In reviewing the literature, Zylstra and colleagues (2014) proposed a conceptual framework encompassing four key components of CN: 1) information about nature; 2) experience in nature; 3) connectedness with nature; and 4) committed connectedness with nature (Figure 4). Information about nature represents cognitive aspects of one's relationship with nature, including knowledge about nature and a desire to learn more about nature, and broadly overlaps with ideas about identity in relation to nature. Experience in nature encompasses time spent in contact with nature through activities such as outdoor education, sport, or leisure pursuits. Connectedness with nature is a product of experiences in nature and information about nature, coupled with emotional elements about or in relation to nature, for example, feelings of love, respect, oneness, or empathy. Another feature of the *connectedness with nature* component is spirit, encompassing ideas of being "in touch with, appreciative of, and inspired by nature" (p. 126). The final component, *committed connectedness with nature*, represents the intersection of cognitions, emotions, experiences, and spirit that translates into a more stable and enduring CN over time, or what Clayton (2017; 2021) has referred to as "environment identity" (see later discussion: CN as state or trait on page 61).

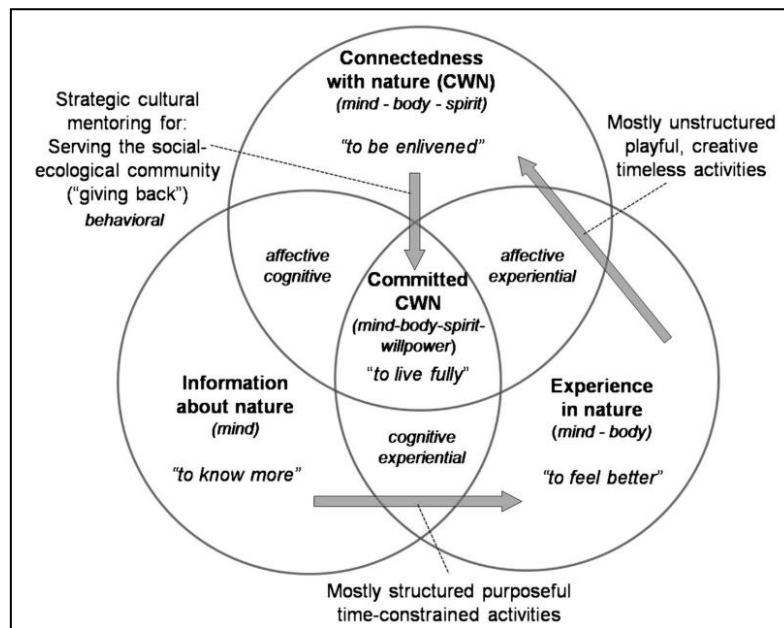


Figure 4: Conceptual framework for CN proposed by Zylstra et al. (2014, p. 125). Reprinted by permission from Springer Nature © 2014

More recently, Ives and colleagues (2017, 2018) conceptualise CN as a multifaceted construct comprising five distinct yet interrelated dimensions, or "types": 1. Material; 2. Experiential; 3. Cognitive; 4. Emotional; 5. Philosophical (see Figure 1 in Chapter 1, page 24). The authors argue that these five dimensions exist along a spectrum from external connections (material) through to increasingly internal connections (philosophical). For Ives et al. (2018, p. 3), these five dimensions "do not operate in isolation – in reality, they interact with and are influenced by one another". For example, participation in nature-based activities such as citizen science (experiential CN) has been associated with greater environmental knowledge (cognitive CN) and emotional connection to the area being studied (emotional CN) (Schuttler et al., 2018), while greater frequency of park visitation (experiential CN) has been associated higher emotional and cognitive CN (Lin et al., 2014; see also Riechers et al., 2020). As Ives et al. (2018, p. 3) note, "many other interactions [between CN dimensions] are likely to exist, but have yet to be examined in depth".





























As this discussion suggests, human relationships with nature have been debated for decades, with academic interest in CN becoming increasingly prevalent around the turn of the century (Ives et al., 2017). A number of theoretical and conceptual frameworks have been used to describe CN and while there is nuance in each, there is also a degree of commonality. CN involves a complex interaction of thoughts, emotions, and behaviours about and toward the natural environment. Direct experience of nature plays an important role in CN, and CN likely changes over time. With this complexity in mind, is it perhaps unsurprising that a multitude of methodologies and instruments have been developed to capture CN.

Measurement of CN

Some of the methodologies that have been used to measure CN include interview techniques (Furness, 2021; Rice & Torquati, 2013), journaling and photography (Ardoin et al., 2014; Talebpour et al., 2020), and interpretation of drawings (Profice, 2018). Some researchers have explored CN qualitatively; Vining and colleagues (2008), for example, asked participants whether they see themselves are part of separate from nature and to explain their answer. Some have asked qualitative questions with respondents offering comments about connection with nature, for example, as a motivation for, or outcome of, participating in citizen science (Chase & Levine, 2017; Ganzevoort & van den Born, 2019).

Other researchers have used implicit or indirect methods for determining CN. Implicit association tests are believed to assess primitive beliefs about one's relationship with nature by assessing reaction times to pairs of concepts (e.g. "me" and "flower"; "me" and "building") (Arendt & Matthes, 2016; Schultz et al., 2004; Schultz & Tabanico, 2007). Indirect methods include asking questions about attitudes and past behaviour in relation to nature to infer CN (Brügger et al., 2011). Such methods are intended to overcome potential difficulties associated with direct questioning about one's relationship with nature, for example, whether an abstract concept such as CN is understood by lay people, or whether a person has conscious awareness of their relationship with nature (Brügger et al., 2011; Schultz et al., 2004; Schultz & Tabanico, 2007).

Another method of assessing CN is using visual scales. Building on the work of Aron et al. (1991) and using the *Inclusion Model* as a framework, Schultz (2001, 2002) developed the *Inclusion of Nature in Self* (INS) scale to assess the extent of perceived closeness between the self and nature. This measure presents two circles indicating the self in one circle and nature in the other; the circles are presented initially side-by-side with subsequent versions showing increasing degrees of overlap between the two circles. The respondent selects the circles that most accurately represents their relationship with the natural environment (i.e. no overlap = *I am separate from nature*; complete overlap = *I am inseparable from / completely part of nature*) (see top row of Figure 5). Recently, researchers have refined the INS to improve its psychometric properties and interpretability; Martin and Czellar (2016) developed an extended version of the INS using different types of images (Figure 5), while Kleespies et al. (2021) included an image of "self" (i.e. a human) and an image of "nature" (i.e. a landscape) (Figure 6). The simple format of these visual scales has enabled them to be used with young children and non-English speakers (Salazar et al., 2020).

Answer options							
	1	2	3	4	5	6	7
Overlap ^a	Self Nature 	Self Nature 	Self Nature 	Self Nature 	Self Nature 	Self Nature 	Self Nature 
Size ^b	Nature 	Nature 	Nature 	Nature 	Nature 	Nature 	Nature 
Distance ^a	Self Nature 	Self Nature 	Self Nature 	Self Nature 	Self Nature 	Self Nature 	Self Nature 
Central ^a	Nature Center 	Nature Center 	Nature Center 	Nature Center 	Nature Center 	Nature Center 	Nature Center 

Note: Instructions preceding the EINS: "Below, please choose the pictures which best describe your relationship with the natural environment. Please answer spontaneously with what comes to your mind first."; Instructions preceding each item: ^a) "Please choose the picture below which best describes your relationship with the natural environment"; ^b) "Please choose the picture below which best describes nature when you think of your relationship with the natural environment"; The overlap item is the original INS measure developed by Schultz (2001).

Figure 5: The Extended Inclusion of Nature in Self scale (Martin & Czellar, 2016, p. 186). Reprinted with permission from Elsevier © 2016.

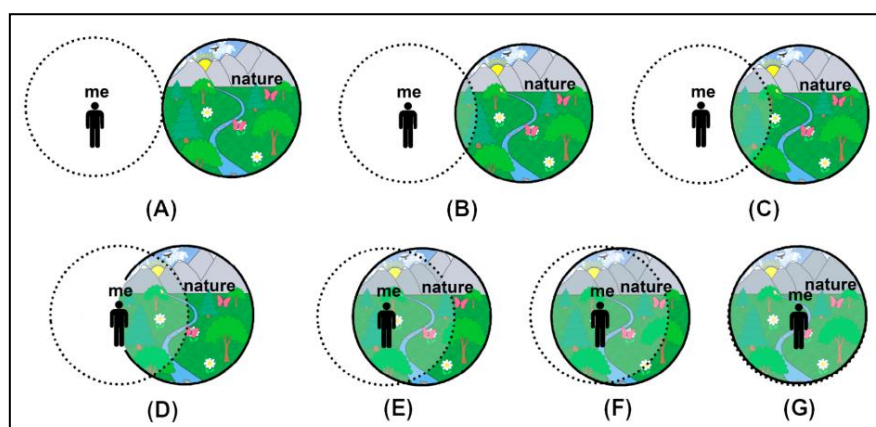


Figure 6: The Illustrated Inclusion of Nature in Self scale (Kleespies et al., 2021, p. 5). Reprinted with permission from the authors.

In the psychology literature, CN has most commonly been captured quantitatively using Likert-type rating scales. Some authors use single questions such as "I feel part of nature" (1 = *completely disagree*, 7 = *completely agree*) (Richardson & Hamlin, 2021) or by asking participants to rate how connected to nature they feel (1 = *very disconnected*, 5 = *very connected*) (Fretwell & Greig, 2019; Taylor, 2018). A variety of self-report multi-item questionnaires have also been developed.

Self-report questionnaires

In recent decades, an assortment of self-report scales and measures have been developed to assess CN and related constructs. The majority of these scales have been developed and validated using adult samples from industrialised societies (Ives et al., 2017; Restall & Conrad, 2015). Some instruments have been developed and/or adapted to assess CN in both adults and children (Hunt et al., 2017; Mayer & Frantz, 2004; Richardson et al., 2019; Salazar et al., 2020) while others have been developed specifically for children (for review, see Chawla, 2020; Salazar et al., 2020). Recently, researchers have begun adapting instruments developed using samples from industrialised societies to suit indigenous cultural groups (Marczak & Sorokowski, 2018; Sedawi et al., 2020, 2021).

While a small number of scales are described as multidimensional, the majority are unidimensional, although there is variation in the dimensions captured. Indeed, some authors conceptualise CN relative to multiple dimensions, typically involving thoughts, emotions, and behaviours (e.g. Richardson et al., 2019; Schultz, 2002), yet the instruments subsequently developed capture a unidimensional construct. A summary of commonly used CN instruments appears in Table 3.

Table 3. A sample of commonly-used self-report instruments to assess CN in adults, presented in chronological order, with CN dimensions represented.

Instrument	Author(s)	Response format	Dimensionality	CN dimensions represented
Emotional affinity toward nature (EATN)	Kals et al. (1999)	16 statements (1=completely agree, 6=completely disagree)	Unidimensional	Emotional
Inclusion of Nature in Self (INS)	Schultz (2001, 2002)	Select a diagram to describe the relationship between self and nature	Unidimensional	Cognitive
Environmental Identity scale (EID); Revised Environmental Identity scale (EID-R)	Clayton (2003); Clayton et al. (2021)	24 statements (1=not at all true of me, 7=completely true of me); revised to 14 statements	Multidimensional (EID) ^{&} ; Unidimensional (EID-R)	Cognitive Emotional Philosophical

Instrument	Author(s)	Response format	Dimensionality	CN dimensions represented
Connectedness to Nature Scale (CNS)	Mayer & Frantz (2004)	14 statements (1=strongly disagree, 5=strongly agree)	Unidimensional	Emotional
Connectivity with Nature (CwN)	Dutcher et al. (2007)	4 statements (1=strongly disagree, 5=strongly agree) & select a diagram to describe the relationship between self and nature	Unidimensional	Philosophical
Commitment to Nature (COM)	Davis, Green & Reed (2009)	11 statements (0=do not agree at all, 8=agree completely)	Unidimensional	Cognitive
Nature Relatedness Scale (NR)	Nisbet et al. (2009)	21 statements (1=strongly disagree, 5=strongly agree)	Multidimensional (NR)*	Cognitive Experiential Philosophical
Love and Care for Nature (LCN)	Perkins (2010)	15 statements (1=strongly disagree, 7=strongly agree)	Unidimensional	Emotional
Disposition to connect with nature (DCN)	Brügger et al. (2011)	40 statements: 26 self-reported behaviours (17 assessing frequency of the behaviour; 9 with yes/no response format); 14 statements with yes/no response format	Unidimensional	Cognitive Experiential
Environmental connectedness (EC)	Beery (2013)	3 statements (Likert scale from completely disagree to completely agree; scale values and range not described)	Unidimensional	Cognitive

Instrument	Author(s)	Response format	Dimensionality	CN dimensions represented
Nature relatedness short form (NR6)	Nisbet & Zelenski (2013)	6 statements (1=strongly disagree, 5=strongly agree)	Unidimensional	Cognitive
Nature connection index (NCI)	Hunt et al. (2017); Richardson et al. (2019)	6 statements (1=strongly disagree, 7=strongly agree)	Unidimensional	Cognitive
Ecological Identity Scale (EIS)	Walton & Jones (2018)	18 statements (5-point Likert scale from 1 to 5, higher scores indicating stronger ecological identity; response options not described)	Unidimensional	Cognitive
Emotional and Cognitive Scale of the Human–Nature Relationship (ECS-HNR)	Mundaca et al. (2021)	24 statements (1=strongly disagree, 5=strongly agree)	Multidimensional	Cognitive Emotional

& Clayton (2003) proposed the EID to be multidimensional yet reported results from a factor analysis suggesting a single factor structure

*Nisbet et al. (2009) proposed the NR to be a multidimensional construct although results from a factor analysis suggest it is likely unidimensional in nature

A common practice in the CN literature is to validate newly developed instruments by assessing convergent validity with existing instruments. Strong correlations are often reported between CN instruments (e.g. Beery, 2013; Hunt et al., 2017; Nisbet & Zelenski, 2013; Olivos et al., 2011) suggesting a great degree of overlap between them. In an effort to assess the degree of convergence and divergence, Tam (2013) reviewed seven commonly cited CN instruments. Results suggested that multidimensional instruments consistently showed stronger relationships with criterion variables – such as PEB and TIN – than unidimensional instruments. Further, Tam (2013) notes that different instruments appeared to capture different dimensions of the CN

construct, "each of which has its own unique conceptual meanings but at the same time shares a substantial overlap with other aspects that warrants an identification of a common core" (p. 74). The author thus concludes that while CN may best be described as a multidimensional construct, the dimensional structure of CN is far from clear, and that many possible dimensions have not yet been assessed. In addition, Tam (2013) proposes that further research is needed to determine how well different dimensions of CN predict different outcomes, such as engagement in PBB/PEB.

Thesis objective 1: Explore and clarify dimensions of connection with nature; develop a brief yet parsimonious self-report connection with nature instrument; investigate relationships between connection with nature, time spent in nature, and pro-biodiversity behaviours.

As this discussion illustrates, a range of techniques and instruments have been used to measure CN. Different techniques and instruments may be more appropriate in specific contexts, for example, drawings or photographs are often used with children and young people while pictorial instruments may be more suitable than self-report questionnaires when English language proficiency is limited (Salazar et al., 2021).

Among self-report instruments, authors have attempted to capture a range of thoughts, emotions, and behaviours in relation to the natural environment, yet while many conceptualisations of CN are multidimensional, the majority of self-report instruments capture a unidimensional construct. This lack of clarity regarding the dimensions of CN warrants further investigation. Further, the three self-report instruments that capture CN as a multidimensional construct (Brügger et al., 2011; Clayton, 2003; Nisbet et al., 2009) are lengthy, comprising 21 to 40 items, and may not be suitable for real-world contexts where time and money are limited (Maloney et al., 2011). In addition, there has also been limited exploration of how different dimensions of CN relate to constructs such as PBB/PEB (Ives et al., 2017; Restall & Conrad, 2015; Tam, 2013).

Critiques of the CN construct

While academic interest in CN has grown exponentially in recent decades (Ives et al., 2017; Restall & Conrad, 2015), a number of critiques have also been noted.

Understanding "nature" relative to "connection with nature"

The CN literature often does not explicitly define nature, and there has been limited consideration of how people understand the term "nature" or what aspects of nature people feel connected to

(Beery & Wolf-Watz, 2014; Ives et al., 2017; Pasca et al., 2020). Indeed, the term "nature" refers to a complex and abstract construct with multiple meanings and no single agreed-upon definition (Clayton & Opatow, 2003; Ducarme & Couvet, 2020).

As a concept, "nature" does not refer to a concrete entity or object and thus is a term that is open to interpretation (Dickinson, 2013; Ducarme & Couvet, 2020; Mcphie & Clarke, 2018). Research has demonstrated differences across ethnic/cultural groups in how people understand the term "nature" (Ducarme et al., 2020; Kloek et al., 2018) while translations of "nature" into 63 different languages revealed a variety of conceptualisations (Coscieme et al., 2020). Differences have also been noted *within* cultural groups, with lay people and conservation professionals tending to describe "nature" in different ways (Buijs & Elands, 2013). As Sedawi et al. (2021) note, "perceptions toward nature cannot be universalized" (pp. 23-24) and this has important implications for how "connection with nature" is understood. Further, how people think about, understand, and describe nature may influence how they relate to it, including behaviours toward its protection (Andrews, 2018; Buijs et al., 2008; Coscieme et al., 2020; Mausner, 1996). Yet, there is a dearth of literature considering how people perceive nature and the language they use to describe nature – their concepts of nature – relative to CN or to PBB/PEB.

Interestingly, most authors appear to consider the relationship between humans and nature in a positive light, although it is unlikely that this is always the case (Hinds & Sparks, 2011). For some people, the "scary" type of nature involving inhospitable wilderness, danger, fear, or disgust is not something to connect to, but rather, something to avoid (Aaron & Witt, 2011; Bixler & Floyd, 1997; Mcphie & Clarke, 2018; Milligan & Bingley, 2007; Olivos-Jara et al., 2020). Similarly, "phlegm, malaria, weeds, sharks, breast cancer, floods...they're all nature too" yet these types of nature are often not considered in conceptualisations of CN (Mcphie & Clarke, 2018, p. 1516). Thus, biophobia, or the adaptive tendency to fear or avoid nature or parts of nature (Ulrich, 1993), has been largely neglected in the CN literature (Olivos-Jara et al., 2020).

Another critique of the CN construct relates to whether humans and human products are considered "nature". Traditional definitions of nature often include all things not human or under human influence, encompassing a sense of wilderness or the natural environment in its "original" state (Clayton & Opatow, 2003; Meis-Harris et al., 2019; Milton, 2002; Schmithüsen & Wild-Eck, 2000). Yet, humans evolved from nature and have altered the natural environment for millennia (Pascoe, 2018; Wilson, 1984). From this perspective, CN is seen as an attempt to measure a relationship between humans and a version of nature that is utopian, romanticised, and somehow distant from the human experience (Mcphie & Clarke, 2018). As Mcphie and Clarke (2018) note, human products such as cutlery, cars, buildings, and books are made from nature yet many people consider these products non-natural, "but if humans are nature too then surely everything we

produce is of nature (the material, force and energy of the world/universe), so at what point does it become 'not nature' or 'unnatural'?" (p. 1517). Thus, notions of connecting or reconnecting with nature become problematic when demarcations between "nature" and "not nature" are contested and unclear (Fletcher, 2017; Mcphie & Clarke, 2018). As Dickinson (2013) argues, notions of reconnecting people with nature must also consider "a true recognition of – and not just a nod to – the notion that nature is everywhere and humans are nature, and not a part of or in nature" (p. 330).

Similarly, while notions of humans as part of or separate from nature have been discussed among industrialised populations, such ideas may not have broader applicability. Indigenous societies in North America (Salmón, 2000), Australia (Sangha et al., 2019), and Israel (Sedawi et al., 2021), for example, typically consider humans as intimate parts of nature thus ideas of reconnecting with nature may not be relevant or useful (Sedawi et al., 2021). Indeed, most CN research has been conducted in developed, high-income countries (Ives et al., 2017; Restall & Conrad, 2015) and this bias toward a relatively small number of cultures raises questions as to the universality of the CN construct (Restall & Conrad, 2015). Thus, while disconnection from nature has been noted in industrialised societies (e.g. Kesebir & Kesebir, 2017), the CN construct, instruments, and notions of reconnecting people with nature may not have universal relevance (Zylstra et al., 2014).

Thesis objective 2: Explore concepts of nature, and investigate relationships between concepts of nature and connection with nature (total and dimension scores), and concepts of nature and nature-based pro-biodiversity behaviours.

CN as state or trait

Another issue not often explicitly discussed in the literature is whether CN is considered a state, a trait, or both. A relatively small proportion of authors are explicit in their descriptions; Zylstra and colleagues (2014), for example, argue that CN "is a stable state of consciousness comprising symbiotic cognitive, affective, and experiential traits" (p. 126). Similarly, Walton and Jones (2018) define ecological identity "as relatively stable socially embedded meaning attached to the self that position individuals within a web of socioecological relationships" (p. 659). Yet, discussions of similar constructs, such as love and care for nature (Perkins, 2010), connectivity with nature (Dutcher et al., 2007), inclusion with nature (Schultz, 2002), commitment to nature (Davis et al., 2009), and human-nature relationships (Mundaca et al., 2021) do not explicitly refer to state or trait.

Many researchers define CN as a trait-like construct, although with recognition that it is not fixed (Clayton, 2003; Martin et al., 2020; Mayer & Frantz, 2004; Nisbet et al., 2009). Evidence suggests

that CN may be dependent upon seasons and weather patterns (Duffy & Verges, 2010; Nisbet et al., 2011; Talebpour et al., 2020) and can be manipulated, for example, through exposure to, and intentional awareness of, natural environments (Mayer et al., 2009; Passmore & Holder, 2017; Richardson & Sheffield, 2017), by viewing photographs of different types of nature (Tomasso et al., 2021), and by priming reflection of activities enjoyed outdoors (Wesselmann et al., 2021). Some have suggested that CN is dependent upon time, space, and context (Kunchambo et al., 2021; Riechers et al., 2020; Zylstra et al., 2014). Recent work has demonstrated that CN appears to develop over the life course, with relatively high CN scores among pre-teens, the lowest scores around middle adolescence, with scores increasing again in late adolescence before plateauing into adulthood (Hughes et al., 2019; Richardson et al., 2019).

Some have argued that while a single exposure to nature may increase state CN, development of a more enduring trait-like CN may require repeated experiences in nature over a period of time (Carr & Hughes, 2021; Chawla, 2020; Clayton, 2017; Clayton et al., 2021; Prévot et al., 2018; Richardson et al., 2020; Salazar et al., 2020; Zelenski et al., 2015). Indeed, in the conceptual framework proposed by Zylstra and colleagues (2014), the component of *connectedness with nature* is somewhat akin to a state-like CN, while *committed connectedness with nature* is in line with ideas about a more enduring trait-like CN that is the product of repeated experiences in and of nature (see Figure 4).

Whether CN is considered a state or trait has important implications for how CN is measured. Carr and Hughes (2021) propose that most CN instruments capture trait CN, hence may not be useful for determining changes in state-like CN following a relatively brief intervention or single event (see also Salazar et al., 2020). A number of researchers have, however, demonstrated change in trait CN scores following a brief intervention (Lumber et al., 2017; McEwan et al., 2019; Mena-García et al., 2020; Richardson et al., 2015) which raises questions as to whether these studies are actually measuring trait or state CN. Some instruments, such as the CNS and INS, have been adapted to capture state CN by including qualifiers such as "right now" or "at the present moment" (Colléony, Levontin, et al., 2020; Mayer et al., 2009; Nisbet et al., 2019; see also Tomasso et al., 2021), and these may be more useful in assessing change in state CN following a brief intervention. As Colléony and colleagues (2020) suggest, while state CN may be experimentally manipulated, increasing trait CN, particularly over the longer term, may be much more difficult. Thus, if the goal of an intervention is to increase CN, researchers and practitioners should be mindful of whether they are attempting to manipulate, and to measure, CN as a state or trait. Research is also needed to explore the potential interactions of CN as state and CN as trait (e.g. Mayer et al., 2009).

Another important implication for the state/trait distinction is the relationship between CN and other constructs. While research has demonstrated a moderate-to-strong relationship between CN and PEB (Mackay & Schmitt, 2019; Whitburn, Linklater, & Abrahamse, 2019), these studies typically assess trait CN using instruments such as the NR, EID, and CNS. Experimental studies often assess change in exposure to nature rather than change in CN, suggesting a more state-like quality, yet these experimental studies typically showed a weaker relationship between CN and PEB (Mackay & Schmitt, 2019). If CN is to be used as a means of increasing PBB/PEB, further research is needed to determine whether influencing state CN has an enduring impact on PBB/PEB, or whether shifting trait CN is needed to influence behaviour in the longer term.

In sum, the CN literature often fails to define "nature" although given the complexity and ambiguity of the term "nature", this is perhaps unsurprising. Yet, how people understand and perceive nature could have important implications for how CN as a construct is interpreted, understood, and measured; for interventions intended to increase state and/or trait CN; and for engagement in PBB/PEB. Therefore, understanding peoples' concepts of nature, and the relationships between such concepts and trait-like CN, and between such concepts and PBB warrants further investigation. In light of the questionable universality of the CN construct, a specific focus on how adults from an industrialised country understand "nature" is indicated.

Nurturing CN

Despite the growing interest in CN, understanding of how a stable, trait-like CN develops, is maintained, or may be nurtured, is somewhat limited (Carr & Hughes, 2021; Cleary et al., 2018; Ives et al., 2018; Zylstra et al., 2014). Time spent in contact with nature has been implicated as an important factor in developing a connection with nature, with early CN research proposing that frequency of time spent in nature is among the strongest predictors of CN (Kals et al., 1999). Indeed, evidence suggests that both adults (e.g. Lin et al., 2014; Pensini et al., 2016; Rosa et al., 2018) and children (reviewed by Chawla, 2020) who spend more time in nature tend to have higher CN scores.

Time spent in contact with nature has been considered relative to the frequency of visits (e.g. rarely, often) as well as duration of time spent in nature (e.g. hours per week), and both appear to be important predictors of CN. A number of studies have reported associations between greater frequency of visits to natural areas and higher trait CN scores (Cleary et al., 2018; Colley & Craig, 2019; Fränkel et al., 2019; Fretwell & Greig, 2019; Nisbet et al., 2009; Prévot, Clayton, et al., 2018), while others have reported positive associations between frequency of visits to natural areas and implicit (trait) CN (Schultz & Tabanico, 2007). Duration of time spent in nature has also been associated with trait CN, including self-reported duration of contact with nature in the past

week (Fretwell & Greig, 2019) and the amount of time spent in nature generally (Dornhoff et al., 2019).

While time spent in nature has been shown to predict CN, there is also evidence that those higher in CN may be more likely to seek out time in nature. A number of studies have reported CN to be a predictor of both frequency and duration of time spent in nature (Colléony et al., 2017; Cox et al., 2018; Lin et al., 2014, 2017; Oh et al., 2021; Soga & Akasaka, 2019), with some arguing that CN may be a more important driver of time spent in nature than the availability of natural areas (Lin et al., 2014). Indeed, people with higher CN scores tend to perceive natural environments to be more attractive and fascinating (Tang et al., 2015), and therefore may be more driven to spend time in such environments. Together, these findings suggest that time spent in nature is related to CN, and that the relationship may be bidirectional (Martin et al., 2020; Oh et al., 2021; Prévot, Clayton, et al., 2018; Roczen et al., 2012; Rosa & Collado, 2019).

Spending time in different types of nature

The above discussion illustrates that time spent in contact with nature appears a useful means of fostering trait CN. Yet, if increasing time spent in nature is to be an effective intervention for enhancing CN, knowing what types of nature may be more or less important for fostering an enduring connection would also be useful. Human-nature interactions occur across many different types of natural settings, including domestic (e.g. backyards, urban parks), managed (e.g. zoos, botanic gardens), and wilder-type nature (e.g. beaches, national parks) (Clayton & Myers, 2009; Frumkin et al., 2016; Keniger et al., 2013). People likely perceive, interact with, and respond to these different types of natural spaces in different ways (Clayton, 2007; Davis et al., 2016; Pasca et al., 2020), for example, wilder spaces such as forests may be more strongly associated with feelings of awe and connection than managed spaces such as parks and gardens (Hinds & Sparks, 2011). Varied perceptions of different types of nature may have implications for how, when, and to what extent people connect with nature (de Bell et al., 2018; Tang et al., 2015). Yet, there has been limited research exploring the different types of natural areas people spend time in and how this relates to CN (Colléony et al., 2017).

Time spent in different types of nature, during both childhood and adulthood, has been shown to influence trait CN in adulthood (Colléony et al., 2019; Wells & Lekies, 2006). Evidence suggests that adults who spent their childhood in rural areas tend to have more positive environment attitudes and greater CN in adulthood than adults who spent their childhood in urban areas (Bashan et al., 2021; Hinds & Sparks, 2008; Prévot, Clayton, et al., 2018). Studies with adults have demonstrated that time spent in rural, protected, and coastal areas have stronger relationships with CN than time spent in urban natural areas, such as golf courses (Bashan et al., 2021; Mena-

García et al., 2020; Schultz & Tabanico, 2007; Wyles et al., 2019). Further, time spent in areas with higher natural values (i.e. greater biodiversity) have been associated with higher CN scores than time spent in areas with lower natural values (Colléony et al., 2017; Mena-García et al., 2020; Scopelliti et al., 2016). Together, these studies suggest that spending time in different types of natural environments may influence the development and/or maintenance of CN. Further, time spent in areas of higher natural value, such as national parks, may have a greater influence on CN than time spent in areas of lower natural value, such as urban parks.

The quality of nature experiences

While spending time in contact with nature appears an important means of enhancing CN, such interactions with nature are likely one element of a more complex picture of how humans encounter nature. In the CN literature, terminology such as "time spent in nature", "contact with nature", "interactions with nature", and "experience of nature" are often used interchangeably although there is nuance in the ideas these terms refer to (Clayton et al., 2017; Gaston et al., 2018; Gaston & Soga, 2020). Interaction with nature involves "an individual person being present in the 'same space' as nature or perceiving a stimulus from nature...through sight, sound, smell, taste or touch" (Gaston et al., 2018, p. 917). An experience of nature, in contrast, *involves* interaction with nature, yet also encompasses a more complex process of emotional, cognitive, behavioural, or spiritual engagement with nature that is context-dependent and has the potential to change knowledge, skills, or behaviour (Clayton et al., 2017; Gaston & Soga, 2020). In this sense, time spent in contact (interacting) with nature is one aspect of richer picture whereby the *quality* of nature experiences becomes important (Colléony et al., 2019; Colléony, Levontin, et al., 2020).

In recent years, literature considering CN relative to the quality of nature experiences – what people do while they're spending time in nature – has become increasingly prevalent. Some authors have described specific activities in or with nature that appear to increase CN, such as creative and artistic pursuits (Arbuthnott & Sutter, 2019; Bruni et al., 2015; Muhr, 2020; Passmore & Holder, 2017; Petersen & Martin, 2020), and mobile apps (Cameron et al., 2020; McEwan et al., 2019) and prompts (Colléony, Levontin, et al., 2020) to encourage active engagement with nature. Interactive and multisensory immersion exhibits, common in zoos and aquaria (Pan et al., 2020; Pennisi et al., 2017), and participation in *30 Days Wild*, a UK-based program that encourages deliberate engagement with nature, have also been shown to increase CN (Richardson et al., 2016; Richardson & McEwan, 2018). Common to all of these experiences is spending time actively engaging with, and noticing, nature. Indeed, interventions to encourage noticing nature have also shown considerable promise in increasing CN (Hamlin & Richardson, 2021; Passmore & Holder, 2017; Richardson et al., 2016; Richardson, Hamlin, et al., 2021; Richardson & Sheffield, 2017).

Yet, while there is a growing body of literature describing interventions to increase CN, understanding about the characteristics of those interventions that actually increase CN remains poorly understood (Carr & Hughes, 2021). It has been proposed that direct physical contact with nature, particularly involving multiple senses, may nurture understanding and compassion for nature, or heighten sensory awareness of nature, and therefore increase CN (Carr & Hughes, 2021; Colléony, Levontin, et al., 2020; Giusti et al., 2018; Macaulay et al., 2022; Zylstra et al., 2014). Activities in or with nature that involve a sense of captivation or absorption may cultivate positive emotions such as awe, joy, or being touched or moved by nature (Ballew & Omoto, 2018). These positive emotions may, in turn, enhance appreciation of nature or make experiences of nature more memorable, thus enhancing CN (Craig et al., 2018; Giusti et al., 2018; Petersen et al., 2019; Petersen & Martin, 2020; Roczen et al., 2012; Zylstra et al., 2014). Further, activities that involve learning about, interest in, or compassion for nature may enhance empathy and a sense of responsibility for protecting nature, leading to an increase in CN (Carr & Hughes, 2021; Chawla, 2020).

Such ideas align with the recent work of Lumber and colleagues (Lumber et al., 2017; Richardson, Dobson, et al., 2020) who propose that CN may be enhanced through five pathways – sensory contact, emotion, beauty, meaning, and compassion. Each of the pathways involve active and intentional experiences of nature – through the senses, through emotions such as awe and wonder, through appreciation of nature's beauty, through reflection on the meaning of nature, and via actions that protect or enhance nature. One group of activities that many of these pathways may be applied to are PBB, and specifically those PBB that typically occur while experiencing nature.

Nature-based pro-biodiversity behaviours

Pro-biodiversity behaviours (PBB) – also known as nature conservation behaviours (Martin et al., 2020), pro-nature conservation behaviours (Barbett et al., 2020; Richardson, Passmore, et al., 2020), or simply biodiversity behaviours (Selinske et al., 2018, 2020) – are those that specifically support, protect, enhance, or conserve biodiversity. While there is a considerable body of evidence demonstrating that people higher in CN tend to do more behaviours of general benefit to the environment (PEB) (for reviews, see Mackay & Schmitt, 2019; Whitburn, Linklater, & Abrahamse, 2019), researchers have only recently begun exploring relationships between CN and PBB (e.g. Martin et al., 2020; Prévot, Cheval, et al., 2018; Richardson, Passmore, et al., 2020). Interestingly, however, research linking CN and PBB/PEB typically implies that CN leads to PBB/PEB (e.g. Mackay & Schmitt, 2019; Restall & Conrad, 2015; Richardson, Passmore, et al., 2020). While the relationships between CN and PBB/PEB are likely bidirectional (Hamlin & Richardson, 2021), few studies have explicitly investigated participation in PBB/PEB as a means of enhancing CN.

While PBB may occur without direct experience of nature, for example, via online activities, consumer choices, or political actions (Barbett et al., 2020; Selinske et al., 2020; Winch et al., 2020), many PBB involve direct and active experiences of nature. Given that active and intentional experience of nature is considered important for developing and maintaining CN (Lumber et al., 2017; Richardson, Dobson, et al., 2020), nature-based PBB, such as picking up litter, wildlife monitoring (e.g. citizen science), or gardening may increase CN, potentially via one of more of the proposed pathways.

Beach clean-ups, for example, involve contact with nature using different senses (e.g. touch, sight), and can foster a sense of meaning (Wyles et al., 2017). Participation in citizen science has been associated with greater appreciation of nature's beauty, with emotions such as enjoyment, wonder and surprise, with greater concern, empathy, and with greater compassion for the area being studied (Chase & Levine, 2017; Cosquer et al., 2012; Ganzevoort & van den Born, 2019; Guiney & Oberhauser, 2010; Haywood, 2016; Haywood et al., 2016, 2020; Schuttler et al., 2018; Toomey & Domroese, 2013). Gardening has been associated with positive emotions, empathy, meaning, and appreciation of nature's beauty (Diduck et al., 2019; Kiesling & Manning, 2010; Ong et al., 2019; Wallace, 2019). Studies have also shown that CN is both a motivator for, and an outcome of, participating in a number of different nature-based PBB (Diduck et al., 2019; Ganzevoort et al., 2017; Kiesling & Manning, 2010; Prévot, Cheval, et al., 2018; Shaw et al., 2013; Whitburn, Linklater, & Milfont, 2019). In light of this evidence, further exploration of nature-based PBB as a means of enhancing CN is warranted.

In regards to state versus trait CN, while experiences of nature have been shown to increase state CN (e.g. Mayer et al., 2009), some have questioned whether brief (i.e. single event) interventions could be expected to increase trait CN (Carr & Hughes, 2021). As previously noted, fostering a more enduring sense of CN likely requires repeated experiences in and of nature. Indeed, interventions to increase CN tend to have the most significant gains when programs occur over a prolonged period of time (Barrable & Booth, 2020; Braun & Dierkes, 2017; Chawla, 2020). Organised nature-based PBB, such as beach cleans, ultimately aim to have participants repeat the behaviour over the longer term (Wyles et al., 2017), and participating in such programs can increase the likelihood of engaging in similar behaviours in future (Dean et al., 2018; Wyles et al., 2017). Carr and Hughes (2021) hypothesise a pathway to CN whereby activities that involve engagement with nature foster state CN and may also trigger behaviours, such as further engagement in nature-based activities. These repeated experiences then lead to the development of trait CN over time. Thus, interventions that involve participation in nature-based PBB are a potentially useful means of enhancing both state and trait CN.

Thesis objective 3: Explore whether time spent in nature and nature-based pro-biodiversity behaviours contribute to change in connection with nature over time.

Understanding of how trait-like CN develops, is maintained, and may be nurtured is not well understood. Time spent in nature, and specifically time spent in natural areas with high biodiversity values, such as national parks, appears an important mechanism through which CN may be fostered. Yet, further research is needed to understand how spending time in nature and in different types of nature may influence change in trait-like CN over time. In addition, experiences of nature, such as participating in nature-based PBB, may be useful pathways for fostering trait-like CN yet few studies have considered nature-based PBB as an antecedent to CN.

Chapter summary

Over the past two decades, literature exploring CN has increased exponentially. Yet, a thorough understanding of the CN construct is currently lacking. While CN is increasingly being recognised as a multidimensional construct, there is ongoing debate regarding its dimensional structure, and most existing self-report instruments capture CN as a unidimensional construct. Further, the small number of existing multidimensional instruments are long and may not be practical in real-world contexts, while brief versions are unidimensional. Within the CN literature, there has been limited consideration of what "nature" means relative to CN, and few studies to date have explored potential relationships between concepts of nature and CN, or between concepts of nature and PBB. Finally, the factors that influence the development, maintenance, and change in CN over time remain poorly understood, including the role of PBB/PEB to foster CN.

This thesis contributes to ongoing debates in the literature via four objectives: 1) Explore and clarify dimensions of CN; develop a brief yet parsimonious self-report connection with nature instrument; investigate relationships between CN, TIN, and PBB (Chapter 5); 2) Explore concepts of nature, and investigate relationships between concepts of nature and CN, and concepts of nature and nature-based PBB (Chapter 6); 3) Explore whether TIN and nature-based PBB contribute to change in CN over time (Chapter 7); and To test the conceptual framework (Chapter 8).

Chapter 4: Methodological overview

As noted in Chapter 1, the *Victorians Value Nature* goal of *Biodiversity 2037* includes the enabling action to "establish reliable baselines about Victorians' awareness of biodiversity, connection with nature, and current activities to protect the natural environment" (DELWP, 2017, p. 15). The *Victorians Valuing Nature Foundations Survey* was developed to provide such baseline data. I led the literature review that informed the development of the survey, and was involved in the development and refinement of some survey items (see also Meis-Harris et al., 2019).

Conducted online in September/October 2018, the *Foundations Survey* (Time 1) explored participants' attitudes toward, and use of, the natural environment. Participants were recruited using a panel survey company in exchange for a small financial reward. The final sample ($N = 3090$) was representative of the Victorian adult population (18+ years of age) on the key demographics of age, gender, and metropolitan/regional residence. Participants initially provided their age, gender, and post code, then responded to a series of qualitative and quantitative questions capturing six broad topic areas in the following order:

1. Nature definition: one open-text item, "What comes to mind when you think about nature? Please describe in your own words" (response length unlimited). After responding to this question, participants were advised (on the following page), "In this survey, we would like you to think about nature as everything that is not made by humans. This includes all the **animals, plants, and vegetation** in **land** and **water** habitats, located in **urban** and **rural** areas, and including **highly modified landscapes** through to **pristine wilderness** areas on land and in the water." (emphasis in original).
2. CN: 20 items intended to capture the five dimensions of CN proposed by Ives et al. (2017, 2018)
3. Values: 12 items to capture biospheric (concern for the environment), altruistic (concern for people), and egocentric (concern for self) values, based on the work of Schwartz (1994);
4. Engagement behaviours: 35 items capturing frequency of time spent in nature, time spent in different types of nature, time spent engaging indirectly with nature (e.g. watching nature documentaries), and time spent engaging in different activities in nature (e.g. picnicking, passing through to reach another destination) over the previous 12-months;
5. Biodiversity knowledge: 12 items assessing awareness of biodiversity in Victoria;
6. Behaviour: 28 items capturing frequency of engaging in 11 different PBB/PEB in the past year, likelihood of engaging in PBB/PEB in the next 12 months, as well as drivers and barriers for engaging in PBB/PEB.

The final page of the survey captured additional demographic information, including employment status, education, language(s) spoken at home, country of birth, identification as Aboriginal and/or Torres Strait Islander, disability, and household income (see Meis-Harris et al., 2019, pp. 81-97, for the full survey). Ethics approval was granted by the Monash University Human Research Ethics Committee (Project ID: 14010).

The *Victorians Valuing Nature Follow-up Survey* was developed to address a number of questions that arose from the results of the *Foundations Survey*. Specifically, I developed the *Follow-up Survey* to provide a bespoke dataset to validate the brief CN instrument (see Chapter 5), over a 12-month period and in relation to two existing multidimensional CN instruments – the Environmental Identity Scale (Clayton, 2003) and the Nature Relatedness Scale (Nisbet et al., 2009). Questions were also included to assess time spent in nature and participation in PBB over the preceding 12-month period.

Conducted online in September/October 2019, the *Follow-up Survey* (Time 2) assessed the views of a subsample of respondents from the *Foundations Survey* ($N = 1069$). Participants initially provided consent to have responses from the *Foundations Survey* matched with responses from the *Follow-up Survey* (those who did not consent were excluded). In a similar manner to that described above, participants initially provided their age, gender, and post code, then responded to a series of qualitative and quantitative questions capturing eight broad topic areas in the following order:

1. Nature definition: as described above;
2. CN: as described above;
3. Values: eight items capturing biospheric (concern for the environment) and altruistic (concern for people) values;
4. Relationship with nature: the 21 items of the Nature Relatedness Scale;
5. Time spent in nature: 12 items capturing frequency of time spent in nature in the past year, in different types of nature in the past year, and frequency of time spent in different types of nature during childhood;
6. Environmental identity: the 24 items of the Environmental Identity Scale;
7. Behaviour: 11 items capturing frequency of participating in PBB/PEB in the past year;
8. Meaningful nature experiences: three items capturing frequency and type of meaningful nature experiences.

Ethics approval was granted by the Monash University Human Research Ethics Committee (Project ID: 21790).

The overall methodological approach was hypothetico-deductive in nature. Study 1 used data from both surveys (Time 1 and Time 2) to explore and confirm the dimensional structure of CN using exploratory and confirmatory factor analyses. Spearman correlations were used to validate the newly developed CN-12 instrument – against criterion variables, over time, and against the Nature Relatedness and Environmental Identity scales.

Study 2 used data from the *Foundations Survey* (Time 1) to explore concepts of nature relative to CN and PBB. Responses to the question "what comes to mind when you think about nature" were thematically coded, and multidimensional scaling used to determine concepts of nature categories. Additional multidimensional scaling analyses and a cluster analysis were then conducted to further support the concepts of nature categories derived. Differences in CN and PBB across concepts of nature categories were investigated using one-way analyses of variance (ANOVA) with Games-Howell post-hoc test and Kruskal-Wallis test with p-value adjusted pairwise comparisons, respectively. Moderation analyses were then conducted to investigate concepts of nature as a potential moderator between CN and PBB, with the experiential concepts of nature category used as the reference group for indicator coding of the concepts of nature variable.

Study 3 used data from both surveys (Time 1 and Time 2) to investigate change in CN over a 12-month period. Hierarchical multiple linear regression analyses were conducted to predict CN at Time 2 from time spent in nature (Time 2), time spent in different types of nature (Time 2), and frequency of participation in PBB (Time 2) while holding CN at Time 1 constant. Parallel multiple mediation analyses were then conducted to determine whether time spent in nature, in different types of nature, and PBB mediated the relationship between CN at Time 1 and CN at Time 2.

Finally, the conceptual framework synthesis used data from both surveys (Time 1 and Time 2). A path analysis was conducted to investigate the overall fit of the conceptual framework (Figure 7).

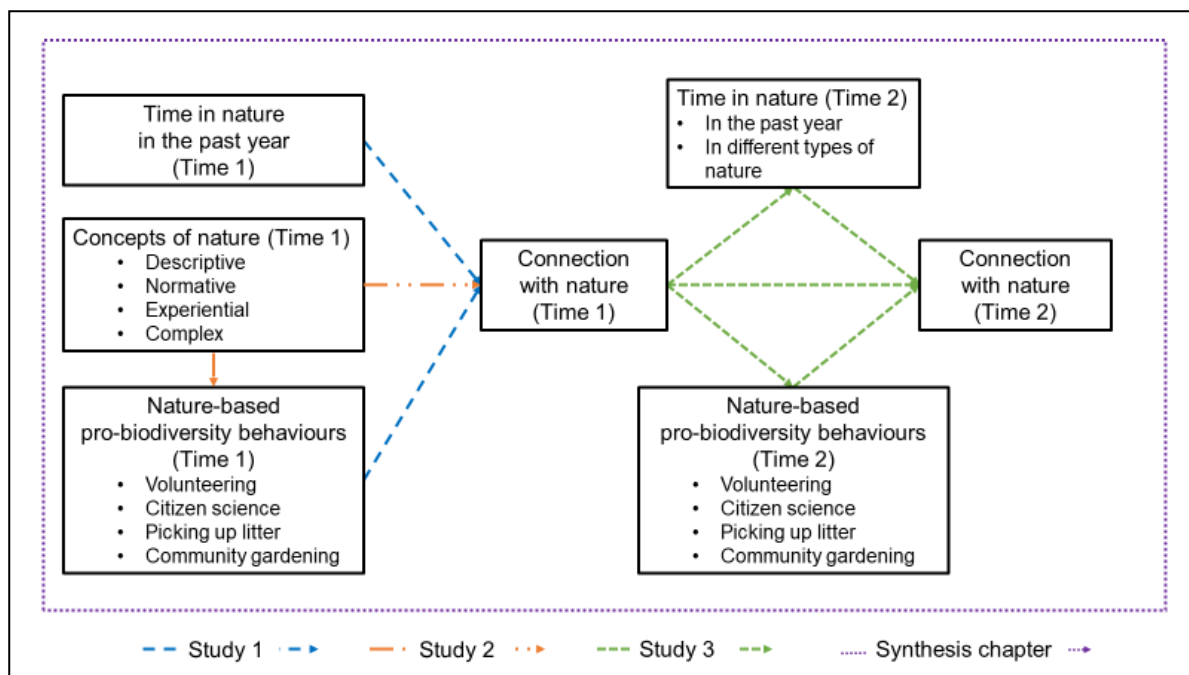


Figure 7: Conceptual framework for this research.

Chapter 5: The CN-12: A brief, multidimensional connection with nature instrument (Study 1)

Objective 1 of this thesis was addressed in Study 1. This study, relative to the conceptual framework, is depicted in Figure 8. These results were published in *Frontiers in Psychology* in July 2020.

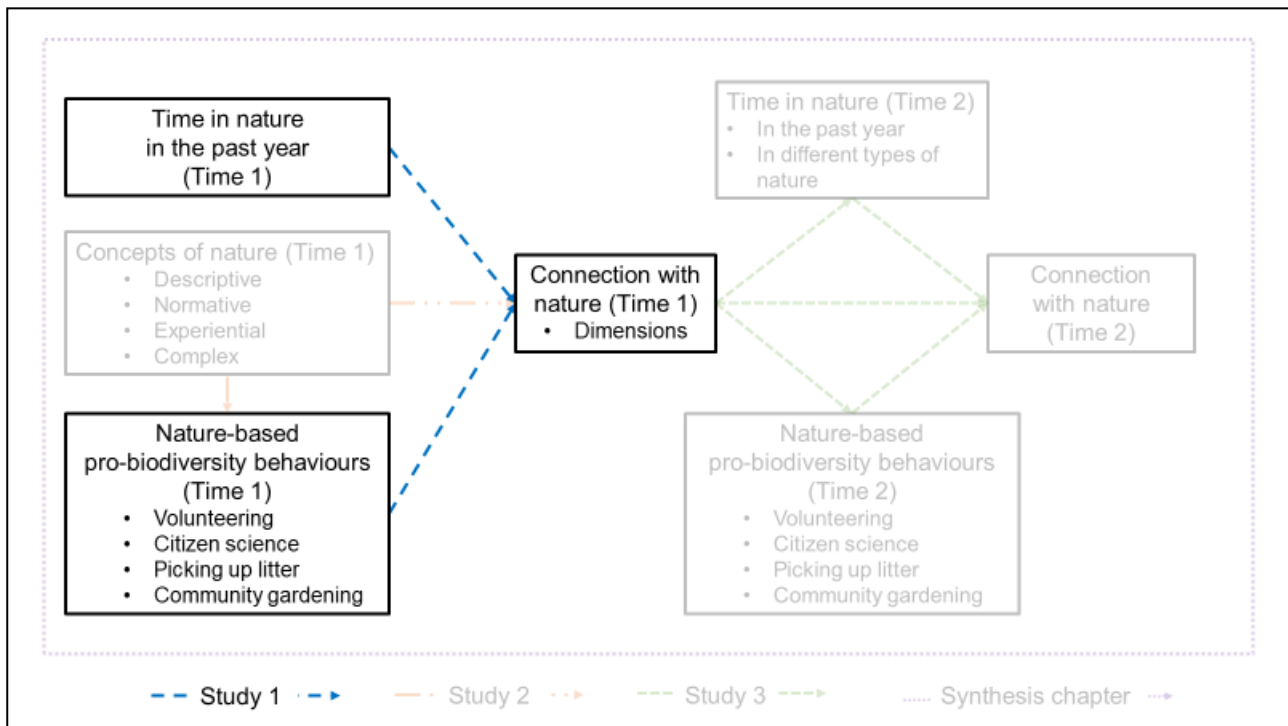


Figure 8: Conceptual framework, with elements included in Study 1 highlighted.



The CN-12: A Brief, Multidimensional Connection With Nature Instrument

Melissa Anne Hatty^{1*}, Liam David Graham Smith¹, Denise Goodwin¹ and Felix Tinoziva Mavondo²

¹ BehaviourWorks Australia, Monash Sustainable Development Institute, Monash University, Clayton, VIC, Australia,

² Department of Marketing, Monash Business School, Monash University, Clayton, VIC, Australia

OPEN ACCESS

Edited by:

César O. Tapia-Fonllem,
University of Sonora, Mexico

Reviewed by:

Pablo Olivos-Jara,
University of Castilla-La Mancha,
Spain

Laura Fernanda
Barrera-Hernández,
Instituto Tecnológico de Sonora
(ITSON), Mexico

*Correspondence:

Melissa Anne Hatty
melissa.hatty@monash.edu

Specialty section:

This article was submitted to
Environmental Psychology,
a section of the journal
Frontiers in Psychology

Received: 31 March 2020

Accepted: 11 June 2020

Published: 14 July 2020

Citation:

Hatty MA, Smith LDG, Goodwin D
and Mavondo FT (2020) The CN-12:
A Brief, Multidimensional Connection
With Nature Instrument.
Front. Psychol. 11:1566.
doi: 10.3389/fpsyg.2020.01566

In recent decades, there has been increasing interest in (re)connecting people with nature to foster sustainability outcomes. There is a growing body of evidence suggesting a relationship between connection with nature and pro-environmental behaviors. Connection with nature has often been conceptualized as a unidimensional construct, and although recent evidence suggests that it is multidimensional, there is ongoing debate regarding the dimensions that make up connection with nature. Existing multidimensional connection with nature instruments capture similar dimensions, yet they are lengthy and may not have practical application in real-world contexts. This research sought to clarify the dimensions of connection with nature and to develop and validate an abbreviated yet multidimensional connection with nature instrument—the CN-12. Analyses of two large datasets revealed three dimensions of connection with nature—identity, experience, and philosophy. Results suggested that the CN-12 and its three dimensions are positively correlated with: (1) environmental and altruistic values; (2) time spent in nature; and (3) a range of pro-environmental behaviors. Results also suggested that the CN-12 and its three dimensions are stable over time and are positively correlated with two existing multidimensional connection with nature instruments, the Nature Relatedness (NR) Scale and Environmental Identity (EID) Scale. The utility of the CN-12 for exploring human connections with nature and the role of fostering connection with nature to increase engagement in pro-environmental behaviors are discussed.

Keywords: connection with nature, pro-environmental behavior, conservation, sustainability, behavior change, multidimensional instrument

INTRODUCTION

In recent decades, there has been increasing interest in human–nature relationships and the links between connection with nature (CN) and pro-environmental behaviors (PEB; Restall and Conrad, 2015; Ives et al., 2017). Disconnection from nature has been implicated as a key factor in ongoing environmental destruction (Nisbet et al., 2009; Zylstra et al., 2014), with some arguing that a sense of connection to nature is a necessary precondition for caring for, and commitment toward, protecting the natural environment (Schultz, 2002b). Thus, (re)connecting people with nature is seen

Abbreviations: CFA, Confirmatory factor analysis; CN, Connection with nature; EFA, Exploratory factor analysis; EID, Environmental Identity scale; NR, Nature Relatedness scale; PEB, Pro-environmental behavior.

as a potentially viable means of addressing sustainability outcomes (Seppelt and Cumming, 2016; Ives et al., 2018).

Such propositions are increasingly supported in the literature. A growing body of evidence suggests that PEB, that is, behaviors that result in minimal negative environmental impact or that protect or enhance the natural environment (Steg and Vlek, 2009), are more likely to occur among people who are more connected with nature (e.g., Geng et al., 2015; Richardson et al., 2019; Navarro et al., 2020). Two recent meta-analyses by Mackay and Schmitt (2019) and Whitburn et al. (2019) reported moderate positive correlations between CN and PEB ($r = 0.37$ and $r = 0.42$, respectively), providing further evidence of the potential utility in enhancing CN as a means of increasing engagement in PEB.

Discussions of how humans perceive, relate to, and interact with nature have seen the development of a range of terminology and definitions, such that the literature has become “characterized by a plurality of disciplinary and conceptual perspectives, language, methods and research approaches” (Ives et al., 2017, p. 106). Terminology used to describe human connections with nature include human–nature connectedness (Ives et al., 2017, 2018), connectedness to nature (Mayer and Frantz, 2004), nature relatedness (Nisbet et al., 2009), ecological identity (Walton and Jones, 2018), inclusion with nature (Schultz, 2002b), love and care for nature (Perkins, 2010), emotional affinity toward nature (Kals et al., 1999), and environmental identity (Clayton, 2003). Despite the plurality of definitions and terminology, a number of key themes are evident across definitions of CN. Typically conceptualized as subjective and personal, CN relates to a sense of personal identity, encompassing a relationship between the self and the natural world that includes cognitions, emotions, and behavior.

Considering the array of definitions of CN-related constructs, it is unsurprising that a diversity of self-report instruments have been developed that purport to capture CN. A summary of key instruments appears in **Table 1**. Most CN instruments have been developed to capture CN as unidimensional construct, although there is variability in the manner in which this construct has been conceptualized. Schultz (2001, 2002b), for example, considers CN as a cognitive construct; thus, the Inclusion of Nature in Self assesses an individual's beliefs about their relationship with nature. Mayer and Frantz (2004) and Perkins (2010), in contrast, considered CN from an affective viewpoint, with the Connectedness to Nature Scale (CNS) and Love and Care for Nature (LCN) scale, respectively, assessing CN as an emotional construct¹. Others have considered CN from a relational perspective, reflected in instruments such as the Connectivity with Nature scale (Dutcher et al., 2007) and Commitment to Nature scale (Davis et al., 2009). Interestingly, there have been no self-report instruments developed to date that consider CN as a purely experiential or behavioral construct. Some researchers have manipulated exposure to nature in experimental studies, for example, by watching a nature documentary (Zelenski et al., 2015; Arendt and Matthes, 2016); viewing pictures of, or walking in,

nature (Klein and Hilbig, 2018; Nisbet et al., 2019; Mena-García et al., 2020); and multisensory nature experience via virtual reality (Soliman et al., 2017). Evidence suggests that exposure to nature may be related to the development of CN (Schultz and Tabanico, 2007; Braun and Dierkes, 2017; Cleary et al., 2018; Martin et al., 2020), although it is unclear whether exposure to nature is in fact an accurate representation of experiential or behavioral CN.

Given the similarity between constructs, Tam (2013) empirically reviewed seven commonly cited CN instruments, with results suggesting a great degree of convergence between them. Tam's findings suggested that multidimensional CN instruments performed better than unidimensional instruments, with the Environmental Identity (EID: Clayton, 2003) and Nature Relatedness (NR: Nisbet et al., 2009) scales showing consistently stronger correlations with criterion variables, including PEB, than unidimensional scales. Tam (2013) argued that “there are multiple aspects or dimensions of connection to nature, each of which has its own unique conceptual meanings but at the same time shares a substantial overlap with other aspects that warrants an identification of a common core” (p. 74). Thus, although instruments appear to be tapping a single underlying CN construct, different instruments emphasize different dimensions of CN (Tam, 2013).

Such findings are supported by two recent reviews. In a meta-analysis of studies exploring the relationship between CN and PEB, Whitburn et al. (2019) noted that the CN instrument used moderated the strength of the relationship between CN and PEB, with multidimensional CN scales, such as the EID, NR, and Disposition to Connect with Nature scale (DCN: Brügger et al., 2011) having the strongest relationships with PEB ($r = 0.44$, $r = 0.51$, and $r = 0.53$, respectively). Further, the authors classified each of the CN instruments as capturing (one or more of) affective, cognitive, or behavioral dimensions of CN, with results also suggesting that the dimensions captured moderated the relationship between CN and PEB. In a similar meta-analysis, Mackay and Schmitt (2019) reported that studies using the EID showed the strongest correlation between CN and PEB ($r = 0.47$), although studies using the multidimensional NR ($r = 0.41$) and unidimensional measures such as the CNS ($r = 0.41$) and emotional measures (e.g., the LCN: $r = 0.44$) showed similar correlations between CN and PEB. Together, these findings suggest that multidimensional CN instruments that distinguish between cognitive, emotional, and behavioral dimensions may be of greater utility in predicting engagement in PEB (Whitburn et al., 2019). Thus, further exploration of multidimensional CN instruments is warranted (Restall and Conrad, 2015).

In considering what dimensions, or combination of dimensions, best represent the CN construct, it is worth noting that definitions of CN typically include a sense of personal identity, encompassing a relationship between the self and the natural world that includes cognitions, emotions, and behavior. Therefore, these dimensions are clear potential candidates. Such ideas are reflected in the recent work of Ives et al. (2017, 2018) who conceptualize CN to comprise five distinct yet interrelated dimensions, or types of CN: philosophical, emotional, cognitive, experiential, and material. The authors consider these different types of CN to exist on a continuum from internal connections,

¹While Mayer and Frantz (2004) argued that the CNS captures emotional connection with nature, later research by Perrin and Benassi (2009) suggested that the CNS captures cognitive CN or an individual's beliefs about their connection with nature.

TABLE 1 | Summary of key self-report connection with nature instruments, in chronological order.

Instrument	Author(s)	Dimensionality	Primary CN dimension(s) captured
Emotional Affinity Toward Nature (EATN)	Kals et al. (1999)	Unidimensional	Emotional
Inclusion of Nature in Self (INS)	Schultz (2001, 2002b)	Unidimensional	Cognitive
Environmental identity (EID)	Clayton (2003)	Multidimensional ²	Cognitive Emotional Experiential Relationship
Connectedness to Nature Scale (CNS)	Mayer and Frantz (2004)	Unidimensional	Emotional ¹
Connectivity with Nature (CwN)	Dutcher et al. (2007)	Unidimensional	Relationship
Commitment to Nature (COM)	Davis et al. (2009)	Unidimensional	Relationship
Nature Relatedness (NR)	Nisbet et al. (2009)	Multidimensional	Cognitive Emotional Experiential
Love and Care for Nature (LCN)	Perkins (2010)	Unidimensional	Emotional
Disposition to Connect with Nature (DCN)	Brügger et al. (2011)	Multidimensional	Cognitive Emotional Experiential
Environmental connectedness (EC)	Beery (2013)	Unidimensional	Emotional
Nature Relatedness short form (NR6)	Nisbet and Zelenski (2013)	Unidimensional	Cognitive
Nature Connection Index (NCI)	Hunt et al. (2017), Richardson et al. (2019)	Unidimensional	Emotional
Ecological Identity Scale (EIS)	Walton and Jones (2018)	Unidimensional	Cognitive

such as worldviews about, and emotions associated with, nature (philosophical, emotional) to external connections, such as physical interaction with nature (material, experiential); these five CN dimensions are also considered relative to the scale of analysis, that is, at the individual and/or societal levels (Ives et al., 2018). These five dimensions are represented, to varying degrees, in two existing multidimensional CN instruments, with the exception of the material dimension (Table 2)³.

As Table 2 shows, the EID and NR share three dimensions. The philosophical dimension, encompassing a worldview or ideology about nature including behaviors in relation to nature, is broadly captured by EID-Environmentalism and NR-Perspective. For Ives et al. (2018), this type of CN represents a person's individual, internal connection yet may also represent the dominant worldview at a broader, societal scale. The experiential dimension, incorporating direct experiences of nature and enjoyment associated with such experiences, is broadly captured by EID-Enjoying nature and NR-Experience. This type of CN represents a more external connection via physical interactions with nature, typically analyzed at the individual level although can be aggregated to capture societal-level experiences (Ives et al., 2018). In their five-dimensional model,

Ives et al. (2017, 2018) described distinct emotional and cognitive dimensions, representing internal connections at the individual level; yet the EID and NR appear to capture these dimensions under a single “identity” dimension (EID-Environmental identity and NR-Self). According to the identity theory, identities involve both cognitive and emotional processes (Stets and Biga, 2003; Burke and Stets, 2009), whereas evidence from psychology and cognitive neuroscience suggests that cognitions and emotions influence each other, such that distinguishing the two mechanisms may be difficult (Phelps, 2006; Barrett et al., 2007; Lerner et al., 2015). Thus, it seems prudent that the EID and NR capture cognitive and emotional dimensions under a single construct of identity.

Interestingly, although the EID and NR are considered multidimensional instruments, there have been few published studies that have explored the unique contribution of individual dimensions to PEB. In developing the NR, Nisbet et al. (2009), for example, reported that the NR-Self and NR-Perspective dimensions predicted vegetarianism whereas NR-Total and NR-Experience did not. Similarly, Forstmann and Sagioglou (2017) reported that only the NR-Self dimension predicted PEB. Indeed, Nisbet et al. (2009) noted that although the NR dimensions “sometimes showed different relationships with criterion variables, these differences were not overwhelming and never went in opposite directions ... suggest[ing] that the factor structure requires further investigation” (p. 732). To the best of our knowledge, only two published studies have considered the unique contribution of EID dimensions to PEB, with EID-Environmentalism and EID-Environmental identity the strongest predictors of PEB (Olivos and Aragonés, 2011; Olivos et al., 2014). Taken together, these findings suggest that the dimensions comprising CN, and the potentially

² While Clayton (2003) proposed the EID to be multidimensional, the author noted that preliminary data suggested the instrument may be unidimensional. Further, whereas Olivos and Aragonés (2011) found evidence of a multidimensional model, a later work by Chew (2019) suggested that the EID was unidimensional.

³ Brügger et al. (2011) did not explicitly describe CN dimensions they are intending to capture using the multidimensional Disposition to Connect with Nature, although personal preferences and attitudes imply cognitive CN, “bonding with nature” implies emotional and perhaps a relationship or philosophical CN, whereas behaviors imply experiential CN. As dimensions have not been made explicit by the authors, the DCN is not included in the analysis described in Table 2.

TABLE 2 | Possible CN dimensions, captured by existing multidimensional CN instruments.

CN dimensions (Ives et al., 2017, 2018)	Environmental Identity (Clayton, 2003; Olivos and Aragonés, 2011)	Nature Relatedness (Nisbet et al., 2009)
<i>Philosophical</i> Perspective or worldview on what nature is, why it matters, and how humans ought to interact with it (e.g., master, participant, steward); perspectives on humanity's relationship to the natural world.	<i>EID-Environmentalism</i> A perspective or ideology capturing commitment to, and behavior toward, the natural environment	<i>NR-Perspective</i> A worldview; a sense of agency regarding human behavior and its impact on the natural environment
<i>Emotional</i> Feelings of attachment to or empathy toward nature; emotional attachments and affective responses in relation to nature.	<i>EID-Environmental identity</i> Self-identification and belonging represented by a sense of attachment or empathy, and thoughts about nature	<i>NR-Self</i> An internal perspective or identity that includes emotions and thoughts about nature
<i>Cognitive</i> Knowledge or awareness of the environment and attitudes/values toward nature; knowledge, beliefs, and attitudes in relation to nature.		
<i>Experiential</i> Direct interaction with natural environments (e.g., parks, forests); recreational activities in green environments.	<i>EID-Enjoying nature</i> Direct experience of nature and the pleasure associated with nature-based experiences	<i>NR-Experience</i> Desire to spend time in—and seeking out—nature, awareness of and fascination with nature
<i>Material</i> Consumption of goods/materials from nature (e.g., food, fiber); resource extraction and use.	—	—

unique contribution of these CN dimensions to PEB, warrant further investigation.

Another issue with existing multidimensional CN instruments is in their length. The DCN, EID, and NR are relatively long instruments (40, 24, and 21 items, respectively), which may not be suitable for real-world contexts where time and money are limited (Maloney et al., 2011). A longer instrument also risks lower response rates and poorer data quality than a shorter instrument (Marcus et al., 2007; Galesic and Bosnjak, 2009). Although shorter versions of the EID and NR have been developed, these brief instruments are unidimensional in nature (Nisbet and Zelenski, 2013; Chew, 2019); thus, the potential utility and uniqueness of individual dimensions is lost. Therefore, there is utility in developing a multidimensional yet parsimonious CN instrument that can be used in real-world contexts.

The aims of the current research are threefold:

- (1) to further explore and clarify CN dimensions, particularly relative to the five-dimensional model proposed by Ives et al. (2017, 2018);
- (2) to develop a parsimonious instrument to capture a range of potential CN dimensions; and
- (3) to assess the reliability, validity, and temporal stability of the CN instrument against criterion variables commonly used in CN research, including the extent to which specific CN dimensions may be related to different PEB.

Two studies were conducted to address these aims. Study 1 describes the analyses of an existing dataset, whereas Study 2 describes the collection and analyses of an additional dataset to complement and extend that described in Study 1.

STUDY 1

Study 1 involved analyses of data (Hatty et al., 2018) presented in the report by Meis-Harris et al. (2019). This report proposed a new, 20-item multidimensional CN instrument, based loosely on the work of Ives et al. (2017, 2018) and intending to capture five CN dimensions: attachment (emotional), self (cognitive), materialism (material), experiential (experiential), and spirituality (philosophical). In the current research, data were analyzed to investigate the dimensionality of the CN instrument (Phase 1), to reduce the number of items while retaining a parsimonious, multidimensional instrument (Phase 2), and to assess construct validity against a series of criterion variables, including PEB (Phase 3). Ethics approval was granted by the Monash University Human Research Ethics Committee (Project ID: 14010).

METHOD

Participants

Participants were recruited via an online panel survey company in exchange for a small financial reward. Participants under the age of 18 and those residing outside the Australian state of Victoria were excluded. The final sample ($N = 3,090$) was representative of residents in the state of Victoria with respect to age, gender, and geographical location (Meis-Harris et al., 2019).

Procedure and Questionnaire

Participants responded to a series of qualitative and quantitative questions assessing four broad areas. These included: (1) CN, 20 items intended to capture the five dimensions described above; (2) values, 12 items to capture biospheric (concern for the environment), altruistic (concern for people), and egocentric (concern for self) values; (3) engagement behaviors, five items capturing time spent in nature and beliefs about spending time in

TABLE 3 | Exploratory factor analysis of the 20-item CN instrument ($n = 1,519$).

	Component			
	1	2	3	4
CN17. My connection to nature is something I would describe as “spiritual”	0.92			
CN1. I think of myself as an “environmentalist”	0.75			
CN4. My relationship to nature is a big part of how I think about myself	0.68			
CN19. Human beings and nature are connected by the same “energy” or “life-force”	0.67	−0.34	0.51	
CN3. Protecting nature is an important part of who I am	0.61			
CN8. I feel a strong emotional connection to nature	0.60	0.30		
CN5. I feel uneasy if I am away from nature for too long	0.58	0.35		
CN2. I think of myself as someone who is very concerned about taking care of nature	0.51			
CN10. I like to get outdoors whenever I get the chance		0.82		
CN9. I enjoy spending time in nature		0.78		
CN11. Being in nature allows me to do the things I like doing most		0.67		
CN12. Getting away on an overnight trip in nature is something I do as often as I can	0.30	0.66	−0.34	
CN6. I feel right at home when I am in nature		0.65		
CN7. Feeling connected to nature helps me deal with everyday stress	0.38	0.43		
CN18. Everything in nature is connected (e.g., animals, plants, humans, water, air, land, fire, etc.)			0.81	
CN20. Human wellbeing depends upon living in harmony with nature			0.67	
CN16. Natural areas are important to people because we use them for recreation	−0.36	0.45	0.62	
CN15. In order to provide us with the goods and services we need we can’t avoid nature being degraded.				0.79
CN13. Forests are valuable mostly because they produce wood products, jobs and income for people				0.75
CN14. Meeting the needs of people requires sacrificing some natural areas				0.73

nature; and (4) PEB, 11 items capturing frequency of engaging in PEB in the past year (Meis-Harris et al., 2019). Items presented in blocks were randomized across participants to minimize question order effects. Data were collected in September and October 2018.

Data Analyses and Results

All variables were screened for normality. Five of the CN items were skewed (item 9, -1.09 ; item 10, -0.78 ; item 16, -0.87 ; item 18, -1.39 ; and item 20, -1.11), however, transformations were not undertaken as doing so would make interpretation more difficult, and it was expected that the large sample would reduce the impact of non-normality on analyses (Tabachnick and Fidell, 2007).

We randomly split the total sample in two to facilitate analyses. Phase 1 involved exploratory factor analysis (EFA) using subsample 1 ($n = 1,519$). Phase 2 involved confirmatory factor analysis (CFA), based on the dimensions found in the EFA, conducted on subsample 2 ($n = 1,571$). Demographic characteristics for the two random samples were comparable with each other (Supplementary Table S1). Analyses were conducted using IBM SPSS Statistics Version 26 (IBM Corp., 2017), with CFA conducted using IBM SPSS AMOS Version 26 (Arbuckle, 2006).

Phase 1: Exploratory Factor Analysis

We conducted EFA on the 20 CN items to assess factor structure ($n = 1,519$). We used principal components analysis with promax rotation ($\kappa = 4$) as the goal was to explore the underlying component structure, and we expected the components to be correlated (Tabachnick and Fidell, 2007). Bartlett’s test of

sphericity was significant ($p < 0.001$), and the Kaiser–Meyer–Olkin (KMO) measure was high (0.95), suggesting that the data were suitable for factor analysis. Community values were between 0.54 and 0.75 for all items. A scree plot suggested a four component solution, accounting for 65.72% of the variance (Table 3). Factor loadings less than 0.3 are not shown (Hair et al., 2014).

The first component appears to represent an identity dimension with cognitive, emotional, and behavioral elements, including self-perception as someone who is emotionally connected to nature and who behaves in such a way as to protect nature. The second component represents an experiential dimension and includes activities undertaken in the natural environment. The third component represents a spiritual or philosophical dimension and embodies notions around humanity’s relationship with nature. The fourth component represents a materialism dimension and relates to notions around human use of natural resources.

A total CN score was calculated by averaging the 20 items, with scores for the four dimensions similarly calculated. Cronbach’s alpha for the 20-item CN scale and the four dimensions were calculated (Total, $\alpha = 0.90$; Identity, $\alpha = 0.91$; Experience, $\alpha = 0.88$; Philosophy, $\alpha = 0.75$; and Material, $\alpha = 0.66$). Spearman correlations (with bias corrected and accelerated bootstrap 95% confidence intervals, shown in square brackets) indicated that the Identity dimension was strongly correlated with the Experience ($r_s = 0.79$, 95% BCa CI [0.77,0.81], $p < 0.001$) and Philosophy ($r_s = 0.65$, 95% BCa CI [0.61,0.68], $p < 0.001$) dimensions, and the Experience and Philosophy dimensions were strongly correlated ($r_s = 0.60$, 95% BCa CI [0.56,0.64], $p < 0.001$). The Material

dimension was weakly and negatively correlated with the Identity dimension ($r_s = -0.09$, 95% BCa CI $[-0.14, -0.03]$, $p < 0.001$), whereas correlations with the Experience ($r_s = -0.03$, 95% BCa CI $[-0.08, 0.03]$, $p = 0.29$) and Philosophy ($r_s = -0.05$, 95% BCa CI $[0.10, 0.00]$, $p = 0.07$) dimensions were non-significant.

Phase 2: Confirmatory Factor Analysis

We used CFA to verify the factor structure described in Phase 1 and to reduce the number of items to determine the most parsimonious model (Hair et al., 2014). We removed the materialism dimension first as this had the lowest internal consistency and the weakest and/or non-significant correlations with the other dimensions.

We inspected standardized factor loadings for individual items and removed items with loadings below 0.7; we also inspected modification indices and removed items with high cross-loadings (Hair et al., 2014). The standardized factor loading (regression weight) for item 19 was 0.677, thus below the “ideal” 0.7 cut-off point yet above the recommended minimum of 0.5; further, retaining item 19 ensured that the “philosophy” dimension contained the recommended minimum of three items (Hair et al., 2014).

The maximum likelihood method was used to test the second-order measurement model. A number of statistics were examined to assess the fit of the model. The goodness of fit index (GFI = 0.95), adjusted goodness of fit index (AGFI = 0.92), the normed fit index (NFI = 0.96), the Tucker–Lewis index (TLI = 0.95), the comparative fit index (CFI = 0.96), and the root mean square error of approximation (RMSEA = 0.07) suggested that the model was an acceptable-to-good fit of the data (Hu and Bentler, 1999; Schermelleh-Engel et al., 2003; Tabachnick and Fidell, 2007). A chi-square difference test indicated the Identity and Experience dimensions were distinct dimensions despite the high correlation between them (Hair et al., 2014). The 12-item model—the CN-12—is shown in **Figure 1**. Cronbach’s alpha for the CN-12 and three dimensions were calculated (CN-Total, $\alpha = 0.93$; CN-Identity, $\alpha = 0.87$; CN-Experience, $\alpha = 0.90$; and CN-Philosophy, $\alpha = 0.75$).

To confirm the three-dimensional structure of the CN-12, we conducted a second EFA ($n = 1,571$) using principal components analysis with promax rotation ($\kappa = 4$). A scree plot suggested a three component solution, accounting for 72.34% of the variance. The pattern and size of factor loadings were similar to those described above with the exception of item 7 loading more strongly on the identity dimension than the experience dimension and item 19 loading similarly on the identity and philosophy dimensions (**Supplementary Table S2**).

Phase 3: Validation and Relationships Between Connection With Nature and Pro-environmental Behavior

We used the total sample ($N = 3,090$) to validate the CN-12 via a series of Spearman correlations. We created an aggregate PEB score by calculating the mean of the 11 PEB. Consistent with previous research, we expected the CN-12 to be positively correlated with biospheric and altruistic values (Stern and Dietz, 1994; Schultz et al., 2005; Martin and Czellar, 2017), with time

spent in nature (Rosa et al., 2018; Rosa and Collado, 2019), and with statements related to spending time in nature that capture general attitudes and beliefs about the natural environment (Cleary et al., 2018). We also expected the CN-12 to be positively correlated with the aggregate PEB score (Mackay and Schmitt, 2019; Whitburn et al., 2019), and with individual PEB (Perkins, 2010; Prévot et al., 2018a).

Results confirmed these hypotheses (**Table 4**). CN-12 scores (CN-Total, CN-Identity, CN-Experience, and CN-Philosophy) were positively related to biospheric and altruistic value orientations, to the amount of time spent in nature in the past year, and to beliefs about spending time in nature. Higher CN-12 scores were associated with greater frequency of participation in a range of PEB. CN-12 scores were weakly or non-significantly related to egoistic value orientation.

To determine the utility of individual dimensions in predicting individual PEB, we compared the correlations between CN-Total and PEB with correlations between each of the CN dimensions and PEB (Meng et al., 1992; Diedenhofen and Musch, 2015). Results suggested that the relationship between CN-Identity and PEB was significantly stronger than that between CN-Total and PEB for seven behaviors: chose sustainable seafood ($z = -2.60$, $p = 0.009$, 95% CI_{diff} $[-0.032, -0.005]$); participated in environmental volunteering ($z = -6.92$, $p < 0.001$, 95% CI_{diff} $[-0.061, -0.034]$); participated in citizen science ($z = -8.96$, $p < 0.001$, 95% CI_{diff} $[-0.073, -0.047]$); donated to environmental organizations ($z = -5.88$, $p < 0.001$, 95% CI_{diff} $[-0.055, -0.027]$); advocated for the environment ($z = -8.74$, $p < 0.001$, 95% CI_{diff} $[-0.074, -0.047]$); cleaned up litter ($z = -2.29$, $p = 0.02$, 95% CI_{diff} $[-0.030, -0.002]$); and involved in community gardening or composting ($z = -8.16$, $p < 0.001$, 95% CI_{diff} $[-0.068, -0.042]$). In contrast, the relationship between CN-Total and PEB was significantly stronger than that between CN-Identity and PEB for controlling the movement of pets ($z = 2.35$, $p = 0.019$, 95% CI_{diff} $[0.004, 0.039]$).

STUDY 2

Study 2 involved the collection of additional data (Hatty, 2019) to support and extend the analyses described in Study 1. In Phase 1, we used EFA and CFA to explore and confirm the dimensionality of the CN-12. In Phase 2, we used Spearman correlations to investigate the reliability, validity, and temporal stability of the CN-12 in relation to criterion variables (including PEB) and relative to two existing multidimensional CN instruments—the EID and NR. Ethics approval was granted by the Monash University Human Research Ethics Committee (Project ID: 21790).

Method

Participants and Procedure

Participants who completed the survey described in Study 1 were re-contacted and invited to complete a follow-up survey. The survey was administered by the same online panel company and in a manner similar to that described in Study 1. Data were collected in September and October 2019. A total of

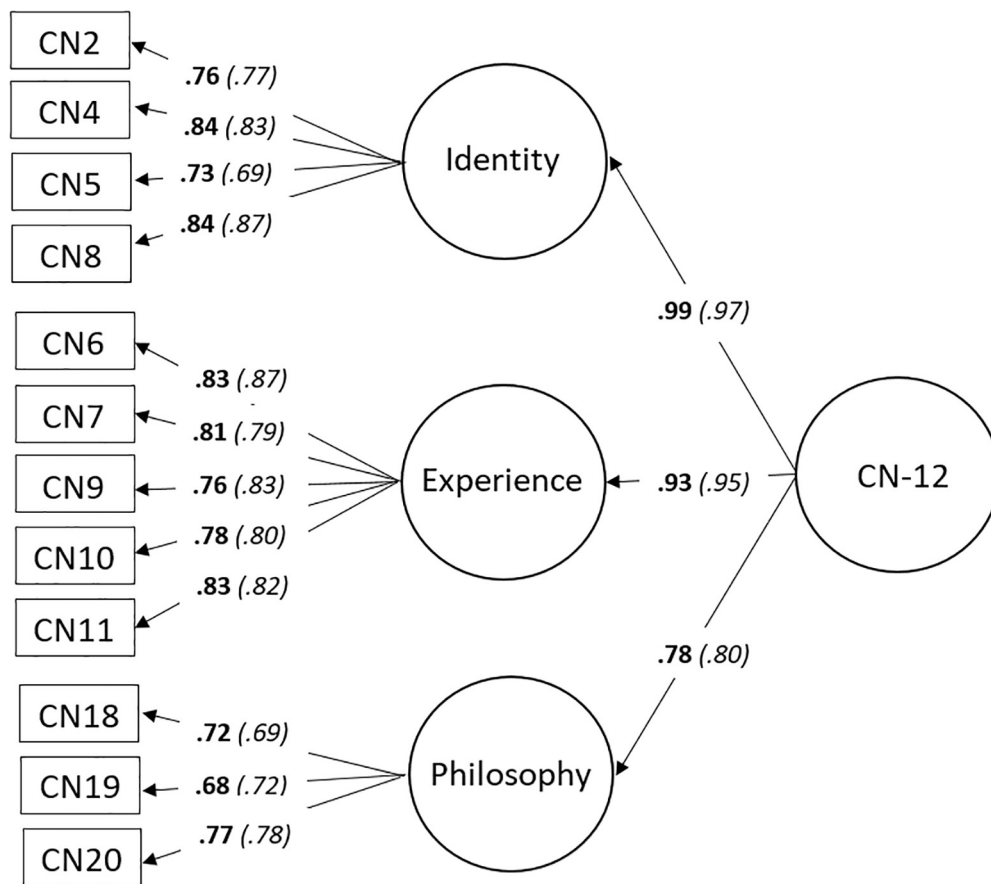


FIGURE 1 | Measurement model for the CN-12. Study 1, $n = 1,571$; model fit indices: GFI = 0.95, AGFI = 0.92, NFI = 0.96, TLI = 0.95, CFI = 0.96, and RMSEA = 0.07; standardized regression weights shown in bold. Study 2, $n = 526$; model fit indices: GFI = 0.92, AGFI = 0.87, NFI = 0.94, TLI = 0.94, and CFI = 0.95; standardized regression weights shown italicized in brackets. GFI, goodness of fit index; AGFI, adjusted goodness of fit index; NFI, normed fit index; TLI, Tucker–Lewis index; CFI, comparative fit index; RMSEA, root mean square error of approximation.

1,193 participants completed the survey, with 124 excluded from further analyses (52 did not consent to having responses from Study 1 and Study 2 matched; 21 could not have responses from Study 1 and Study 2 matched; and 51 provided conflicting information regarding age and/or gender between Study 1 and Study 2)⁴. The final sample for Study 2 ($N = 1,069$) comprised 48.7% females ($n = 521$) with age range of 19 to 88 years ($M = 52.81$, $SD = 14.81$). Owing to time and space limitations, demographic questions were limited to age and gender.

Questionnaire

A questionnaire was developed to validate the CN-12 described in Study 1, using items from the original questionnaire (the 20-item CN instrument, biospheric and altruistic value orientations, time spent in nature in the past year, and frequency of engaging in the 11 PEB in the past year). Two existing multidimensional CN instruments—the NR and EID—were included. Following feedback from pilot testing ($n = 23$), items were adapted to

suit an Australian context (e.g., “forest” instead of “woods” and “holiday” instead of “vacation”) and amended to improve item clarity (e.g., “I would rather live in a small room or house with A NICE VIEW than a bigger room or house with a view of other buildings” was changed to “I would rather live in a small room or house with A VIEW OF NATURE than a bigger room or house with a view of other buildings”; “I really enjoy camping AND hiking outdoors” was changed to “I really enjoy camping AND/OR hiking outdoors”). Although the original NR instrument used a 5-point Likert scale, we used a 7-point scale to enable comparability with other CN instruments. A third multidimensional CN instrument—the DCN—was not included, as the inclusion of an additional 40 items would have added considerable time and cognitive burden.

Data Analyses and Results

Phase 1: Exploratory and Confirmatory Factor Analysis

Analyses were conducted using IBM SPSS Statistics Version 26 (IBM Corp., 2017), with CFA conducted using IBM SPSS AMOS Version 26 (Arbuckle, 2006). Descriptive statistics provided

⁴As Study 1 and Study 2 were conducted approximately 12 months apart, it was expected that age would increase by 1 year between Study 1 and Study 2. An age difference of up to 2 years was considered acceptable to account for human error.

TABLE 4 | Spearman correlations between the CN-12 total score, dimensions scores, and criterion variables ($N = 3,090$).

	CN- Total	CN-Identity	CN-Experience	CN-Philosophy
Value orientations				
Biospheric	0.68** [0.66,0.70]	0.62** [0.59,0.64]	0.59** [0.56,0.61]	0.67** [0.65,0.69]
Altruistic	0.46** [0.43,0.49]	0.39** [0.36,0.42]	0.40** [0.37,0.43]	0.50** [0.47,0.52]
Egoistic	0.02 ^{ns} [-0.02,0.05]	0.03 ^{ns} [-0.01,0.06]	0.03 ^{ns} [-0.01,0.06]	-0.08 ^{ns} [-0.07,0.00]
Time spent in nature				
In the past year	0.38** [0.35,0.41]	0.38** [0.34,0.41]	0.39** [0.37,0.42]	0.22** [0.19,0.25]
Beliefs about time spent in nature				
I spend as much time as possible in nature	0.64** [0.62,0.66]	0.61** [0.59,0.64]	0.66** [0.63,0.68]	0.40** [0.37,0.43]
It is important to me that my child/children spend time in nature ($n = 723$) ^a	0.53** [0.47,0.58]	0.43** [0.37,0.49]	0.53** [0.47,0.59]	0.45** [0.38,0.51]
I would like to spend more time in nature	0.53** [0.50,0.56]	0.46** [0.43,0.49]	0.53** [0.50,0.56]	0.41** [0.38,0.44]
Pro-environmental behaviors (past year)				
Aggregate PEB	0.46** [0.43,0.49]	0.50** [0.47,0.53]	0.39** [0.36,0.42]	0.32** [0.29,0.35]
Controlled the movements of pets ($n = 1,556$) ^b	0.25** [0.20,0.29]	0.23** [0.18,0.27]	0.21** [0.16,0.26]	0.24** [0.19,0.29]
Plant with native species	0.36** [0.33,0.39]	0.36** [0.33,0.40]	0.33** [0.30,0.36]	0.25** [0.22,0.28]
Reduced energy use	0.30** [0.27,0.33]	0.29** [0.26,0.32]	0.26** [0.22,0.29]	0.28** [0.25,0.31]
Chose sustainable seafood	0.33** [0.30,0.36]	0.34** [0.31,0.38]	0.27** [0.24,0.30]	0.26** [0.23,0.30]
Used public transport	0.07** [0.03,0.11]	0.08** [0.04,0.12]	0.06** [0.02,0.10]	0.04* [0.00,0.07]
Participated in environmental volunteering	0.29** [0.25,0.32]	0.33** [0.30,0.36]	0.25** [0.22,0.29]	0.16** [0.12,0.20]
Participated in citizen science	0.20** [0.16,0.23]	0.26** [0.22,0.29]	0.17** [0.14,0.20]	0.08** [0.04,0.11]
Donated to environmental organizations	0.33** [0.30,0.36]	0.36** [0.33,0.39]	0.26** [0.23,0.29]	0.25** [0.21,0.28]
Advocated for the environment	0.30** [0.26,0.32]	0.35** [0.32,0.38]	0.24** [0.21,0.27]	0.19** [0.16,0.23]
Cleaned up litter	0.34** [0.31,0.38]	0.36** [0.33,0.39]	0.31** [0.28,0.35]	0.22** [0.19,0.26]
Involved in community gardening or composting	0.19** [0.16,0.23]	0.25** [0.21,0.28]	0.16** [0.12,0.19]	0.09** [0.05,0.12]

Bias corrected and accelerated bootstrap 95% confidence intervals shown in brackets. ns, not significant ($p > 0.05$). ^aOnly shown to participants who reported they were the parent/guardian of a child/children aged 17 years or younger. ^bOnly shown to participants who reported owning a pet. * $p < 0.05$; ** $p < 0.01$.

an overview of the data, and variables were screened for normality. While five CN items were skewed (item 9, -1.11; item 10, 0.82; item 16, -0.84; item 18, -1.50; item 20, -1.21), transformations were not undertaken as doing so would make interpretation more difficult, and it was expected that the large sample would reduce the impact of non-normality on analyses (Tabachnick and Fidell, 2007).

We randomly split the database in two to facilitate validation of the CN-12. Using the first random sample ($n = 543$), we conducted EFA using principal components analysis with promax rotation ($\kappa = 4$). A scree plot suggested a three component solution, accounting for 74.08% of the variance. The pattern and size of factor loadings were consistent with those described in Study 1 with the exception of items 7 and 19 loading more strongly on the identity dimension than the experience and philosophy dimensions, respectively (Supplementary Table S3).

We conducted CFA (maximum likelihood) on the CN-12 using the second random sample ($n = 526$). The GFI (0.92), AGFI (0.87), NFI (0.94), TLI (0.94), and CFI (0.95) suggested the model was an acceptable-to-good fit of the data (Schermelleh-Engel et al., 2003; Tabachnick and Fidell, 2007; Figure 1).

Total CN was calculated by averaging the 12 items, with scores for the three CN dimensions calculated by averaging the items comprising each dimension (Figure 1). Cronbach's alpha was calculated using the total sample ($N = 1,069$), with values for CN-Total ($\alpha = 0.94$), and for the three dimensions (CN-Identity,

$\alpha = 0.88$; CN-Experience, $\alpha = 0.90$; and CN-Philosophy, $\alpha = 0.77$) consistent with Study 1. CN-Identity was strongly correlated with CN-Experience ($r_s = 0.82$, 95% BCa CI [0.79,0.84], $p < 0.001$) and CN-Philosophy ($r_s = 0.64$, 95% BCa CI [0.60,0.68], $p < 0.001$), and CN-Experience was strongly correlated with CN-Philosophy ($r_s = 0.62$, 95% BCa CI [0.58,0.67], $p < 0.001$).

Phase 2: Validation and Relationships Between Connection With Nature and Pro-environmental Behavior

As per Study 1, we used the total sample ($N = 1,069$) to assess construct validity of the CN-12. We calculated Spearman correlations between CN-Total, dimensions, and criterion variables including biospheric and altruistic value orientations, time spent in nature in the past year, and 11 PEB. Results were consistent with those from Study 1 (Supplementary Table S4).

To determine predictive validity of the CN-12, we calculated Spearman correlations between CN-Total and dimensions at Time 1 (Study 1: 2018) and criterion variables at Time 2 (Study 2: 2019). Correlations were consistent with those reported previously (Supplementary Table S5), indicating predictive validity.

To assess temporal stability of the CN-12, we calculated Spearman correlations (with bias corrected and accelerated bootstrap 95% confidence intervals shown in brackets) between scores at Time 1 (Study 1: 2018) and Time 2 (Study 2: 2019).

Results suggested strong correlations between Time 1 and Time 2 for CN-Total ($r_s = 0.77$, 95% BCa CI [0.73,0.81], $p < 0.001$), CN-Identity ($r_s = 0.75$, 95% BCa CI [0.71,0.78], $p < 0.001$), CN-Experience ($r_s = 0.72$, 95% BCa CI [0.68,0.76], $p < 0.001$), and CN-Philosophy ($r_s = 0.66$, 95% BCa CI [0.63,0.70], $p < 0.001$). These results are consistent with those of prior research (Nisbet et al., 2011; Knepple Carney, 2018), indicating that CN is relatively stable over time.

As is common practice in the CN literature, we assessed convergent validity of the CN-12 using two existing CN instruments. In order to compare dimensions across instruments, we first explored the factor structure of the EID and NR using the total sample ($N = 1,069$). Owing to the lack of clarity around the dimensionality of the EID, we conducted EFA on the 24 items. A principal components analysis with promax rotation ($\kappa = 4$) revealed a four-component solution accounting for 61.51% of the variance (**Supplementary Table S6**). The factor structure was similar to that described by Olivos and Aragonés (2011), although the identity dimension included elements of the “environmentalism” dimension described by the authors. We conducted CFA (maximum likelihood) to verify the four-component model (**Supplementary Table S7**); fit indices suggested the model was a poor fit of the data (GFI = 0.87, AGFI = 0.84, NFI = 0.89, TLI = 0.89, CFI = 0.90, and RMSEA = 0.07), although removing item 7 improved the fit to an acceptable level (GFI = 0.90, AGFI = 0.87, NFI = 0.90, TLI = 0.91, CFI = 0.92, and RMSEA = 0.07) (Schermelleh-Engel et al., 2003; Tabachnick and Fidell, 2007). However, we retained item 7 in the final model to ensure consistency with previous literature.

The four dimensions were labeled EID-Identity, EID-Enjoying nature (experience); EID-Philosophy, and EID-Appreciation of nature. Cronbach's alpha for the EID-Total and the four dimensions [EID-Total, $\alpha = 0.94$; EID-Identity, $\alpha = 0.93$; EID-Enjoying nature (experience), $\alpha = 0.79$; EID-Philosophy, $\alpha = 0.83$; EID-Appreciation of nature, $\alpha = 0.75$] were comparable with those reported by Olivos and Aragonés (2011) (EID-Total, $\alpha = 0.90$; EID-Environmental identity, $\alpha = 0.74$; EID-Enjoying nature, $\alpha = 0.80$; EID-Environmentalism, $\alpha = 0.80$; EID-Appreciation of nature, $\alpha = 0.69$). We calculated the total EID score by averaging all 24 items. We calculated scores for

each of the four dimensions using the mean score of items in that dimension.

Prior to analyses of NR data, relevant items were reverse coded. As the factor structure of the NR requires further investigation (Nisbet et al., 2009), we conducted principal components analysis with promax rotation ($\kappa = 4$); a three-component solution was revealed, accounting for 55.70% of the variance (**Supplementary Table S8**). The factor structure was similar to that described by Nisbet et al. (2009), although with items 9, 19, and 20 loading on NR-Self and item 14 loading on NR-Perspective. We conducted CFA (maximum likelihood) to verify the three-component model (**Supplementary Table S9**); fit indices suggested the model was an adequate fit of the data (GFI = 0.88, AGFI = 0.85, NFI = 0.86, TLI = 0.86, CFI = 0.88, and RMSEA = 0.08) (Schermelleh-Engel et al., 2003; Tabachnick and Fidell, 2007). To ensure consistency with previous literature, we calculated mean scores for the NR-total and the three NR dimensions as per the authors' guidelines (Nisbet et al., 2009). Cronbach's alpha (NR-Total, $\alpha = 0.89$; NR-Self, $\alpha = 0.87$; NR-Experience, 0.76; NR-Perspective, $\alpha = 0.74$) were consistent with those reported by Nisbet et al. (2009) (NR-Total, $\alpha = 0.87$; NR-Self, $\alpha = 0.84$; NR-Experience, 0.80; NR-Perspective, $\alpha = 0.66$).

We calculated Spearman correlations between the CN-12, EID, and NR. We expected the total CN score to be positively correlated with total EID and NR scores. In considering the similar pattern of dimensions across the three instruments, we also expected the dimensions to correlate (CN-Identity with EID-Identity and NR-Self; CN-Experience with EID-Enjoying nature and NR-Experience; and CN-Philosophy with EID-Philosophy and NR-Perspective). Results confirmed these hypotheses (**Table 5**).

DISCUSSION

This research sought to: (1) further explore and clarify CN dimensions; (2) develop a parsimonious instrument to capture a range of potential CN dimensions; and (3) assess the reliability, validity, and temporal stability of the instrument against criterion variables commonly used in CN research,

TABLE 5 | Spearman correlations between the CN-12, Nature Relatedness Scale, and Environmental Identity Scale (total and dimension scores) ($N = 1,069$), with corresponding dimensions shown in bold (all correlations are statistically significant, $p < 0.001$).

	CN-Total	CN-Identity	CN-Experience	CN-Philosophy
NR-Total	0.80 [0.78,0.83]	0.75 [0.72,0.78]	0.73 [0.69,0.76]	0.68 [0.64,0.72]
NR-Self	0.83 [0.80,0.85]	0.82 [0.80,0.84]	0.72 [0.68,0.75]	0.68 [0.64,0.72]
NR-Experience	0.72 [0.68,0.75]	0.67 [0.63,0.71]	0.74 [0.71,0.77]	0.45 [0.40,0.50]
NR-Perspective	0.43 [0.38,0.49]	0.37 [0.31,0.43]	0.35 [0.29,0.40]	0.52 [0.47,0.56]
EID-Total	0.82 [0.79,0.84]	0.81 [0.78,0.83]	0.74 [0.71,0.77]	0.62 [0.57,0.66]
EID-Identity	0.75 [0.72,0.78]	0.77 [0.74,0.80]	0.64 [0.60,0.68]	0.59 [0.54,0.64]
EID-Enjoying nature (experience)	0.60 [0.55,0.65]	0.60 [0.55,0.65]	0.62 [0.57,0.66]	0.32 [0.26,0.37]
EID-Philosophy	0.75 [0.71,0.79]	0.68 [0.64,0.72]	0.71 [0.67,0.75]	0.63 [0.59,0.68]
EID-Appreciation of nature	0.65 [0.61,0.69]	0.65 [0.61,0.69]	0.58 [0.54,0.63]	0.50 [0.45,0.55]

Bias corrected and accelerated bootstrap 95% confidence intervals shown in brackets.

including PEB. Analyses of two large datasets revealed a 12-item CN instrument capturing three dimensions: Identity, Experience, and Philosophy. Results suggested that scores on the CN-12 (total and dimensions) are positively related to biospheric and altruistic values, time spent in nature, general attitudes toward spending time in nature, and 11 different PEB. Results also suggested that the CN-12 was stable over a 12-month period, with total and dimension scores strongly related to two existing multidimensional CN instruments.

Connection With Nature Dimensions

In responding to calls for further exploration of the dimensionality of CN (Tam, 2013; Restall and Conrad, 2015), this research revealed three dimensions that broadly represent four of the five described by Ives et al. (2017, 2018). CN-Identity includes cognitive, emotional, and behavioral elements, including self-perception as someone who feels emotionally connected to nature and who behaves in such a way as to protect nature. CN-Experience represents a sense of enjoyment, wellbeing, and belonging associated with activities undertaken in the natural environment. The CN-Philosophy dimension embodies ideas around humanity's relationship with nature, including a sense of interconnectedness between humans and nature. Together, these three dimensions align with existing definitions of CN as a sense of personal identity, encompassing a relationship between the self and the natural world that includes cognitions, emotions, and behavior. Two dimensions, CN-Experience and CN-Philosophy, are closely aligned with the experiential and philosophical dimensions (Ives et al., 2017, 2018). Although Ives et al. (2017, 2018) and Meis-Harris et al. (2019) proposed that emotional and cognitive CN are distinct, albeit related, dimensions, the results of the present studies suggest that these two dimensions can be aligned under the CN-Identity dimension. This is consistent with previous research suggesting that an identity dimension may broadly capture emotions and cognitions (Nisbet et al., 2009; Olivos and Aragonés, 2011). In addition, the dimensions captured by the CN-12 are conceptually similar to those of the NR and the EID. The moderate-to-strong correlations between the Identity (CN-Identity, EID-Identity, and NR-Self), Experience (CN-Experience, EID-Enjoying nature, and NR-Experience), and Philosophy (CN-Philosophy, EID-Philosophy, and NR-Perspective) dimensions suggest that the three instruments likely have a similar underlying structure. This provides further evidence that Identity, Experience, and Philosophy are important dimensions of the CN construct.

In the analyses presented above, CN-Identity accounted for the largest proportion of variance of the CN instrument. These results are similar to those described by Olivos and Aragonés (2011) and Nisbet et al. (2009), who noted that the EID-Environmental Identity and NR-Self dimensions, respectively, accounted for the largest proportion of variance. This suggests that identity may make the most significant contribution to the CN construct, relative to other dimensions. Interestingly, a recent meta-analysis suggested that CN and environmental identity were distinct yet highly correlated constructs (Balundé

et al., 2019). However, 10 of the 11 studies included in the meta-analyses assessed environmental identity using the EID; thus, it is plausible that the EID-Identity dimension made the largest contribution to the overlap between environmental identity and CN in that study. Nevertheless, it appears that a sense of self-identification with the natural environment—encompassing thoughts, beliefs, and attitudes as well as emotional responses about and toward nature—is an integral part of CN.

Similarly, the results presented here suggest that the CN-12 is strongly correlated with both the EID and NR, in total and in dimension scores. Although this may suggest redundancy in the CN-12, it is worth noting that the three existing multidimensional CN instruments—the EID, NR, and the DCN—are lengthy, with 21, 24, and 40 items, respectively. The CN-12 is significantly shorter than existing multidimensional instruments while also capturing three dimensions; brief versions of the EID and NR, in contrast, are unidimensional (Nisbet and Zelenski, 2013; Chew, 2019). Preliminary evidence also suggests that different dimensions of the CN-12 may be stronger predictors of some PEB than other dimensions or the total CN score.

Connection With Nature and Pro-environmental Behavior

Consistent with the findings of Nisbet et al. (2009), the results of these studies suggest some differences in the strength of correlations between CN dimensions and particular PEB. The relationships between CN-Identity and PEB were significantly stronger than the relationships between CN-Total and PEB for seven specific behaviors, including environmental volunteering, citizen science, donations to environmental organizations, and advocacy for the environment. From an applied perspective, fostering a sense of emotional connection to nature and self-identification as someone who protects nature (CN-Identity) may facilitate engagement in these seven behaviors.

The pattern and magnitude of correlations between the CN-12 and the aggregate PEB score, and between the CN-12 and individual PEB presented here were consistent with prior research (Prévot et al., 2018a; Mackay and Schmitt, 2019; Whitburn et al., 2019). This provides further evidence that people higher in CN tend to engage in a greater number of PEB and with greater frequency, than people lower in CN. Thus, fostering a sense of CN, and particularly CN-Identity, may be a useful means of encouraging engagement in PEB.

Limitations

This paper details the development of a brief, multidimensional CN instrument with sound psychometric properties that is related to existing multidimensional CN instruments and to PEB. Nevertheless, a number of limitations are evident. Differences were noted in the strength of relationships between some CN dimensions and PEB, and although these were statistically significant, they were also relatively small. Although this provides preliminary evidence of the utility of individual CN dimensions in predicting specific PEB, further exploration of such relationships is warranted.

From a methodological perspective, participants completed the 20-item version of the instrument at Time 1 (2018) and Time 2 (2019), limiting the ability to demonstrate that the overlapping variance between the 12-item and 20-item instruments is sufficient (Smith et al., 2000). In addition, the CN-12 should be administered with additional, independent samples to confirm reliability and validity (Smith et al., 2000).

Finally, most CN research to date has been conducted in developed countries (Restall and Conrad, 2015; Ives et al., 2017), and the present research is no exception. Although the samples described were representative of the population of Victoria, which may facilitate generalization to the wider Australian or perhaps Western populations, the representation of respondents from diverse cultural and ethnic groups or Indigenous populations was not explicitly considered. Thus, the applicability of the CN construct to non-Western cultural groups and individuals in developing countries remains largely unexplored. Evidence suggests that values and beliefs about, and attitudes toward, the natural environment differ across cultural groups (e.g., Schultz, 2002a); thus, cross-cultural variability of the CN construct—at both individual and societal levels—warrants further investigation.

Future Research

Given that research into the dimensionality of the CN construct is still in its infancy, further exploration of other possible dimensions is indicated. In particular, Ives et al. (2017, 2018) described material CN as the consumption of materials from nature (e.g., food and fiber) and resource extraction and use, such ideas that have largely been unexplored in the CN literature (Ives et al., 2017). Also of interest is the EID-Appreciation of nature dimension that encompasses elements of aesthetic appreciation of nature. Evidence suggests that perceptions of the aesthetic beauty of nature may be related to CN (Zhang et al., 2014; Lumber et al., 2017); thus, further exploration of the role of aesthetic appreciation in CN is warranted. Another potential dimension that merits investigation is spatial or contextual CN; that is, the role that specific geographical locations may have in CN (Klaniecki et al., 2018; Giusti, 2019), perhaps leveraging insights from the place attachment literature (e.g., Gosling and Williams, 2010; Ramkissoon et al., 2013; Beery and Wolf-Watz, 2014). As noted by Balundé et al. (2019), a comprehensive understanding of the breadth of the CN construct may provide insights that enable targeted interventions to foster PEB.

Another area of consideration for future research is the conceptualization of CN as trait versus state. Some authors consider CN to be a trait-like construct that is relatively stable over time (Clayton, 2003; Mayer and Frantz, 2004; Nisbet et al., 2009; Martin et al., 2020), a notion that is supported by the present studies. Yet research suggests that CN may be more state-like, dependent upon seasons and weather patterns (Duffy and Verges, 2010; Nisbet et al., 2011) and able to be manipulated, for example, through exposure to natural environments (Mayer et al., 2009). Some have argued that while a single exposure to nature may increase state CN, a more enduring trait-like CN—likely to be developed with repeated experiences in nature—may

be needed to trigger PEB (Zelenski et al., 2015; Clayton, 2017; Prévot et al., 2018b). Given that people higher in CN are more likely to engage in PEB, further understanding of CN as a state-like construct could enhance interventions aimed at increasing PEB, particularly among people lower in state CN.

CONCLUSION

In recent years, an increasing interest in human connections with nature has resulted in a variety of definitions of CN, as well as instruments, to capture the construct. Although most instruments are unidimensional, recent evidence suggests that CN is multidimensional, although there is ongoing debate as to which dimensions make up the CN construct. Existing multidimensional CN instruments capture a similar array of dimensions, however, they are lengthy and may not be suitable for real-world contexts. The present studies describe the development of a brief CN instrument—the CN-12—that is multidimensional and is strongly related to existing multidimensional CN instruments. With an increasing body of evidence suggesting a relationship between CN and PEB, fostering a sense of connection with the natural world, and particularly a sense of identity relative to nature, may be a useful means through which to foster sustainability outcomes.

DATA AVAILABILITY STATEMENT

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found at: Open Science Framework (https://osf.io/py2ad/?view_only=4ef4a4545aa64626aa7baaea6d9811f2).

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Monash University Human Research Ethics Committee (Project IDs: 14010 and 21790). The participants provided their written informed consent to participate in these studies.

AUTHOR CONTRIBUTIONS

All authors contributed to the study conception and design. MH prepared the materials, collected the data, and wrote the first draft of the manuscript. MH and FM analyzed the data. All authors commented on previous versions of the manuscript, read and approved the final manuscript.

FUNDING

This research was commissioned and funded by the Victorian Government Department of Environment, Land,

Water and Planning. This research was also funded by an Australian Government Research Training Program (RTP) Scholarship.

ACKNOWLEDGMENTS

We thank Kim Lowe, Fern Hames, and the DELWP Victorians Value Nature team for their input into this research. We also

thank two reviewers, whose input improved the clarity and presentation of the manuscript.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpsyg.2020.01566/full#supplementary-material>

REFERENCES

- Arbuckle, J. L. (2006). *Amos (Version 25) [Computer Program]*. Chicago, IL: IBM Corp.
- Arendt, F., and Matthes, J. (2016). Nature documentaries, connectedness to nature, and pro-environmental behavior. *Environ. Commun.* 10, 453–472. doi: 10.1080/17524032.2014.993415
- Balundè, A., Jovarauskaitė, L., and Poškus, M. S. (2019). Exploring the relationship between connectedness with nature, environmental identity, and environmental self-identity: a systematic review and meta-analysis. *SAGE Open* 9, 1–12. doi: 10.1177/2158244019841925
- Barrett, L. F., Mesquita, B., Ochsner, K. N., and Gross, J. J. (2007). The experience of emotion. *Annu. Rev. Psychol.* 58, 373–403. doi: 10.1146/annurev.psych.58.110405.085709
- Beery, T. H. (2013). Establishing reliability and construct validity for an instrument to measure environmental connectedness. *Environ. Educ. Res.* 19, 81–93. doi: 10.1080/13504622.2012.687045
- Beery, T. H., and Wolf-Watz, D. (2014). Nature to place: rethinking the environmental connectedness perspective. *J. Environ. Psychol.* 40, 198–205. doi: 10.1016/j.jenvp.2014.06.006
- Braun, T., and Dierkes, P. (2017). Connecting students to nature – how intensity of nature experience and student age influence the success of outdoor education programs. *Environ. Educ. Res.* 23, 937–949. doi: 10.1080/13504622.2016.1214866
- Brügger, A., Kaiser, F. G., and Roczen, N. (2011). One for all? Connectedness to nature, inclusion of nature, environmental identity, and implicit association with nature. *Eur. Psychol.* 16, 324–333. doi: 10.1027/1016-9040/a000032
- Burke, P. J., and Stets, J. E. (2009). *Identity Theory*. New York, NY: Oxford University Press, doi: 10.1093/acprof:oso/9780195388275.003.0017
- Chew, P. K. H. (2019). Psychometric evaluation of two instruments to assess connection to nature. *Psychology* 10, 1–31. doi: 10.1080/21711976.2019.1607470
- Clayton, S. (2003). “Environmental identity: a conceptual and operational definition,” in *Identity and the Natural Environment: The Psychological Significance of Nature*, eds S. D. Clayton and S. Opatow (Cambridge, MA: MIT Press), 45–66.
- Clayton, S. (2017). Social issues and personal life: considering the environment. *J. Soc. Issues* 73, 667–681. doi: 10.1111/josi.12237
- Cleary, A., Fielding, K. S., Murray, Z., and Roiko, A. (2018). Predictors of nature connection among urban residents: assessing the role of childhood and adult nature experiences. *Environ. Behav.* 52, 579–610. doi: 10.1177/0013916518811431
- Davis, J. L., Green, J. D., and Reed, A. (2009). Interdependence with the environment: commitment, interconnectedness, and environmental behavior. *J. Environ. Psychol.* 29, 173–180. doi: 10.1016/j.jenvp.2008.11.001
- Diedenhofen, B., and Musch, J. (2015). Cocor: a comprehensive solution for the statistical comparison of correlations. *PLoS One* 10:e0121945. doi: 10.1371/journal.pone.0121945
- Duffy, S., and Verges, M. (2010). Forces of nature affect implicit connections with nature. *Environ. Behav.* 42, 723–739. doi: 10.1177/0013916509338552
- Dutcher, D. D., Finley, J. C., and Johnson, J. B. (2007). Connectivity with nature as a measure of environmental values. *Environ. Behav.* 39, 474–493. doi: 10.1177/0013916506298794
- Forstmann, M., and Sagioglou, C. (2017). Lifetime experience with (classic) psychedelics predicts pro-environmental behavior through an increase in nature relatedness. *J. Psychopharmacol.* 31, 975–988. doi: 10.1177/0269881117714049
- Galesic, M., and Bosnjak, M. (2009). Effects of questionnaire length on participation and indicators of response quality in a web survey. *Public Opin. Q.* 73, 349–360. doi: 10.1093/poq/nfp031
- Geng, L., Xu, J., Ye, L., Zhou, W., and Zhou, K. (2015). Connections with nature and environmental behaviors. *PLoS One* 10:e0127247. doi: 10.1371/journal.pone.0127247
- Giusti, M. (2019). Human-nature relationships in context. Experiential, psychological, and contextual dimensions that shape children's desire to protect nature. *PLoS One* 14:e0225951. doi: 10.1371/journal.pone.0225951
- Gosling, E., and Williams, K. J. H. (2010). Connectedness to nature, place attachment and conservation behaviour: testing connectedness theory among farmers. *J. Environ. Psychol.* 30, 298–304. doi: 10.1016/j.jenvp.2010.01.005
- Hair, J. F., Black, W. C., Babin, B. J., and Anderson, R. E. (2014). *Multivariate Data Analysis*, 7th Edn. Harlow: Pearson.
- Hatty, M. (2019). *Data from: Victorians Valuing Nature Follow-up Survey*. Charlottesville, VA: Open Science Framework.
- Hatty, M., Borg, K., Meis, J., and Jorgensen, B. (2018). *Data from: Victorians Valuing Nature Foundations Survey*. Charlottesville, VA: Open Science Framework.
- Hu, L. T., and Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Struct. Equ. Model.* 6, 1–55. doi: 10.1080/10705519909540118
- Hunt, A., Stewart, D., Richardson, M., Hinds, J., Bragg, R., White, M., et al. (2017). *Monitor of engagement with the natural environment: developing a method to measure nature connection across the English population (adults and children)*. (Natural England Commissioned Reports, Number 233). New York, NY. Available online at: <http://publications.naturalengland.org.uk/publication/5337609808642048>
- IBM Corp. (2017). *IBM SPSS Statistics for Windows, Version 25*. Armonk, NY: IBM Corp.
- Ives, C. D., Abson, D. J., von Wehrden, H., Dörninger, C., Klaniecki, K., and Fischer, J. (2018). Reconnecting with nature for sustainability. *Sustain. Sci.* 13, 1–9. doi: 10.1007/s11625-018-0542-9
- Ives, C. D., Giusti, M., Fischer, J., Abson, D. J., Klaniecki, K., Dörninger, C., et al. (2017). Human-nature connection: a multidisciplinary review. *Curr. Opin. Environ. Sustain.* 26–27, 106–113. doi: 10.1016/j.cosust.2017.05.005
- Kals, E., Schumacher, D., and Montada, L. (1999). Emotional affinity toward nature as a motivational basis to protect nature. *Environ. Behav.* 31, 178–202. doi: 10.1177/00139169921972056
- Klaniecki, K., Leventon, J., and Abson, D. J. (2018). Human-nature connectedness as a ‘treatment’ for pro-environmental behavior: making the case for spatial considerations. *Sustain. Sci.* 13, 1375–1388. doi: 10.1007/s11625-018-0578-x
- Klein, S. A., and Hilbig, B. E. (2018). How virtual nature experiences can promote pro-environmental behavior. *J. Environ. Psychol.* 60, 41–47. doi: 10.1016/j.jenvp.2018.10.001
- Knepple Carney, A. (2018). *How Connectedness to Nature Relates to Well-Being Over Time*. Available online at: <https://researchrepository.wvu.edu/etd/5992/> (accessed December 1, 2019).

- Lerner, J. S., Li, Y., Valdesolo, P., and Kassam, K. S. (2015). Emotion and decision making. *Annu. Rev. Psychol.* 66, 799–823. doi: 10.1146/annurev-psych-010213-115043
- Lumber, R., Richardson, M., and Sheffield, D. (2017). Beyond knowing nature: contact, emotion, compassion, meaning, and beauty are pathways to nature connection. *PLoS One* 12:e0177186. doi: 10.1371/journal.pone.0177186
- Mackay, C. M. L., and Schmitt, M. T. (2019). Do people who feel more connected to nature do more to protect it? A meta-analysis. *J. Environ. Psychol.* 65, 1–9. doi: 10.1016/j.jenvp.2019.101323
- Maloney, P., Grawitch, M. J., and Barber, L. K. (2011). Strategic item selection to reduce survey length: reduction in validity? *Consult. Psychol. J.* 63, 162–175. doi: 10.1037/a0025604
- Marcus, B., Bosnjak, M., Lindner, S., Pilischenko, S., and Schütz, A. (2007). Compensating for low topic interest and long surveys: a field experiment on nonresponse in web surveys. *Soc. Sci. Comput. Rev.* 25, 372–383. doi: 10.1177/0894439307297606
- Martin, C., and Czellar, S. (2017). Where do biospheric values come from? A connectedness to nature perspective. *J. Environ. Psychol.* 52, 56–68. doi: 10.1016/j.jenvp.2017.04.009
- Martin, L., White, M. P., Hunt, A., Richardson, M., Pahl, S., and Burt, J. (2020). Nature contact, nature connectedness and associations with health, wellbeing and pro-environmental behaviours. *J. Environ. Psychol.* 68, 101389. doi: 10.1016/j.jenvp.2020.101389
- Mayer, F. S., Frantz, C. M., Bruehlman-Senecal, E., and Dolliver, K. (2009). Why is nature beneficial? The role of connectedness to nature. *Environ. Behav.* 41, 607–643. doi: 10.1177/0013916508319745
- Mayer, F. S., and Frantz, C. M. P. (2004). The connectedness to nature scale: a measure of individuals' feeling in community with nature. *J. Environ. Psychol.* 24, 503–515. doi: 10.1016/j.jenvp.2004.10.001
- Meis-Harris, J., Saeri, A., Boulet, M., Borg, K., Faulkner, N., and Jorgensen, B. (2019). *Victorians Value Nature: Survey Results*. Melbourne, VIC: Government of Victoria.
- Mena-García, A., Olivos, P., Loureiro, A., and Navarro, O. (2020). Effects of contact with nature on connectedness, environmental identity and evoked contents. [Efectos del contacto con la naturaleza en conectividad, identidad ambiental y contenidos evocados]. *Psycology* 11, 21–36. doi: 10.1080/21711976.2019.1643663
- Meng, X.-L., Rosenthal, R., and Rubin, D. B. (1992). Comparing correlated correlation coefficients. *Psychol. Bull.* 111, 172–175. doi: 10.1037/0033-2909.111.1.172
- Navarro, O., Tapia-Fonllem, C., Fraijo-Sing, B., Roussiau, N., Ortiz-Valdez, A., Guillard, M., et al. (2020). Connectedness to nature and its relationship with spirituality, wellbeing and sustainable behaviour. *Psycology* 11, 37–48. doi: 10.1080/21711976.2019.1643662
- Nisbet, E. K., and Zelenski, J. M. (2013). The NR-6: a new brief measure of nature relatedness. *Front. Psychol.* 4:813. doi: 10.3389/fpsyg.2013.00813
- Nisbet, E. K., Zelenski, J. M., and Grandpierre, S. (2019). Mindfulness in nature enhances connectedness and mood. *Ecopsychology* 11, 81–91. doi: 10.1089/eco.2018.0061
- Nisbet, E. K., Zelenski, J. M., and Murphy, S. A. (2009). The nature relatedness scale: linking individuals' connection with nature to environmental concern and behavior. *Environ. Behav.* 41, 715–740. doi: 10.1177/0013916508318748
- Nisbet, E. K., Zelenski, J. M., and Murphy, S. A. (2011). Happiness is in our nature: exploring nature relatedness as a contributor to subjective well-being. *J. Happiness Stud.* 12, 303–322. doi: 10.1007/s10902-010-9197-7
- Olivos, P., and Aragonés, J.-I. (2011). Psychometric properties of the environmental identity scale (EID). *Psycology* 2, 65–74. doi: 10.1174/217119711794394653
- Olivos, P. J., Talayero, F., Aragonés, J.-I., and Moyano-Diaz, E. (2014). Dimensiones del comportamiento proambiental y su relación con la conectividad e identidad ambientales. *Psico* 45, 369–376. doi: 10.15448/1980-8623.2014.3.17309
- Perkins, H. E. (2010). Measuring love and care for nature. *J. Environ. Psychol.* 30, 455–463. doi: 10.1016/j.jenvp.2010.05.004
- Perrin, J. L., and Benassi, V. A. (2009). The connectedness to nature scale: a measure of emotional connection to nature? *J. Environ. Psychol.* 29, 434–440. doi: 10.1016/j.jenvp.2009.03.003
- Phelps, E. A. (2006). Emotion and cognition: insights from studies of the human amygdala. *Annu. Rev. Psychol.* 57, 27–53. doi: 10.1146/annurev.psych.56.091103.070234
- Prévot, A. C., Cheval, H., Raymond, R., and Cosquer, A. (2018a). Routine experiences of nature in cities can increase personal commitment toward biodiversity conservation. *Biol. Conserv.* 226, 1–8. doi: 10.1016/j.biocon.2018.07.008
- Prévot, A. C., Clayton, S., and Mathevet, R. (2018b). The relationship of childhood upbringing and university degree program to environmental identity: experience in nature matters. *Environ. Educ. Res.* 24, 263–279. doi: 10.1080/13504622.2016.1249456
- Ramkissoon, H., Smith, L. D. G., and Weiler, B. (2013). Testing the dimensionality of place attachment and its relationships with place satisfaction and pro-environmental behaviours: a structural equation modelling approach. *Tour Manag.* 36, 552–566. doi: 10.1016/j.tourman.2012.09.003
- Restall, B., and Conrad, E. (2015). A literature review of connectedness to nature and its potential for environmental management. *J. Environ. Manage.* 159, 264–278. doi: 10.1016/j.jenvman.2015.05.022
- Richardson, M., Hunt, A., Hinds, J., Bragg, R., Fido, D., Petronzi, D., et al. (2019). A measure of nature connectedness for children and adults: validation, performance, and insights. *Sustainability* 11:3250. doi: 10.3390/su11123250
- Rosa, C. D., and Collado, S. (2019). Experiences in nature and environmental attitudes and behaviors: setting the ground for future research. *Front. Psychol.* 10:763. doi: 10.3389/fpsyg.2019.00763
- Rosa, C. D., Profice, C. C., and Collado, S. (2018). Nature experiences and adults' self-reported pro-environmental behaviors: the role of connectedness to nature and childhood nature experiences. *Front. Psychol.* 9:1055. doi: 10.3389/fpsyg.2018.01055
- Schermerle-Engel, K., Müller, H., and Moosbrugger, H. (2003). Evaluating the fit of structural equation models. *Methods Psychol. Res.* 8, 23–74.
- Schultz, P. W. (2001). The structure of environmental concern: concern for self, other people, and the biosphere. *J. Environ. Psychol.* 21, 327–339. doi: 10.1006/jenvp.2001.0227
- Schultz, P. W. (2002a). Environmental attitudes and behaviors across cultures. *Online Read. Psychol. Cult.* 8, 1–12. doi: 10.9707/2307-0919.1070
- Schultz, P. W. (2002b). "Inclusion with nature: the psychology of human-nature relations," in *Psychology of Sustainable Development*, eds P. Schmuck and W. P. Schultz (New York: Springer Science and Business Media), 61–78. doi: 10.1007/978-1-4615-0995-0_4
- Schultz, P. W., Gouveia, V. V., Cameron, L. D., Tankha, G., Schmuck, P., and Franek, M. (2005). Values and their relationship to environmental concern and conservation behavior. *J. Cross Cult. Psychol.* 36, 457–475. doi: 10.1177/0022022105275962
- Schultz, P. W., and Tabanico, J. J. (2007). Self, identity, and the natural environment: exploring implicit connections with nature. *J. Appl. Soc. Psychol.* 37, 1219–1247. doi: 10.1111/j.1559-1816.2007.00210.x
- Seppelt, R., and Cumming, G. S. (2016). Humanity's distance to nature: time for environmental austerity? *Landsc. Ecol.* 31, 1645–1651. doi: 10.1007/s10980-016-0423-5
- Smith, G. T., McCarthy, D. M., and Anderson, K. G. (2000). On the sins of short-form development. *Psychol. Assess.* 12, 102–111. doi: 10.1037/1040-3590.12.1.102
- Soliman, M., Peetz, J., and Davydenko, M. (2017). The impact of immersive technology on nature relatedness and pro-environmental behavior. *J. Media Psychol.* 29, 8–17. doi: 10.1027/1864-1105/a000213
- Steg, L., and Vlek, C. (2009). Encouraging pro-environmental behaviour: an integrative review and research agenda. *J. Environ. Psychol.* 29, 309–317. doi: 10.1016/j.jenvp.2008.10.004
- Stern, P. C., and Dietz, T. (1994). The value basis of environmental concern. *J. Soc. Issues* 50, 65–84. doi: 10.1111/j.1540-4560.1994.tb02420.x
- Stets, J. E., and Biga, C. F. (2003). Bringing identity theory into environmental sociology. *Sociol. Theory* 21, 398–423. doi: 10.1046/j.1467-9558.2003.00196.x
- Tabachnick, B. G., and Fidell, L. S. (2007). *Using Multivariate Statistics*, 5th Edn. Boston, MA: Pearson Education Inc.
- Tam, K. P. (2013). Concepts and measures related to connection to nature: similarities and differences. *J. Environ. Psychol.* 34, 64–78. doi: 10.1016/j.jenvp.2013.01.004

- Walton, T. N., and Jones, R. E. (2018). Ecological identity: the development and assessment of a measurement scale. *Environ. Behav.* 50, 657–689. doi: 10.1177/0013916517710310
- Whitburn, J., Linklater, W., and Abrahamse, W. (2019). Meta-analysis of human connection to nature and proenvironmental behavior. *Conserv. Biol.* 34, 180–193. doi: 10.1111/cobi.13381
- Zelenski, J. M., Dopko, R. L., and Capaldi, C. A. (2015). Cooperation is in our nature: nature exposure may promote cooperative and environmentally sustainable behavior. *J. Environ. Psychol.* 42, 24–31. doi: 10.1016/j.jenvp.2015.01.005
- Zhang, J. W., Howell, R. T., and Iyer, R. (2014). Engagement with natural beauty moderates the positive relation between connectedness with nature and psychological well-being. *J. Environ. Psychol.* 38, 55–63. doi: 10.1016/j.jenvp.2013.12.013
- Zylstra, M. J., Knight, A. T., Esler, K. J., and Le Grange, L. L. L. (2014). Connectedness as a core conservation concern: an interdisciplinary review of theory and a call for practice. *Springer Sci. Rev.* 2, 119–143. doi: 10.1007/s40362-014-0021-3

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Copyright © 2020 Hatty, Smith, Goodwin and Mavondo. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Chapter 6: Speaking of nature: Relationships between how people think about, connect with, and act to protect nature (Study 2)

Study 1 identified three dimensions of connection with nature – CN-Identity, CN-Experience, and CN-Philosophy – that broadly represent four of the five dimensions in the theoretical model described by Ives and colleagues (2017, 2018: see Figure 1 on page 24). The CN-Identity dimension – encompassing thoughts and emotions about one's relationship with nature and self-perception as someone who acts to protect nature – accounted for the most variance in the CN construct. Study 1 was among the first to compare the different CN dimensions captured by existing self-report multidimensional instruments. In contrast to existing multidimensional CN instruments (Clayton, 2003; Nisbet et al., 2009), the CN-12 retains its multidimensional structure despite being shorter in length, providing a means of capturing CN where time and/or money may be limited (e.g. programs related to *Biodiversity 2037*). Further, the CN-12 (total and dimension scores) were correlated with time spent in nature (generally) and frequency of participation in PBB/PEB in the past year.

The findings of Study 1 raised a number of questions regarding the relationships between CN, TIN, and PBB/PEB. These questions included, what does "nature" actually mean to participants, particularly when they consider their connection with "nature"? Are such thoughts about nature associated with CN and behaviours toward "nature" (PBB/PEB)? Similarly, what type(s) of nature may be most relevant for nurturing trait-like CN? Further, what is the direction of the relationships between CN, TIN, and PBB/PEB? Does spending time in nature while participating in PBB influence CN? These questions were addressed in Studies 2 and 3.

Within the CN literature, the term "nature" is rarely defined, while the type of nature people feel connected is often not made explicit (Beery & Wolf-Watz, 2014; Ives et al., 2017; Pasca et al., 2020). Yet, if (re)connection with nature is a desirable outcome, knowing what nature actually *is* and means to different people becomes particularly important (Mcphie & Clarke, 2018).

People hold different ideas and understandings about what "nature" is (Coscieme et al., 2020; Ducarme & Couvet, 2020) which could have important implications for conservation (Buijs & Elands, 2013; Ducarme et al., 2020). Researchers have investigated peoples' thoughts about, and understandings of, nature using a range of terminology, including visions of nature (van den Born et al., 2001) and images of nature (Buijs, 2009; Buijs et al., 2009), and representations of nature (Buijs & Elands, 2013). This thesis adopts the term *concepts of nature* to refer to how people perceive and know nature and the language used to describe nature (see also Keulartz et al., 2004; Muhar et al., 2018).

There has been little research to date investigating concepts of nature relative to CN or to PBB. Study 2 sought to address these gaps by investigating: 1) what comes to mind when people think about "nature", and whether such thoughts be categorised using statistical methods (e.g. Buijs & Elands, 2013); 2) whether concepts of nature relate to CN and/or the different dimensions of CN; and 3) whether concepts of nature relate to frequency of participation in PBB. These elements are highlighted in the conceptual framework shown in Figure 9. At the time of thesis submission, these results had been accepted for publication with the journal *Ecology and Society*.

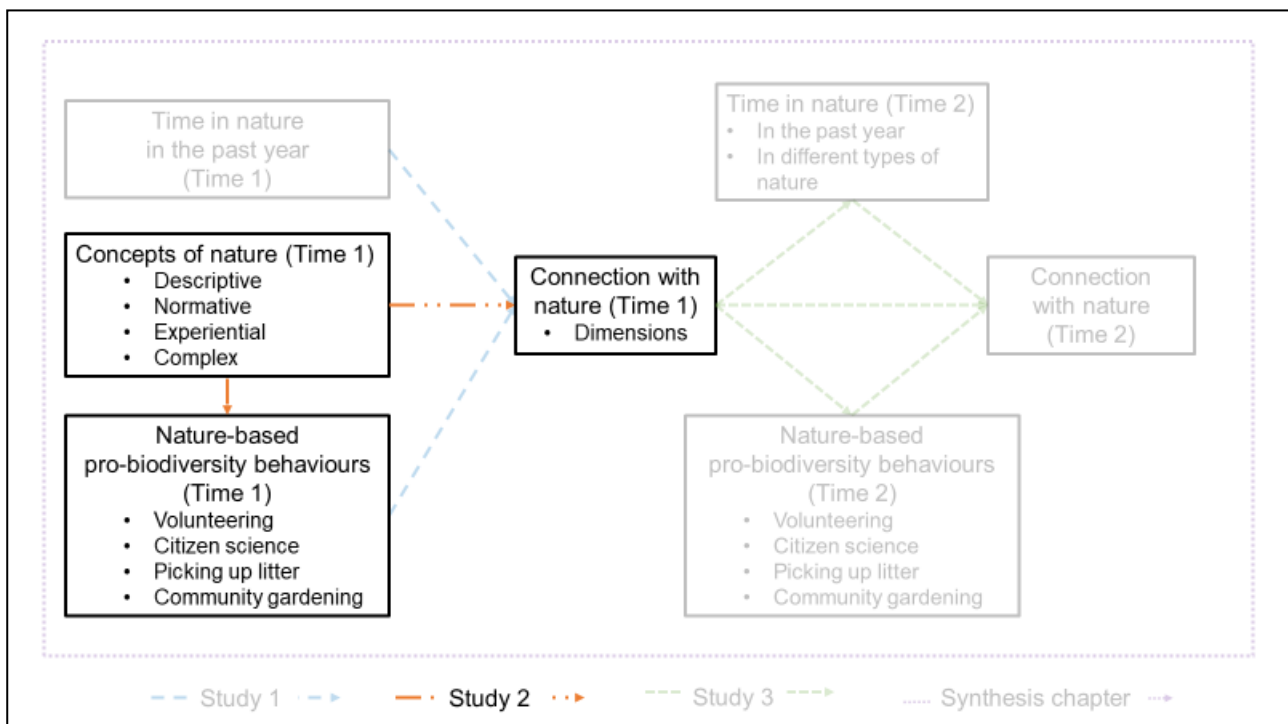


Figure 9: Conceptual framework, with elements included in Study 2 highlighted.

SPEAKING OF NATURE: RELATIONSHIPS BETWEEN HOW PEOPLE THINK ABOUT, CONNECT WITH, AND ACT TO PROTECT NATURE.

Melissa Anne Hatty ^{a*}, Denise Goodwin ^a, Liam David Graham Smith ^a, Felix Tinoziva Mavondo ^b

^a BehaviorWorks Australia, Monash Sustainable Development Institute, Monash University, Clayton, Victoria, Australia 3800

^b Department of Marketing, Faculty of Business and Economics, Monash University, Clayton, Victoria, Australia 3800

* Corresponding author

Email: melissahatty@gmail.com (M. A. Hatty)

Address: BehaviorWorks Australia, Monash Sustainable Development Institute, Monash University, 8 Scenic Boulevard, Clayton, Victoria, Australia 3800

Acknowledgements

Thank you to Kim Lowe, Fern Hames, and the DELWP Victorians Value Nature team for their input into this research.

Funding

This research was commissioned and funded by the Victorian Government Department of Environment, Land, Water and Planning (DELWP). This research was also funded by an Australian Government Research Training Program (RTP) Scholarship.

Author contributions (CRediT)

Melissa Hatty: Conceptualization, methodology, validation, formal analysis, writing - original draft, writing - review & editing, visualization; Denise Goodwin: conceptualization, formal analysis, writing - review & editing, supervision; Liam Smith: conceptualization, methodology, writing - review & editing, supervision; Felix Mavondo: conceptualization, methodology, formal analysis, writing - review & editing, supervision.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Data availability statement

The data/code for this research are available at Open Science Framework (https://osf.io/zugd/?view_only=e3e109fa17934042bea3d5f183442474). Ethical approval for this research was granted by the Monash University Human Research Ethics Committee (Project ID: 14010).

ABSTRACT

Human relationships with nature are increasingly being recognized as an important factor in environmental conservation. Understanding how people perceive and know nature, and the language they use to describe nature - their concepts of nature - could have important implications for conservation policy and management. This empirical research sought to examine and categorize concepts of nature, and explore how such thoughts relate to connection with nature and conservation behaviors. Multidimensional scaling revealed three concepts of nature categories: descriptive (e.g. plants, animals, landscapes), normative (e.g. conservation, balance, life), and experiential (e.g. activities in nature, positive emotions, aesthetic qualities), plus a complex category (two or more of the descriptive, normative, or experiential categories). Connection with nature scores (total and dimensions) were higher among participants who described nature in experiential or complex terms than those who described nature in descriptive terms. Participants who described nature in experiential terms were more likely to have participated in environmental volunteering, citizen science, picking up litter, and community gardening in the past year than those who used descriptive terms. Concepts of nature moderated the relationship between connection with nature and picking up litter. These results may usefully inform conservation policies and campaigns intended to increase connection with nature and participation in conservation behaviors, through the use of language emphasizing experiential and more complex concepts of nature, by encouraging personal reflection on one's experiences of nature, and through the design of natural spaces that encourage active engagement with nature.

Introduction

Academic interest in human relationships with nature has grown exponentially in recent years (Restall and Conrad 2015, Ives et al. 2017). Researchers have explored human thoughts, emotions, and behaviors in relation to the natural environment through constructs such as environmental identity (Clayton, 2003), human-nature connectedness (Ives et al. 2017, 2018), connectedness to nature (Mayer and Frantz 2004), and nature relatedness (Nisbet et al. 2009; for reviews, see also Tam 2013, Zylstra et al. 2014, Restall and Conrad 2015). Following Ives et al. (2017), we seek to capture the range of terminology and ideas presented in the literature, adopting the term connection with nature (CN) "because it evokes the subtle yet important idea that (1) humans are already an intimate part of nature and (2) that the state imbues a sense of reciprocity and mutualism" (Zylstra et al., 2014 pp. 121-122). We consider CN as a multidimensional construct encompassing identity, experiential, and philosophical perspectives of one's relationship with the natural world (Hatty et al., 2020).

Of particular interest in the CN literature - and increasingly in government policy (e.g. Biodivcanada 2015, Department of Environment, Land, Water and Planning 2017, Department of Conservation 2020) - is the relationship between CN and conservation outcomes. Recent evidence suggests that people higher in CN are more likely to engage in behaviors of general benefit to the natural environment (pro-environmental behaviors: PEB) and in behaviors of specific benefit to biodiversity (pro-biodiversity behaviors: PBB) (Mackay and Schmitt 2019, Whitburn et al. 2019a, Martin et al. 2020, Richardson et al. 2020b). Therefore, (re)connecting people with nature and the enhancement of CN is seen as a potentially useful means of addressing a range of conservation goals (Zylstra et al. 2014, Restall and Conrad 2015, Ives et al. 2018).

Yet, despite the recognized utility of CN in environmental conservation, the CN literature often does not explicitly define nature, and there is limited exploration of how people understand the word "nature" or what aspects of nature people feel connected to (Ives et al. 2017, Pasca et al. 2020). The term "nature" in English (and comparable terms in other European languages) refers to a complex, abstract construct with multiple meanings, making it difficult to define (Clayton and Opatow, 2003; Ducarme and Couvet, 2020). Indeed, some Indigenous language groups "do not have words equivalent or even approximate to our [Western] idea of nature" (Zent 2015:10), further highlighting the complexity of human understandings of "nature". How people think about, understand, and describe nature may, however, influence how they relate to it, including attitudes and behaviors toward its protection (Mausner 1996, Buijs et al. 2008, Andrews 2018, Coscieme et al. 2020). Further, peoples' experience of nature has been shown to shape their perceptions of it (Adams and Savahl 2015, Collado et al. 2016), and such differences are reflected in the language used to describe nature (Coscieme et al. 2020). Thus, understanding how people perceive and know nature and the language used to describe nature - herein, concepts of nature - may be useful for informing conservation policy and management decisions. This research seeks to address these issues, by exploring how concepts of nature may relate to CN and to PBB.

Previous concepts of nature research

Researchers have sought to understand concepts of nature using a variety of methodologies. Some have used interview or survey questions to explore terms that come to mind when thinking about nature (Taylor 2018); what the terms "nature" (Aaron and Witt 2011, Pointon 2014) or "biodiversity" (Levé et al. 2019) mean; how "nature" would be explained to another (Pérez-López et al. 2020); or translations of the term "nature" into different languages (Coscieme et al. 2020). Others have considered ratings of perceived naturalness (e.g. of the arctic, of a soccer field) (van den Born et al. 2001), or explored thoughts, emotions, or meanings associated with recent nature experiences (Mena-García et al. 2020) and significant places (Schroeder 1991, 2002, 2007). Word association (Buijs and Elands 2013, Taylor 2019) and picture sorting tasks (Mausner 1996) have been used with adults, while drawings of nature and/or activities in nature are commonly used with children (Aaron and Witt 2011, Collado et al. 2016, Bolzan-de-Campos et al. 2018, Fraijo-Sing et al. 2020). These different approaches have identified a range of concepts of nature themes (Table 1).

Table 1: Concepts of nature themes identified in previous research.

Themes and example terms	Authors
<i>What nature is</i>	
Elements within nature (flora, water, earth, animals, forest, beach, humans)	Bolzan-de-Campos et al. 2018, Buijs and Elands 2013, Keulartz et al. 2004, Mausner 1996, Taylor 2019, van den Born et al. 2001
Attributes of nature (green, blue)	
Processes (seasonal changes, earthquakes)	
Types of nature (wilderness, domestic, agricultural)	
<i>Relationships within nature</i>	
Ecosystems, biodiversity	Collado et al. 2016, Keulartz et al. 2004, Pointon 2014, Taylor 2019
Landscapes	
Growing, living	
Human interactions with natural systems	
<i>Experiences in nature, emotional experiences related to nature</i>	
Relaxation, freedom, wellbeing	Bolzan-de-Campos et al. 2018, Buijs and Elands 2013, Collado et al. 2016, Keulartz et al. 2004, Mausner 1996, Pointon 2014, Taylor 2019
Solitude, few people	
Aesthetic appreciation of nature (beauty, powerful)	
Positive emotions (wonder, enjoyment)	
Negative emotions (sadness)	
Actions and activities (explore, harvest)	
<i>Human relationships with nature, values of nature</i>	
Functional, utilitarian, intrinsic value	Bolzan-de-Campos et al. 2018, Collado et al. 2016, Keulartz et al. 2004, Mausner 1996, Pointon 2014, Taylor 2019, van den Born et al. 2001
People as separate from nature (natural environments are untouched by humans, inaccessible)	
Type of relationship (dominance, stewardship, participation)	
Anthropocentrism, ecocentrism	
Dependence on nature (water, food)	
Concern for nature, conservation	

Themes and example terms	Authors
<i>How nature should be managed</i>	
Moral status of nature, informing management actions	Buijs and Elands 2013,
In need of protection	Keulartz et al. 2004, Pointon
Delicate, fragile, important	2014, Taylor 2019
Unspoiled, free from human interference	
<i>Human productions and impacts on nature, non-natural elements</i>	
Pollution, noise	Bolzan-de-Campos et al.
Human-built structures (cities, cars)	2018, Collado et al. 2016,
Human productions (parks)	Mausner 1996
Industries, smoke	

While some researchers have considered large numbers of themes without sorting them into categories (e.g. Taylor 2018, Mena-García et al. 2020), a more common approach is to manually sort concepts of nature themes into categories (e.g. Pointon 2014, Collado et al. 2016, Bolzan-de-Campos et al. 2018, Taylor 2019; although see Buijs and Elands, 2013 for a statistical approach). As a result, there is little agreement in the literature as to how these themes may be categorised. Given that experiences of nature shape perceptions of it, it is likely that researchers' own experiences shape their categorization processes, thus this lack of agreement is perhaps unsurprising.

An experience of nature has been described as a process involving interaction with nature, within a specific context, that has the potential to change knowledge, skills, or behavior (Clayton et al. 2019). For Clayton and colleagues (2019), individual factors (e.g. prior encounters with, or beliefs about, nature) can act as both precursors to, and outcomes of, the experience of nature. From this perspective, a person's concepts of nature may also be a precursor to, and/or an outcome of, their experiences of nature.

A number of studies have demonstrated links between experiences of nature (e.g. through professional or recreational activities) and concepts of nature. Research in The Netherlands suggested that conservation professionals were more likely to describe nature in normative terms while lay people were more likely to use descriptive terms, a difference the authors attributed to the professionals' education and working environment (Buijs and Elands 2013). Similarly, research in Scotland suggested that adults engaged in nature-based recreational pursuits (e.g. mountaineers, bird watchers) tended to view biodiversity in normative terms, while tourists tended to view biodiversity in experiential or aesthetic terms (Fischer and Young 2007). Research with children suggests that those with more direct experience of nature tend to describe nature relative to specific or daily experiences, conservation, and positive emotions while those with less direct experience of nature tend to use non-specific terms such as outside, not made by humans, and fear or discomfort (Aaron and Witt 2011, Collado et al. 2016). While there is a lack of empirical evidence linking PBB with concepts of nature, research has shown that participating in citizen science and other environmental volunteering activities are associated with greater knowledge and awareness of the natural environment, and more positive attitudes and behaviors toward conservation (Measham and Barnett 2008, Cosquer et al. 2012, Merenlender et al. 2016, Chase and Levine 2017). These

findings suggest that direct experiences of nature through PBB such as environmental volunteering may influence - or be influenced by - concepts of nature.

One area that has received little attention in the academic literature is the relationship between concepts of nature and connection with nature (CN). Some researchers have explored both concepts of nature and CN within a single study, although they have not reported potential relationships between the constructs (e.g. Olivos-Jara et al. 2013, Taylor 2018, Pérez-López et al. 2020). A notable exception is the work of Mena-García et al. (2020) who explored thoughts about nature and CN scores following experiences of nature. Participants either walked in nature or viewed images of nature then described the natural elements observed and experiences (e.g. emotions, memories, sensations) evoked. Results suggested that for those on nature walks, CN scores were higher among those who described specific sensory experiences (e.g. sounds, smells), feelings of wellbeing (e.g. reduced stress, freedom), and spiritual/personal reflections than those who did not. These findings suggest a relationship between perceptions of nature and CN, whereby active awareness of one's physiological and/or psychological response to nature (sensory experiences, wellbeing, personal reflections) results in greater CN. Alternatively, people higher in CN may be more conscious of aesthetic elements and sensory experiences of nature, and may be more likely to personally reflect as a result of experiences in nature; that is, people higher in CN may be more mindful in, and of, nature (Schutte and Malouff 2018).

While there is a growing body of literature linking CN and PEB/PBB, understanding of the potential mechanisms underlying the CN-PEB/PBB relationship is limited (Mackay and Schmitt 2019). Recent evidence suggests that noticing nature (Hamlin and Richardson 2021) and biospheric values (Martin and Czellar 2017) may mediate the CN-PEB relationship, although studies investigating the potential moderating role of concepts of nature are lacking (Mackay and Schmitt 2019). Given different concepts of nature appear related to different experiences of nature (including experiences of nature through PBB), and potentially also CN, we anticipate that concepts of nature may also moderate the relationship between CN and PBB.

The current research

This research seeks to address gaps in the literature by evaluating concepts of nature, and investigating whether concepts of nature relate to CN and to nature-based PBB. In contrast to previous manual categorization approaches, and to reduce the influence of researcher bias, we adopted a data-driven, statistical methodology (multidimensional scaling) to categorize concepts of nature themes. Due to the lack of prior research investigating relationships between concepts of nature, CN, and nature-based PBB, we used an exploratory approach with four broad aims:

1. To evaluate and categorize concepts of nature;
2. To investigate whether CN scores differ according to peoples' concepts of nature;
3. To examine whether participation in nature-based PBB is related to concepts of nature;
4. To investigate whether concepts of nature moderated the relationships between CN and nature-based PBB.

Method

Participants and procedure

Data were collected during September and October 2018 as part of a study exploring the attitudes toward, and use of, the natural environment in the state of Victoria, Australia (Meis-Harris et al. 2019). The final sample ($N = 3090$) was representative of the Victorian population with respect to gender, age, and geographical location (female: 50.194%, $n = 1551$; age range: 18 to 89 years ($m = 46.973$, $SD = 16.313$); residents of metropolitan Melbourne: 83.630%, $n = 2580$). The majority of participants spoke only English at home (87.346%, $n = 2699$), most had completed tertiary education (76.537%, $n = 2365$), almost half were working full-time (45.761%, $n = 1414$), while 2.492% ($n = 77$) worked in the environment sector. Participants were recruited via an online panel survey company in exchange for a small financial reward.

Participants provided their age, gender, and postcode, then answered the open-text question, "What comes to mind when you think of 'nature'? Please describe in your own words" (response length unlimited). On the following page, after providing an initial answer, participants were advised, "In this survey, we would like you to think about nature as everything that is not made by humans. This includes all the *animals*, *plants*, and *vegetation* in *land* and *water* habitats, located in *urban* and *rural* areas, and including *highly modified landscapes* through to *pristine wilderness* areas on land and in the water" (Meis-Harris et al 2019 p. 82 [emphasis in original]).

Participants then answered a series of quantitative questions capturing CN (e.g. "I feel a strong emotional connection to nature"; "I enjoy spending time in nature"; "Feeling connected to nature helps me deal with everyday stress"; 1 = strongly disagree, 7 = strongly agree), and frequency of engaging in 11 PEB/PBB in the past year (e.g. "Donated money to organisations that take care of the environment"; "Collected information on the natural environment for scientific projects or databases (citizen science)"; 1 = never, 5 = always) (Appendix 1). Four of the 11 behaviors typically involving direct experiences of nature (participated in environmental volunteering; citizen science; picking up litter; community gardening) were selected to assess nature-based PBB.

Data preparation

Responses to the question "what comes to mind when you think about nature?" varied in length from single words to multiple sentences. Responses were coded using the thematic analysis process recommended by Braun and Clarke (2006). To ensure codes were data-driven, the first author used a sematic inductive approach to extract content themes and code all responses during the latter half of 2019, prior to engagement with the concepts of nature literature. As the goal was to capture general themes about concepts of nature (Collado et al. 2016), codes were developed to capture terms (single words or simple phrases) describing thematically similar propositions containing a minimum number of words that made sense (e.g. "fauna", "animals", and "wild animals" were coded as "fauna"). Multiple word responses could be assigned one or more codes (e.g. "Relaxation, clean, pure and peaceful" was assigned two codes: "tranquil" and "natural"; see also Table 2 and Appendix 2). A total of 61 themes were initially identified (Appendix 2).

After six months, the same author recoded responses to enable calculation of intra-rater reliability (Crocetti, 2016). The same 61 themes were identified. Conflicts were minimal thus the second round of coded responses were used in subsequent analyses. Themes were then revised and consolidated (e.g. "birds", "fish", and "insects" were merged with "fauna"), resulting in 34 themes (Table 2). To determine inter-rater reliability, the second author coded a random sample (10%, $n = 306$) of the data, using the 34 content themes developed by the first author, in late 2020. Conflicts were discussed and agreement reached. Intra- and inter-rater reliability were calculated using the method described by Landis and Koch (1977). Across the 34 themes, the mean intra-rater and inter-rater kappa coefficients were $\kappa = 0.928$ (range: 0.729 to 1.000) and $\kappa = 0.956$ (range: 0.594 to 1.000), respectively.

CN was calculated by averaging the 12 items of the CN-12, with scores for the three CN dimensions calculated by averaging the items comprising each dimension (Hatty et al. 2020). Cronbach's alpha for the CN-12 and three dimensions were calculated (CN-Total, $\alpha = 0.931$; CN-Identity, $\alpha = 0.871$; CN-Experience, $\alpha = 0.896$; and CN-Philosophy, $\alpha = 0.758$).

Table 2: Concepts of nature themes, example terms, and participants mentioning terms within each theme (N = 3090).

Concepts of nature theme	Examples	Participants mentioning each theme	
		n [†]	% [‡]
flora	plants, trees, grass, flowers, vegetation, leaves	1431	46
fauna	animals, wildlife, wild animals, birds, fish, insects, reptiles, creatures	1098	36
natural	untouched, unspoiled, uninhabited, pure, pristine, not made/influenced by humans	615	20
forest	bushland, woods, rainforest	528	17
waterways	rivers, lakes, waterfalls, ocean, beach, mangroves	524	17
outdoors	outside, the great outdoors	497	16
environment	environment, surroundings	451	15
earth	planet, dirt, sand, rocks, atmosphere, clouds, seasons, weather, stars, sky	350	11
terrestrial	land, mountains, fields, valleys, landscape, desert	350	11
green	green, greenery, green space	310	10
park	national parks, urban parks, gardens, marine parks	242	8
air	fresh air, oxygen, clean air	210	7
rural	open space, out of the city, non-urban, the country	218	7
tranquil	peacefulness, relaxed, quiet, comfort, calm	188	6
beauty	beauty, elegance	142	5
water	clean water, running water	163	5
activities	hiking, camping, gardening, adventure, visit	132	4
life	life, living things, growing	132	4
protect	in need of protection, sustainability, essential, precious	96	3
balance	balance, interconnectivity, ecosystem, biodiversity	71	2
wilderness	wilderness, wild	67	2
aesthetic	color, smells, sounds, views	63	2
positive emotions	awe, wonder, enjoyment, appreciation	61	2

Concepts of nature theme	Examples	Participants mentioning each theme	
		n [†]	% [‡]
vast	uncontrollable, huge, expansive, lethal, rugged	55	1.8 [§]
native	native, local, endemic, indigenous	51	1.7 [§]
human	humans, personality, science, history	50	1.6 [§]
everything	nature, total, whole	47	1.5 [§]
free	free, freedom	38	1.2 [§]
health	healthy, flourishing, lush, fertile	38	1.2 [§]
habitat	habitat	37	1.2 [§]
resources	food, minerals, energy	27	0.9 [§]
local	Tasmania, Africa, my backyard	25	0.8 [§]
solitude	few people, isolation	12	0.4 [§]
negative emotions	boredom, dread, distress	7	0.2 [§]

[†]Total mentions $n=7939$

[‡]Some participants mentioned terms from more than one theme, thus the sum exceeds 100%

[§]Excluded due to being mentioned by fewer than 2% of participants

Data analyses

All analyses were conducted using SPSS 26 (IBM Corp. 2019). Following Buijs and Elands (2013), we used multidimensional scaling (MDS) to explore the arrangement of concepts of nature themes into categories. MDS is used to determine the relative position of objects (i.e. concepts of nature) in multidimensional space, such that the closer objects appear on the perceptual map, the more similar they are deemed to be (Hair et al. 2014). As some themes were mentioned by a small number of participants, and to simplify interpretation of the perceptual map, we excluded themes that were mentioned by fewer than 2% ($n = 61$) of participants (11 themes were excluded). Across the remaining 23 themes, there were 7939 concepts of nature analyzed (Table 2).

To enable validation of results, we randomly split the sample in two and ran MDS analyses on both subsamples. We compared results across both subsamples and selected the analyses where the perceptual maps most closely resembled each other and had acceptable Stress and Index of Fit measures (Hair et al. 2014). We then re-ran the final MDS analysis on the total sample. The final analysis used the ALSCAL procedure with the Euclidian Distance and Binary Lance-and-Williams Nonmetric Measure.

To explore differences in CN and PBB across concepts of nature categories, we conducted one-way analyses of variance (ANOVA) with Games-Howell post-hoc test and Kruskal-Wallis test with p-value adjusted pairwise comparisons, respectively (Field, 2013). To explore concepts of nature as a potential moderator between CN and PBB, we performed a series of simple moderation analyses using the PROCESS v3.5 macro (Hayes, 2018).

Results

Multidimensional scaling

MDS analyses revealed that participants' thoughts about nature could be grouped into three broad categories. The first category represented descriptive terms such as flora and fauna, forests, landscapes, and waterways. The second category represented normative terms, including ideas related to conservation, ecosystems in balance, biodiversity, and living things. The third category represented experiences in or of nature, such as hiking, positive emotions, beauty, tranquility, and aesthetic qualities such as sights or sounds. As these categories were generally consistent with those reported by Buijs and Elands (2013), we labelled them "descriptive", "normative", and "experiential" (Figure 1).

The majority of participants ($n = 2260$, 73.139%) mentioned terms from the descriptive category only, while a considerably smaller proportion mentioned terms from only the normative ($n = 55$, 1.780%) or experiential ($n = 110$, 3.560%) categories. A total of 587 participants (18.997%) mentioned terms from two or more categories (herein "complex"), and of these, only 13 (2.215%) did not mention terms from the descriptive category. Seventy-eight participants (2.524%) mentioned terms from none of the categories (Table 2, lower rows). We used the sample of participants who mentioned one (or more) of the three concepts of nature categories ($n = 3012$) to compare differences in CN and PBB across concepts of nature categories.

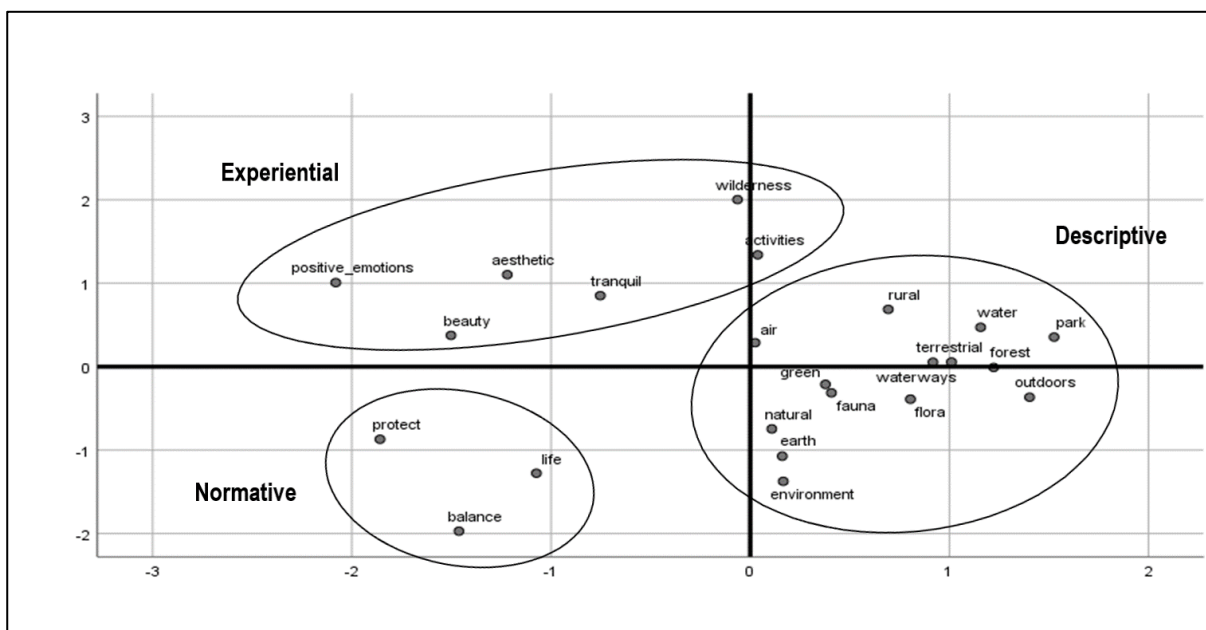


Figure 1: Multidimensional scaling of concepts of nature themes (Stress = 0.22, RSQ = 0.75). The three categories (descriptive, normative, and experiential) are circled.

Connection with nature (CN) scores across concepts of nature categories

CN data (total and dimension scores) were screened for assumptions, and outliers (z scores ± 3.29) removed (final $n = 2975$). Within each concepts of nature category, some CN variables were skewed (Appendix 3, Table A3.1) although it was expected that the large sample size would reduce

the impact of non-normality on analyses (Field 2013). Levene statistics suggested heterogeneous variances for all CN scores (Appendix 3, Table A3.2), thus Welch's F are reported (Field 2013). ANOVA results suggested that participants who described nature in purely experiential or in more complex terms had higher CN scores (total and dimensions) than participants who described nature in purely descriptive terms. Further, participants who described nature in purely normative terms scored higher on the CN-Identity dimension than participants who described nature in purely descriptive terms (Table 3, Figure 2, and Appendix 4).

Table 3: One-way analyses of variance comparing connection with nature (CN: total and dimension scores) across the four concepts of nature categories ($n = 2975^{\dagger}$).

	<i>df</i>	Welch's <i>F</i>	η^2
CN-Total	3, 183.32	29.32***	0.025
CN-Identity	3, 184.77	28.23***	0.024
CN-Experience	3, 183.91	23.43***	0.021
CN-Philosophy	3, 181.39	18.44***	0.016

[†] $n = 42$ outliers removed; $n = 78$ mentioned none of the concepts of nature categories;

*** $p < 0.001$

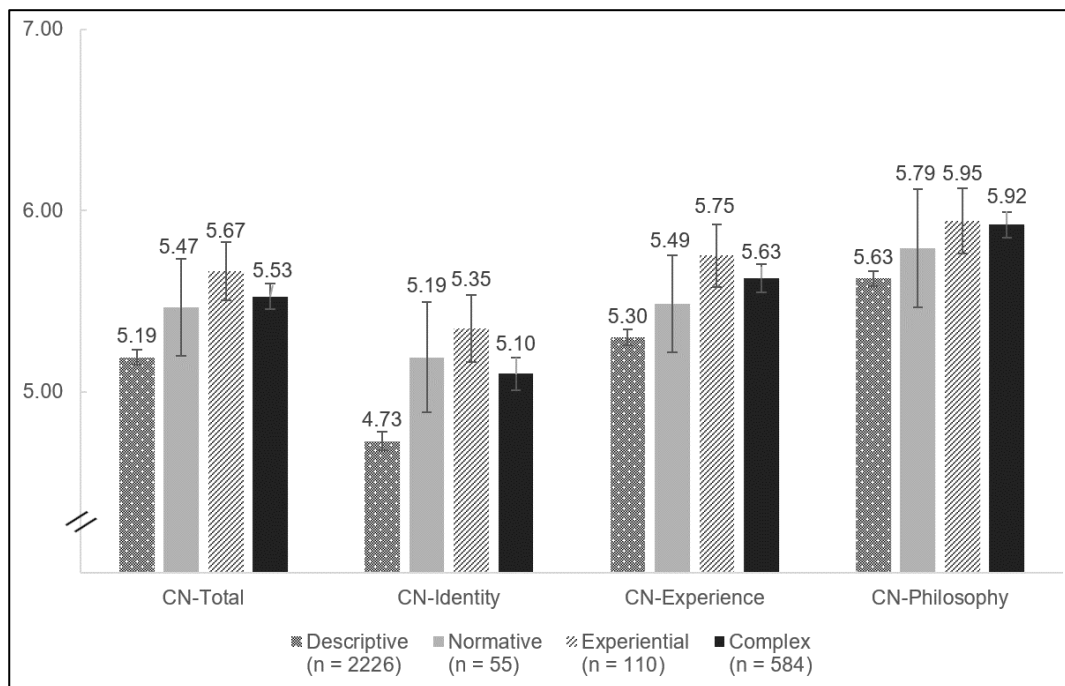


Figure 2: Mean connection with nature scores (total and dimensions) for each of the four concepts of nature categories. Error bars show 95% confidence interval of the mean.

Pro-biodiversity behavior (PBB) participation across concepts of nature categories

Data for the four PBBs violated the assumption of normality (Appendix 3, Table A3.3). Kruskal-Wallis tests indicated significant differences in frequency of participation in the four PBB across concepts of nature categories (Table 4). Pairwise comparisons with adjusted p-values revealed that

participants who described nature in experiential terms participated in the four PBB more often than those who used descriptive terms (environmental volunteering: $X^2 = -402.636$, $SE = 77.823$, $p < 0.001$, $adj. p < 0.001$, $r = -0.106$; citizen science: $X^2 = -332.532$, $SE = 71.713$, $p < 0.001$, $adj. p < 0.001$, $r = -0.095$; picking up litter: $X^2 = -295.712$, $SE = 82.106$, $p < 0.001$, $adj. p = 0.002$, $r = -0.074$; community gardening: $X^2 = -372.455$, $SE = 71.859$, $p < 0.001$, $adj. p < 0.001$, $r = -0.106$). Further, participants who described nature in experiential terms participated in environmental volunteering, citizen science, and community gardening more often than those who described nature in complex terms (environmental volunteering: $X^2 = 353.706$, $SE = 82.811$, $p < 0.001$, $adj. p < 0.001$, $r = 0.162$; citizen science: $X^2 = 283.072$, $SE = 76.309$, $p < 0.001$, $adj. p = 0.001$, $r = 0.141$; community gardening: $X^2 = 355.064$, $SE = 76.464$, $p < 0.001$, $adj. p < 0.001$, $r = 0.176$). All effect sizes (r) may be considered small (Cohen, 1977).

Table 4: Kruskal-Wallis tests (H) assessing differences in frequency of participation in four nature-based pro-biodiversity behaviors (PBB) across concepts of nature categories ($n = 3012$).

	Kruskal-Wallis test	Concepts of nature category	Mean rank
Environmental volunteering	$H(3) = 27.973$, $p < 0.001$	Descriptive	1480.368
		Normative	1583.936
		Experiential	1883.005
		Complex	1529.299
Citizen science	$H(3) = 26.042$, $p < 0.001$	Descriptive	1480.882
		Normative	1690.891
		Experiential	1813.414
		Complex	1530.342
Picking up litter	$H(3) = 20.293$, $p < 0.001$	Descriptive	1472.856
		Normative	1692.873
		Experiential	1768.568
		Complex	1569.458
Community gardening	$H(3) = 30.224$, $p < 0.001$	Descriptive	1485.840
		Normative	1686.709
		Experiential	1858.295
		Complex	1503.232

Concepts of nature as moderator between CN and PBB

As the experiential concepts of nature category appeared to have different relationships with CN and PBB than most other concepts of nature categories, we used the experiential category as the reference group for indicator coding of the concepts of nature variable (Hayes, 2018). CN variables were mean-centered, and entered as the antecedent (X) with each of the four PBB as the consequent (Y). In the interests of brevity, only CN-Total scores and moderation effects are reported.

Results suggested the relationship between CN and frequency of picking up litter was moderated by concepts of nature. Among those who described nature in experiential terms, the conditional effect of CN on picking up litter was not significant ($t = 0.471$, $p = 0.638$, 95% confidence interval (CI) [-0.184, 0.300]). In contrast, among those who described nature in descriptive, normative, or complex terms, the conditional effect of CN on picking up litter was positive and significant (descriptive: $t = 17.343$, $p < 0.001$, 95% CI [0.339, 0.426]; normative: $t = 2.038$, $p = 0.042$, 95% CI [0.012, 0.603]; complex: $t = 9.321$, $p < 0.001$, 95% CI [0.373, 0.572]; Figure 3). Moderation effects for environmental volunteering, citizen science, and community gardening were not significant (Appendix 5).

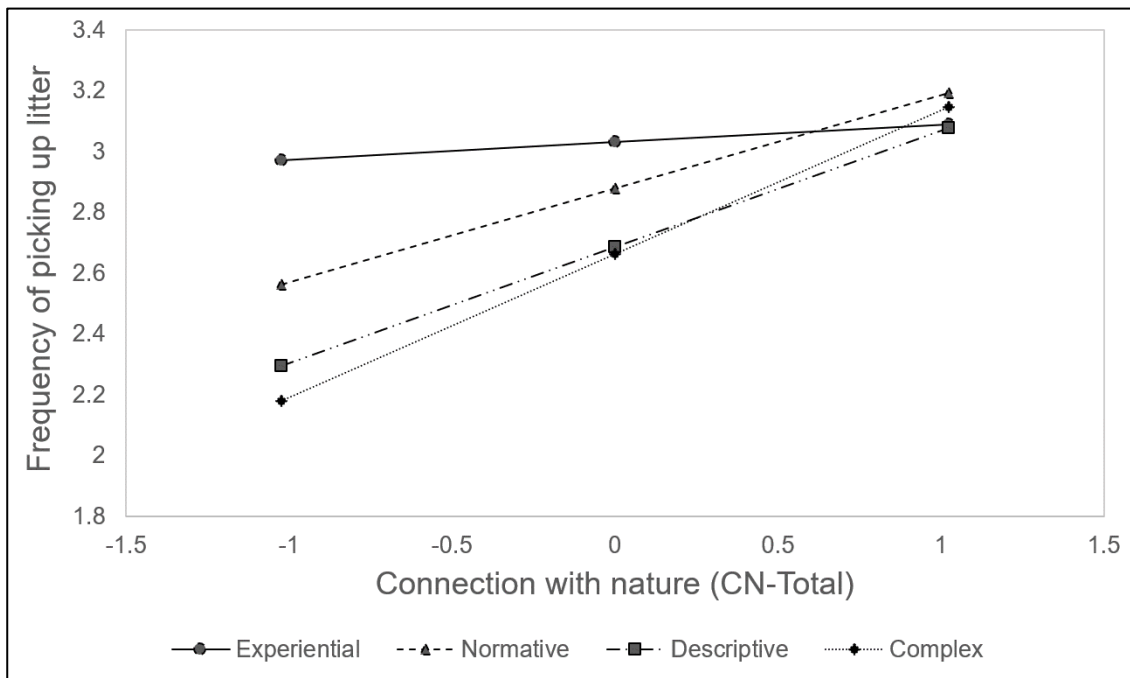


Figure 3: Visual representation of the moderation effect of connection with nature (X) on frequency of participating in litter clean-ups (Y) as a function of concepts of nature.

Discussion

This research sought to investigate and statistically categorize concepts of nature, to consider differences in CN scores and participation in nature-based PBB across concepts of nature categories, and to investigate concepts of nature as a potential moderator of the CN-PBB relationship. MDS results revealed three broad categories of concepts of nature: descriptive, normative, and experiential. The descriptive category (e.g. flora, waterways, outdoors) broadly represents elements within nature. The normative category (e.g. protection, balance, life) represents ideas of nature as precious and needing protection, of living things, and of systems in balance. The experiential category (e.g. activities in nature, beauty, tranquility) represents different ways of encountering and appreciating nature, including via activities such as camping, emotions such as wonder, or enjoyment of beauty, peacefulness, or sounds within nature. The complex category (e.g. descriptive + normative, descriptive + normative + experiential) captures a richer perception of nature that includes not only elements within nature (descriptive) but also reflection on emotional experiences of nature (experiential), aesthetic appreciation of nature (experiential), beliefs about the fragility and importance of nature (normative), and/or awareness of natural cycles and systems (normative).

The vast majority of respondents described nature in descriptive terms, with comparatively fewer respondents using terms categorized into the normative, experiential, or complex categories. These results, broadly consistent with previous literature (Mausner 1996, van den Born et al. 2001, Keulartz et al. 2004, Buijs and Elands 2013, Taylor 2019), suggest that most people in this sample think about nature relative to elements within nature, as well as attributes (e.g. green), processes (e.g. seasons), and types of nature (e.g. parks).

In contrast to previous findings (Mausner 1996, Buijs and Elands 2013), the present results indicated that the "natural" theme - encompassing ideas of nature as untouched, uninhabited, or pristine - appeared closer to the descriptive category than to the normative category. This suggests that for these participants, descriptive features of nature may be more commonly thought of in their pure or original form and devoid of human influence. It has been argued that conceptualizations of nature as external to and not including humans - common in industrialized societies - may be contributing to disconnection from nature and ongoing environmental destruction (Clayton and Opatow 2003, Vining et al. 2008, Zylstra et al. 2014, Andrews 2018). Thus, the current results suggest that strategies to reduce perceptions of humans as separate from nature may be useful for increasing CN and addressing sustainability outcomes, such as increasing PBB.

Comparison of CN scores across concepts of nature categories suggested that CN scores (total and dimensions) tended to be higher among participants who described nature in experiential or more complex terms, than those who described nature in descriptive terms. These findings are consistent with Mena-García et al. (2020) who reported higher CN scores among people who described aesthetic appreciation of nature, sensory experiences, and feelings of wellbeing. As a multidimensional construct, CN encompasses identity, experiential, and philosophical relative to one's relationship with the natural world that includes thoughts, emotions, and behaviors (Hatty et al., 2020). The descriptive concepts of nature category represents a predominantly cognitive perspective of nature, thus people who consider nature in purely descriptive terms may also perceive their relationship with nature from a more superficial perspective (e.g. primarily thoughts). Those who describe nature in richer terms (experiential or complex concepts of nature), in contrast, may see their relationship with nature from a more multifaceted or meaningful (e.g. philosophical) perspective.

In addition, scores on the CN-Identity dimension were higher among those who described nature in normative terms than those who described nature in descriptive terms. CN-Identity encompasses "self-perception as someone who feels emotionally connected to nature and who behaves in such a way as to protect nature" (Hatty et al. 2020 p. 10). Thus, people who perceive themselves as having a stronger emotional connection to nature and to engage in behaviors that protect nature (higher CN-Identity) are perhaps more likely to think about nature as living systems in balance that need protection – ideas that are represented by the normative concept of nature category. Together, these findings suggest a relationship between how people think about nature and their connection to it (Andrews 2018, Coscieme et al. 2020).

Recently, Richardson and colleagues (Lumber et al. 2017, Richardson et al. 2020a) proposed that CN may be enhanced through five pathways - sensory contact, emotion, beauty, meaning, and compassion. The first three pathways involve active engagement with nature - through the senses, through emotions such as awe and wonder, and through appreciation of nature's beauty - ideas that

broadly overlap with the experiential concepts of nature category described above. Further, the latter two pathways, encompassing reflection on the meaning of nature and actions that protect or enhance nature, are represented in the experiential and complex concepts of nature categories. Thus, the present findings support the pathways model (Lumber et al. 2017, Richardson et al. 2020a) and suggest that interventions intended to enhance CN may benefit from portraying nature in experiential and more complex terms.

Results also revealed associations between participation in nature-based PBB and concepts of nature category. Participants who described nature in experiential terms were more likely to have participated in the four nature-based PBB than those who used descriptive terms. Further, participants who described nature in experiential terms participated in environmental volunteering, citizen science, and community gardening more often than those who described nature in complex terms. While the cross-sectional design prevents inference of causality, it is possible that experiencing nature through PBB triggers reflection of nature relative to experiential characteristics including positive emotional experience, aesthetic appreciation, or beauty. Equally, people who consider nature in such terms may be more likely to want to spend time in it, perhaps through nature-based PBB. Indeed, citizen science (Cosquer et al. 2012), gardening (Diduck et al. 2019), and PBB generally (Alcock et al. 2020) have been associated with greater appreciation of nature, while positive emotions (enjoyment of the activity, love of nature), being outside, and relaxation have been identified as important motivations for participating in environmental volunteering and community gardening (Asah et al. 2014, Kingsley et al. 2019, Ganzevoort and van den Born 2020, Maund et al. 2020).

Results of moderation analyses suggested that the relationship between CN and picking up litter differed across concepts of nature categories. Among those who described nature in experiential terms, increase in CN did not lead to greater frequency of picking up litter. In contrast, for those who described nature in descriptive or more complex terms, increase in CN score was positively associated with increased frequency of picking up litter. Thus, for those who consider nature in terms of activities in nature, peacefulness, or positive emotions (experiential concepts of nature), picking up litter may be a behavior they are likely to do – or perhaps have more opportunity to do – independent of the level of CN. Yet, for those who consider nature in descriptive or more complex terms, enhancing one's relationship with nature (CN) may subsequently increase the likelihood or frequency of the behavior.

Contrary to expectations, concepts of nature did not moderate the relationships between CN and environmental volunteering, citizen science, or community gardening (Appendix 5). In contrast to environmental volunteering, citizen science, or community gardening, picking up litter is a relatively quick and simple behavior that provides immediate feedback and has been associated with personal and social norms (The Behavioural Insights Team 2014, Gould et al. 2016) – it may therefore be a behavior that is generally more likely to occur. Further, while previous research has demonstrated associations between CN and environmental volunteering (Guiney and Oberhauser 2010), citizen science (Chase and Levine 2017), and gardening practices (Hamlin and Richardson 2021), the current findings suggest that the pathways linking these constructs are likely more intricate than a simple moderation via concepts of nature. Exploring other potential moderators and/or mediators of the CN-PBB relationship(s) could be a useful avenue for future research.

Implications for conservation policy

Understanding how people experience, know, and describe nature provides a platform for policymakers to engage the public in, and enable more effective communication about, conservation issues (Buijs et al. 2008, Buijs 2009). This research demonstrates an association between how people think about nature and how they relate to it, including their connection with nature and behaviors toward its protection (Mausner 1996, Buijs et al. 2008). Thus, a change in language used to describe nature could play a role in shifting attitudes and beliefs about conservation (Ives et al. 2019). Policies and campaigns using language that emphasizes experiential and more complex concepts of nature, including activities in nature, positive emotional experiences, and the beauty and tranquility of nature, could help to shift beliefs about one's relationship with nature (CN) and encourage more experiences of nature, including through nature-based PBB.

Policies and programs that encourage personal reflection on one's experiences of nature could be useful for not only attracting people to spend more time in nature but also positively influence their connection to it. Recent research indicates that the quality of nature experiences - that is, what people do while they're in nature - is a more important predictor of CN and PBB than merely spending time in nature (Colléony et al. 2020a, Richardson et al. 2020b). Interventions that encourage people to actively engage with nature, via simple activities such as smelling flowers (Richardson et al. 2016, 2020b, Richardson and McEwan 2018) or noticing good things in nature (Richardson and Sheffield 2017) have demonstrated potential in this regard. Prompts (Colléony et al. 2020b) and smartphone apps (McEwan et al. 2019, Cameron et al. 2020) can also encourage more active engagement with nature.

Another important policy consideration relates to how natural spaces are designed. Policies should promote the design and development of spaces that encourage cognitive, emotional, and psychomotor interaction with nature, through activities such as tree planting, urban agriculture, or other collective actions (Amel et al. 2017, Lin et al. 2018, Whitburn et al. 2019b, Colding et al. 2020). Interactive and multisensory immersion exhibits, common in zoos and aquaria, can also encourage reflection about nature relative to experiential concepts of nature, as well as increase CN and PEB intentions (Pennisi et al. 2017, Pan et al. 2020). Thus, well-designed natural spaces could encourage people to reflect on their experiences of nature, including emotional responses to nature, and to incorporate these experiences to develop richer concepts of nature, which may, in turn, result in positive conservation outcomes (Levé et al. 2019).

Limitations and future research

A key limitation of this study relates to the lack of exploration of how concepts of nature may differ across different population groups. Buijs and Elands (2013), for example, found that environmental professionals were more likely to endorse normative concepts of nature than lay people, although such differences could not be tested with the current sample due to the relatively low number (2.492%, $n = 77$) of people working in the environment sector. Further, evidence suggests that concepts of nature differ across ethnic/cultural groups (Kloek et al. 2018) as well as across language groups (Zent, 2015; Coscieme et al. 2020). Within the current sample, 11.327% ($n = 350$) of participants spoke a language other than English at home, yet the sample size was too small to detect meaningful differences in concepts of nature categories across language groups (Appendix

6). Thus, while the present study presents a preliminary exploration of concepts of nature across a sample of English-speakers in Australia, future research is needed to explore how concepts of nature may relate to CN and nature-based PBB across different ethnic, cultural, and language groups. In addition, researchers have identified different types of human-nature relationships, each with different patterns of thoughts, emotions, and behaviors in relation to nature (e.g. Flint et al. 2013, MacDonald et al. 2019, Marais-Potgieter and Thatcher 2020). Further research is also needed to determine how typologies of human-nature relationships could be applied to understanding concepts of nature.

From a methodological perspective, the assumption that the four PBB involved direct experience of nature may be misguided. Citizen science, for example, may involve online activities (e.g. Waldispühl et al., 2020), thus future research may benefit from more refined measures of nature-based PBB. Another methodological limitation relates to the investigation of aggregate CN score as the antecedent for PBBs. Evidence suggests that different CN dimensions may have different relationships with some PBB (Hatty et al. 2020), indicating that further exploration of CN dimensions as antecedents PBBs is warranted. Further, the relationship between CN and PBB is likely reciprocal (Richardson and Hamlin 2021), thus future research should investigate CN and PBB as both antecedent (X) and consequent (Y) in moderation/mediation analyses.

An additional area for future research relates to thoughts people have about different types of nature. The present study defined "nature" in a generic form, yet there are many different types of natural spaces, including domestic and urban nature, zoos and other "managed" nature, as well as protected areas such as national parks (Clayton and Myers, 2009; Frumkin et al., 2016; Keniger et al., 2013). Similarly, concepts of nature may be context specific, in that "nature" in a highly built city such as Hong Kong is likely different to nature experienced in less built areas (Sobko et al. 2018, Chawla 2020). Understanding what comes to mind when people think about these different contexts or types of nature could reveal important variations in how people relate to, connect with, spend time in, and behave toward different types of natural spaces.

Conclusion

Understanding human relationships with nature is increasingly being recognized as an important mechanism for addressing conservation challenges. This research suggests that how people perceive, understand, and describe nature relates to their thoughts, emotions, and behaviors about and toward the natural world. Inspiring people to think about nature in richer terms could play a useful role in addressing not only the ongoing disconnect from nature that is prevalent across many developed countries, but also encourage behaviors that protect the natural environment.

Literature cited

(See consolidated thesis reference list, page 162).

Appendices

(See thesis Appendix D, page 202).

During thesis examination, two concerns were raised regarding the methods by which the concepts of nature categories (descriptive, normative, experiential) were derived from the multidimensional scaling perceptual map. First, the grouping of themes into categories appeared subjective (e.g. the spatial relationships between themes may be better accounted for by more or fewer than three categories; inclusion of the *wilderness* theme in the experiential category was unexpected). Second, including themes from the complex concepts of nature category (i.e. descriptive + normative; experiential + normative; descriptive + experiential; descriptive + normative + experiential) in the multidimensional scaling analysis may have invalidated the results.

To address these concerns, a series of hierarchical cluster analyses were conducted using the binary Lance and Williams measure with different cluster methods. These analyses were conducted with the total sample ($n = 3090$: Figure 10), and with participants from the complex concepts of nature category excluded ($n = 2425$: Figure 11). The different cluster methods produced very similar dendrograms, thus only those using the between-groups linkage method are shown.

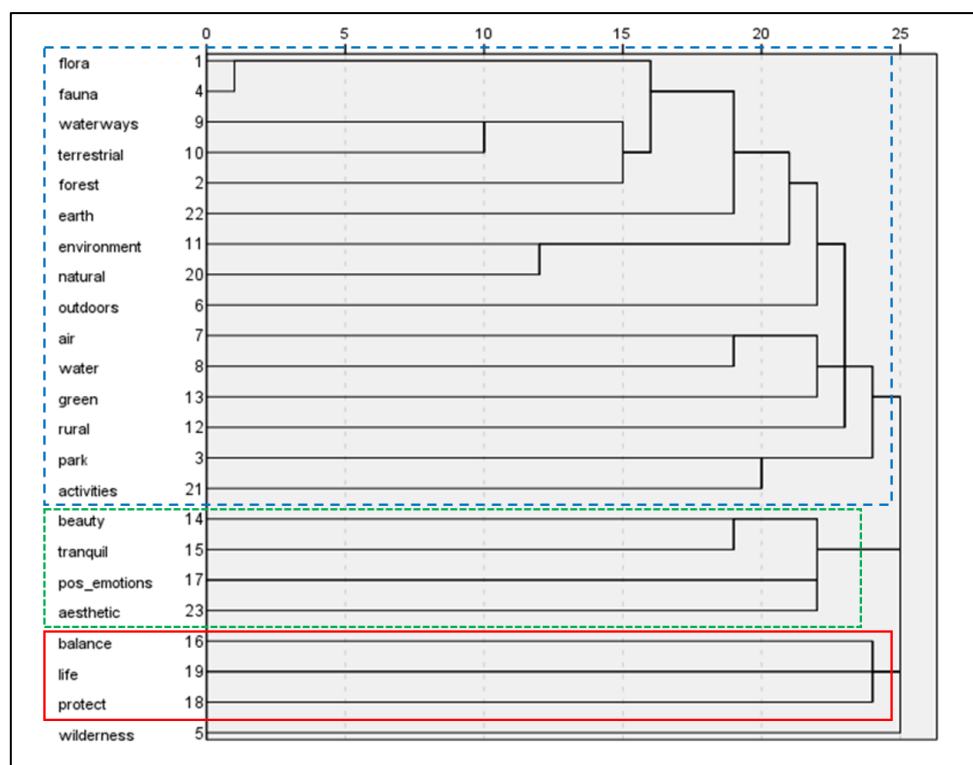


Figure 10: Dendrogram of concepts of nature themes using the total sample ($n = 3090$). The descriptive (blue dashed line), experiential (green dotted line), and normative (red solid line) categories are highlighted.

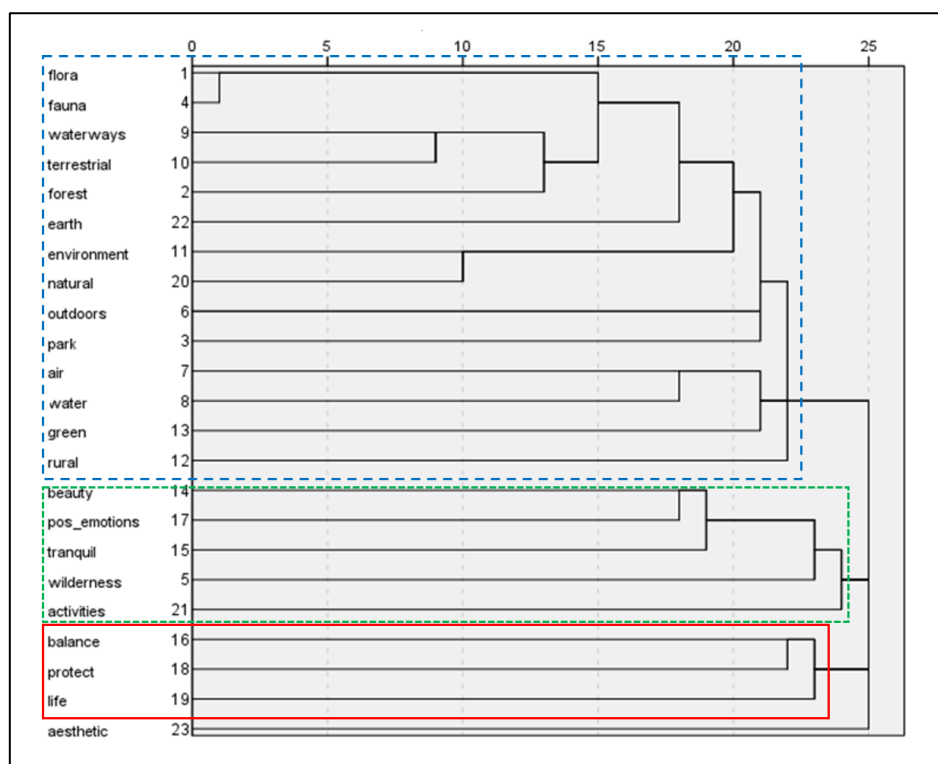


Figure 11: Dendrogram of concepts of nature themes with participants from the complex concepts of nature category excluded ($n = 2425$). The descriptive (blue dashed line), experiential (green dotted line), and normative (red solid line) categories are highlighted.

These dendrograms suggest that the descriptive category (blue dashed line) includes the same themes as described in Study 2, while the experiential (green dotted line) and normative (red solid line) categories also include almost all of the same themes. Two exceptions are, however, worth noting. In Figure 10 (total sample), the *wilderness* theme appeared to stand alone, joining the descriptive, experiential, and normative clusters at the final stage, while in Figure 11 (with participants from the complex concepts of nature category excluded), the *aesthetic* theme appeared to stand alone. Nevertheless, these analyses largely confirm the categories reported in the multidimensional scaling perceptual map in Study 2 (see also Figure 20 on page 138).

To further address the second concern noted above, the multidimensional scaling analysis described in Study 2 was repeated with participants from the complex concepts of nature category removed ($n = 2425$). The perceptual map (Figure 12) revealed largely the same concepts of nature categories that were described in Study 2, with the exception of the *aesthetic* theme appearing closer to the normative category than the experiential category (c.f. Figure 20 on page 138).

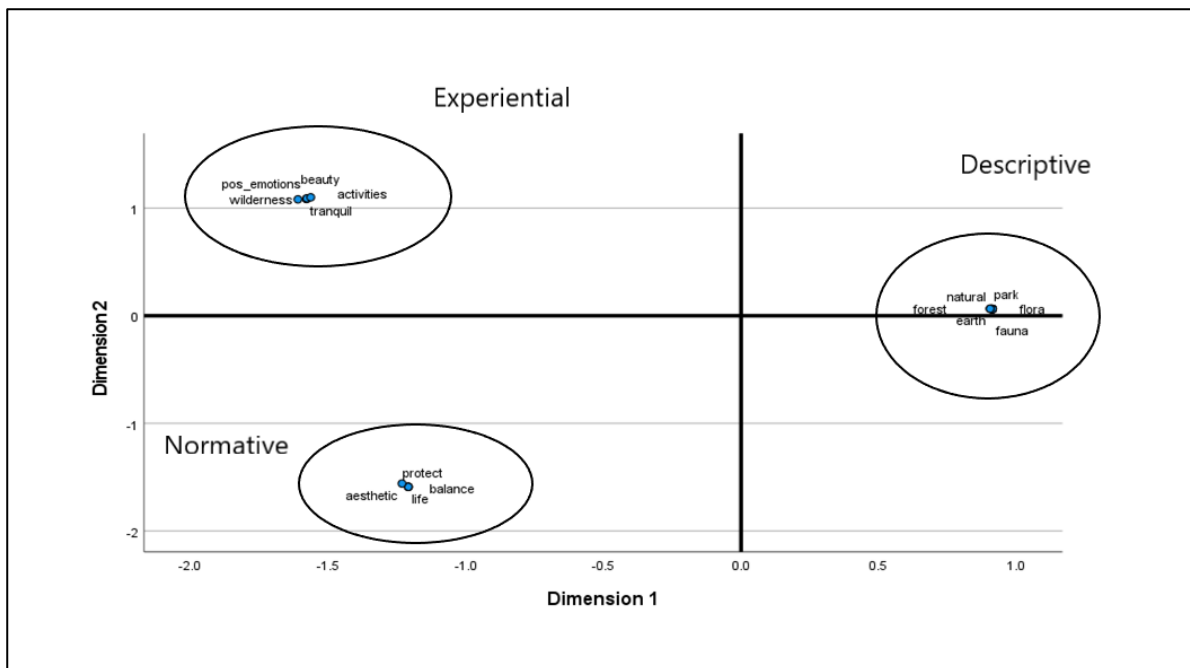


Figure 12: Multidimensional scaling of concepts of nature themes with participants from the complex category excluded ($n = 2425$; Stress = 0.180, RSQ = 0.923). The three categories (descriptive, normative, experiential) are circled.

Note: eight themes from the descriptive category ('outdoors', 'air', 'water', 'waterway', 'terrestrial', 'environment', 'rural', 'green') are not shown due to appearing very close in perceptual space (coordinates: 0.913, 0.062) to the 'flora', 'fauna', 'forest', and 'park' themes (coordinates: 0.911, 0.064).

Chapter 7: Nurturing connection with nature: The role of spending time in nature and nature-based conservation behaviours (Study 3)

Study 2 considered how people think about and understand the term "nature" – their concepts of nature – and how such concepts relate to CN and to PBB. Three broad concepts of nature categories were identified: 1) descriptive (e.g. forest, animals, water); 2) normative (e.g. living entities, ecosystems, sustainability); and 3) experiential (e.g. hiking, awe, peacefulness), with a fourth "complex" category comprising concepts of nature that included two or more of the descriptive, normative, and/or experiential categories. This was among the few studies to statistically categorise concepts of nature, reducing the potential of researcher bias that may occur with categorising data manually.

Results suggested that people who described nature in experiential or complex terms had higher CN scores (total and dimensions) than people who used only descriptive terms, while people who described nature in normative terms had higher CN-Identity scores than those who used only descriptive terms. People who described nature in experiential terms had also participated in environmental volunteering, citizen science, picking up litter, and community gardening more often in the previous 12-months than those who described nature using descriptive terms. Finally, moderation results suggested that concepts of nature moderated the relationship between CN and frequency of picking up litter – for people who described nature using terms from the descriptive, normative, or complex categories, as CN increased so too did frequency of picking up litter, while for people who described nature in experiential terms, an increase in CN was not associated with greater frequency of picking up litter. These findings suggest that how people think about and understand nature is associated with how they relate to and interact with it, including actions to protect nature (Andrews, 2018; Buijs et al., 2008; Mausner, 1996).

A number of additional moderation analyses were conducted that were not included in the publication for Study 2. In addition to CN-Total score, moderation analyses were also conducted with the three CN dimensions (CN-Identity, CN-Experience, and CN-Philosophy) as the focal antecedent (X) and participation in PBB as consequent (Y) with concepts of nature as moderator (the experiential category was used as the reference group for indicator coding). Results suggested significant moderation effects of concepts of nature between CN-Identity and picking up litter, and between CN-Experience and picking up litter (but not CN-Philosophy). At relatively low CN dimension scores, frequency of picking up litter was highest among those in the experiential concepts of nature group, and relatively low among those in the descriptive, normative, and complex groups. Yet, increased CN dimension scores were associated with increased frequency of picking up litter among those in the descriptive, normative, or complex concepts of nature groups,

such that at relatively high CN dimension scores, frequency of picking up litter was comparable to those in the experiential group (Figure 13 and Appendix A [Table A1]). There were no significant moderation effects for environmental volunteering, citizen science, or community gardening.

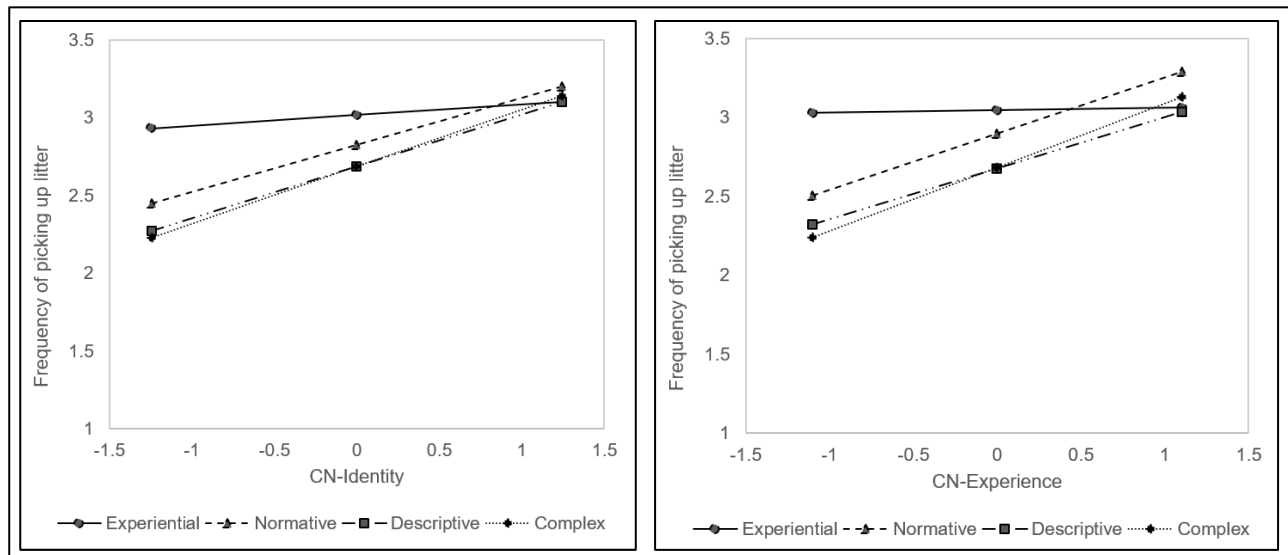


Figure 13: Visual representations of the moderation effect of CN dimensions (X: CN-Identity [left], CN-Experience [right]) on frequency of picking up litter (Y) as a function of concepts of nature.

To explore potential directionality of relationships between CN and PBB, moderation analyses were repeated with participation in PBB as the focal antecedent (X) and CN (total and dimension scores) as consequent (Y). Results indicated concepts of nature moderated the relationships between picking up litter and CN-Total, between picking up litter and CN-Identity, and between picking up litter and CN-Experience. When frequency of picking up litter was low, the relationship with CN (Total, Identity, and Experience) was strongest among those in the experiential concepts of nature group. When frequency of picking up litter was high, the relationship with CN (Total, Identity, and Experience) was similar those in the experiential, normative, and complex concepts of nature groups. The relationship between CN and picking up litter remained weakest among those in the descriptive concepts of nature group (Figure 14 and Appendix A [Table A2]).

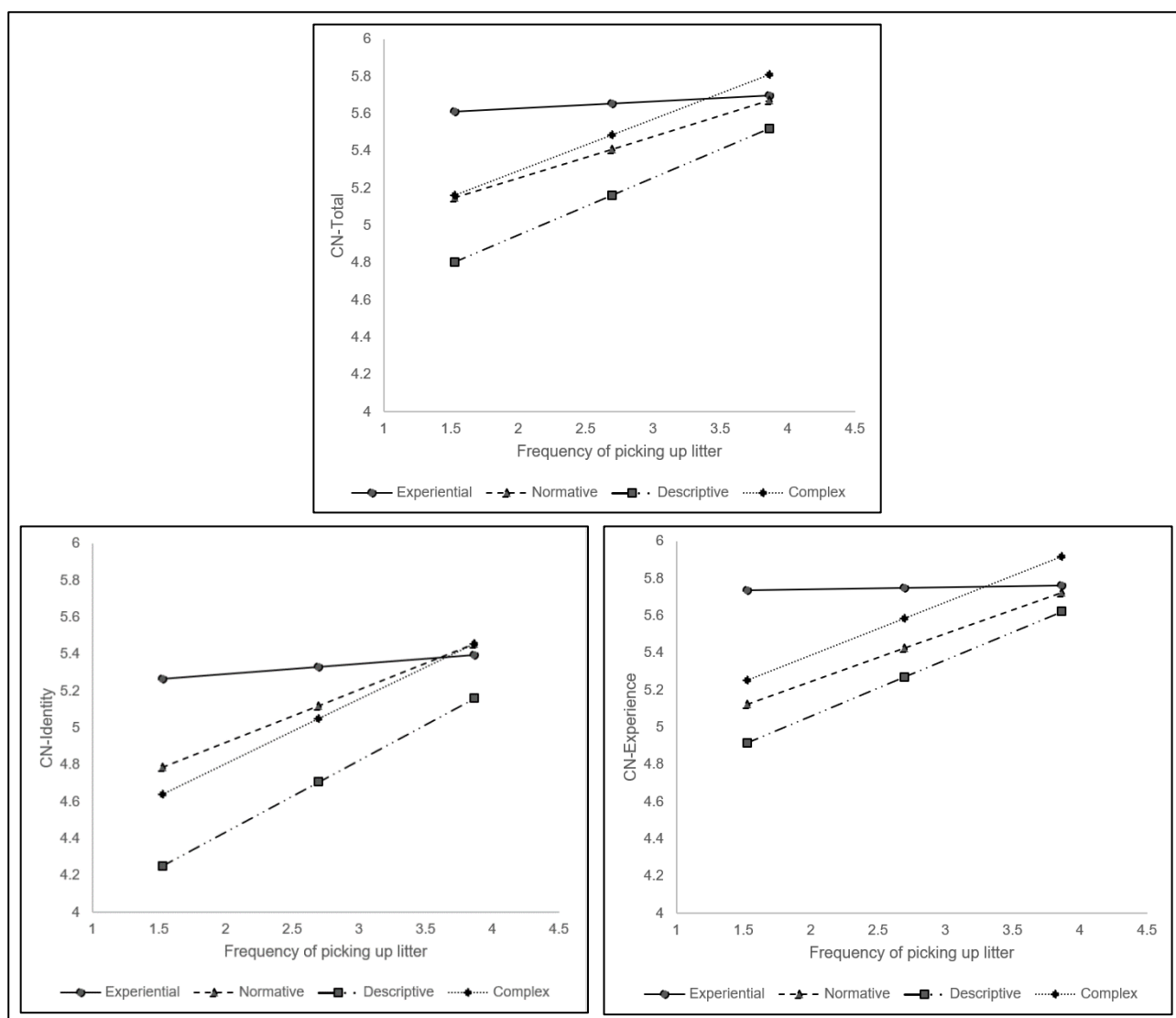


Figure 14: Visual representations of the moderation effect of frequency of picking up litter (X) on CN scores (Y: CN-Total [top]; CN-Identity [bottom left]; CN-Experience [bottom right]) as a function of concepts of nature.

In addition, environmental volunteering and concepts of nature significantly interacted in their influence on CN-Experience, while a significant interaction was also noted between community gardening and concepts of nature in their influence on CN-Experience. For people in the descriptive and complex concepts of nature group, greater frequency of environmental volunteering and community gardening were associated with higher CN-Experience scores, although the effect was not significant for people in the normative concepts of nature group (Figure 15 and Appendix A [Table A3]).

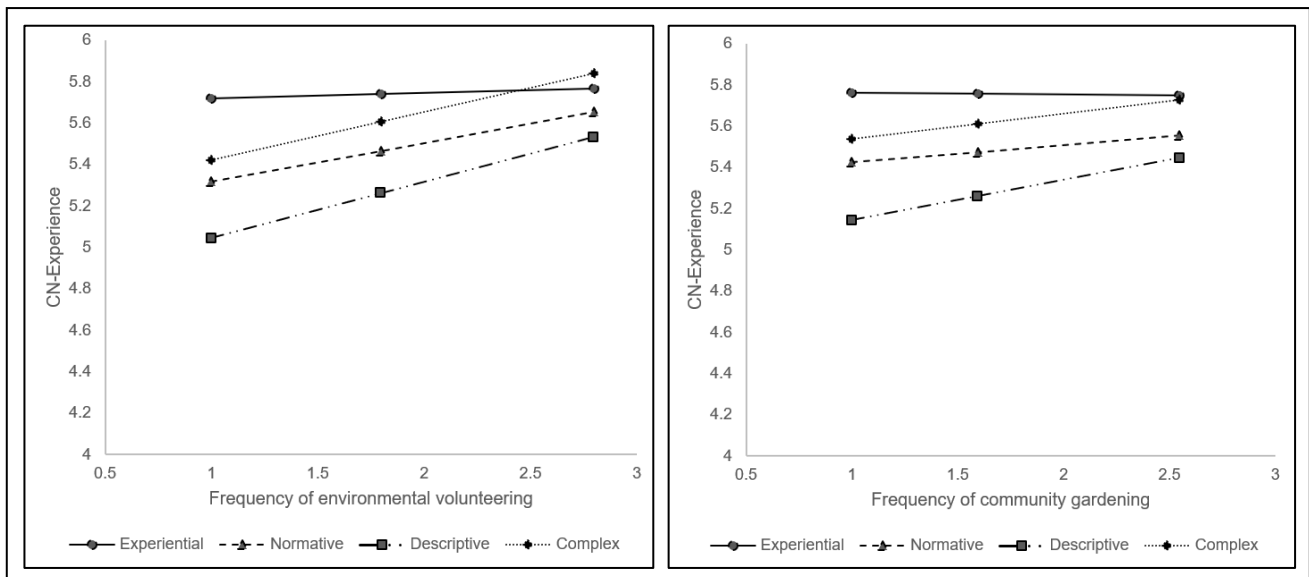


Figure 15: Visual representations of the moderation effect of frequency of environmental volunteering (X: left) and community gardening (X: right) on CN-Experience (Y) as a function of concepts of nature.

These additional moderation results highlight a general pattern of relationships between CN and PBBs as a function of concepts of nature. For people who think about nature in experiential terms, relationships between CN and frequency of PBB participation were strongest. For those who think about nature in descriptive, normative, and complex terms, the strength of the relationship approached that for the experiential group at high frequency of the PBB. This indicates that for people who think about nature relative to activities in nature, positive emotions, beauty, or tranquillity (experiential concepts of nature), CN scores tend to be relatively high regardless of PBB participation, while they are also more likely to participate in PBB regardless of CN scores. Thus, for this group of people, interventions to increase CN may have minimal impact on PBB (suggesting a possible ceiling effect).

In contrast, interventions to increase participation in PBB such as environmental volunteering, picking up litter, or community gardening could facilitate an increase in CN (total and/or some dimensions) when targeted to those who describe nature in normative and complex terms. Such interventions may, however, have minimal effect on those who describe nature in descriptive terms. Similarly, among people who describe nature using terms from the descriptive, normative, or complex categories, interventions to increase CN – total score (as reported in the publication for Study 2), or identity or experience dimension scores (as discussed above) – may increase the likelihood of picking up litter.

These findings, together with those of Study 1, highlight the role of spending time in and experiencing nature in shaping one's relationship with nature. Such ideas have been discussed

elsewhere; for example, peoples' perception of, and language used to describe, nature are shaped by prior experiences in and of nature (Adams & Savahl, 2015; Collado et al., 2016; Coscieme et al., 2020; Tomasso et al., 2021) and experiences of nature predict CN (e.g. Oh et al., 2021; Pirchio et al., 2021; Richardson, Hamlin, et al., 2021).

A question remains, however, as to what types of nature may be more or less effective for nurturing CN. As people differ in their concepts of nature, it's likely that people also differ in the types of nature that they choose to spend time in or the influence that spending time in different types of nature might have on their CN. In addition, experiences of nature that involve protecting or enhancing nature, such as environmental volunteering or citizen science, may also be useful avenues for nurturing CN. These questions are addressed in Study 3 (Figure 16).

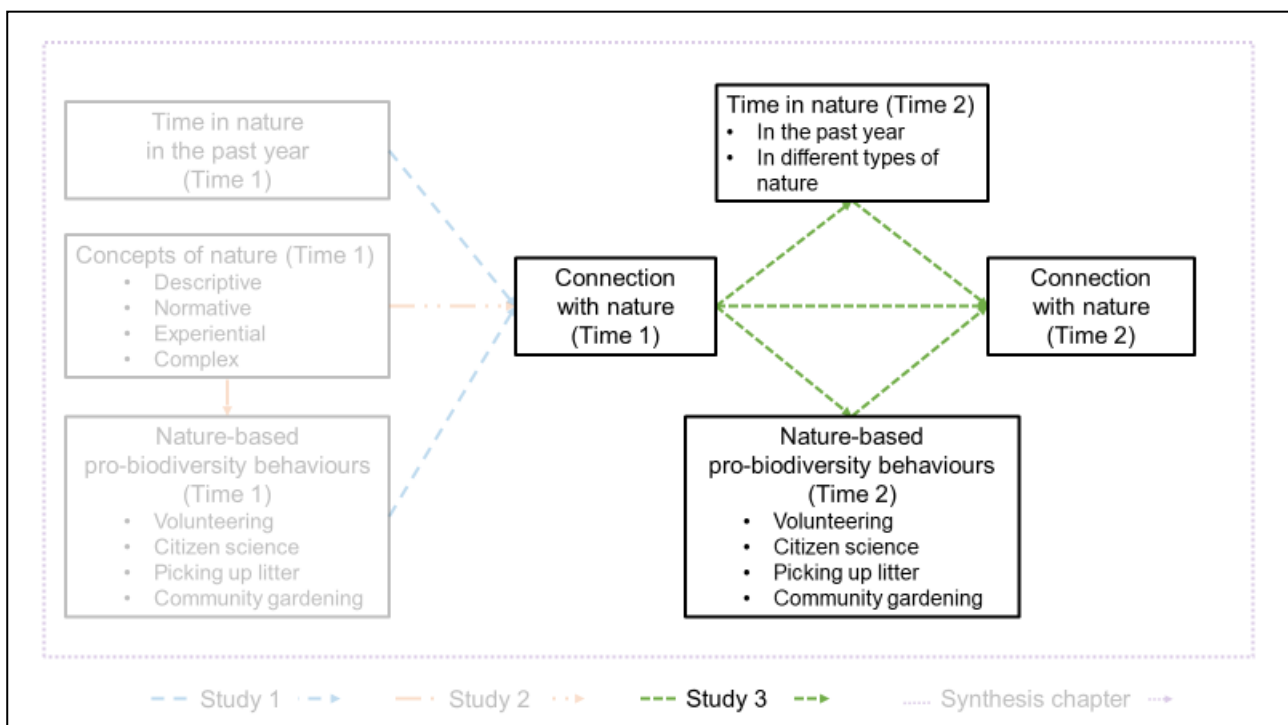


Figure 16: Conceptual framework, with elements included in Study 3 highlighted.

It should be noted that while individual CN dimensions are of particular interest in this thesis, analyses included in Study 3 used only CN-Total scores. This was due to the strong correlations between CN dimensions (Appendix B: Table B1) that increased the likelihood of multicollinearity in multiple regression analyses. The *Connection with nature (Time 1)* box in Figure 16 above has been amended to reflect this change. At the time of thesis submission, Study 3 was being redrafted in response to request for revisions by the journal *Ecosystems and People*.

NURTURING CONNECTION WITH NATURE: THE ROLE OF SPENDING TIME IN NATURE AND NATURE-BASED CONSERVATION BEHAVIOURS.

Melissa Anne Hatty ^{a*}, Felix Tinoziva Mavondo ^b, Denise Goodwin ^a, Liam David Graham Smith ^a

^a BehaviourWorks Australia, Monash Sustainable Development Institute, Monash University, Clayton, Victoria, Australia

^b Department of Marketing, Faculty of Business and Economics, Monash University, Clayton, Victoria, Australia

* Corresponding author

Email: melissahatty@gmail.com (M. A. Hatty)

Abstract

Connection with nature has been associated with greater participation in a range of biodiversity conservation behaviours, and is increasingly being recognised as a potentially useful policy tool to address conservation outcomes. Yet, understanding of how connection with nature develops or may be nurtured remains poorly understood. This research investigates the extent to which spending time in nature, in different types of nature, and participating in nature-based pro-biodiversity behaviours predicted change in connection with nature over a 12-month period, using data from a representative sample of the adult population in the state of Victoria, Australia. Results of multiple linear regression and mediation analyses suggest that more time spent in nature (generally), and more time spent in protected areas and urban parks (specifically), predicted change in connection with nature, while greater frequency of participating in environmental volunteering and picking up litter also predicted change in connection with nature. These findings suggest that policies that encourage spending more time in nature, including in protected areas and urban parks, as well as participating in nature-based pro-biodiversity behaviours, could be useful for increasing connection with nature and addressing biodiversity conservation outcomes. The findings of this research should be of interest to policymakers interested in addressing biodiversity conservation issues.

Keywords

Connection with nature; human-nature relationships; biodiversity conservation behaviours; conservation psychology; contact with nature; nature experiences

1. Introduction

In recent decades, relationships between humans and nature are gaining increased prominence in the conservation literature, with calls to (re)connect people with nature to foster conservation outcomes and sustainability transformations (Ives et al., 2018; Riechers et al., 2021; Zylstra et al., 2014).

Researchers have considered human relationships with nature via constructs such as environmental identity (Clayton, 2003) and nature relatedness (Nisbet et al., 2009; see also Restall & Conrad, 2015; Tam, 2013; Zylstra et al., 2014), and we use *connection with nature* (CN) to refer to this suite of interrelated constructs. Some have argued that CN – a relatively stable sense of interrelationship with nature that includes thoughts, emotions, and behaviours – is an important driver of behaviours that protect the natural environment (Otto & Pensini, 2017; Schultz, 2002; Zylstra et al., 2014).

While less often studied, it is likely that participation in such behaviours also influences CN, that is, the relationship between CN and nature-protective behaviours is reciprocal (Hamlin & Richardson, 2021). Recent work supports this notion, with positive relationships described between CN and a broad range of pro-environmental behaviours (PEB) (Mackay & Schmitt, 2019; Whitburn, Linklater, & Abrahamse, 2019), and between CN and behaviours that specifically protect and enhance biodiversity, or pro-biodiversity behaviours (PBB) (Martin et al., 2020; Prévot, Cheval, et al., 2018; Richardson, Passmore, et al., 2020).

In recent years, policymakers internationally are increasingly recognising human-nature relationships in conservation. The Convention on Biological Diversity (CBD) includes the vision "living in harmony with nature" (CBD Secretariat, 2011, 2021), while the importance of nurturing CN for conservation has been presented at a recent CBD Convention of the Parties meeting (CBD, 2018) and appears in the Global Biodiversity Outlook 5 report (CBD Secretariat, 2020). Such ideas are also reflected in the biodiversity conservation strategies of countries such as New Zealand (Department of Conservation, 2020) and Malaysia (Ministry of Natural Resources and Environment, 2016). In Australia, the role of (re)connecting people with nature to leverage biodiversity conservation has been recognised by both federal and state governments, with the assumption that doing so will enhance Australians' valuing of, and willingness to protect, nature (Australian Government, 2019; Department of Environment, Land, Water and Planning [DELWP], 2017). For (re)connection with nature to be a useful tool in environmental policy and management, however, it is necessary to understand the factors that influence CN over time (Hughes et al., 2019; Restall & Conrad, 2015).

Despite increasing recognition of the important role CN may play in fostering PEB/PBB, understanding how a stable sense of CN develops, is maintained, or may be nurtured, is somewhat limited (Cleary et al., 2018; Ives et al., 2018). While researchers have identified a number of factors that predict CN (e.g. Chawla, 2020; Lumber et al., 2017; Richardson, Dobson, et al., 2020), of particular interest are time spent in, and experiences of, nature as these provide guidance for policymakers seeking to nurture such experiences.

Early research proposed that frequency of time spent in nature (TIN) was among the strongest predictors of CN (Kals et al., 1999). Indeed, both frequency of visits to nature (Cleary et al., 2018; Prévot, Clayton, et al., 2018) and longer duration of TIN (e.g. hours per day/week: Dornhoff et al., 2019; Pérez-Ramírez et al., 2021) have been associated with greater CN. Further, environmental

education programs of longer duration may facilitate higher CN scores post-program than shorter programs (Barrable & Booth, 2020; Braun & Dierkes, 2017).

Another question is what types of nature may best facilitate CN. Much research to date has considered CN as a generic construct without considering the context or type of nature people connect to (Giusti et al., 2018; Ives et al., 2017). Yet, there are many different types of spaces where human-nature interactions occur, such as domestic, urban and botanic gardens; beaches and waterways; and protected areas including national parks (Clayton & Myers, 2009; Keniger et al., 2013). People likely perceive, interact with, and respond to these different types of natural spaces in different ways (Davis et al., 2016; Pasca et al., 2020) which may have implications for how and when they connect with nature (de Bell et al., 2018).

Some researchers have explored relationships between time spent in different types of nature and CN. Schultz and Tabanico (2007) reported increased CN following a day at a wildlife park, and positive correlations between CN and the amount of time spent at a beach or hiking trail, but not a golf course. Scopelliti and colleagues (2016) noted that users of parks with higher natural values tended to have higher CN scores than users of parks with lower natural values, while Mena-García et al. (2020) reported that walking in the countryside was associated with greater increase in CN than walking in urban parks. Wyles and colleagues (2019) described higher CN following visits to rural than to urban natural areas, and for visits to protected areas than to non-protected areas. Together, these studies suggest that time spent in different types of natural environments may influence CN in different ways, with time spent in areas with higher natural values, such as national parks, likely to have a greater influence on CN than time spent in areas with lower natural values, such as urban parks.

Yet, with increasing urbanisation and decreasing opportunities to experience wilder-type nature (Australian Bureau of Statistics, 2020; United Nations Department of Economic and Social Affairs, 2019), connecting urban residents with nature may require spending time in "managed" contexts such as zoos or urban parks (Clayton, 2017; Cleary et al., 2018). Indeed, future conservation efforts may depend on fostering relationships with urban nature, as this is where nature is most likely to be encountered (Dunn et al., 2006; Gaston & Soga, 2020). Thus, understanding the relationship between time spent in different types of nature and CN may have utility in informing policy and programs intended to (re)connect people with nature (e.g. DELWP, 2017), particularly in urban contexts.

In addition to the quantity of TIN, what people do while they're spending time in nature appears another important predictor of CN (Colléony et al., 2019; Colléony, Levontin, et al., 2020). Lumber and colleagues (2017) propose that CN may be enhanced through five pathways – sensory contact, emotion, beauty, meaning, and compassion – with each of these pathways involving active, rather than passive, interaction with nature (Richardson, Dobson, et al., 2020). Indeed, many programs intended to connect people with nature involve active and direct experiences of nature, such as outdoor and environmental education, tactile and experiential activities, and land regeneration (Braun & Dierkes, 2017; Colahan & Chapple, 2019).

A number of PBB involving active and direct experiences of nature have been associated with increases in CN, including tree planting (Whitburn, Linklater, & Milfont, 2019), citizen science

(Chase & Levine, 2017; Schuttler et al., 2018), and environmental volunteering (Rogerson et al., 2017; Schild, 2018). Higher CN scores have also been associated with a range of gardening practices (Kiesling & Manning, 2010; Prévot, Cheval, et al., 2018; Shaw et al., 2013). Thus, participating in PBB involving direct experience of nature could be a useful means of fostering CN.

1.1. The current research

The primary aim of this research is to explore relationships between TIN and CN, and between nature-based PBB and CN. While previous research has used cross-sectional (e.g. Cleary et al., 2018) or pre-post experimental methodologies (e.g. Braun & Dierkes, 2017), this research will consider change over a 12-month period without an experimental manipulation but allowing for natural variation in experience.

It has been suggested that repeated experiences in nature over time are required to develop a stable sense of CN (Carr & Hughes, 2021; Chawla, 2020; Clayton et al., 2021; Salazar et al., 2020). This research, therefore, considers whether the frequency of spending time in nature, spending time in different types of nature, and spending time in nature while engaged in PBB predicts change in CN over time. As TIN and PBB have been shown to influence CN, we anticipate that TIN and PBB may mediate the relationship between CN at Time 1 and CN at Time 2.

Two research questions are proposed:

RQ1. Does frequency of time spent in nature, and time spent in different types of nature, predict change in CN over a 12-month period?

RQ2. Does frequency of participation in nature-based PBB predict change in CN over a 12-month period?

2. Method

2.1. Participants and procedure

Data for this research were collected as part of a larger study exploring attitudes toward, and use of, the natural environment in the state of Victoria, Australia (Hatty et al., 2020; Meis-Harris et al., 2019). Data were collected using an online panel survey company with participants responding to questionnaires at two time points: September/October 2018 (Time 1) and September/October 2019 (Time 2). Survey questions captured CN, TIN, PBB, demographics, and concepts of nature, as described below (Appendix A). The total sample ($N=1069$) comprised 48.7% females ($n=521$) with age range of 19 to 88 years ($m=52.81$, $SD=14.81$) (Appendix B).

2.2. Measures

2.2.1. Dependent variable: Connection with nature at Time 2 (CN at Time 2)

The CN-12 was used to capture CN at Time 2. This scale comprises three dimensions (CN-Identity, CN-Experience, CN-Philosophy) that are strongly correlated yet contribute to a higher order construct (CN-Total). The scale was originally validated on a representative sample of the participants from the state of Victoria, Australia (Hatty et al., 2020). Responses are provided on a 7-point Likert scale (1=*strongly disagree*, 7=*strongly agree*). Items were averaged to create a composite score ($\alpha=0.930$).

2.2.2. Independent variables

2.2.2.1. Demographics (age and gender)

Age and gender have both been associated with CN and TIN, although in varying ways. CN scores are typically higher among older people and females (Hughes et al., 2019; Prévot, Clayton, et al., 2018; Wyles et al., 2019) although some authors have reported higher CN scores among males (Dornhoff et al., 2019). Other authors reported that males were more likely to visit particular types of natural areas than females (Richards et al., 2020), while others have found no relationship between TIN and gender (Prévot, Clayton, et al., 2018). Following Cleary et al. (2018) and Richardson and Hamlin (2021), we included age (*in years*) and gender (*male, female, other*) as control variables.

2.2.2.2. Connection with nature at Time 1 (CN at Time 1)

CN at Time 1, captured using the CN-12 (Hatty et al., 2020), was included as a control variable to enable assessment of change in CN over the 12-month period. Items were averaged in the same manner as described above ($\alpha=0.933$).

2.2.2.3. Time spent in nature in the past year at Time 2

The frequency of time spent in nature in the previous 12 months (captured at Time 2) was assessed using seven items. Participants reported how often they had generally spent time in nature in the past year (TIN past year) on a 9-point ordinal scale (1=*never* to 9=*every day*). Responses were recoded into five categories (1=*never*; 2=*rarely [twice yearly or less]*; 3=*sometimes [monthly]*; 4=*often [weekly or fortnightly]*; 5=*very often [daily or every other day]*) to ensure consistency of response options with questions assessing time spent in different types of nature.

Participants also reported how often they spent time in six different types of natural areas in the past year on a 5-point ordinal scale (1=*never* to 5=*very often [e.g. daily or every other day]*): 1) a protected or wilderness area (TIN wilderness); 2) the beach or coastal areas (TIN beach); 3) a lake, river or other waterway (TIN waterway); 4) a zoo, wildlife park, or botanical garden (TIN zoo); 5) an urban park (TIN urban park); and 6) your garden at home, or the garden of a friend, neighbour or family member (TIN garden).

2.2.2.4. Nature-based PBB at Time 2

Participants indicated the frequency in which they had participated in 11 different PEB/PBB in the previous 12 months (1=*never*, 5=*very often*). Four reported behaviours that typically involve direct experiences of nature – participated in environmental volunteering (volunteer); participated in citizen science (citizen science); picked up litter in a public space, park or forest (litter); and participated in community gardening or composting (community gardening) – were selected to assess nature-based PBBs.

2.3. Data analyses

We ran descriptive statistics and correlations to provide an overview of the data (Appendix B). We conducted two hierarchical multiple linear regression analyses to predict CN at Time 2. In each analysis, age, gender, concepts of nature, and CN at Time 1 were entered as control variables at

Step 1. To assess RQ1, TIN past year and time spent in the six types of nature were entered together at Step 2. To assess RQ2, the four PBB were entered together at Step 2. Next, two mediation analyses were conducted using the PROCESS v3.5 macro (Hayes, 2018). Analyses were conducted using IBM SPSS Statistics Version 26 (IBM Corp., 2019).

Data were screened for assumptions. Cases with standardised residuals greater than 3.29 were removed ($n=15$). One case was removed due to missing data (final $n=1053$). Inspection of P-P and ZPRED*ZRESID plots suggested the assumptions of normality of residuals, linearity, and homoscedasticity (respectively) were met. Durbin-Watson (1.995-1.983), VIF (1.024-2.103), and tolerance (0.476-0.977) statistics indicated the assumptions of independent errors and multicollinearity were met (Field, 2013). An a priori power analysis suggested the sample would be adequate to detect a small effect ($n=818$ required for $f^2=0.020$, $\alpha=0.050$, power=0.800, with 10 predictor variables).

3. Results

Descriptive statistics suggested CN variables were negatively skewed (CN at Time 1: $m=5.231$, $SD=1.015$, skew=-0.361, SE skew=0.075; CN at Time 2: $m=5.286$, $SD=0.990$, skew=-0.359, SE skew=0.075) although the large sample size reduced the impact of non-normality on analyses (Tabachnick & Fidell, 2007). Most participants (55%, $n=580$) reported spending time in nature often or very often (daily to weekly) in the previous 12-months, with one quarter ($n=267$) spending time in nature never or rarely (up to two times) in the past year. Sixteen percent ($n=168$) of participants had never spent time in a protected or wilderness area in the previous year, while a majority (58-61%) had never participated in environmental volunteering, citizen science, or community gardening (Appendix B).

3.1. RQ1: Does frequency of time spent in nature, and time spent in different types of nature, predict change in CN over a 12-month period?

The full model (Table 1) accounted for 69% of the variance in CN at Time 2. As expected, CN at Time 1 accounted for the most variance, with time spent in nature (generally), and in different types of nature, together accounting for 3% of the variance. Of the seven TIN variables, three significantly predicted CN at Time 2: time spent in nature (generally: TIN past year); in wilderness or protected areas (TIN wilderness); and at an urban park (TIN urban park).

Table 1: Hierarchical multiple linear regression predicting connection with nature at Time 2 (CN at Time 2) from time spent in nature (generally) and in different types of nature in the past year (n=1053).

	β	t	p [95% CI]
Step 1: Control variables (age, gender, concepts of nature, and CN at Time 1)			
$F(3,1049)=702.666$, Adj. $R^2=0.667$, $p<0.001$, $f^2=2.003$			
Constant		7.474	<0.001 [0.652, 1.116]
Age	0.037	2.038	0.042 [<0.001, 0.005]
Gender	0.055	3.049	0.002 [0.039, 0.179]
CN at Time 1	0.805	44.726	<0.001 [0.751, 0.820]
Step 2: Time spent in nature (different types of nature) in the past year			
$\Delta F(7,1042)=14.372$, Adj. $R^2=0.694$, $\Delta R^2=0.029$, $p<0.001$, $f^2=2.268$			
Constant		3.818	<0.001 [0.236, 0.734]
Age	0.045	2.345	0.019 [<0.001, 0.005]
Gender	0.062	3.520	<0.001 [0.054, 0.192]
CN at Time 1	0.722	37.017	<0.001 [0.667, 0.742]
TIN past year	0.093	4.316	<0.001 [0.044, 0.116]
TIN wilderness	0.055	2.529	0.012 [0.014, 0.113]
TIN beach	0.004	0.180	0.857 [-0.036, 0.044]
TIN waterway	0.034	1.552	0.121 [-0.009, 0.077]
TIN zoo	0.004	0.191	0.849 [-0.045, 0.055]
TIN urban park	0.066	3.264	0.001 [0.024, 0.098]
TIN garden	0.007	0.336	0.737 [-0.032, 0.046]

Note. CI=confidence interval

We conducted a parallel multiple mediator analysis to determine whether time spent in nature and/or in different types of nature mediated the relationship between CN at Time 1 and CN at Time 2. The final model suggested complementary mediation (Zhao et al., 2010). The total effect of CN at Time 1 on CN at Time 2 was 0.786 ($t=44.726$, $p<0.001$), with a direct effect (c') of 0.704 ($t=37.017$, $p<0.001$). CN at Time 1 predicted all time spent nature variables (a_1 - a_7). Results based on 5000 bootstrap samples suggested specific indirect effects of three mediators (in the presence of other mediators): TIN past year ($a_1b_1=0.034$, $t=3.778$, 95% CI [0.017, 0.052]; TIN wilderness ($a_2b_2=0.019$, $t=2.375$, 95% CI [0.004, 0.034]; and TIN urban park ($a_6b_6=0.015$, $t=3.000$, 95% CI [0.006, 0.025] (unstandardized coefficients) (Figure 1).

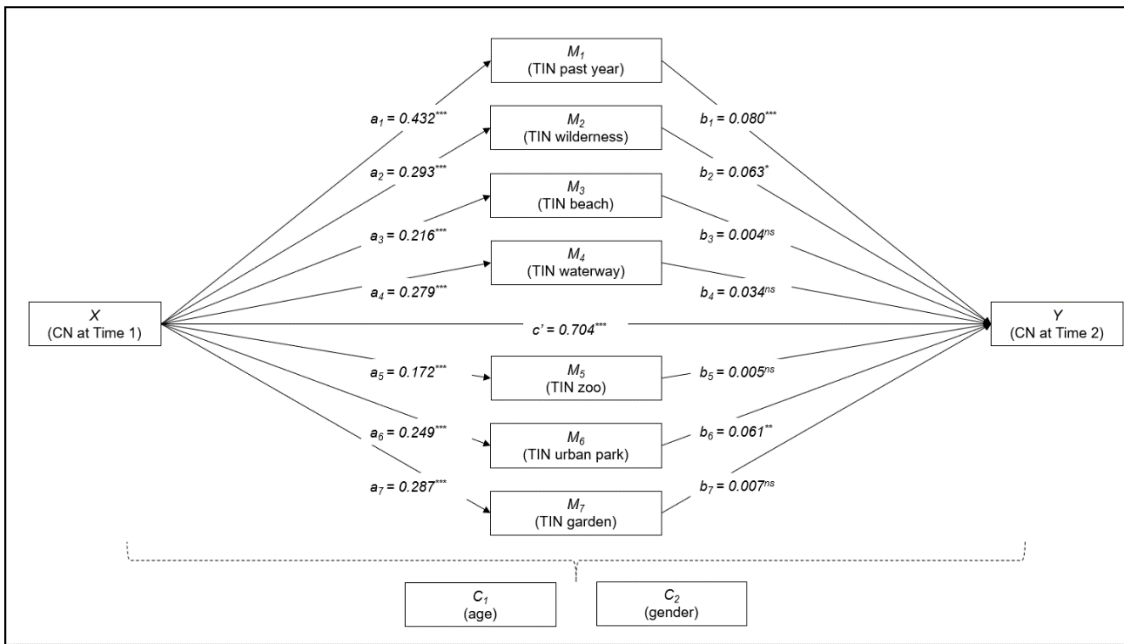


Figure 1: Mediation analysis predicting connection with nature at Time 2 (Y) from connection with nature at Time 1 (X) with time spent in nature (generally: M_1) and in six types of nature as mediators (protected or wilderness area (M_2); beach or coastal area (M_3); lake, river or other waterway (M_4); zoo, wildlife park, or botanical garden (M_5); urban park (M_6); own garden at home (M_7)). Age (C_1) and gender (C_2) are entered as covariates (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; $^{ns}p > 0.05$).

3.2. RQ2: Does frequency of participation in nature-based PBB predict change in CN over a 12-month period?

The full model (Table 2) accounted for 68% of the variance in CN at Time 2, with CN at Time 1 making the largest contribution. Nature-based PBB together accounted for 2% of the variance in CN at Time 2. Of the four PBB variables, two significantly predicted CN at Time 2: participated in environmental volunteering (volunteer) and picked up litter in a public space, park or forest (litter).

Table 2: Hierarchical multiple linear regression predicting CN at Time 2 (CN Time 2) from nature-based pro-biodiversity behaviors (PBB) ($n=1053$).

	β	t	p [95% CI]
Step 1: Control variables (age, gender, and CN at Time 1)			
$F(3,1049)=702.666$, Adj. $R^2=0.667$, $p<0.001$, $f^2=2.003$			
Constant		7.474	<0.001 [0.652, 1.116]
Age	0.037	2.038	0.042 [<0.001, 0.005]
Gender	0.055	3.049	0.002 [0.039, 0.179]
CN at Time 1	0.805	44.726	<0.001 [0.751, 0.820]
Step 2: Nature-based PBB in the past year			
$\Delta F(4,1045)=12.603$, Adj. $R^2=0.681$, $\Delta R^2=0.015$, $p<0.001$, $f^2=2.135$			
Constant		6.485	<0.001 [0.540, 1.008]
Age	0.050	2.755	0.006 [0.001, 0.006]
Gender	0.065	3.635	<0.001 [0.059, 0.197]
CN at Time 1	0.753	39.329	<0.001 [0.698, 0.771]
Volunteer	0.055	2.158	0.031 [0.005, 0.102]
Citizen science	0.044	1.805	0.071 [-0.004, 0.089]
Litter	0.094	4.580	<0.001 [0.043, 0.108]
Community gardening	-0.038	-1.506	0.132 [-0.082, 0.011]

CI=confidence interval

We conducted a parallel multiple mediator analysis to determine whether any of the four PBB mediated the relationship between CN at Time 1 and CN at Time 2. Results suggested complementary mediation (Zhao et al., 2010), with the total effect of 0.786 ($t=44.726$, $p<0.001$), and a direct effect (c') of 0.735 ($t=39.329$, $p<0.001$). CN at Time 1 predicted all PBB (a_1 - a_4). Results based on 5000 bootstrap samples suggested a significant indirect effect of two mediators (in the presence of other mediators): volunteer ($a_1b_1=0.014$, $t=2.000$, 95% CI [0.001, 0.028] and litter ($a_3b_3=0.033$, $t=4.125$, 95% CI [0.018, 0.058] (Figure 2).

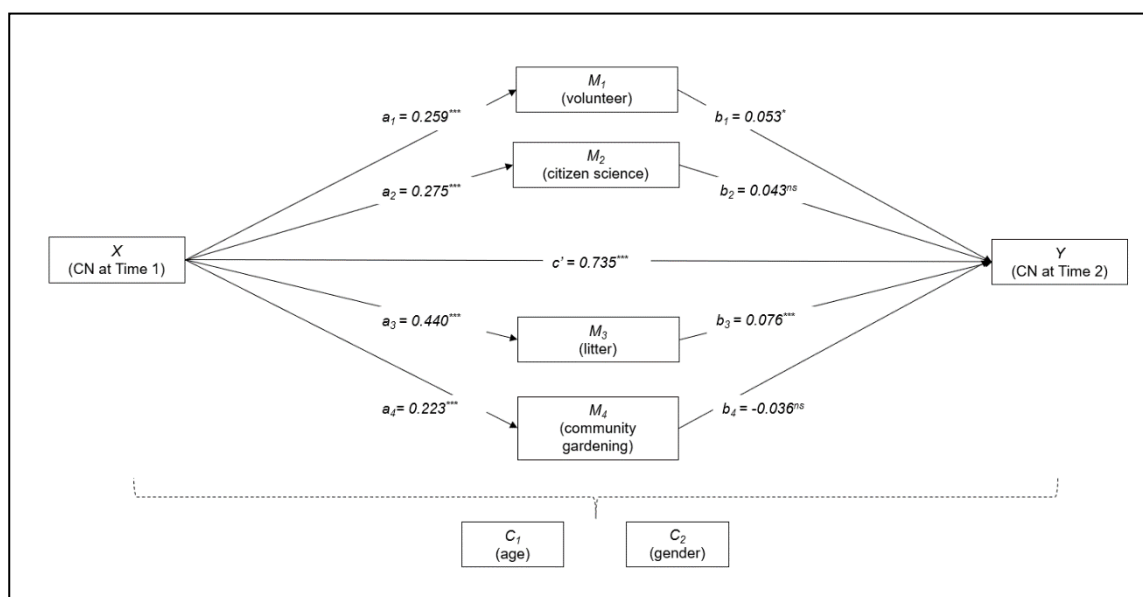


Figure 2: Mediation analysis predicting connection with nature at Time 2 (Y) from connection with nature at Time 1 (X). Environmental volunteering (M_1), citizen science (M_2), picking up litter (M_3), and community gardening (M_4) are entered as mediators, and age (C_1) and gender (C_2) as covariates. Unstandardized coefficients are shown. (* $p < 0.05$; *** $p < 0.001$; $ns p > 0.05$).

4. Discussion

For CN to be useful in conservation policy and management, understanding how a stable sense of CN develops, is maintained, or may be nurtured is essential. This research sought to determine the extent to which time spent in, and experiences of, nature contributed to change in CN over a 12-month period.

As CN is relatively stable over time (Hatty et al., 2020; Nisbet et al., 2011), it is important to note that small changes in CN at Time 2 were expected. Overall, the findings suggest that more time spent in nature was associated with slightly higher CN scores at Time 2. Results further suggested that participants who spent more time in nature – generally, in wilderness/protected areas, and in urban parks – tended to have slightly higher CN at Time 2, regardless of CN at Time 1.

Previous research has suggested that areas with higher natural values may be more useful for fostering CN than areas with lower natural values (Mena-García et al., 2020; Scopelliti et al., 2016; Wyles et al., 2019). The present findings suggest that while spending time in wilder-type areas does predict change in CN over time, so too does spending time in urban parks. These results are consistent with those of Lumber and colleagues (2017) and Restall et al. (2021) who also reported positive relationships between CN and time spent in both urban and protected areas. These findings also provide support for the notion that repeated experiences in nature over time are needed to foster an enduring sense of CN (e.g. Clayton et al., 2021; Richardson, Dobson, et al., 2020).

Further, respondents who participated in environmental volunteering and picking up litter more often during the year had higher CN at Time 2 than those who participated in these activities less often. This is consistent with the findings of Rogerson et al. (2017), Schild (2018), and Whitburn et

al. (2019). However, in contrast to previous research (Chase & Levine, 2017; Prévot, Cheval, et al., 2018; Schuttler et al., 2018), participating in citizen science and community gardening did not contribute to change in CN scores. While tolerance statistics were within acceptable range (environmental volunteering: 0.476, citizen science: 0.516, community gardening: 0.482), it is possible that the presence of environmental volunteering in the analysis rendered the contribution of citizen science and community gardening non-significant ($p=0.071$ and $p=0.132$, respectively).

Also consistent with previous research (Colléony et al., 2017; Colléony, Cohen-Seffer, et al., 2020; Cox et al., 2018; Lin et al., 2014), results of the three mediation analyses suggest that those higher in CN tended to spend more time in nature – generally, in protected and urban areas, and while participating in some PBB – than those lower in CN. While not explicitly tested, it is possible that a bidirectional relationship between TIN and CN may also be present, as has been suggested previously (Martin et al., 2020; Rosa & Collado, 2019).

4.1. Characteristics of nature experiences

Together these findings highlight the role that time spent in nature may play in fostering CN, and suggest that policies and programs intended to encourage people to spend more time in nature, including different types of nature and while engaged in nature-based PBB, could help to foster CN. Yet, the small effect sizes and complementary mediation in both analyses (Zhao et al., 2010) suggest that other factors also likely influence change in CN over time, such as what people do while they're in nature, or how they experience nature (Colléony, Cohen-Seffer, et al., 2020; Colléony, Levontin, et al., 2020; Richardson, Dobson, et al., 2020).

Recent evidence suggests that intentional awareness while in nature (Schutte & Malouff, 2018) and active engagement with nature through smell or touch (Carr & Hughes, 2021; Colléony, Levontin, et al., 2020; Lumber et al., 2017) are associated with higher CN scores. Further, emotions such as wonder and excitement appear to play a role in fostering CN (Carr & Hughes, 2021; Giusti et al., 2018; Richardson, Dobson, et al., 2020), perhaps by facilitating learning and openness to experience (Yang et al., 2018). Learning something new and a sense of compassion for the natural environment while experiencing nature may also be important (Carr & Hughes, 2021; Lumber et al., 2017).

Given that CN comprises multiple dimensions (Ives et al., 2018), activities that target each of these dimensions may be most effective in fostering an enduring sense of CN (Zylstra et al., 2014). Similarly, activities that involve simultaneous activation of different pathways to CN may be also be valuable (Carr & Hughes, 2021; Richardson, Dobson, et al., 2020). As this research suggest, engaging with nature via meaningful and compassionate activities that use multiple senses, such as environmental volunteering (Cosquer et al., 2012; Schuttler et al., 2018) or litter clean-ups (Wyles et al., 2017) could be pivotal in this sense. Gardening to attract wildlife (Shaw et al., 2013), arts-based activities (Muh, 2020; Raatikainen et al., 2020), or technology-based interventions (Mattijssen et al., 2020) could also be useful, particularly if they encourage noticing "good things" in nature (McEwan et al., 2020) or engagement with natural beauty (Richardson & McEwan, 2018).

4.2. Implications for conservation policy

While policymakers have begun to consider human-nature relationships in conservation planning and management, policies and land management practices that specifically nurture CN are needed

(Richardson et al., 2021). This research suggests that policies and practices that facilitate spending time in nature, including urban parks, and that promote environmental volunteering and picking up litter, could be useful.

Biophilic urban design may be one means of encouraging people to spend more time in and with nature. Urban spaces that include different types of natural elements provide opportunities for incidental and intentional interactions with nature (Church, 2018; Lin et al., 2018) which may enhance CN (Cox et al., 2017; Shanahan et al., 2017). Designing public natural spaces to include food plants and opportunities for urban agriculture (Kingsley et al., 2021; Palliwoda et al., 2017) and to facilitate interactive and sensory immersion with nature (Pan et al., 2020; Pennisi et al., 2017; Souter-Brown, 2015) can also encourage citizens to spend more time in, actively engage with, and connect to nature in such spaces.

Involving citizens in the design, installation, and management of natural spaces may be another mechanism for encouraging time spent in nature, CN, and participation in nature-based PBB (Church, 2018; Light, 2006; Mattijssen et al., 2020). Citizen engagement in the design and management of natural spaces can increase psychological ownership of, and connection to, those spaces, as well as stewardship behaviours such as picking up litter (de Bell et al., 2018; Mullenbach et al., 2019; Peck et al., 2021; Preston & Gelman, 2020). Psychological ownership has also been associated with enjoyment of, and connection to, natural areas as well as to PEB and PBB such as environmental volunteering (Ganzevoort & van den Born, 2020; Kuo et al., 2021).

4.3. Limitations and future research

A number of limitations are evident in the current research. Firstly, the measures of time spent in nature lacked specificity – memory limitations, for example, may impede accurate recollection of the frequency of time spent in nature over the previous 12-months. Further, time spent in specific types of nature, such as urban parks, does not capture differences in quality (e.g. amount of tree cover, level of biodiversity) of different, albeit similarly classified, types of nature. In addition, the present study assumed that the PBBs involved direct experience of nature, although this may not actually be the case. Environmental volunteering, for example, may involve indoor as well as outdoor activities (Winch et al., 2020). Future research would benefit from more refined measures of TIN and nature-based PBB.

Regarding connection with nature, CN scores were relatively high (Time 1: $m=5.231$, $SD=1.015$; Time 2: $m=5.286$, $SD=0.990$) thus the small change may be due to a ceiling effect. Further, interventions designed to foster CN typically show the greatest increases among participants with lower CN scores pre-intervention than participants with higher CN scores (Barrable & Booth, 2020; Braun & Dierkes, 2017; Chawla, 2020). While not explicitly tested here, it's possible that participants with low CN scores at Time 1 who spent more time in nature over the year would show greater increases in CN than participants with higher CN scores at Time 1. Additional investigation is needed to tease out possible differences between people with low versus high CN at Time 1.

Another area for future research lies in the frequency, total number, or type of nature experiences needed to facilitate a stable sense of CN. While it has been proposed that repeated experiences of nature are needed to develop an enduring trait-like CN (e.g. Clayton et al., 2021; Richardson,

Dobson, et al., 2020; Salazar et al., 2020), such experiences may differ across groups. People with lower initial CN scores may, for example, require fewer or less intense experiences of nature to increase CN, while those with higher initial CN scores may require more or greater intensity experiences of nature, such as a multi-day wilderness expedition, to effect an increase in CN (Salazar et al., 2020).

Finally, future research should consider the broader socio-cultural and contextual factors that influence peoples' experiences of natural environments. Cultural and social factors influence landscape preferences and attitudes to natural spaces (Buijs et al., 2009; Clayton et al., 2017; Özgüner, 2011) which may impact the ways in which different people experience nature. Investigation of the role of socio-cultural and contextual factors in the TIN-CN-PBB relationship warrants further investigation.

5. Conclusion

Connection with nature is increasingly being recognised as a potentially useful policy lever to address conservation issues, including increasing participation in pro-biodiversity behaviours. Understanding the mechanisms by which connection with nature develops, is maintained, or may be nurtured can usefully inform conservation policies and programs for which nurturing connection with nature is an outcome. Encouraging people to spend more time in nature – including protected areas and urban parks – and to participate in nature-based pro-biodiversity behaviours, could be useful.

6. Acknowledgements

Thank you to Kim Lowe, Fern Hames, and the Victorians Value Nature team for their input into this research.

7. Disclosure statement

The authors report there are no competing interests to declare.

8. Funding

This research was commissioned and funded by the Victorian Government Department of Environment, Land, Water and Planning (DELWP), and was also funded by an Australian Government Research Training Program (RTP) Scholarship.

9. Data availability statement

The data and syntax for this research are available at Open Science Framework (https://osf.io/3ca7f/?view_only=82164315080249d49d0eec6e5a34e21f)

10. References

(See consolidated thesis reference list, page 162).

11. Appendices

(See thesis Appendix E, page 217).

Chapter 8: Conceptual framework synthesis

The previous chapters sought to better understand CN – dimensionality, how people think about nature relative to CN, and factors that may contribute to the development, maintenance, and/or change in CN over time, including time spent in nature, time spent in different types of nature, and participating in nature-based pro-biodiversity behaviours. These elements were brought together in the conceptual framework shown in Figure 17. If this framework is to be a useful tool for conservation policy, it would be useful to know the extent to which it fits together. This was assessed quantitatively using a path analysis.

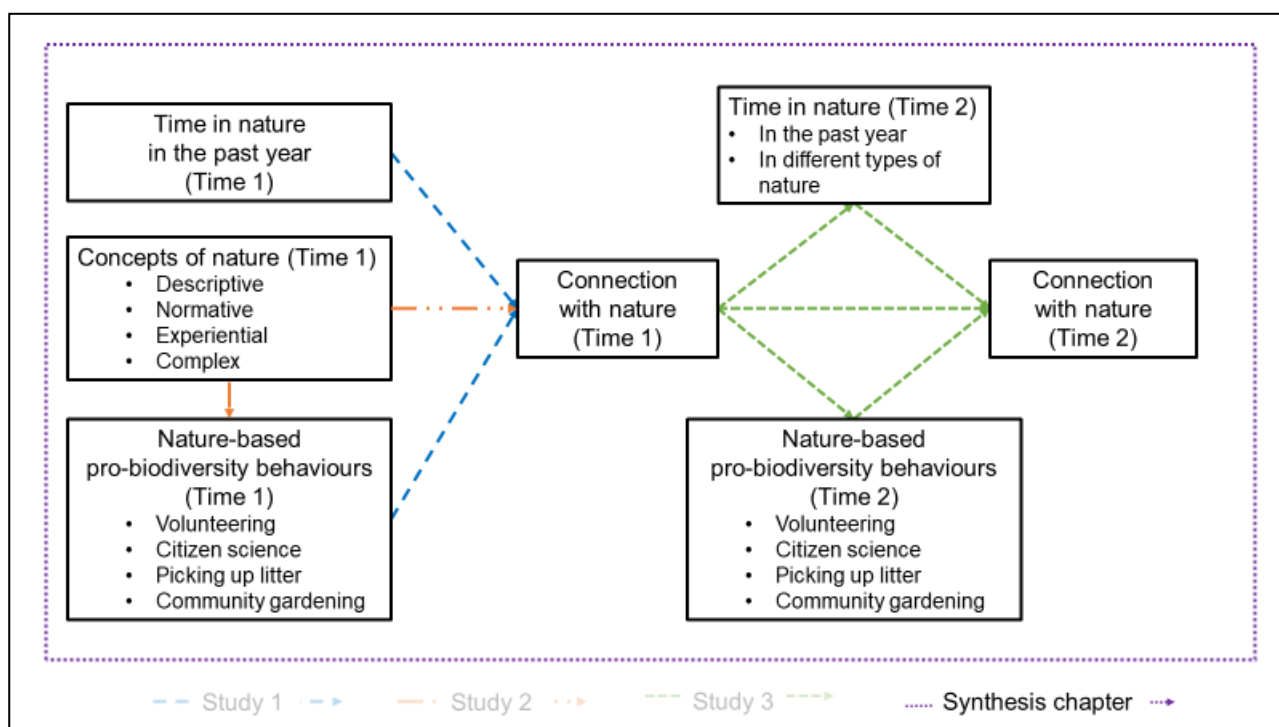


Figure 17: Conceptual framework for this thesis showing elements included in the path analysis

Method

Data from the *Victorians Valuing Nature Foundations Survey* (Time 1) and the *Victorians Valuing Nature Follow-up Survey* (Time 2) were used for the path analysis ($N = 1069$). Thirty-two participants were excluded due to missing concepts of nature data, resulting in $n = 1037$.

Data screening

Data for the two CN variables (CN at Time 1 and CN at Time 2) were screened for univariate outliers and ten cases removed (z scores ± 3.29). Following Tabachnick and Fidell (2007), data were screened for multivariate outliers using linear regression, with respondentID as the

dependent variable and the 13 variables to be included in the path analysis as independent variables; cases with Mahalanobis distance greater than or equal to 34.53 were removed ($n = 17$). There were no cases with standardized residuals greater than 3.29. Inspection of P-P and ZPRED*ZRESID plots suggested the assumptions of normality of residuals, linearity, and homoscedasticity (respectively) were met, while there was no evidence of multicollinearity.

Data analysis

IBM SPSS AMOS Version 26 (Arbuckle, 2019) was used to construct and analyse the model. Only variables that were statistically significant predictors in earlier chapters were entered into the model (e.g. volunteering and picking up litter at Time 2 but not citizen science or community gardening at Time 2). To explore the potential contribution of individual concepts of nature categories, the single concepts of nature variable was dummy coded into three variables (descriptive, normative, experiential); the complex category was excluded due to the strong correlation with the descriptive category ($r_s = -0.855$, $p < 0.001$)⁹. The maximum likelihood estimation method was used (Tabachnick & Fidell, 2007). Standardized regression weights are shown in Figure 18. The final sample was $n = 1010$.

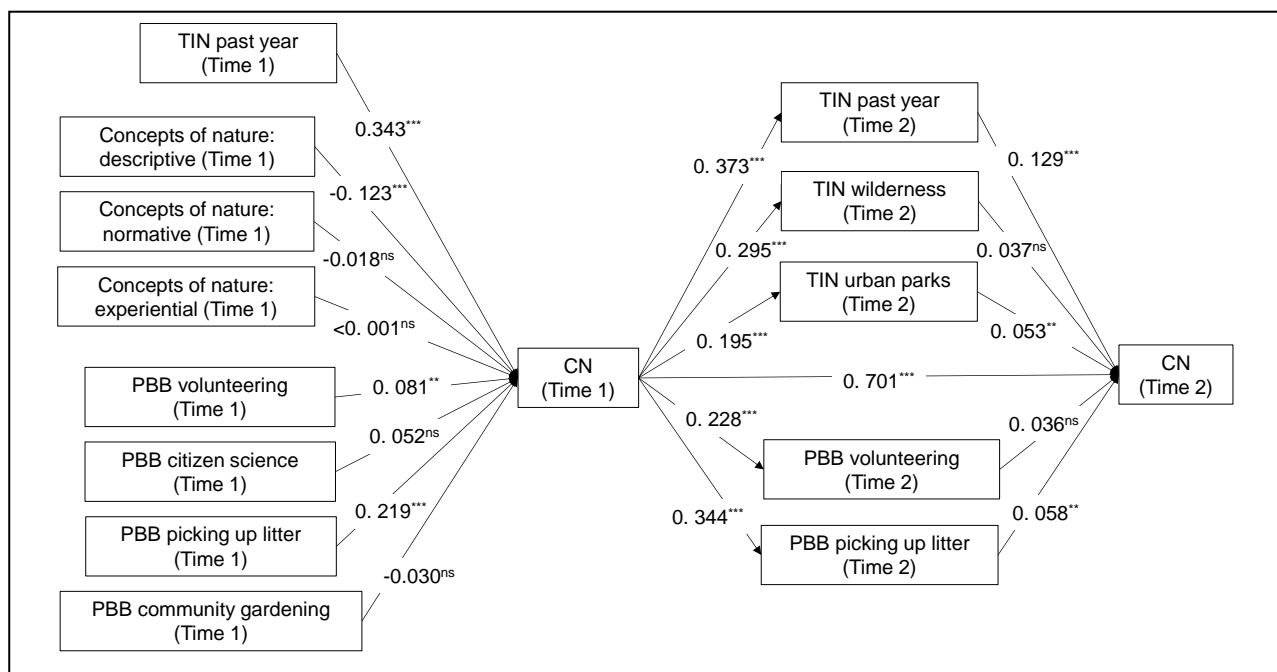


Figure 18: Results of path analysis showing standardized regression coefficients (*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; ^{ns} $p > 0.05$)

⁹ The strong correlation between descriptive and complex categories was due to the complex category comprising a combination of the descriptive, normative, and/or experiential categories.

Results

The strongest predictor of CN at Time 1 was time spent in nature in the past year ($\beta = 0.343$, $p < 0.001$) followed by picking up litter ($\beta = 0.219$, $p < 0.001$) and environmental volunteering ($\beta = 0.081$, $p < 0.001$). Citizen science was statistically significant at the 0.1 level ($t = 1.831$, $p = 0.067$, $\beta = 0.054$). The descriptive concepts of nature category was negatively related to CN at Time 1 ($\beta = -0.123$, $p < 0.001$).

Results also suggest that CN at Time 1 predicted time spent in nature – generally, in wilderness/protected areas, and in urban parks – during the following year (TIN past year (Time 2): $\beta = 0.373$, $p < 0.001$; TIN wilderness (Time 2: $\beta = 0.295$, $p < 0.001$; TIN urban parks: $\beta = 0.195$, $p < 0.001$). Further, CN at Time 1 predicted environmental volunteering ($\beta = 0.228$, $p < 0.001$) and picking up litter ($\beta = 0.344$, $p < 0.001$) in the following year.

Finally, the strongest relationship of the model was between CN at Time 1 and CN at Time 2 ($\beta = 0.701$, $p < 0.001$). Further, relationships between TIN, some PBB, and CN at Time 2 were similar to those at Time 1, with time spent in nature (generally: $\beta = 0.129$, $p < 0.001$) and in urban parks ($\beta = 0.053$, $p < 0.01$), as well as picking up litter ($\beta = 0.058$, $p < 0.01$) each predicting CN at Time 2. Time spent in wilderness/protected areas ($t = 1.919$, $p = 0.055$) and environmental volunteering ($t = 1.890$, $p = 0.059$) were significant at the 0.1 level.

Considering variances explained, the amount of variance accounted for in CN at Time 2 was relatively large (66.0%), most of which is attributable to CN at Time 1. In contrast, the amount of variance accounted for by the remaining variables in the model was generally quite small (Table 4). These results are discussed in the following chapter.

Table 4: Variances explained for key variables in the model

Variable	R^2
CN (Time 1)	0.191
Time spent in urban parks in the past year (Time 2)	0.038
Time spent in wilderness/protected areas in the past year (Time 2)	0.087
Time spent in nature in the past year (Time 2)	0.139
Picking up litter in the past year (Time 2)	0.119
Environmental volunteering in the past year (Time 2)	0.052
CN (Time 2)	0.660

Chapter 9: Discussion and conclusions

The overarching aim for this research was to better understand CN, and its relationships with TIN, concepts of nature, and nature-based PBB among adults living in Victoria, Australia. Four objectives were proposed:

1. Explore and clarify dimensions of CN; develop a brief yet parsimonious self-report connection with nature instrument; investigate relationships between CN, TIN, and PBB (Study 1);
2. Explore concepts of nature, and investigate relationships between concepts of nature and CN, and concepts of nature and nature-based PBB (Study 2);
3. Explore whether TIN and nature-based PBB contribute to change in CN over time (Study 3);
4. To test the overall conceptual framework (synthesis chapter).

Objective 1: Explore and clarify dimensions of CN; develop a brief yet parsimonious self-report connection with nature instrument; investigate relationships between CN, TIN, and PBB (Study 1)

Throughout the literature, CN is generally considered a trait-like multidimensional construct. While a number of models have been proposed to capture the emotional, cognitive, and behavioural aspects of CN (e.g. Schultz, 2001; Zylstra et al., 2014), the dimensional structure of CN remains unclear (Restall & Conrad, 2015; Tam, 2013). In an analysis of seven commonly used self-report CN instruments, Tam (2013) reported a high degree of overlap between the instruments, proposing that "there are multiple aspects or dimensions of connection to nature, each of which has its own unique conceptual meanings but at the same time shares a substantial overlap with other aspects that warrants an identification of a common core" (p. 74). Study 1, therefore, sought to explore and clarify the dimensions of CN using a self-report questionnaire (Meis-Harris et al., 2019) developed to capture the five dimensions, or "types", of CN proposed by Ives and colleagues (2017, 2018): philosophical, emotional, cognitive, experiential, and material.

Two existing multidimensional CN instruments – the Environmental Identity Scale (EID: Clayton, 2003; see also Olivos & Aragonés, 2011) and the Nature Relatedness Scale (NR: Nisbet et al., 2009) comprise three common dimensions that broadly overlap with those proposed by Ives et al. (2017, 2018) (Table 5). These two instruments were, therefore, included to compare and validate the identified dimensions.

Table 5: Possible CN dimensions, captured by existing multidimensional CN instruments.

CN dimensions (Ives et al., 2017, 2018)	Environmental Identity (Clayton, 2003; Olivos & Aragonés, 2011)	Nature Relatedness (Nisbet et al., 2009)
<i>Philosophical</i>	<i>EID-Environmentalism</i>	<i>NR-Perspective</i>
Perspective or worldview on what nature is, why it matters, and how humans ought to interact with it (e.g., master, participant, steward); perspectives on humanity's relationship to the natural world.	A perspective or ideology capturing commitment to, and behaviour toward, the natural environment	A worldview; a sense of agency regarding human behaviour and its impact on the natural environment
<i>Emotional</i>	<i>EID-Environmental identity</i>	<i>NR-Self</i>
Feelings of attachment to or empathy towards nature; emotional attachments and affective responses in relation to nature.	Self-identification and belonging represented by a sense of attachment or empathy, and thoughts about nature	An internal perspective or identity that includes emotions and thoughts about nature
<i>Cognitive</i>		
Knowledge or awareness of the environment and attitudes/values towards nature; knowledge, beliefs, and attitudes in relation to nature.		
<i>Experiential</i>	<i>EID-Enjoying nature</i>	<i>NR-Experience</i>
Direct interaction with natural environments (e.g., parks, forests); recreational activities in green environments.	Direct experience of nature and the pleasure associated with nature-based experiences	Desire to spend time in – and seeking out – nature, awareness of and fascination with nature
<i>Material</i>	–	–
Consumption of goods/materials from nature (e.g., food, fibre); resource extraction and use.		

The results of Study 1 suggested a three-dimensional model of CN, encompassing CN-Identity, CN-Experience, and CN-Philosophy. That scores were relatively stable over a 12-month period indicates that Study 1 captured trait-like CN. The three dimensions broadly overlap with four of the five dimensions proposed by Ives et al. (2017, 2018), although with the emotional and cognitive dimensions represented together by CN-Identity. Results also suggested moderate-to-strong

correlations ($r_s = 0.52$ to $r_s = 0.82$) between these three dimensions and corresponding dimensions captured by the EID and NR (CN-Identity, EID-Identity, NR-Self; CN-Experience, EID-Enjoying nature, NR-Experience; CN-Philosophy, EID-Philosophy, NR-Perspective [Appendix B: Table B2]). Thus, these three dimensions appear pivotal "types" of trait-like CN.

CN-12 dimensions

The three dimensions of the CN-12 broadly represent thoughts, feelings, and behaviours in relation to nature. As was defined in Study 1

CN-Identity includes cognitive, emotional, and behavioral elements, including self-perception as someone who feels emotionally connected to nature and who behaves in such a way as to protect nature. CN-Experience represents a sense of enjoyment, wellbeing, and belonging associated with activities undertaken in the natural environment. The CN-Philosophy dimension embodies ideas around humanity's relationship with nature, including a sense of interconnectedness between humans and nature." (Hatty et al., 2020, p. 10).

These three dimensions conceptually align with those captured by the EID and NR (Table 5).

While the three dimensions are distinct, it is important to note that there is also commonality between them, as evidenced by the moderate to strong correlations between dimensions ($r_s = 0.61$ to $r_s = 0.82$ [Appendix B: Table B1]). CN-Identity incorporates a sense of belonging to, and emotional bonding with, nature that is captured by items such as *I feel a strong emotional connection to nature*. A notion of bonding overlaps with the sense of interconnectedness and relationship that is a feature of CN-Philosophy, represented by items such as *Human beings and nature are connected by the same 'energy' or 'life-force'*. The CN-Experience dimension also includes elements of connection, captured via items such as *Feeling connected to nature helps me deal with everyday stress*. Similarly, CN-Identity includes a sense of motivation to spend time in nature, captured by items such as *I feel uneasy if I am away from nature for too long*. The CN-Experience dimension captures thematically similar notions of a drive to spend time in nature and enjoyment from such experiences, captured by items such as *I like to get outdoors whenever I get the chance*. Thus, while this research identified distinctions between the CN dimensions, as well as different patterns of relationships between dimensions and some PBB (see, for example, pages 135, 141, and 145), the overlap between the dimensions should also be noted. Nurturing an overall a sense of CN may, therefore, be most effective when considering individual dimensions as well as the associations between them.

Interrelationships between CN dimensions have been discussed elsewhere. Ives and colleagues (2018) propose that the different CN dimensions are likely to influence each other, and suggest that "many interventions relating to strengthened connections to nature need to occur in concert, because they can be expected to interact" (p. 6). Recent research by Riechers et al. (2020) reported interrelationships between the five dimensions proposed by Ives et al. (2018). The emotional and experiential dimensions in particular had multiple links to other dimensions, and could therefore be useful targets for strengthening other dimensions "through ripple effects" (Riechers et al., 2020, p. 6). In their conception of the different pathways to CN, Richardson and colleagues (2020) propose that "the pathways to nature connectedness rarely work alone. Sensory contact involves noticing beauty, it elicits emotions, brings meaning and can involve care for nature" (p. 395). The authors also suggest that the pathways of emotion and compassion could be particularly useful targets to nurture CN (see also Lumber et al., 2017). Together, these findings suggest that in order to foster an overall sense of trait-like CN, focusing on emotional *and* experiential aspects of human relationships with nature could be particularly useful.

Such notions are further supported by the results of Study 1. Consistent with existing literature (Nisbet et al., 2009; Olivos & Aragonés, 2011), the CN-Identity dimension accounted for the most variance of the CN construct ($\beta = 0.99$ [Study 1], $\beta = 0.97$ [Study 2]), followed by CN-Experience ($\beta = 0.93$ [Study 1], $\beta = 0.95$ [Study 2]) and CN-Philosophy ($\beta = 0.78$ [Study 1], $\beta = 0.80$ [Study 2]). This suggests that nurturing a sense of identity in relation to nature (CN-Identity, a dimension that includes emotional connection with nature) – in concert with experiences in and of nature (CN-Experience) – are likely to be important. In addition, identity theory suggests that identities can be influenced by context, and tend to become more salient when the identity is accessible and fits the context (Burke & Stets, 2009; Clayton, 2012; McConnell et al., 2012). CN-Identity may, therefore, be most salient when actually experiencing the natural environment. Kunchambo et al. (2021) argue that "an individual's relationship with nature is...mostly experienced in real-time" (p. 486), while contextual factors such as weather (e.g. Duffy & Verges, 2010; Talebpour et al., 2020) and the type of environment (e.g. urban vs natural: Mayer et al., 2009) have also been shown to influence CN. The natural environment itself does, therefore, appear to be a particularly important context for nurturing CN-Identity (Clayton, 2012; Prévot, Clayton, et al., 2018), reinforcing the notion of nurturing CN-Identity in conjunction with CN-Experience.

Time in nature and CN

Consistent with prior research (e.g. Cleary et al., 2018; Dornhoff et al., 2019), the findings of Study 1 also found that frequency of time spent in nature was moderately correlated with CN (total and dimensions). The results also suggested strong correlations between perceptions about spending time in nature (e.g. "I spend as much time in nature as possible") and CN, further emphasising the

important role of spending time in nature to develop and/or maintain a stable, trait-like CN (see also discussion of Study 3 on page 144). Recent work by Wesselmann et al. (2021) suggested that priming people to think about their relationship with nature (e.g. activities they enjoy doing outside) can increase CN, thus perhaps actually experiencing nature acts as a similar prime, particularly if one is actively engaged with nature while spending time in it (e.g. Richardson, Hamlin, et al., 2021).

Some years ago, Davis and colleagues (2009) noted that respondents who were primed to think about their relationship with nature had higher self-reported PEB and were more likely to agree to participate in a future environmental volunteering activity than people in the control condition. More recently, Martin et al. (2020) reported a positive relationship between spending time in nature and PEB, and that the relationship between CN and PBB was stronger for people who actively spent time in nature at least once per week compared with those who spent time in nature less often. Thus, spending time in nature (context) appears important for both nurturing CN as well as increasing the likelihood of PBB/PEB.

Pro-biodiversity behaviours and CN

Within the CN literature, there have been calls to better understand how CN may be usefully applied to environmental policy and management, including how different dimensions of CN may relate to different pro-environmental outcomes (Abson et al., 2017; Balundé et al., 2019; Ives et al., 2017; Restall & Conrad, 2015). In responding to such calls, Study 1 explored how different CN dimensions related to different PBB/PEB.

Results suggested that CN-Identity was more strongly correlated with some PBB – such as environmental volunteering, citizen science, picking up litter, and community gardening – than the CN total score. Fostering a sense of identity in relation to nature (CN-identity) could, therefore, be more useful for encouraging these PBB than nurturing other types of CN, such as experiences relative to nature (CN-Experience) or perspectives of humanity's relationship with nature (CN-Philosophy). While the cross-sectional nature of the analysis prevents inference of causality, CN-Identity could be a driver of these behaviours. Identity relative to nature has been shown to influence PEB and PEB intentions (e.g. Lokhorst et al., 2014; Schmitt et al., 2019), perhaps by facilitating a greater sense of personal responsibility and commitment to care for nature (Clayton, 2012; Kunchamboo et al., 2021). Indeed, peoples' inner worlds – including their emotions, beliefs, and identities – could function as an important leverage point for pro-environmental behaviour change (Ives et al., 2019). As Korach and McConnell (2021, p. 2) suggest "protecting nature requires more than having positive attitudes toward the environment – it requires integrating nature

into one's self-concept". Equally, participating in these behaviours may also influence CN-Identity, as discussed below (page 145).

Summary – Study 1 contribution to knowledge

The primary objective of Study 1 was to examine and clarify the dimensions of CN, and to investigate relationships between CN, TIN, and PBB (Figure 19).

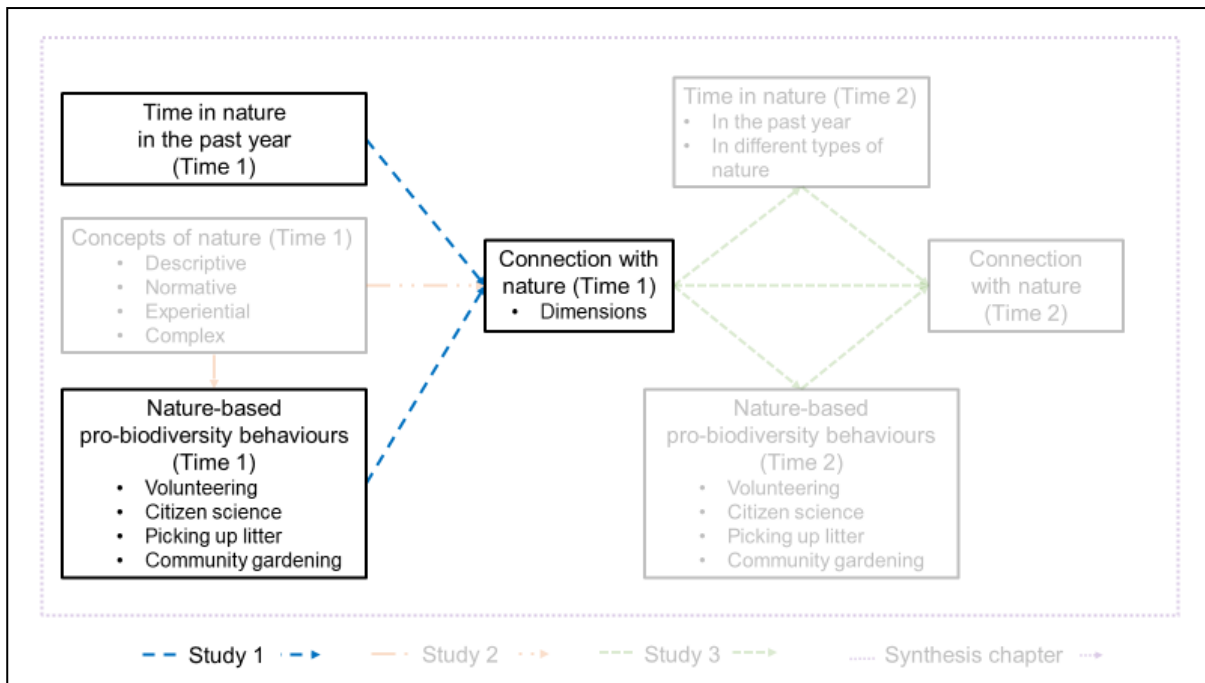


Figure 19: Conceptual framework, with elements included in Study 1 highlighted.

A comparison of the five-dimensional model of CN proposed by Ives et al. (2017, 2018) with two existing multidimensional self-report CN instruments (Clayton, 2003; Nisbet et al., 2009) suggested at least three possible dimensions (Table 5). Analyses revealed the dimensions of CN-Identity, CN-Experience, and CN-Philosophy appear to be important types of CN. Results also indicated that the CN-12 is related to existing multidimensional CN instruments, and retains its multidimensional structure despite being significantly shorter than existing instruments. The CN-Identity dimension accounted for the most variance of the CN construct, followed by CN-Experience, suggesting that interventions to nurture a sense of identity in relation to nature could be useful targets for enhancing CN, particularly if such interventions occur while actually experiencing the natural environment. Nurturing CN-Identity may also help to facilitate participation in some PBB.

Objective 2: Explore concepts of nature, and investigate relationships between concepts of nature and CN, and concepts of nature and nature-based PBB (Study 2)

A topic rarely considered in the CN literature is what the term "nature" refers to or means to those who feel connected to (or disconnected from) it. The concept of "nature" has an extensive history, with linguistic origins traced to ancient Greece, Rome, and China (Ducarme & Couvet, 2020). Modern definitions of nature are complex, ambiguous, and contested, with the term "nature" being used to refer to a vast array of elements, entities, and processes (Clayton & Opatow, 2003; Ducarme & Couvet, 2020; Mcphie & Clarke, 2018). Indeed, some have argued that the sheer breadth of different meanings of "nature" largely nullifies the term's utility as a means of explaining or describing phenomena (Ducarme & Couvet, 2020; Simberloff, 2014). Yet, "nature" is an ubiquitous concept (Ducarme et al., 2020) and thus understanding how people interpret and use the term has important implications for both connection with nature, and the conservation and management of natural areas. Understanding "nature" was, therefore, a focus of Study 2.

Three broad categories of concepts of nature were identified (Figure 20). The descriptive category broadly captures names or labels of elements within nature, such as animals, landscapes, and waterways, as well as general terms such as outdoors, rural, and environment. The normative category depicts ideas of living and growing things, interconnected systems and ecosystems in balance, and notions of nature as essential, precious, and needing protection. The experiential category represents physical experiences in nature, such as camping or hiking, as well as psychological experiences in relation to nature, such as perceptions of beauty, tranquillity, and aesthetic qualities (e.g. colours, sounds, views) as well as emotions such as awe or wonder. These categories are broadly consistent with those described by Buijs and Elands (2013) – what nature is (descriptive), how nature is valued (normative), and how nature is enjoyed (experiential). Similar categories have also been described by Keulartz et al. (2004), Mausner (1996), and van den Born et al. (2001).

The majority of participants ($n = 2290$, 73.14%) described nature using terms from only the descriptive category. Comparatively fewer participants mentioned terms from only the normative ($n = 55$, 1.78%) or experiential ($n = 110$, 3.56%) categories. A fourth category, labelled "complex", included descriptions of nature from two or more of the descriptive, normative, and/or experiential categories (e.g. descriptive + normative; descriptive + normative + experiential), and this was the second most populous category ($n = 587$, 19.49%). These findings are broadly consistent with those of Buijs and Elands (2013), Keulartz et al. (2004), Taylor (2019), and van den Born et al. (2001) and suggest that for most participants, nature is considered in terms of elements or entities within nature.

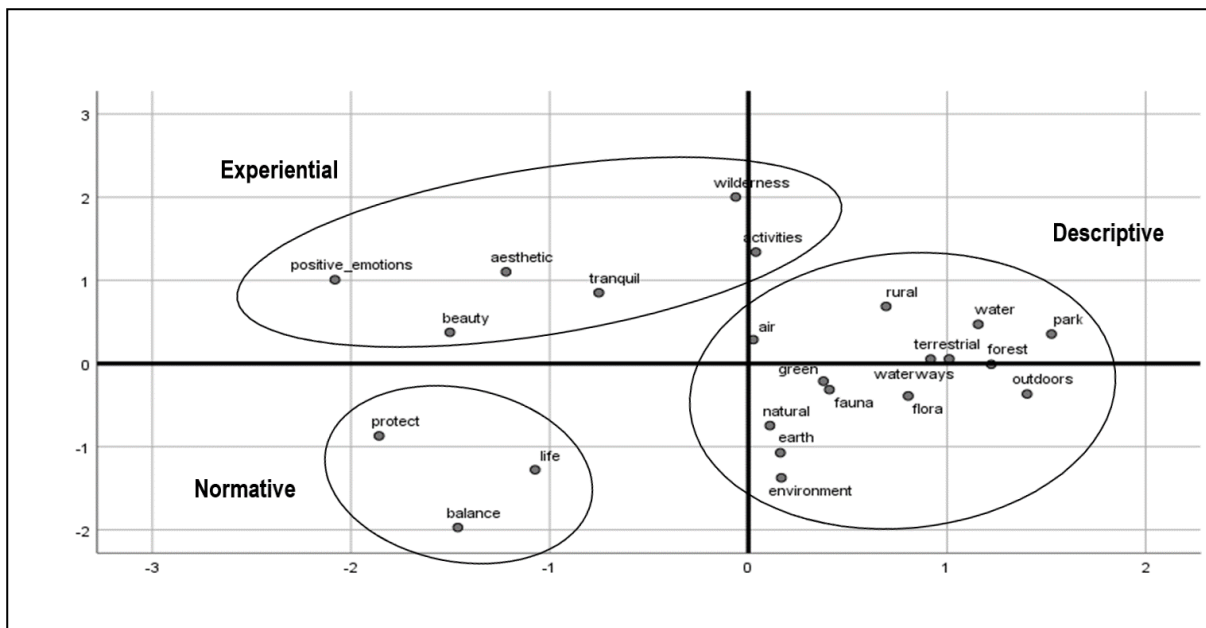


Figure 20: Multidimensional scaling of concepts of nature themes. The three categories (descriptive, normative, and experiential) are circled.

Interestingly, the "wilderness" and "activities" themes appeared close in multidimensional space. In contrast, the "park" (national parks, urban parks, gardens, marine parks) and "waterways" (rivers, lakes, waterfalls, beach, ocean) themes appeared at a greater distance from the "activities" theme (Figure 20). This may suggest that activities in nature are more strongly associated with wilderness or protected areas than with parks or waterways. These findings may present an opportunity for communicating urban and managed nature (i.e. parks and waterways) as places where experiences of nature can occur. This may, in turn, help to foster perceptions that urban and managed spaces are "nature", increase time spent in those areas, and to enhance CN (see also Study 3 on page 144).

Results also suggested that thoughts about nature as "natural" (e.g. untouched, unspoiled, uninhabited, pure, pristine, not made/influenced by humans) were most closely aligned with the descriptive category. This may suggest that for these participants, elements within nature (e.g. trees, forests, landscapes) are considered in a "pure" or "untouched" form that is devoid of human influence. Indeed, previous research has suggested that natural environments that have been altered by human activity are considered less "natural" than environments with less (or no) perceived human influence (Church, 2018; de Groot & van den Born, 2003; McMahan et al., 2016). Further, people may be less likely to support conservation of areas that are considered less natural (McMahan et al., 2016). This points to an opportunity to communicate the diversity of nature, diversity that includes types of "nature" that have been influenced by humans and human activities, as a means of expanding perceptions of what nature is, increasing CN, and potentially also support for, and participation in, conservation.

Relatedly, relatively few participants ($n = 50$, 1.6%) mentioned humans or human products (e.g. personality, science) in their descriptions of nature. This may reflect the general perception that humans and human products are not nature (Mcphie & Clarke, 2018). It has been proposed that perceptions of nature as something that is separate from and doesn't include humans may contribute to disconnection from nature (Andrews, 2018; Clayton & Opatow, 2003; Vining et al., 2008; Zylstra et al., 2014). Thus, interventions to increase perceptions that humans are not only part of nature but *are* nature may be important for increasing CN (see Dickinson, 2013).

Finally, there is a general assumption in the CN literature that human-nature relationships are positive, with very little consideration of biophobia (Mcphie & Clarke, 2018; Olivos-Jara et al., 2020; Ulrich, 1993). In this sample, relatively few respondents ($n = 7$, 0.2%) described nature using negative terms such as boredom, dread, or distress. This may be indicative of sampling bias (see limitations and future research on page 156) or may reflect a general perception of nature as positive. Yet for some, nature is considered in negative terms (e.g. Bixler & Floyd, 1997), thus further research is needed to better understand CN among people who hold negative perceptions of nature (e.g. Olivos-Jara et al., 2020).

Study 2 is among the few studies to date that have considered relationships between concepts of nature, trait-like CN, and PBB. The findings demonstrate that that how people think about nature does in fact relate to their relationship with nature (CN) and behaviours that protect nature (PBB).

Concepts of nature and CN

The results of Study 2 suggested that people who describe nature in experiential or complex terms tended to have higher trait-like CN scores than people who described nature in purely descriptive terms. This is broadly consistent with the findings of Mena-García et al. (2020) who reported associations between descriptions of sensory experiences and reflections on nature with higher CN scores. While causality cannot be inferred from the cross-sectional design, it is possible that people higher in trait-like CN pay more attention to nature (e.g. how it makes them feel, aesthetic qualities, colours or sounds), as suggested by the contact via the senses, beauty, and emotions pathways to CN described by Lumber and colleagues (Lumber et al., 2017; Richardson, Dobson, et al., 2020). Mindfulness has been associated with CN (see Macaulay et al., 2022; Schutte & Malouff, 2018 for reviews) thus perhaps people higher in CN are more mindful in nature and this, in turn, heightens perceptual awareness of the natural environment (Macaulay et al., 2022). In addition, people higher in CN may have a stronger preference for, and feel safer in, "wilder" areas such as forests than people lower in CN (Tang et al., 2015), which may be reflected in descriptions of nature relative to wilderness (experiential concepts of nature).

These findings suggest that how "nature" is communicated and perceived may influence CN. Framing nature relative to experiential concepts (e.g. positive emotions, beauty, tranquillity, activities in nature) or more complex concepts (e.g. nature is trees and forests but is also beautiful and needs protection) may be one means of shifting perceptions away from just what nature "is" (e.g. trees, forests) to also include why it's important, how it's valued, and how it makes us feel. In contrast, Buijs and Elands (2013) suggest that communicating nature in descriptive terms may facilitate greater engagement with nature and conservation, as such terms are what the majority of people understand.

The results of Study 2 also indicated that people who described nature in normative terms tended to have higher CN-Identity scores than people who used descriptive terms. That is, people who describe nature as precious, fragile, needing protection, and/or systems in balance (normative concepts) tend to identify more strongly with nature (higher CN-Identity) than people who merely describe elements within nature such as trees or forests (descriptive concepts). Therefore, interventions to strengthen CN-identity, as discussed above, may help to shift perceptions of nature as fragile systems in balance and needing protection, and this, in turn, may increase support for, and involvement in, conservation.

Concepts of nature and PBB

Study 2 investigated frequency of participation in PBB across concepts of nature categories. Participants who described nature in experiential terms had participated in the four PBB more often in the past year than participants who used descriptive terms. Personal experiences can have a powerful influence on how something is perceived and responded to (van der Linden et al., 2015), thus experiencing nature via conservation activities may facilitate reflection of nature relative to aesthetic qualities, emotional experience, perceptions of tranquillity, or the experience of nature itself (e.g. gardening, planting trees, picking up litter). Likewise, perceiving nature in experiential terms may encourage spending more time in nature, including via nature-based PBB. A bidirectional relationship is also likely, whereby participating in PBB influences concepts of nature, and these concepts then influence future participation in PBB. Communicating nature relative to experiential concepts may, therefore, have a role to play in increasing participation in these PBB.

Emotional experiences of nature, including feelings of awe and wonder, were included in the experiential concepts of nature category. Awe and wonder are generally considered positive experiences and have been associated with perceptions of beauty and peacefulness (Piff et al., 2015; Yaden et al., 2019) – thus it is perhaps unsurprising that these perceptions of nature appeared together in the experiential concepts of nature category. Jordan and Kristjánsson (2017, p. 1217) suggest that "wonder of the natural world is not only associated with feelings of aesthetic

appreciation, rejuvenation, fascination or delight, but...involves being part of something larger than the self, a sense of being part of a complex ecosystem". Indeed, awe and wonder tend to be associated with perceptions of the self as small or insignificant in comparison to something larger, such as the natural environment, which can "significantly alter the self-concept, in ways that reflect a shift in attention toward larger entities and diminishment of the individual self" (Piff et al., 2015, p. 884).

Nurturing feelings of awe and wonder toward the natural environment, and a sense of the self as relatively small compared to nature, may provide a useful means of increasing participation in PBB/PEB (McConnell & Jacobs, 2020; Yang et al., 2018; Zelenski & Desrochers, 2021). As Clayton (2021) suggests,

...it may not be an overstatement to say that experiences of nature may be able to increase virtuous behavior, apparently by shifting attention away from the self. It would be only fitting if this virtuous behavior included behaving more sustainably, taking care of the nature that was responsible for the feeling of awe. (p. 20)

Recently, Yang et al. (2018) reported that the relationship between awe and PBB/PEB was mediated by CN thus perhaps the link between positive emotions such as awe and wonder (experiential concepts of nature) and PBB/PEB is via CN.

Concepts of nature as moderator of the CN-PBB relationship

Another novel finding of Study 2 was the moderation effect of concepts of nature between CN and PBB. Specifically, concepts moderated the relationship between CN-Total and picking up litter. For people who described nature in experiential terms, CN did not influence picking up litter (these people may be more inclined to pick up litter anyway, regardless of their CN score). In contrast, among people who described nature in descriptive, normative, and complex terms, the moderation effect was significant; as CN increased, so too did the frequency of picking up litter, such that at relatively high CN-Total scores, frequency of picking up litter was comparable across all four groups. Thus, strategies to enhance CN may be useful for increasing the frequency of picking up litter among people who think about nature in descriptive, normative, or complex terms.

Results not reported in the publication for Study 2 (see Chapter 7, page 110) suggested concepts of nature moderated relationships between the CN dimensions and some PBB. In a similar manner to the CN-Total score, the relationships between CN-Identity and picking up litter and between CN-Experience and picking up litter (but not CN-Philosophy) were moderated by concepts of nature. For those who described nature in descriptive, normative, or complex terms, low CN dimension

scores were associated with less frequent picking up litter, compared with those who described nature in experiential terms. Yet, as CN dimension scores increased, so too did frequency of picking up litter whereby at relatively high CN dimension scores, the frequency of picking up litter was similar across concepts of nature groups. The reverse was also true – as frequency of picking up litter increased, so too did CN-Total, CN-Identity, and CN-Experience (but not CN-Philosophy) among those using descriptive, normative, or complex terms to describe nature, relative to those using experiential terms. Among people who thought about nature in descriptive terms, the relationship between CN (Total, Identity, and Experience) and picking up litter remained relatively weak. These results suggest a mutually reinforcing relationship between CN-Total, CN-Identity, CN-Experience, and picking up litter among those who think of nature relative to descriptive, normative, or complex concepts of nature.

Interestingly, while the moderation effect of concepts of nature between CN-Experience (X) and environmental volunteering (Y) and between CN-Experience (X) and community gardening (Y) were not statistically significant, concepts of nature did moderate the relationship between volunteering (X) and CN-Experience (Y) and between community gardening (X) and CN-Experience (Y). As frequency of volunteering increased, so too did CN-Experience scores but only for people who described nature in descriptive or complex terms. A similar pattern was evident for community gardening. For people who think about nature in descriptive or complex terms, participating in environmental volunteering and community gardening may increase CN-Experience scores, perhaps due to enjoyment of the activity translating into a general sense of enjoyment of and desire to spend time in nature (CN-Experience).

The moderation results highlight a general pattern of relationships between CN and PBB as a function of concepts of nature that have broader implications for conservation. Relationships between CN and PBB are strongest among people who think about nature in experiential terms, thus interventions to increase CN may have minimal impact on frequency of PBB, while increasing PBB may have minimal influence on CN among this group of people. In contrast, for people who describe nature in normative, descriptive, or complex terms, increases in CN are associated with increased frequency of PBB. Thus, interventions to increase CN may increase PBB participation, and increasing PBB participation may increase CN, when targeted to those who consider nature relative to normative, descriptive, or complex concepts of nature. These results highlight the importance of tailoring communications and interventions to specific audiences (Kidd et al., 2019; Rare and BIT, 2019).

Summary – Study 2 contribution to knowledge

Salazar and colleagues (2020) argue that in future CN research, "it will be important to consider the ways in which connecting with nature varies from one place to another, from one way of knowing to another, and from one experience to another" (p. 57). If concepts of nature are considered different ways of knowing nature, there is utility in understanding how CN relates to concepts of nature.

Study 2 contributed to the literature by exploring what comes to mind when people think about nature – their concepts of nature – and how such concepts relate to CN and to PBB (Figure 21).

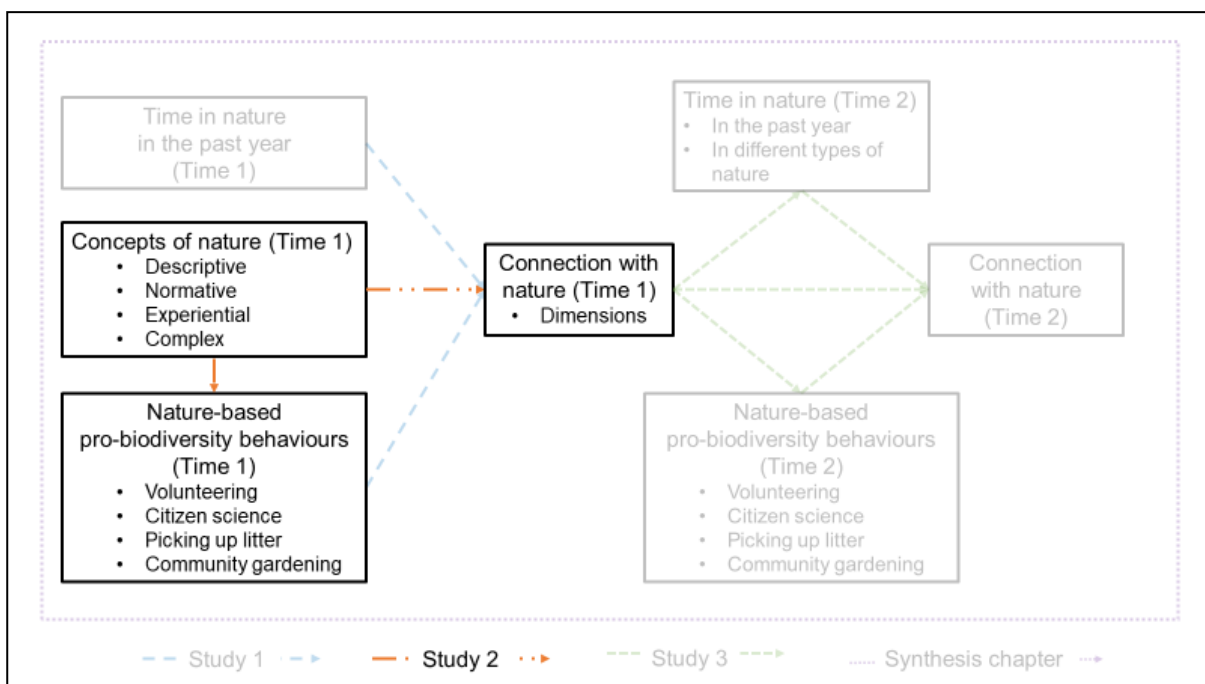


Figure 21: Conceptual framework, with elements included in Study 2 highlighted.

This study was among the few to statistically categorise concepts of nature, reducing potential researcher bias in categorisation. Results suggested that most respondents thought about nature in descriptive terms, while relatively few considered nature in negative terms, or specifically mentioned humans when thinking about nature. The findings also suggest that people in this sample may think of elements within nature (e.g. trees, forests, landscapes) in a "pure" or "untouched" form.

Concepts of nature were related to CN and to PBB, supporting the notion that how people think about nature does in fact relate to their relationship with nature (CN) and behaviours that protect nature (PBB). Thoughts about nature in experiential or complex terms were associated with higher CN scores than descriptive thoughts about nature, while thoughts about nature in experiential

terms were associated with more frequent participation in PBB than descriptive thoughts. Thinking about nature in normative terms was associated with higher CN-Identity than descriptive concepts, while concepts of nature moderated the relationships between CN and picking up litter, between environmental volunteering and CN-Experience, and between community gardening and CN-Experience.

Objective 3: Explore whether TIN and nature-based PBB contribute to change in CN over time (Study 3)

The previous studies highlighted that time spent in nature, and how people think about nature, appear related to CN. If peoples' thoughts about nature differ, then so too may their perceptions of different types of nature, and their subsequent behaviours related to spending time in those different types of nature. Also, given that "nature" is rarely defined in the CN literature, and there is limited understanding of what aspects of nature feel connected to (Giusti et al., 2018; Ives et al., 2017), understanding how and whether different types of nature are important for nurturing CN could be useful. Although understanding of how different types of natural environments, including modified environments such as urban parks, impact CN is limited (Colléony et al., 2017; Restall & Conrad, 2015)

If people do perceive and interact with different types of nature in different ways, this has implications for policies and programs intended to (re)connect people with nature (Davis et al., 2016; de Bell et al., 2018; Pasca et al., 2020; Tang et al., 2015). Further, the previous studies suggested that CN was related to PBB, although most CN research seems to assume that CN is an antecedent to PBB (e.g. Mackay & Schmitt, 2019; Restall & Conrad, 2015; Richardson, Passmore, et al., 2020). The CN-PBB relationship is, however, likely bidirectional (Hamlin & Richardson, 2021), as the moderation results of Study 2 suggested. Thus, a question remains about whether participation in PBB might be a useful avenue for nurturing CN. The focus of Study 3, therefore, was to investigate the role of spending time in nature, in different types of nature, and spending time in nature while engaged in PBB on change in CN over a 12-month period.

Within the CN literature, CN is generally described as a relatively stable trait-like construct that is also malleable relative to influences such as weather patterns and time spent in nature (Clayton, 2003; Duffy & Verges, 2010; Mayer et al., 2009; Mayer & Frantz, 2004). It has also been argued that with repeated experiences in nature, state-like CN becomes trait-like CN (Carr & Hughes, 2021; Chawla, 2020; Clayton, 2017; Clayton et al., 2021; Prévot et al., 2018; Richardson et al., 2020; Salazar et al., 2020; Zelenski et al., 2015). While Study 3 did not specifically assess state-like CN, the findings provide some support for the notion that repeated experiences in nature can increase trait-like CN.

Time spent in nature predicts change in CN over a 12-month period

Study 1 demonstrated that CN captured by the CN-12 is relatively stable over time, while the conceptual framework synthesis (see below, page 148) indicates that the greatest variance in CN at Time 2 is attributable to CN at Time 1. Therefore, any change over a 12-month period, as assessed in Study 3, was expected to be small. Nevertheless, the results of Study 3 did suggest that participants who reported spending more time in nature over the year had slightly higher CN scores at Time 2 than those who reported spending less time in nature. This is consistent with prior literature suggesting that greater frequency of visits to nature (e.g. Cleary et al., 2018; Colley & Craig, 2019; Fränkel et al., 2019) and duration of time spent in nature (e.g. Dornhoff et al., 2019; Fretwell & Greig, 2019) are associated with higher CN. While the effect size was small, these results nonetheless suggest that spending time in nature has a role to play in nurturing and maintaining CN.

The results of Study 3 also suggested that more time spent in wilderness or protected areas, and more time spent in urban parks, was associated with slightly higher CN scores at Time 2. Previous research has suggested that spending time in natural areas with higher natural values (more biodiversity) may be more important for nurturing CN than time in areas with lower natural values (less biodiversity) (e.g. Mena-García et al., 2020; Schultz & Tabanico, 2007; Scopelliti et al., 2016). Yet, this research suggests that time spent in natural urban areas is also associated with increased CN. This finding is particularly important in the context of population growth in urban areas (Australian Bureau of Statistics, 2020; United Nations Department of Economic and Social Affairs, 2019). Urban nature is more accessible for a large proportion of the population thus encouraging people to spend time in urban parks may be a relatively easier approach for nurturing CN within these populations than encouraging people into wilderness-type areas.

The small effect sizes and complementary mediation (Zhao et al., 2010) of Study 3 indicate that factors other than simply time in nature are likely important in nurturing and maintaining CN over time. Recent research has highlighted the importance of actively engaging with and noticing nature (e.g. Colléony, Levontin, et al., 2020; Passmore & Holder, 2017; Richardson, Hamlin, et al., 2021) in nurturing CN. Study 3 considered participating in nature-based PBB, such as environmental volunteering and community gardening, as experiences that involve such active engagement with nature.

Participating in nature-based PBB predicts change in CN over a 12-month period

Results suggested that participating in environmental volunteering and picking up litter more often over the 12-month period was associated with higher CN scores at Time 2 compared with CN

scores at Time 1. These findings are consistent with prior research reporting increases in CN scores associated with tree planting (Whitburn, Linklater, & Milfont, 2019), citizen science (Chase & Levine, 2017; Schuttler et al., 2018), and environmental volunteering (Rogerson et al., 2017; Schild, 2018). This suggests that interventions intended to increase participation in volunteering and picking up litter could also increase CN.

There are multiple dimensions or "types" of CN (Ives et al., 2018) and activities that involve activation or nurturing of more than one dimension are likely to be particularly useful for nurturing CN (Carr & Hughes, 2021; Richardson, Dobson, et al., 2020; Zylstra et al., 2014). The current results support this proposition – nature-based activities such as environmental volunteering activate many of the pathways to CN described by Lumber et al. (2017) including meaning, compassion, and contact via the senses (Asah et al., 2014; Asah & Blahna, 2013; Cosquer et al., 2012; Schuttler et al., 2018) thus may be particularly useful mechanisms by which to nurture and maintain CN over time.

Mediation effects of time spent in nature and nature-based PBB

Mediation results suggested that time spent in nature – generally, in protected areas and in urban parks – and time spent in nature while participating in environmental volunteering and picking up litter, indirectly mediated the relationship between CN at Time 1 and CN at Time 2. People higher in CN tended to spend more time in nature (generally, and in protected and urban areas) and to participate in these nature-based PBB more often than people lower in CN, and such activities then appear to have a nurturing effect on trait-like CN. In addition, the mediation results revealed that CN (at Time 1) was a stronger predictor of time spent in nature (Study 3, Figure 1, page 122) and of these nature-based PBB (Study 3, Figure 2, page 124) than PBB and time spent in nature were of CN (at Time 2).

A number of potential mechanisms may account for these relationships. People higher in trait CN may have a stronger sense of interdependence with nature – they are more likely to see themselves as part of nature – thus caring for nature via PBB is a way of caring for the self and the self-environment relationship (Schultz, 2002). Active awareness of nature while spending time in it, such as when participating in PBB, may be a precursor to activation of the different pathways to CN (Richardson, Hamlin, et al., 2021) or may increase perceptual sensitivity to the surrounding environment, thus enhancing CN via the sensory contact and/or beauty pathways to CN (Lumber et al., 2017; Macaulay et al., 2022). Spending time in nature may also decrease the extent to which a person focuses on how others perceive them – their public self-awareness – which may, in turn, increase CN (Lengieza & Swim, 2021; Mayer et al., 2009).

Summary – Study 3 contribution to knowledge

Spending time in nature has been recognised as an important mechanism by which to nurture and maintain CN over time, although the role of different types of nature has not been thoroughly investigated. It has been suggested that time spent in "wilder" and more biodiverse natural environments, such as national parks, may be more useful for nurturing trait-like CN than time spent in "managed" and less biodiverse environments, such as urban parks (e.g. Mena-García et al., 2020; Scopelliti et al., 2016). The findings of Study 3 suggest that while spending time in wilderness/protected areas can help to maintain CN over time, so too can spending time urban parks. In addition, while research to date had tended to assume that CN is an antecedent to PBB (e.g. Mackay & Schmitt, 2019), the results of Study 3 suggest that the frequency of participating in PBB, such as environmental volunteering and picking up litter, can have a positive influence on CN (Figure 22), although while also recognising that CN appears to be a stronger predictor of PBB than PBB is of CN. Finally, these findings provide some support for the notion that repeated experiences in nature can help to nurture trait-like CN (e.g. Chawla, 2020).

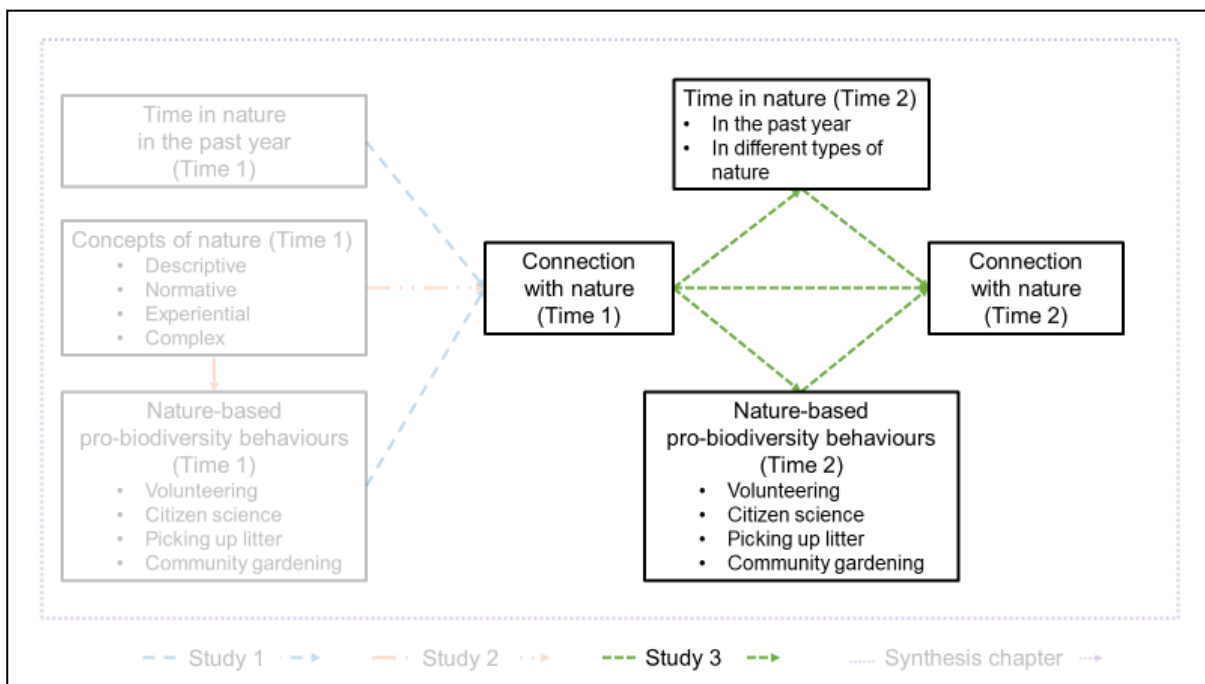


Figure 22: Conceptual framework, with elements included in Study 3 highlighted.

Objective 4: To test the conceptual framework

The final objective of this thesis was to assess the conceptual framework in its entirety, as illustrated in Figure 23.

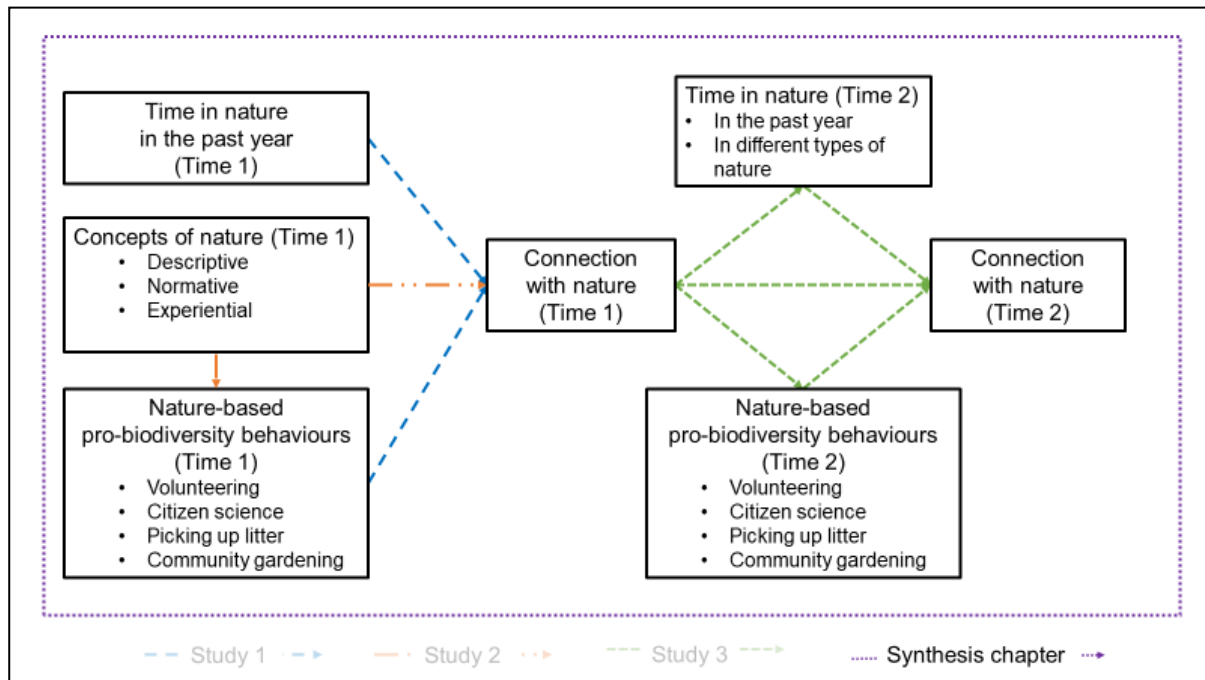


Figure 23: Entire conceptual framework for this thesis highlighting elements included in the path analysis.

The results of the path analysis provided insights into factors influencing the development and maintenance of CN over time (Figure 24). The strongest predictors of CN at Time 1 were spending time in nature in the past year ($\beta = 0.343$), picking up litter ($\beta = 0.220$), and environmental volunteering ($\beta = 0.081$). Participating in citizen science was a significant predictor at the 0.1 level ($t = 1.831$, $p = 0.067$, $\beta = 0.054$). Thus, encouraging these behaviours is likely to play a useful role in nurturing CN. In addition, there was a negative relationship between the descriptive concepts of nature category and CN at Time 1 ($\beta = -0.123$) suggesting that thinking about nature in purely descriptive terms is associated with lower CN scores.

Once CN is established, a number of reinforcement behaviours could be encouraged to maintain CN over time. Spending time in nature ($\beta = 0.129$), spending time in urban parks ($\beta = 0.053$), picking up litter ($\beta = 0.058$) (captured at Time 2) each made small but significant contributions to CN at Time 2. Spending time in wilderness/protected areas ($t = 1.919$, $p = 0.055$, $\beta = 0.037$) and environmental volunteering ($t = 1.890$, $p = 0.059$, $\beta = 0.036$) were significant at the 0.1 level.

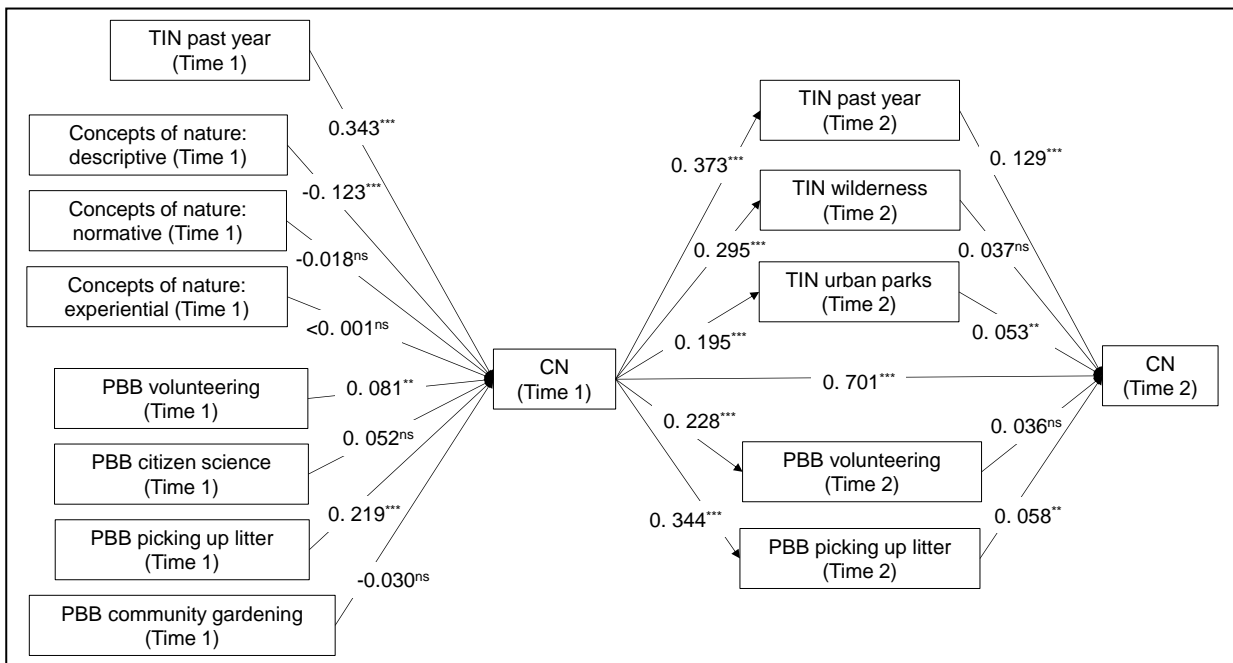


Figure 24: Results of path analysis showing standardized regression coefficients (^{***} $p < 0.001$; ^{**} $p < 0.01$; ^{*} $p < 0.05$; ^{ns} $p > 0.05$)

Another notable finding of the path analysis relates to the relationships between CN at Time 1 and CN at Time 2. CN at Time 1 was the strongest predictor of CN at Time 2 ($\beta = 0.701$), highlighting the stability of CN over time. CN at Time 1 also predicted time spent in nature – generally ($\beta = 0.373$), in wilderness/protected areas ($\beta = 0.295$), and urban parks ($\beta = 0.195$) – as well as environmental volunteering ($\beta = 0.228$) and picking up litter ($\beta = 0.344$) at Time 2. Thus, while participating in nature-based PBB is likely to provide some influence on the development of CN (e.g. litter at Time 1 to CN at Time 1: $\beta = 0.219$; volunteering at Time 1 to CN at Time 1: $\beta = 0.081$), once CN is developed, it becomes a stronger influence on nature-based PBB (CN at Time 1 to litter at Time 2: $\beta = 0.344$; CN at Time 1 to volunteering at Time 2: $\beta = 0.228$).

These results suggest a mutually reinforcing relationship between time spent in nature and CN, and between PBB and CN (e.g. Martin et al., 2020; Oh et al., 2021; Prévot, Clayton, et al., 2018; Rosa & Collado, 2019), although with CN a stronger predictor of time spent in nature and PBB than time spent in nature and PBB are of CN. Thus, people higher in CN appear to seek out time in nature to a greater extent than people lower in CN (e.g. Cox et al., 2018; Lin et al., 2014; Oh et al., 2021; Soga & Akasaka, 2019), and this time in nature appears to reinforce CN. People higher in CN also appear to seek out nature-based PBB (e.g. Ganzevoort et al., 2017; Guiney & Oberhauser, 2010) and participating in such PBB then reinforces CN (Rogerson et al., 2017; Schild, 2018).

The amount of variance accounted for across the different variables in the path analysis were generally quite small (Table 6). This suggests there are a number of other factors, not included in this framework, that contribute to these variables (e.g. what people do while they're in nature, individual characteristics). The one exception is CN at Time 2 – 66.0% of the variance is accounted for, and most of this is due to CN at Time 1, again highlighting the stability of CN over time.

Table 6: Variances explained for variables in the path analysis.

Variable	R^2
CN (Time 1)	0.191
Time spent in urban parks in the past year (Time 2)	0.038
Time spent in wilderness/protected areas in the past year (Time 2)	0.087
Time spent in nature in the past year (Time 2)	0.139
Picking up litter in the past year (Time 2)	0.119
Environmental volunteering in the past year (Time 2)	0.052
CN (Time 2)	0.660

Implications for conservation policy

Protecting Victoria's Environment – Biodiversity 2037 is the Victorian state government's 20-year plan to slow and reverse biodiversity destruction across the state (DELWP, 2017). Within the *Victorians Value Nature* goal of *Biodiversity 2037* is the statewide target to have all Victorians connecting with nature by 2037. The findings of this research can usefully inform policies and interventions to achieve this statewide target. Broadly, policies and programs could target nurturing identity relative to nature in conjunction with experiences in and of nature; how nature is communicated, thought of, and understood; designing natural spaces that encourage spending time in nature, as well as reflection on, and active engagement with, nature; and encourage participation in nature-based PBB.

Identity relative to, and experiences of, nature

The results of Study 1 suggest that the CN-Identity and CN-Experience dimensions accounted for the most variance of the CN construct, and are also strongly correlated ($r_s = 0.82$). The CN-Identity dimension captures a sense of emotional attachment and belonging, and a perception of the self in relation to nature that includes behaviours that take care of nature; the CN-Experience dimension represents a drive to spend time in nature, and a sense of enjoyment, comfort, and wellbeing associated with experiences of nature. To nurture an overall sense of trait-like CN, therefore, interventions could focus on enhancing this sense of identity in relation to nature, with a particular

focus on strategies that nurture a sense of identity while actually experiencing nature. Given the stability of CN over time, interventions may be particularly useful when targeted toward young people, as doing so is likely to facilitate an enduring trait-like CN into adulthood (Giusti et al., 2018; Sachs et al., 2020).

Context can be an important influence on identity (Burke & Stets, 2009; Clayton, 2012; McConnell et al., 2012) thus the natural environment is likely an important context for influencing identity in relation to nature. Priming people to think about their relationship with nature (Wesselmann et al., 2021) and prompts to smell or touch nature (Colléony, Levontin, et al., 2020) have been associated with higher CN scores, thus direct experiences of nature may serve as a prime to reflect on one's relationship with nature, particularly when cues to actively engage with nature are also used. Furness (2021) argues that experiences of nature may facilitate a sense of belonging and feeling part of a larger system (CN-Identity), which could translate into a greater felt sense of CN. Further, recent work by Riechers et al. (2020) identified emotional and experiential CN to be predominant dimensions, with these two dimensions also having multiple links to other CN dimensions. Thus, nurturing CN-Identity (emotional CN) while directly experiencing nature (experiential CN) could provide a mechanism by which to nurture other dimensions of CN (see Riechers et al., 2020).

Communicating "nature"

The findings of Study 2 suggested that people who think about nature in experiential or more complex terms tend to have higher CN scores than people who think about nature in purely descriptive terms. Further, those who described nature in experiential terms had participated in nature-based PBB more often in the previous year than those who used only descriptive terms. In addition, the results of the path analysis suggested a negative relationship between purely descriptive thoughts about nature and CN at Time 1. These preliminary findings suggest that how nature is communicated is an area for future empirical investigation that may, in turn, usefully inform conservation policy.

Nature framed in experiential or complex terms – that nature is not only forests, animals, and landscapes but also beautiful and peaceful, full of awe and wonder, and a context in which to engage in a range of enjoyable activities – could play a role in nurturing and maintaining CN. Encouraging people to think about nature in such terms may also encourage more time spent in nature, and inspire greater participation in nature-based PBB. As Ives et al. (2019) suggest, a shift in language has the potential to change beliefs, and may also drive changes in behaviour.

Designing communication campaigns that encourage people to think about nature in all its diversity – including the various forms of urban nature, such as street trees, urban parks, and roadside

verges – may also be useful. People in industrialised societies tend to think about nature as pristine wilderness and remote landscapes that are separate from the human experience, rather than nature found in urban areas (Clayton, 2019; Taylor, 2019, 2021). Similarly, there is often a perception that "wilder" spaces, such as national parks, tend to be more "natural" (Church, 2018). Such perceptions of nature as separate or distant from humans may, however, be contributing to disconnection from nature and to ongoing environmental destruction (Andrews, 2018; Clayton & Opatow, 2003; Vining et al., 2008; Zylstra et al., 2014).

Yet, "nature" is everywhere. Pets, pot plants, and gardens; urban parks and golf courses; zoos, botanic gardens, and aquaria; beaches, lakes, and rivers; as well as large scale and protected areas are all "nature" (Clayton & Myers, 2009; Frumkin et al., 2016; Keniger et al., 2013; McPhie & Clarke, 2018). Macaulay et al. (2022) argue that perceptions of nature that are limited to wilder-type spaces can prevent engagement with the pathways to CN (e.g. if nature is only wilderness, people may not recognise the beauty of nature in urban areas), thus communicating nature in all its diversity may challenge such limited perceptions. Similarly, people could be encouraged to think of the conservation of nature as more than just protecting "pristine" wilderness or remote locations, but also conservation of other types of nature, including urban spaces (Ducarme & Couvet, 2020; Dunn et al., 2006; Sato et al., 2021).

Another important consideration is how such communications are tailored to specific audiences. Recent research suggests that those who have greater familiarity with, and exposure to, nature in their daily lives tend to view "nature" relative to wilder spaces and landscapes while those living in urban areas with less daily experience of nature tend to have a broader perception of what "nature" is – and that includes nature found in urban areas (Tomasso et al., 2021). Considering also that people of different cultural and language backgrounds tend to think of nature differently (Buijs et al., 2009; Coscieme et al., 2020; Taylor, 2021), messages must be tailored to the specific audience (Kidd et al., 2019).

Encouraging people to think about nature close to their homes may also promote more time spent in nature, which is likely to then increase CN. One way to encourage people to think about nature close to their homes may be rethinking how natural spaces are designed, particularly in urban areas.

Design of natural spaces

The relationships between concepts of nature, CN, and nature-based PBB reported in Study 2 and the conceptual framework synthesis highlight the potential utility of policies that specifically address how natural spaces are designed. Well-designed urban spaces that incorporate natural elements

can provide opportunities for both incidental and intentional experiences of nature (Beery et al., 2017; Church, 2018) which have been associated with higher CN (Cox et al., 2017; Shanahan et al., 2017) as well pro-environmental attitudes and behaviour (Alcock et al., 2020; Dean et al., 2019; Martin et al., 2020). Urban planners should incorporate different types of natural spaces – including streetscapes, waterways, community gardens, pop-up parks, and larger urban parks and forests – into the planning process to encourage spending time in, and actively engaging with nature in urban areas (Church, 2018; Lev et al., 2020; Mata et al., 2019). People may feel more connected to natural areas that seem "wilder" (Meis-Harris et al., 2019; Tomasso et al., 2021), thus increasing urban forests (e.g. City of Melbourne, 2012) may also be important for nurturing trait-like CN.

In addition, the relationship between experiential concepts of nature and higher CN scores (Study 2) suggest that natural spaces should be designed to encourage reflection on or about nature, including emotional responses, aesthetic qualities (e.g. colours, scents), and a sense of tranquillity. Mindful engagement with nature increases awareness of surroundings and has also been linked to greater CN (Choe et al., 2020; Nisbet et al., 2019), and the observing part of mindfulness seems particularly useful for nurturing CN as well as PEB (Barbaro & Pickett, 2016). Natural spaces that invite and encourage mindful and active engagement through activities such as taking photographs, smelling flora, watching birds and insects, or that encourage quiet personal reflection could be useful (McEwan et al., 2020; Richardson, Hamlin, et al., 2021; Richardson & Sheffield, 2015). Incorporating food plants into urban parks may be another way of encouraging active engagement with nature (Colding et al., 2020; Palliwoda et al., 2017), while initiatives to encourage urban agriculture (Kingsley et al., 2021) and urban foraging (Schunko & Brandner, 2021) may also be useful. Initiatives such as the City of Melbourne's allocation of an email address for each tree (e.g. Burin, 2018) could be another means of encouraging reflection on, appreciation of, and connection to, nature.

To accompany how natural spaces are designed, policies should target the development and use of specific initiatives that facilitate active engagement and reflection while actually in natural spaces. For example, using smartphone apps (Cameron et al., 2020; McEwan et al., 2019, 2020; see also Jepson & Ladle, 2015), noticing and reflecting on the good things in nature (Richardson & Sheffield, 2017), or prompts (Colléony, Levontin, et al., 2020) have been shown to encourage active engagement with nature. Planned programs and activities, such as those that occur through outdoor education programs and forest schools (e.g. Cudworth & Lumber, 2021; Kuo et al., 2019; Pirchio et al., 2021) are also important. Such initiatives may help to nurture both CN-Experience and encourage more time spent in nature.

Contact with nature using the senses has been identified as one pathway to CN that has potential utility at a societal level (Lumber et al., 2017; Richardson, Dobson, et al., 2020). While research

investigating human sensory experience of nature tends to focus on vision, other senses are also important during experiences of nature (Franco et al., 2017); recent work, for example, suggested that smells may be an important mechanism by which to nurture CN (Truong et al., 2020). Designing and installing sensory or therapeutic gardens (Souter-Brown, 2015) or interactive immersion exhibits (Pan et al., 2020; Pennisi et al., 2017) could be a useful means of encouraging active, multisensory engagement with nature. Further, sensory experience is linked to emotional experience (see Franco et al., 2017 for review) thus encouraging time in nature that involves multiple senses and reflection on emotional aspects of nature could target multiple dimensions of CN and/or activate multiple pathways which may further enhance CN (Carr & Hughes, 2021; Richardson, Dobson, et al., 2020; Zylstra et al., 2014). As Richardson and colleagues (2021) note, "policies to improve access and encouraging people to spend time *in* nature is a good thing, but for the maximum benefits there is a clear need to encourage people to spend time *with* nature" (p. 7).

While well-designed natural spaces may encourage time spent in, and engagement with, nature, merely providing access to natural spaces does not necessarily lead to spending time in those spaces (Lin et al., 2014; Soga et al., 2018). In industrialised societies, direct experience of nature in urban areas is relatively rare, with one UK study reporting that 75% of experiences of nature involved only 32% of the population (Cox et al., 2017). Data from Study 3 aligns with this, with one quarter of respondents ($n = 267$) reporting that they had spent time in nature only twice or less in the past year, while one fifth ($n = 206$) reporting time in nature monthly in the past year. Another recent study using GPS data to track urban greenspace use suggested that most experiences of nature were incidental (i.e. traveling through, rather than spending time in, a natural area) and less than 10 minutes duration (Mears et al., 2021). Thus, understanding the barriers to spending time in nature, and how different barriers impact different population groups, is important. Barriers such as competing responsibilities, lack of time, negative attitude toward nature or lack of interest, social or cultural factors, or structural/contextual issues such as lack of transport or appropriate facilities (D'amore, 2016; Soga et al., 2018; Wright & Matthews, 2015) have been identified. Such barriers may be addressed by designing natural spaces in consultation with community members.

Community members have a greater sense of ownership over urban spaces, and are more likely to see that space as an asset, when actively involved in the planning of that space (Mullenbach et al., 2019). Further, psychological ownership increases the likelihood of stewardship behaviours, such as picking up litter (Peck et al., 2021; Preston & Gelman, 2020). Providing opportunities for community members to become involved in local stewardship activities is particularly important for people who do not have access to private natural spaces such as backyards (Church, 2018). Thus, policy processes that actively include citizens in the design, implementation, and management of natural spaces may be useful for increasing time spent in those areas, and may also facilitate the development or maintenance of CN as well as participation in nature-based PBB.

Participation in nature-based pro-biodiversity behaviours

A final implication for conservation policy is to ensure policies and programs are designed that maximise participation in nature-based PBB. The results of Study 3 and the conceptual framework synthesis suggest that environmental volunteering and picking up litter in public natural areas could be particularly useful PBB to encourage. The Victorian state government's *Environmental Volunteering Plan* (DELWP, 2021a) is one such initiative that could be further expanded, particularly with the application of a behavioural science lens.

Behavioural science offers a wealth of theoretical models, frameworks, and strategies for understanding and influencing behaviour. In designing interventions to increase nature-based PBB, such knowledge could be applied to develop targeted interventions for specific population groups and nature-based PBB (e.g. BehaviourWorks Australia, 2021; BVA Nudge Unit, 2021; Hagger et al., 2020; Rare and BIT, 2019).

For example, activities such as picking up litter are relatively quick and simple, and require minimal time or commitment. Policies that target social norms (e.g. picking up litter is what everyone does), context (e.g. providing portable rubbish containers and hand sanitiser), or perceived behavioural control (e.g. picking up litter is easy to do) could be useful (Curtis et al., 2021; Darnton, 2008; Farrow et al., 2017; Klöckner, 2013). Communicating picking up litter as a meaningful or compassionate action of nature stewardship may also help to foster CN (Lumber et al., 2017; Wyles et al., 2017) and reinforce the behaviour. Further, leveraging the extensive body of literature describing drivers and barriers to environmental volunteering (e.g. Asah et al., 2014; Asah & Blahna, 2013; Bruyere & Rappe, 2007; Caissie & Halpenny, 2003; Domroese & Johnson, 2017; Hobbs & White, 2012; Hoye et al., 2020; Kingsley et al., 2019; Maund et al., 2020; McDougale et al., 2011; Measham & Barnett, 2008; Merenlender et al., 2016) will also be important.

Implications for conservation policy at the national and international levels

Biodiversity conservation policies at the national and international levels have, to date, focused largely on awareness raising (e.g. Australian Government, 1996; CBD Secretariat, 2012; United Nations, 1992), with some recent efforts considering the importance of access to nature (CBD Secretariat, 2021a). Yet, such policies are insufficient. While awareness raising has a role to play in conservation, such strategies must be accompanied by policies that target behaviour change, and particularly behaviours that either directly contribute to the protection and enhancement of biodiversity and/or that nurture CN. Policies that recognise the importance of access to, and spending time in, nature are also useful (e.g. Australian Government, 2019) although these must

be extended to facilitate nurturing of human relationships with nature (Richardson, 2021; Richardson, Hamlin, et al., 2021).

This research provides guidance for nurturing human-nature relationships, through fostering a sense of identity relative to nature while actually experiencing nature, language used to describe and communicate nature, spending time in nature, and nature-based PBB. These findings must also be applied while considering the unique needs, values, and beliefs of individual population groups (Curtis et al., 2021; Kidd et al., 2019), including different typologies of human-nature relationships (e.g. MacDonald et al., 2019; Marais-Potgieter & Thatcher, 2020). These findings should also be incorporated into policies with concrete measures and targets – such as the proportion of the population with a strong connection with nature, or participating in nature-based PBB, as is included in the Victorian State Government's *Biodiversity 2037* (DELWP, 2017).

Limitations and future research

A number of methodological and conceptual limitations of this research should be noted. First, participants were recruited using a panel survey company and while the sample was broadly representative of the Victorian population relative to key demographics (age, gender, metropolitan/regional residence), the sample was not random and may not be representative of the Victorian population on characteristics such as income, education, or household composition (Meis-Harris et al., 2019). Further, research using online panel samples may be subject to data quality concerns, such as sampling and response biases (Callegaro et al., 2014; Pennay et al., 2018). Relatedly, participants self-selected to complete both surveys, thus it is possible this group of people had a greater interest in the natural environment than may be present in the general population. Indeed, mean CN scores (total and dimensions) at both time points were relatively high and negatively skewed (Appendix C), suggesting a possible ceiling effect.

A second limitation relates to how nature-based PBB were defined. This research assumed that the activities of environmental volunteering, citizen science, picking up litter, and community gardening typically occurred while actually in the physical presence of nature, although this might not necessarily be the case. Environmental volunteering, for example, may include nature-based activities such as planting trees and clearing weeds, yet may also include indoor or online activities that do not involve direct contact with nature (Winch et al., 2020). Relatedly, the four activities broadly encompass categories of behaviour rather than specific behaviours, thus there could be great deal of variation in the behaviours that fall within each category. Research using intervention or experimental methodologies is needed to better understand the relationships between nature-based PBB, CN, TIN, and concepts of nature.

A third limitation relates to the manner in which PBB and TIN were measured. Participants were asked to reflect on the frequency of behaviours over the previous 12-month period, yet the accuracy of such reflections may be limited by memory or cognitive biases (e.g. Pogrebna et al., 2021). In addition, broadly classified types of nature, such as a "zoo, wildlife park, or botanical garden" do not consider nuances in the qualities of such spaces (e.g. amount or type of biodiversity) that may influence time spent in, or the responses to, such spaces.

A final limitation relates to the conceptual framework. The framework included a number of factors that contribute to the development and/or maintenance of CN, such as time spent in nature and participation in nature-based PBB (Figure 23). Yet, the results of the path analysis suggested there are other factors, not included in the framework, that may account for variance within the CN-TIN-PBB relationships. The explanatory power of the model may be increased with the inclusion of additional factors, such as other CN dimensions, connections to specific types of nature, or what people do while they're in nature. As noted in Chapter 1 (page 22), CN has also been associated with individual characteristics such as personality traits, mindfulness, and wellbeing thus inclusion of such factors may also increase the explanatory power of the model.

Study 1 identified three dimensions of CN – Identity, Experience, and Philosophy – yet, other potential dimensions of CN also warrant investigation. Research suggests that aesthetic appreciation of nature could be another dimension of CN (Clayton, 2003; Lumber et al., 2017; Olivos & Aragonés, 2011; Richardson, Dobson, et al., 2020) while material connections discussed by Ives et al. (2017, 2018) may also be important. Relatedly, peoples' connection to nature may differ depending on the type (e.g. urban vs marine) or geographic location of nature (Klaniécki et al., 2018; Meis-Harris et al., 2019), thus further research is needed to better understand peoples' relationships with these different types and locations of nature.

As has been noted, spending time in nature is an important element of nurturing CN, yet it is increasingly being recognised that what people do while they're in nature may be a more important consideration in nurturing CN. Activities that involve active, rather than passive, engagement with nature appear important for the development and maintenance of CN (e.g. Colléony, Levontin, et al., 2020; Richardson, Hamlin, et al., 2021; Richardson & McEwan, 2018) yet these elements were not given full consideration here. The present studies considered participation in nature-based PBB as experiences of nature that involve active engagement with nature, although this was inferred by the activity rather than explicitly assessed. Further work is needed that considers how and why specific aspects of a nature-based activity relate to CN and concepts of nature. In addition, what people do while they're in nature may also be related to concepts of nature – people who describe nature in experiential terms may, for example, be more likely to notice nature and to active engage

with nature (Lumber et al., 2017; Richardson, Dobson, et al., 2020) – and further work is needed to better understand this.

The present research highlighted a number of other avenues for future research. First, understanding of negative perceptions of nature and "biophobia", particularly in the context of CN, are currently lacking (Olivos-Jara et al., 2020; Ulrich, 1993). This may be particularly relevant in the context of ongoing environmental destruction – for example, how CN is understood and expressed relative to polluted landscapes (Clayton, 2021) or fears about complex global issues such as biodiversity destruction or climate change (Chawla, 2020). Second, understanding of CN among different ethnic and cultural groups is also lacking (Ives et al., 2017; Sedawi et al., 2021; Zylstra et al., 2014), which may have implications for how CN and biodiversity conservation are communicated and understood. Third, there has been limited research considering the mechanisms by which CN may facilitate PBB/PEB (Mackay & Schmitt, 2019), or indeed how PBB/PEB may facilitate CN. Finally, the relationships between state-like and trait-like CN warrant further investigation. While it has been argued that repeated experiences of nature (state-like CN) are needed to nurture an enduring relationship with nature (trait-like CN) (e.g. Chawla, 2020; Clayton et al., 2021; Richardson, Dobson, et al., 2020), further work is needed to understand the relationship between state-like and trait-like CN. For example, what frequency, duration, type, or intensity of experiences of nature are needed for specific population groups (e.g. Richardson, Passmore, et al., 2021; Salazar et al., 2020; White et al., 2019).

Finally, it is worth reiterating that biodiversity destruction is a complex "wicked problem", and as such, solutions to address it are far from simple (Game et al., 2014). CN and PBB are potentially useful targets, yet more research is needed to understand the role that such individual-level factors may play in the in the transformational system-level changes that are needed to address the drivers and pressures (e.g. habitat loss, over-exploitation of resources, systems of agriculture, patterns of consumption: WWF, 2020) of biodiversity destruction on a global scale. Research to identify which PBB have the most impact on biodiversity outcomes is still in its infancy (e.g. Barbett et al., 2020; Maynard et al., 2020; Selinske et al., 2020), while the role of behaviour change interventions in conservation more broadly is "still largely unevaluated and undervalued" (Selinske et al., 2021, p. 11). Further, while relationships between CN and PBB/PEB are now well established (e.g. Mackay & Schmitt, 2019; Richardson, Passmore, et al., 2020), more work is needed to understand whether enhancing CN at individual and/or societal levels can subsequently influence system-level factors driving biodiversity destruction.

Summary and conclusions

Biodiversity destruction is a global issue that is threatening human civilizations as we currently know them. As a wicked problem, biodiversity destruction is exceedingly complex yet overwhelmingly the product of human behaviour, and a vast array of policies and interventions targeting behaviour – across multiple levels of intervention – are needed to slow and to reverse the detrimental impacts of human activities. Public support and involvement are essential if future conservation efforts are to succeed, and one means by which to involve the public is by nurturing human relationships with nature, and specifically trait-like CN.

People who have stronger relationships with nature do more to protect nature, thus nurturing CN has an important role to play in biodiversity conservation and management. The utility of enhancing CN across human populations is increasingly being recognised as a potentially useful policy lever, although there remains a great deal of scope for policymakers to include CN and interventions to enhance CN to improve biodiversity conservation outcomes.

While the CN literature has grown exponentially in recent decades, a thorough understanding of the CN construct and how it may be applied to conservation policy is currently lacking. With an applied focus, this research contributed to ongoing debates in the literature by investigating the dimensional structure of CN and developing a brief yet multidimensional self-report instrument; by exploring understandings of "nature" relative to CN and nature-based PBB; and by examining the influence of time spent in nature – generally, in different types of nature, and while participating in PBB – on change in CN over a 12-month period.

The CN construct comprises at least three dimensions – CN-Identity, CN-Experience, and CN-Philosophy – with the identity dimension a central component of the construct. CN, as captured by the CN-12 instrument – is stable over time, indicating trait-like qualities, and is correlated with TIN and PBB/PEB. The CN-Identity dimension is more strongly related to PBB including environmental volunteering, citizen science, picking up litter, and community gardening than the CN-Total score. Nurturing CN-Identity across the population does, therefore, have the potential to facilitate stronger relationships with nature and to increase participation in some PBB which may, in turn, improve biodiversity conservation outcomes.

How people think about and understand nature – their concepts of nature – is associated with how they relate to it. Most people think about nature in purely descriptive terms, such as tree, forest, river, or animal. Yet, those who think about nature in experiential terms – including activities in or emotions in response to nature, perceptions of beauty, tranquillity, or aesthetic qualities – tend to have higher trait-like CN scores and to participate in nature-based PBB more often than people

who think about nature in purely descriptive terms. People who think about nature in more complex terms, for example, a combination of descriptive and experiential terms, also tend to have higher CN scores than those who use only descriptive terms. How people think about nature also influences the relationships between CN and some PBB. For example, for people who think about nature in experiential terms, any increase in (already high) CN is not associated with change in frequency of picking up litter. In contrast, among people who think about nature in descriptive, normative, or complex terms, increases in CN are associated with greater frequency of picking up litter. Policies and programs that communicate nature relative to experiential or more complex concepts, and that encourage active engagement with natural spaces, could play a useful role in nurturing CN, as well as increasing participation in some PBB.

The frequency of time spent in nature is associated with increases in CN scores over a 12-month period. People who spend more time in nature – generally, in wilderness/protected areas, and in urban parks – tend to have slightly higher trait-like CN scores at the end of the 12-month period than people who spend less time in nature. In addition, people who participate in environmental volunteering and picking up litter more often also tend to have slightly higher CN scores than people who do these PBB less often. Further, people higher in CN tend to spend more time in nature – generally, in protected areas, and in urban parks – and be involved with environmental volunteering and picking up litter more often than people lower in CN. Such activities also appear to have a nurturing effect on trait-like CN. Thus, strategies that encourage more time in nature – including in urban parks – as well as engagement in environmental volunteering and picking up litter may help nurture and maintain CN among the Victorian population.

The conceptual framework synthesis provides insights into the interrelationships between the variables included in this research. The strong relationship between CN at Time 1 and CN at Time 2 highlights the stability of CN over time, again suggesting trait-like qualities. Spending time in nature and picking up litter play important roles in both the development and maintenance of CN over time. Further, there appears to be reciprocal relationships between time spent in nature and CN, and between PBB and CN. Thus, interventions that encourage spending more time in nature, including while participating in nature-based PBB, are likely to increase CN which may, in turn, further increase participation in these activities.

The findings of this research highlight a number of useful targets for conservation policy aimed at nurturing trait-like CN in the Victorian population. Policies and programs should be developed that foster a sense of identity relative to nature, with a particular focus on interventions that develop CN-Identity while actually experiencing the natural environment. Policies should consider how nature is communicated and understood, with a particular emphasis on communicating experiential and more complex concepts of nature. Natural spaces, particularly in urban areas, should be

designed to encourage reflection on, and active engagement with nature. Policies should also maximise participation in nature-based PBB, and particularly environmental volunteering and picking up litter. Together, such policies and interventions may usefully contribute to target of having all Victorians connecting with nature by 2037.

References

- Aaron, R. F., & Witt, P. A. (2011). Urban students' definitions and perceptions of nature. *Children, Youth and Environments*, 21(2), 145–167.
<https://www.jstor.org/stable/10.7721/chilyoutenvi.21.2.0145>
- Abraham, C., & Denford, S. (2020). Design, implementation, and evaluation of behavior change interventions: A ten task guide. In M. S. Hagger, L. D. Cameron, K. Hamilton, N. Hankonen, & T. Lintunen (Eds.), *The Handbook of Behavior Change* (pp. 269–284). Cambridge University Press.
- Abson, D. J., Fischer, J., Leventon, J., Newig, J., Schomerus, T., Vilsmaier, U., von Wehrden, H., Abernethy, P., Ives, C. D., Jager, N. W., & Lang, D. J. (2017). Leverage points for sustainability transformation. *Ambio*, 46(1), 30–39. <https://doi.org/10.1007/s13280-016-0800-y>
- Adams, S., & Savahl, S. (2015). Children's perceptions of the natural environment: a South African perspective. *Children's Geographies*, 13(2), 196–211.
<https://doi.org/10.1080/14733285.2013.829659>
- Alcock, I., White, M. P., Pahl, S., Duarte-Davidson, R., & Fleming, L. E. (2020). Associations between pro-environmental behaviour and neighbourhood nature, nature visit frequency and nature appreciation: Evidence from a nationally representative survey in England. *Environment International*, 136, 2–10. <https://doi.org/10.1016/j.envint.2019.105441>
- Amel, E., Manning, C., Scott, B., & Koger, S. (2017). Beyond the roots of human inaction: Fostering collective effort toward ecosystem conservation. *Science*, 356, 275–279.
<https://doi.org/10.1016/b978-012091560-6/50013-5>
- Andrews, N. (2018). How cognitive frames about nature may affect felt sense of nature connectedness. *Ecopsychology*, 10(1), 61–71. <https://doi.org/10.1089/eco.2017.0014>
- Arbuckle, J. L. (2019). *SPSS AMOS (Version 26.0)*. IBM SPSS.
- Arbuthnott, K. D., & Sutter, G. C. (2019). Songwriting for nature: increasing nature connection and well-being through musical creativity. *Environmental Education Research*, 25(9), 1300–1318.
<https://doi.org/10.1080/13504622.2019.1608425>
- Ardoin, N. M., DiGiano, M., Bundy, J., Chang, S., Holthuis, N., & O'Connor, K. (2014). Using digital photography and journaling in evaluation of field-based environmental education programs. *Studies in Educational Evaluation*, 41, 68–76. <https://doi.org/10.1016/j.stueduc.2013.09.009>
- Arendt, F., & Matthes, J. (2016). Nature documentaries, connectedness to nature, and pro-environmental behavior. *Environmental Communication*, 10(4), 453–472.
<https://doi.org/10.1080/17524032.2014.993415>
- Aron, A., Aron, E. N., Tudor, M., & Nelson, G. (1991). Close relationships as including other in the self. *Journal of Personality and Social Psychology*, 60(2), 241–253.
<https://doi.org/10.1037//0022-3514.60.2.241>
- Arts, I., Buijs, A. E., & Verschoor, G. (2018). Regimes of justification: competing arguments and the

construction of legitimacy in Dutch nature conservation practices. *Journal of Environmental Planning and Management*, 61(5–6), 1070–1084.

<https://doi.org/10.1080/09640568.2017.1319346>

Asah, S. T., & Blahna, D. J. (2013). Practical implications of understanding the influence of motivations on commitment to voluntary urban conservation stewardship. *Conservation Biology*, 27(4), 866–875. <https://doi.org/10.1111/cobi.12058>

Asah, S. T., Lenentine, M. M., & Blahna, D. J. (2014). Benefits of urban landscape eco-volunteerism: Mixed methods segmentation analysis and implications for volunteer retention. *Landscape and Urban Planning*, 123, 108–113.

<https://doi.org/10.1016/j.landurbplan.2013.12.011>

Australian Bureau of Statistics. (2020). *Australian Historical Population Statistics, 2016*. Cat. No 3105.0.65.001. <https://www.abs.gov.au/AUSSTATS/abs@.nsf/mf/3105.0.65.001>

Australian Government. (n.d.). *Biodiversity conservation*. Biodiversity Conservation. Retrieved May 13, 2020, from <https://www.environment.gov.au/biodiversity/conservation>

Australian Government. (1996). *National strategy for the conservation of Australia's biological diversity*. <http://nrmonline.nrm.gov.au/catalog/mql:2330>

Australian Government. (2010). *Australia's Biodiversity Conservation Strategy 2010-2030*. <http://www.environment.gov.au/biodiversity/publications/australias-biodiversity-conservation-strategy>

Australian Government. (2016). *Report on the review of the first five years of Australia's Biodiversity Conservation Strategy 2010-2030*. <https://www.environment.gov.au/biodiversity/publications/australias-biodiversity-conservation-strategy-five-year-review>

Australian Government. (2019). *Australia's Strategy for Nature 2019-2030*. <https://www.australiasnaturehub.gov.au/national-strategy>

Ballew, M. T., & Omoto, A. M. (2018). Absorption: How nature experiences promote awe and other positive emotions. *Ecopsychology*, 10(1), 26–35. <https://doi.org/10.1089/eco.2017.0044>

Balundé, A., Jovarauskaitė, L., & Poškus, M. S. (2019). Exploring the relationship between connectedness with nature, environmental identity, and environmental self-identity: A systematic review and meta-analysis. *SAGE Open*, 9(2), 1–12.

<https://doi.org/10.1177/2158244019841925>

Bamberg, S., & Möser, G. (2007). Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behaviour. *Journal of Environmental Psychology*, 27(1), 14–25. <https://doi.org/10.1016/j.jenvp.2006.12.002>

Barbaro, N., & Pickett, S. M. (2016). Mindfully green: Examining the effect of connectedness to nature on the relationship between mindfulness and engagement in pro-environmental behavior. *Personality and Individual Differences*, 93, 137–142.

<https://doi.org/10.1016/j.paid.2015.05.026>

- Barbett, L., Stuppel, E., Sweet, M., Schofield, M., & Richardson, M. (2020). Measuring actions for nature - Development and validation of a pro-nature conservation behaviour scale. *Sustainability*, 12(12), 4885. <https://doi.org/10.3390/su12124885>
- Barrable, A., & Booth, D. (2020). Increasing nature connection in children: A mini review of interventions. *Frontiers in Psychology*, 11(March). <https://doi.org/10.3389/fpsyg.2020.00492>
- Barrett, L. F., Mesquita, B., Ochsner, K. N., & Gross, J. J. (2007). The experience of emotion. *Annual Review of Psychology*, 58(1), 373–403. <https://doi.org/10.1146/annurev.psych.58.110405.085709>
- Barthel, S., Belton, S., Raymond, C. M., & Giusti, M. (2018). Fostering children's connection to nature through authentic situations: The case of saving salamanders at school. *Frontiers in Psychology*, 9(JUN), 1–15. <https://doi.org/10.3389/fpsyg.2018.00928>
- Bashan, D., Colléony, A., & Shwartz, A. (2021). Urban versus rural? The effects of residential status on species identification skills and connection to nature. *People and Nature*, 3(2), 347–358. <https://doi.org/10.1002/pan3.10176>
- Baxter, D. E., & Pelletier, L. G. (2019). Is nature relatedness a basic human psychological need? A critical examination of the extant literature. *Canadian Psychology*, 60(1), 21–34. <https://doi.org/10.1037/cap0000145>
- Beery, T. H. (2013). Establishing reliability and construct validity for an instrument to measure environmental connectedness. *Environmental Education Research*, 19(1), 81–93. <https://doi.org/10.1080/13504622.2012.687045>
- Beery, T. H., Raymond, C. M., Kyttä, M., Olafsson, A. S., Plieninger, T., Sandberg, M., Stenseke, M., Tengö, M., & Jönsson, K. I. (2017). Fostering incidental experiences of nature through green infrastructure planning. *Ambio*, 46(7), 717–730. <https://doi.org/10.1007/s13280-017-0920-z>
- Beery, T. H., & Wolf-Watz, D. (2014). Nature to place: Rethinking the environmental connectedness perspective. *Journal of Environmental Psychology*, 40, 198–205. <https://doi.org/10.1016/j.jenvp.2014.06.006>
- BehaviourWorks Australia. (2021). *The Method Book*. <https://www.behaviourworksaustralia.org/the-method-book/>
- Bell, S. L., Wheeler, B. W., & Phoenix, C. (2017). Using Geonarratives to Explore the Diverse Temporalities of Therapeutic Landscapes: Perspectives from "Green" and "Blue" Settings. *Annals of the American Association of Geographers*, 107(1), 93–108. <https://doi.org/10.1080/24694452.2016.1218269>
- Bergstrom, D. M., Wienecke, B. C., van den Hoff, J., Hughes, L., Lindenmayer, D. B., Ainsworth, T. D., Baker, C. M., Bland, L., Bowman, D. M. J. S., Brooks, S. T., Canadell, J. G., Constable, A. J., Dafforn, K. A., Depledge, M. H., Dickson, C. R., Duke, N. C., Helmstedt, K. J., Holz, A., Johnson, C. R., ... Shaw, J. D. (2021). Combating ecosystem collapse from the tropics to the Antarctic. *Global Change Biology*, January, 1692–1703. <https://doi.org/10.1111/gcb.15539>

- Biodivcanada. (2015). *2020 Biodiversity Goals and Targets for Canada*. <https://biodivcanada.chm-cbd.net/2020-biodiversity-goals-and-targets-canada>
- Bixler, R. D., & Floyd, M. F. (1997). Nature is scary, disgusting and uncomfortable. *Environment and Behavior*, 29(4), 443–467.
- Bolzan-de-Campos, C., Fedrizzi, B., & Santos-Almeida, C. R. (2018). How do children from different settings perceive and define nature? A qualitative study conducted with children from southern Brazil / ¿Cómo niños de contextos diferentes perciben y definen la naturaleza? Estudio cualitativo con niños del sur de Brasil. *Psyecology*, 9(2), 177–203. <https://doi.org/10.1080/21711976.2018.1432526>
- Bragg, E. A. (1996). Towards ecological self: Deep ecology meets constructionist self-theory. *Journal of Environmental Psychology*, 16(2), 93–108. <https://doi.org/10.1006/jevp.1996.0008>
- Braitto, M. T., Böck, K., Flint, C., Muhar, A., Muhar, S., & Penker, M. (2017). Human-nature relationships and linkages to environmental behaviour. *Environmental Values*, 26(3), 365–389. <https://doi.org/10.3197/096327117X14913285800706>
- Braun, T., & Dierkes, P. (2017). Connecting students to nature - how intensity of nature experience and student age influence the success of outdoor education programs. *Environmental Education Research*, 23(7), 937–949. <https://doi.org/10.1080/13504622.2016.1214866>
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp063oa>
- Brügger, A., Kaiser, F. G., & Roczen, N. (2011). One for all?: Connectedness to nature, inclusion of nature, environmental identity, and implicit association with nature. *European Psychologist*, 16(4), 324–333. <https://doi.org/10.1027/1016-9040/a000032>
- Brulle, R. J. (2010). From environmental campaigns to advancing the public dialog: Environmental communication for civic engagement. *Environmental Communication*, 4(1), 82–98. <https://doi.org/10.1080/17524030903522397>
- Bruni, C. M., Chance, R. C., Schultz, P. W., & Nolan, J. M. (2012). Natural connections: Bees sting and snakes bite, but they are still nature. *Environment and Behavior*, 44(2), 197–215. <https://doi.org/10.1177/0013916511402062>
- Bruni, C. M., Winter, P. L., Schultz, P. W., Omoto, A. M., & Tabanico, J. J. (2015). Getting to know nature: evaluating the effects of the Get to Know Program on children's connectedness with nature. *Environmental Education Research*, 23(1), 43–62. <https://doi.org/10.1080/13504622.2015.1074659>
- Bruyere, B., & Rappe, S. (2007). Identifying the motivations of environmental volunteers. *Journal of Environmental Planning and Management*, 50(4), 503–516. <https://doi.org/10.1080/09640560701402034>
- Buijs, A. E. (2009). Lay people's images of nature: Comprehensive frameworks of values, beliefs, and value orientations. *Society and Natural Resources*, 22(5), 417–432. <https://doi.org/10.1080/08941920801901335>

- Buijs, A. E., & Elands, B. H. M. (2013). Does expertise matter? An in-depth understanding of people's structure of thoughts on nature and its management implications. *Biological Conservation*, 168, 184–191. <https://doi.org/10.1016/j.biocon.2013.08.020>
- Buijs, A. E., Elands, B. H. M., & Langers, F. (2009). No wilderness for immigrants: Cultural differences in images of nature and landscape preferences. *Landscape and Urban Planning*, 91(3), 113–123. <https://doi.org/10.1016/j.landurbplan.2008.12.003>
- Buijs, A. E., Fischer, A., Rink, D., & Young, J. C. (2008). Looking beyond superficial knowledge gaps: Understanding public representations of biodiversity. *International Journal of Biodiversity Science and Management*, 4, 65–80. <https://doi.org/10.3843/Biodiv.4.2>
- Buijs, A., Hovardas, T., Figari, H., Castro, P., Devine-Wright, P., Fischer, A., Mouro, C., & Selge, S. (2012). Understanding people's ideas on natural resource management: Research on social representations of nature. *Society and Natural Resources*, 25(11), 1167–1181. <https://doi.org/10.1080/08941920.2012.670369>
- Bujold, P. M., Williamson, K., & Thulin, E. (2020). *The science of changing behavior for environmental outcomes: A literature review*. <https://behavior.rare.org/literature-review/>
- Burin, M. (2018). *People from all over the world are sending emails to Melbourne's trees*. ABC News. <https://www.abc.net.au/news/2018-12-12/people-are-emailing-trees/10468964?nw=0&r=HtmlFragment>
- Burivalova, Z., Butler, R. A., & Wilcove, D. S. (2018). Analyzing Google search data to debunk myths about the public's interest in conservation. *Frontiers in Ecology and the Environment*, 16(9), 509–514. <https://doi.org/10.1002/fee.1962>
- Burke, P. J., & Stets, J. E. (2009). *Identity Theory*. Oxford University Press / USA. <https://doi.org/10.1093/acprof:oso/9780195388275.003.0017>
- BVA Nudge Unit. (2021). *Applying & Infusing Behavioral Science* (S. Young & E. Singler (Eds.)). BVA Nudge Unit. <https://bvanudgeunit.com/book/>
- Caissie, L. T., & Halpenny, E. A. (2003). Volunteering for nature: Motivations for participating in a biodiversity conservation volunteer program. *World Leisure Journal*, 45(2), 38–50. <https://doi.org/10.1080/04419057.2003.9674315>
- Callegaro, M., Villar, A., Krosnick, J., & Yeager, D. (2014). A critical review of studies investigating the quality of data obtained with online panels. In M. Callegaro, R. Baker, J. Bethlehem, A. Goritz, J. Krosnick, & P. Lavrakas (Eds.), *Online Panel Research: A Data Quality Perspective* (pp. 23–53). John Wiley & Sons. <http://openaccess.city.ac.uk/1189/>
- Cameron, R. W. F., Brindley, P., Mears, M., McEwan, K., Ferguson, F., Sheffield, D., Jorgensen, A., Riley, J., Goodrick, J., Ballard, L., & Richardson, M. (2020). Where the wild things are! Do urban green spaces with greater avian biodiversity promote more positive emotions in humans? *Urban Ecosystems*, 23(2), 301–317. <https://doi.org/10.1007/s11252-020-00929-z>
- Cane, J., O'Connor, D., & Michie, S. (2012). Validation of the theoretical domains framework for use in behaviour change and implementation research. *Implement Science*, 7(37), 37.

<https://doi.org/10.1186/1748-5908-7-37>

- Capaldi, C. A., Dopko, R. L., & Zelenski, J. M. (2014). The relationship between nature connectedness and happiness: A meta-analysis. *Frontiers in Psychology*, 5(AUG), 1–15. <https://doi.org/10.3389/fpsyg.2014.00976>
- Capaldi, C. A., Passmore, H.-A., Ishii, R., Chistopolskaya, K. A., Vowinckel, J., Nikolaev, E. L., & Semikin, G. I. (2017). Engaging with natural beauty may be related to well-being because it connects people to nature: Evidence from three cultures. *Ecopsychology*, 9(4), 199–211. <https://doi.org/10.1089/eco.2017.0008>
- Capaldi, C., Passmore, H.-A., Nisbet, E., Zelenski, J., & Dopko, R. (2015). Flourishing in nature: A review of the benefits of connecting with nature and its application as a wellbeing intervention. *International Journal of Wellbeing*, 5(4), 1–16. <https://doi.org/10.5502/ijw.v5i4.449>
- Carr, V., & Hughes, J. (2021). Predicting the development of adult nature connection through nature activities: Developing the evaluating nature activities for connection tool. *Frontiers in Psychology*, 12(March), 1–12. <https://doi.org/10.3389/fpsyg.2021.618283>
- Convention on Biological Diversity [CBD]. (2018). *Recommendations for increased focus on connecting people with nature to inspire enhanced action on biodiversity conservation*. <https://www.cbd.int/doc/strategic-plan/Post2020/postsbi/C%26nn3.pdf>
- Convention on Biological Diversity [CBD] Secretariat. (2000). *Sustaining life on Earth: How the Convention on Biological Diversity promotes nature and human well-being*. <https://www.cbd.int/doc/publications/cbd-sustain-en.pdf>
- Convention on Biological Diversity [CBD] Secretariat. (2011). *Strategic Plan for Biodiversity 2011-2020 and the Aichi Targets*. <https://www.cbd.int/sp/>
- Convention on Biological Diversity [CBD] Secretariat. (2012). *Convention on Biological Diversity: Safeguarding life on Earth*. <https://www.cbd.int/intro/default.shtml>
- Convention on Biological Diversity [CBD] Secretariat. (2018). *Biodiversity and the Sustainable Development Goals*. <https://www.cbd.int/cop/cop-14/media/briefs/en/cop14-press-brief-sdgs.pdf>
- Convention on Biological Diversity [CBD] Secretariat. (2020). *Global Biodiversity Outlook*. <https://www.cbd.int/gbo/>
- Convention on Biological Diversity [CBD] Secretariat. (2021a). *First Draft of the Post-2020 Global Biodiversity Framework*. <https://www.cbd.int/doc/c/abb5/591f/2e46096d3f0330b08ce87a45/wg2020-03-03-en.pdf>
- Convention on Biological Diversity [CBD] Secretariat. (2021b). *History of the Convention*. <https://www.cbd.int/history/>
- Convention on Biological Diversity [CBD] Secretariat. (2021c). *Kunming Declaration: Ecological civilization: Building a shared future for all life on earth*. <https://www.cbd.int/doc/c/c2db/972a/fb32e0a277bf1ccff742be5/cop-15-05-add1-en.pdf>
- Convention on Biological Diversity [CBD] Secretariat. (2021d). *Update on the preparations for the*

UN Biodiversity Conference: China to host a two-part summit on nature.

<https://www.cbd.int/article/new-dates-cop15-virtual-2021-facetoface-2022>

Cetas, E. R., & Yasué, M. (2017). A systematic review of motivational values and conservation success in and around protected areas. *Conservation Biology*, 31(1), 203–212.

<https://doi.org/10.1111/cobi.12770>

Chase, S. K., & Levine, A. (2017). Citizen science: Exploring the potential of natural resource monitoring programs to influence environmental attitudes and behaviors. *Conservation Letters*, 11(April), 1–10. <https://doi.org/10.1111/conl.12382>

Chawla, L. (1998). Significant life experiences revisited: A review of research on sources of environmental sensitivity. *Journal of Environmental Education*, 29(3), 11–21.

<https://doi.org/10.1080/00958969809599114>

Chawla, L. (2020). Childhood nature connection and constructive hope: A review of research on connecting with nature and coping with environmental loss. *People and Nature*, 2(3), 619–642. <https://doi.org/10.1002/pan3.10128>

Chew, P. K. H. (2019). Psychometric evaluation of two instruments to assess connection to nature. *Psychology*, 10(3), 1–31. <https://doi.org/10.1080/21711976.2019.1607470>

Choe, E. Y., Jorgensen, A., & Sheffield, D. (2020). Does a natural environment enhance the effectiveness of Mindfulness-Based Stress Reduction (MBSR)? Examining the mental health and wellbeing, and nature connectedness benefits. *Landscape and Urban Planning*, 202(June), 1–12. <https://doi.org/10.1016/j.landurbplan.2020.103886>

Church, S. P. (2018). From street trees to natural areas: retrofitting cities for human connectedness to nature. *Journal of Environmental Planning and Management*, 61(5–6), 878–903. <https://doi.org/10.1080/09640568.2018.1428182>

City of Melbourne. (2012). *Urban Forest Strategy*.

<https://www.melbourne.vic.gov.au/sitecollectiondocuments/urban-forest-strategy.pdf>

Clayton, S. (2003). Environmental identity: A conceptual and operational definition. In Susan D. Clayton & S. Opatow (Eds.), *Identity and the natural environment: The psychological significance of nature* (pp. 45–66). MIT Press.

Clayton, S. (2007). Domesticated nature: Motivations for gardening and perceptions of environmental impact. *Journal of Environmental Psychology*, 27(3), 215–224.

<https://doi.org/10.1016/j.jenvp.2007.06.001>

Clayton, S. (2012). Environment and identity. In S.D. Clayton (Ed.), *The Oxford Handbook of Environmental and Conservation Psychology* (pp. 164–180). Oxford University Press.

<https://doi.org/10.1093/oxfordhb/9780199733026.013.0010>

Clayton, S. (2017). Social issues and personal life: Considering the environment. *Journal of Social Issues*, 73(3), 667–681. <https://doi.org/10.1111/josi.12237>

Clayton, S. (2019). The psychology of rewilding. In N. Pettorelli, S. M. Durant, & J. T. du Toit (Eds.), *Rewilding* (pp. 182–200). Cambridge University Press.

<https://doi.org/10.1017/9781108560962.010>

- Clayton, S. (2021). Virtue and sustainable behavior: A psychological perspective. In J. Kawai (Ed.), *The Virtues of Sustainability* (pp. 3–26). Oxford University Press.
<https://doi.org/10.1093/oso/9780190919818.003.0001>
- Clayton, S., Colléony, A., Conversy, P., Maclouf, E., Martin, L., Torres, A. C., Truong, M. X., & Prévot, A. C. (2017). Transformation of experience: Toward a new relationship with nature. *Conservation Letters*, 10(5), 645–651. <https://doi.org/10.1111/conl.12337>
- Clayton, S., Czellar, S., Nartova-Bochaver, S., Skibins, J. C., Salazar, G., Tseng, Y.-C., Irkhin, B., & Monge-Rodriguez, F. S. (2021). Cross-cultural validation of a revised Environmental Identity Scale. *Sustainability*, 13(2387), 1–12. <https://doi.org/10.3390/su13042387>
- Clayton, S., & Myers, G. (2009). *Conservation psychology: Understanding and promoting human care for nature*. Wiley-Blackwell, Ltd.
- Clayton, S., & Opatow, S. (2003). Introduction: Identity and the natural environment. In Susan D. Clayton & S. Opatow (Eds.), *Identity and the natural environment: The psychological significance of nature* (pp. 1–24). MIT Press.
- Clayton, S. D. (2021). Environment, identity, and response to polluted landscapes. *Sustainability*, 13(16), 9422. <https://doi.org/10.3390/su13169422>
- Cleary, A., Fielding, K. S., Bell, S. L., Murray, Z., & Roiko, A. (2017). Exploring potential mechanisms involved in the relationship between eudaimonic wellbeing and nature connection. *Landscape and Urban Planning*, 158, 119–128.
<https://doi.org/10.1016/j.landurbplan.2016.10.003>
- Cleary, A., Fielding, K. S., Murray, Z., & Roiko, A. (2018). Predictors of nature connection among urban residents: Assessing the role of childhood and adult nature experiences. *Environment and Behavior*, 0013916518. <https://doi.org/10.1177/0013916518811431>
- Colahan, C., & Chapple, R. (2019). *Connecting Nature Connection Activities in Australia* (Issue June). <https://www.bmwhi.org/s/Nature-Connections-in-Australia-Report-by-ColahanChapple-June2019.pdf>
- Colding, J., Giusti, M., Haga, A., Wallhagen, M., & Barthel, S. (2020). Enabling relationships with nature in cities. *Sustainability (Switzerland)*, 12(11), 1–16. <https://doi.org/10.3390/su12114394>
- Collado, S., Íñiguez-Rueda, L., & Corraliza, J. A. (2016). Experiencing nature and children's conceptualizations of the natural world. *Children's Geographies*, 14(6), 716–730.
<https://doi.org/10.1080/14733285.2016.1190812>
- Collado, S., Staats, H., & Corraliza, J. A. (2013). Experiencing nature in children's summer camps: Affective, cognitive and behavioural consequences. *Journal of Environmental Psychology*, 33, 37–44. <http://www.apnet.com>
- Colléony, A., Cohen-Seffer, R., & Shwartz, A. (2020). Unpacking the causes and consequences of the extinction of experience. *Biological Conservation*, 251(July), 108788.
<https://doi.org/10.1016/j.biocon.2020.108788>

- Colléony, A., Levontin, L., & Schwartz, A. (2020). Promoting meaningful and positive nature interactions for visitors to green spaces. *Conservation Biology*, 34(6), 1373–1382. <https://doi.org/10.1111/cobi.13624>
- Colléony, A., Prévot, A. C., Saint Jalme, M., & Clayton, S. (2017). What kind of landscape management can counteract the extinction of experience? *Landscape and Urban Planning*, 159, 23–31. <https://doi.org/10.1016/j.landurbplan.2016.11.010>
- Colléony, A., White, R., & Schwartz, A. (2019). The influence of spending time outside on experience of nature and environmental attitudes. *Landscape and Urban Planning*, 187(April), 96–104. <https://doi.org/10.1016/j.landurbplan.2019.03.010>
- Colley, K., & Craig, T. (2019). Natural places: Perceptions of wildness and attachment to local greenspace. *Journal of Environmental Psychology*, 61(December 2018), 71–78. <https://doi.org/10.1016/j.jenvp.2018.12.007>
- Coscieme, L., da Silva Hyldmo, H., Fernández-Llamazares, Á., Palomo, I., Mwampamba, T. H., Selomane, O., Sitas, N., Jaureguiberry, P., Takahashi, Y., Lim, M., Barral, M. P., Farinaci, J. S., Diaz-José, J., Ghosh, S., Ojino, J., Alassaf, A., Baatuuwie, B. N., Balint, L., Basher, Z., ... Valle, M. (2020). Multiple conceptualizations of nature are key to inclusivity and legitimacy in global environmental governance. *Environmental Science and Policy*, 104(November 2019), 36–42. <https://doi.org/10.1016/j.envsci.2019.10.018>
- Cosquer, A., Raymond, R., & Prevot-Julliard, A. C. (2012). Observations of everyday biodiversity: A new perspective for conservation? *Ecology and Society*, 17(4). <https://doi.org/10.5751/ES-04955-170402>
- Costanza, R., de Groot, R., Braat, L., Kubiszewski, I., Fioramonti, L., Sutton, P., Farber, S., & Grasso, M. (2017). Twenty years of ecosystem services: How far have we come and how far do we still need to go? *Ecosystem Services*, 28, 1–16. <https://doi.org/10.1016/j.ecoser.2017.09.008>
- Cox, D. T. C., Hudson, H. L., Shanahan, D. F., Fuller, R. A., & Gaston, K. J. (2017). The rarity of direct experiences of nature in an urban population. *Landscape and Urban Planning*, 160, 79–84. <https://doi.org/10.1016/j.landurbplan.2016.12.006>
- Cox, D. T. C., Shanahan, D. F., Hudson, H. L., Fuller, R. A., & Gaston, K. J. (2018). The impact of urbanisation on nature dose and the implications for human health. *Landscape and Urban Planning*, 179(July), 72–80. <https://doi.org/10.1016/j.landurbplan.2018.07.013>
- Craig, T. P., Fischer, A., & Lorenzo-Arribas, A. (2018). Shopping versus nature? An exploratory study of everyday experiences. *Frontiers in Psychology*, 9(JAN), 1–11. <https://doi.org/10.3389/fpsyg.2018.00009>
- Crocetti, E. (2016). Systematic reviews with meta-analysis. *Emerging Adulthood*, 4(1), 3–18. <https://doi.org/10.1177/2167696815617076>
- Cudworth, D., & Lumber, R. (2021). The importance of Forest School and the pathways to nature connection. *Journal of Outdoor and Environmental Education*, 0123456789, 1–15.

<https://doi.org/10.1007/s42322-021-00074-x>

Curtis, J., Tear, M., Garivaldis, F., & Tull, F. (2021). "You are not normal!" Understanding the influences on behaviour. In *The Method Book* (pp. 1–16).

<https://www.behaviourworksaustralia.org/the-method-book/>

D'amore, C. (2016). Family nature clubs: An intergenerational opportunity to foster love of the natural world. *Families, Relationships and Societies*, 5(3), 431–446.

<https://doi.org/10.1332/204674316x14758471234542>

Darnton, A. (2008). Reference Report: An overview of behaviour change models and their uses. In *GSR Behaviour Change Knowledge Review* (Issue July).

https://doi.org/https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/498065/Behaviour_change_reference_report_tcm6-9697.pdf

Davis, J. L., Green, J. D., & Reed, A. (2009). Interdependence with the environment: Commitment, interconnectedness, and environmental behavior. *Journal of Environmental Psychology*, 29(2), 173–180. <https://doi.org/10.1016/j.jenvp.2008.11.001>

Davis, N., Daams, M., van Hinsberg, A., & Sijsma, F. (2016). How deep is your love – Of nature? A psychological and spatial analysis of the depth of feelings towards Dutch nature areas. *Applied Geography*, 77, 38–48. <https://doi.org/10.1016/j.apgeog.2016.09.012>

de Bell, S., Graham, H., & White, P. C. L. (2018). The role of managed natural spaces in connecting people with urban nature: A comparison of local user, researcher, and provider views. *Urban Ecosystems*, 21, 875–886. <https://doi.org/10.1007/s11252-018-0762-x>

de Groot, W. T., & van den Born, R. J. G. (2003). Visions of nature and landscape type preferences: An exploration in The Netherlands. *Landscape and Urban Planning*, 63(3), 127–138. [https://doi.org/10.1016/S0169-2046\(02\)00184-6](https://doi.org/10.1016/S0169-2046(02)00184-6)

Dean, A. J., Barnett, A. G., Wilson, K. A., & Turrell, G. (2019). Beyond the 'extinction of experience' – Novel pathways between nature experience and support for nature conservation. *Global Environmental Change*, 55(January), 48–57. <https://doi.org/10.1016/j.gloenvcha.2019.02.002>

Dean, A. J., Church, E. K., Loder, J., Fielding, K. S., & Wilson, K. A. (2018). How do marine and coastal citizen science experiences foster environmental engagement? *Journal of Environmental Management*, 213, 409–416. <https://doi.org/10.1016/j.jenvman.2018.02.080>

Department of Environment, Land, Water and Planning [DELWP]. (2017). *Protecting Victoria's Environment – Biodiversity 2037*. https://www.environment.vic.gov.au/__data/assets/pdf_file/0022/51259/Protecting-Victorias-Environment-Biodiversity-2037.pdf

Department of Environment, Land, Water and Planning [DELWP]. (2020). *Threatened species overview*. Conserving Threatened Species. <https://www.environment.vic.gov.au/conserving-threatened-species/threatened-species-overview>

Department of Environment, Land, Water and Planning [DELWP]. (2021a). *Environmental Volunteering*. <https://www.environment.vic.gov.au/biodiversity/volunteering>

- Department of Environment, Land, Water and Planning [DELWP]. (2021b). *Progress toward our targets*. Implementing Biodiversity 2037.
<https://www.environment.vic.gov.au/biodiversity/Implementing-Biodiversity-2037>
- Department of Conservation. (2020). *Aotearoa New Zealand Biodiversity Strategy*.
<https://doi.org/10.4135/9781412952453.n56>
- Department of Natural Resources and Environment. (1997a). *Directions in Management* (No. 3; Victoria's Biodiversity).
https://www.environment.vic.gov.au/__data/assets/pdf_file/0015/50235/Victorias-Biodiversity_Directions-in-Management_1997.pdf
- Department of Natural Resources and Environment. (1997b). *Our Living Wealth* (No. 1; Victoria's Biodiversity).
https://www.environment.vic.gov.au/__data/assets/pdf_file/0012/50232/Victorias-Biodiversity_Our-Living-Wealth_1997-.pdf
- Department of Natural Resources and Environment. (1997c). *Sustaining Our Living Wealth* (No. 2; Victoria's Biodiversity).
https://www.environment.vic.gov.au/__data/assets/pdf_file/0013/50233/Victorias-Biodiversity_Sustaining-Our-Living-Wealth_1997.pdf
- Dickinson, E. (2013). The misdiagnosis: Rethinking "nature-deficit disorder." *Environmental Communication*, 7(3), 315–335. <https://doi.org/10.1080/17524032.2013.802704>
- Diduck, A. P., Raymond, C. M., Rodela, R., Moquin, R., & Boerchers, M. (2019). Pathways of learning about biodiversity and sustainability in private urban gardens. *Journal of Environmental Planning and Management*, 1–21.
<https://doi.org/10.1080/09640568.2019.1633288>
- Domroese, M. C., & Johnson, E. A. (2017). Why watch bees? Motivations of citizen science volunteers in the Great Pollinator Project. *Biological Conservation*, 208, 40–47.
<https://doi.org/10.1016/j.biocon.2016.08.020>
- Dornhoff, M., Sothmann, J. N., Fiebelkorn, F., & Menzel, S. (2019). Nature relatedness and environmental concern of young people in Ecuador and Germany. *Frontiers in Psychology*, 10(MAR), 1–13. <https://doi.org/10.3389/fpsyg.2019.00453>
- Ducarme, F., & Couvet, D. (2020). What does "nature" mean? *Palgrave Communications*, 6(1), 1–8. <https://doi.org/10.1057/s41599-020-0390-y>
- Ducarme, F., Flipo, F., & Couvet, D. (2020). How the diversity of human concepts of nature affects conservation of biodiversity. *Conservation Biology*, 35(3), 1019–1028.
<https://doi.org/10.1111/cobi.13639>
- Duffy, S., & Verges, M. (2010). Forces of nature affect implicit connections with nature. *Environment and Behavior*, 42(6), 723–739. <https://doi.org/10.1177/0013916509338552>
- Dunlap, R. E., van Liere, K. D. Van, Mertig, A. G., & Jones, R. E. (2000). Measuring endorsement of the New Ecological Paradigm: A revised NEP scale. *Journal of Social Issues*, 56(3), 425–

- Dunn, R. R., Gavin, M. C., Sanchez, M. C., & Solomon, J. N. (2006). The pigeon paradox: Dependence of global conservation on urban nature. *Conservation Biology*, 20(6), 1814–1816. <https://doi.org/10.1111/j.1523-1739.2006.00533.x>
- Dutcher, D. D., Finley, J. C., Luloff, A. E., & Johnson, J. B. (2007). Connectivity with nature as a measure of environmental values. *Environment and Behavior*, 39(4), 474–493. <https://doi.org/10.1177/0013916506298794>
- Elliot, E., Eycke, K. Ten, Chan, S., & Müller, U. (2014). Taking kindergartners outdoors: Documenting their explorations and assessing the impact on their ecological awareness. *Children, Youth and Environments*, 24(2), 102. <https://doi.org/10.7721/chilyoutenvi.24.2.0102>
- Food and Agriculture Organization of the United Nations [FAO]. (2019). *The State of the World's Biodiversity for Food and Agriculture*. <https://doi.org/10.4060/ca3129en>
- Farrow, K., Grolleau, G., & Ibanez, L. (2017). Social norms and pro-environmental behavior: A review of the evidence. *Ecological Economics*, 140, 1–13. <https://doi.org/10.1016/j.ecolecon.2017.04.017>
- Field, A. (2013). *Discovering statistics using IBM SPSS Statistics* (M. Carmichael (Ed.); 4th ed.). SAGE Publications Ltd.
- Fischer, A., & Young, J. C. (2007). Understanding mental constructs of biodiversity: Implications for biodiversity management and conservation. *Biological Conservation*, 136(2), 271–282. <https://doi.org/10.1016/j.biocon.2006.11.024>
- Fischer, J., Dyball, R., Fazey, I., Gross, C., Dovers, S., Ehrlich, P. R., Brulle, R. J., Christensen, C., & Borden, R. J. (2012). Human behavior and sustainability. *Frontiers in Ecology and the Environment*, 10(3), 153–160. <https://doi.org/10.1890/1>
- Fisher, A. (2013). *Radical ecopsychology psychology in the service of life* (2nd ed.). State University of New York Press.
- Fletcher, R. (2017). Connection with nature is an oxymoron: A political ecology of "nature-deficit disorder." *Journal of Environmental Education*, 48(4), 226–233. <https://doi.org/10.1080/00958964.2016.1139534>
- Flint, C. G., Kunze, I., Muhar, A., Yoshida, Y., & Penker, M. (2013). Exploring empirical typologies of human-nature relationships and linkages to the ecosystem services concept. *Landscape and Urban Planning*, 120, 208–217. <https://doi.org/10.1016/j.landurbplan.2013.09.002>
- Forstmann, M., & Sagioglou, C. (2017). Lifetime experience with (classic) psychedelics predicts pro-environmental behavior through an increase in nature relatedness. *Journal of Psychopharmacology*, 31(8), 975–988. <https://doi.org/10.1177/0269881117714049>
- Fraijo-Sing, B. S., Beltrán Sierra, N. I., Tapia-Fonllem, C., & Valenzuela Peñúñuri, R. (2020). Pictographic representations of the word "nature" in preschool education children. *Frontiers in Psychology*, 11, 1–8. <https://doi.org/10.3389/fpsyg.2020.00575>
- Franco, L. S., Shanahan, D. F., & Fuller, R. A. (2017). A review of the benefits of nature

- experiences: More than meets the eye. *International Journal of Environmental Research and Public Health*, 14(8), 1–29. <https://doi.org/10.3390/ijerph14080864>
- Fränkel, S., Sellmann-Risse, D., & Basten, M. (2019). Fourth graders' connectedness to nature - does cultural background matter? *Journal of Environmental Psychology*, 66(September 2018), 1–7. <https://doi.org/10.1016/j.jenvp.2019.101347>
- Frantz, C. M. P., & Mayer, F. S. (2014). The importance of connection to nature in assessing environmental education programs. *Studies in Educational Evaluation*, 41, 85–89. <https://doi.org/10.1016/j.stueduc.2013.10.001>
- Frantz, C., Mayer, F. S., Norton, C., & Rock, M. (2005). There is no "I" in nature: The influence of self-awareness on connectedness to nature. *Journal of Environmental Psychology*, 25(4), 427–436. <https://doi.org/10.1016/j.jenvp.2005.10.002>
- Fretwell, K., & Greig, A. (2019). Towards better understanding of the relationship between individual's self-reported connection to nature, personal well-being and environmental awareness. *Sustainability*, 11, 1–21. <https://doi.org/10.3390/su11051386>
- Frumkin, H., Bratman, G. N., Breslow, S. J., Cochran, B., Jr, P. H. K., Lawler, J. J., Levin, P. S., Tandon, P. S., Varanasi, U., Wolf, K. L., & Wood, S. A. (2016). Nature contact and human health: A research agenda. *Environmental Health Perspectives*, 125(7), 1–18. <https://doi.org/10.1289/EHP1663>
- Furness, E. (2021). Understanding the lived experience of connection to nature. *Conservation Science and Practice*, 3(7), 1–8. <https://doi.org/10.1111/csp2.440>
- Galesic, M., & Bosnjak, M. (2009). Effects of questionnaire length on participation and indicators of response quality in a web survey. *Public Opinion Quarterly*, 73(2), 349–360. <https://doi.org/10.1093/poq/nfp031>
- Game, E. T., Meijaard, E., Sheil, D., & McDonald-Madden, E. (2014). Conservation in a wicked complex world; challenges and solutions. *Conservation Letters*, 7(3), 271–277. <https://doi.org/10.1111/conl.12050>
- Ganzevoort, W., & van den Born, R. (2019). The thrill of discovery: Significant nature experiences among biodiversity citizen scientists. *Ecopsychology*, 11(1), 22–32. <https://doi.org/10.1089/eco.2018.0062>
- Ganzevoort, W., & van den Born, R. J. G. (2020). Understanding citizens' action for nature: The profile, motivations and experiences of Dutch nature volunteers. *Journal for Nature Conservation*, 55(December 2019), 125824. <https://doi.org/10.1016/j.jnc.2020.125824>
- Ganzevoort, W., van den Born, R. J. G., Halffman, W., & Turnhout, S. (2017). Sharing biodiversity data: Citizen scientists' concerns and motivations. *Biodiversity and Conservation*, 26(12), 2821–2837. <https://doi.org/10.1007/s10531-017-1391-z>
- Gaston, K. J., & Soga, M. (2020). Extinction of experience: The need to be more specific. *People and Nature*, December 2019, 1–7. <https://doi.org/10.1002/pan3.10118>
- Gaston, K. J., Soga, M., Duffy, J. P., Garrett, J. K., Gaston, S., & Cox, D. T. C. (2018).

- Personalised ecology. *Trends in Ecology and Evolution*, 33(12), 916–925.
<https://doi.org/10.1016/j.tree.2018.09.012>
- Geng, L., Xu, J., Ye, L., Zhou, W., & Zhou, K. (2015). Connections with nature and environmental behaviors. *PLoS ONE*, 10(5), 1–11. <https://doi.org/10.1371/journal.pone.0127247>
- Gifford, R. (2011). The dragons of inaction: Psychological barriers that limit climate change mitigation and adaptation. *American Psychologist*, 66(4), 290–302.
<https://doi.org/10.1037/a0023566>
- Gifford, R., & Nilsson, A. (2014). Personal and social factors that influence pro-environmental concern and behaviour: A review. *International Journal of Psychology*, 49(3), 141–157.
<https://doi.org/10.1002/ijop.12034>
- Giusti, M. (2019). Human-nature relationships in context. Experiential, psychological, and contextual dimensions that shape children's desire to protect nature. *PLoS ONE*, 14(12), 1–25. <https://doi.org/10.1371/journal.pone.0225951>
- Giusti, M., Svane, U., Raymond, C. M., & Beery, T. H. (2018). A framework to assess where and how children connect to nature. *Frontiers in Psychology*, 8(JAN), 1–21.
<https://doi.org/10.3389/fpsyg.2017.02283>
- Gosling, E., & Williams, K. J. H. (2010). Connectedness to nature, place attachment and conservation behaviour: Testing connectedness theory among farmers. *Journal of Environmental Psychology*, 30(3), 298–304. <https://doi.org/10.1016/j.jenvp.2010.01.005>
- Guiney, M. S., & Oberhauser, K. S. (2010). Conservation volunteers' connection to nature. *Ecopsychology*, 1(4), 187–197. <https://doi.org/10.1089/eco.2009.0030>
- Hagger, M. S., Cameron, L. D., Hamilton, K., Hankonen, N., & Lintunen, T. (Eds.). (2020). *The Handbook of Behavior Change*. Cambridge University Press.
<https://doi.org/10.1017/9781108677318>
- Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2014). *Multivariate Data Analysis* (7th ed.). Pearson.
- Hamlin, I., & Richardson, M. (2021). *Visible garden biodiversity leads to an increase in noticing nature, which in turn leads to an increase in nature connectedness*. 1–9.
<https://doi.org/10.31234/osf.io/uamwg>
- Hatty, M. A., Smith, L. D. G., Goodwin, D., & Mavondo, F. T. (2020). The CN-12: A brief, multidimensional connection with nature instrument. *Frontiers in Psychology*, 11(1566), 1–14.
<https://doi.org/10.3389/fpsyg.2020.01566>
- Hayes, A. F. (2018). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach* (Second ed.). Guilford Publications Inc.
- Haywood, B. K. (2016). Beyond data points and research contributions: The personal meaning and value associated with public participation in scientific research. *International Journal of Science Education, Part B: Communication and Public Engagement*, 6(3), 239–262.
<https://doi.org/10.1080/21548455.2015.1043659>

- Haywood, B. K., Parrish, J. K., & Dolliver, J. (2016). Place-based and data-rich citizen science as a precursor for conservation action. *Conservation Biology*, 30(3), 476–486.
<https://doi.org/10.1111/cobi.12702>
- Haywood, B. K., Parrish, J. K., & He, Y. (2020). Shapeshifting attachment: Exploring multi-dimensional people–place bonds in place-based citizen science. *People and Nature*, February 2020, 51–65. <https://doi.org/10.1002/pan3.10174>
- Hinds, J., & Sparks, P. (2008). Engaging with the natural environment: The role of affective connection and identity. *Journal of Environmental Psychology*, 28(2), 109–120.
<https://doi.org/10.1016/j.jenvp.2007.11.001>
- Hinds, J., & Sparks, P. (2011). The affective quality of human-natural environment relationships. *Evolutionary Psychology*, 9(3), 451–469. <https://doi.org/10.1177/147470491100900314>
- Hobbs, S. J., & White, P. C. L. (2012). Motivations and barriers in relation to community participation in biodiversity recording. *Journal for Nature Conservation*, 20(6), 364–373.
<https://doi.org/10.1016/j.jnc.2012.08.002>
- Hoye, J., McGowan, K., Tiwst, S., & Reeves, D. (2020). *Environmental volunteering social research report*.
https://www.environment.vic.gov.au/__data/assets/pdf_file/0015/510810/NGR-2005009-Environmental-Volunteering-Research-Report-Public-Final.pdf
- Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling*, 6(1), 1–55.
<https://doi.org/10.1080/10705519909540118>
- Hughes, J., Rogerson, M., Barton, J., & Bragg, R. (2019). Age and connection to nature: When is engagement critical? *Frontiers in Ecology and the Environment*, 17(5), 265–269.
<https://doi.org/10.1002/fee.2035>
- Hunt, A., Stewart, D., Richardson, M., Hinds, J., Bragg, R., White, M., & Burt, J. (2017). *Monitor of Engagement with the Natural Environment: Developing a method to measure nature connection across the English population (adults and children)* (Issue June).
- Hurly, J., & Walker, G. J. (2019). Nature in our lives: Examining the human need for nature relatedness as a basic psychological need. *Journal of Leisure Research*, 50(4), 290–310.
<https://doi.org/10.1080/00222216.2019.1578939>
- Hurst, M., Dittmar, H., Bond, R., & Kasser, T. (2013). The relationship between materialistic values and environmental attitudes and behaviors: A meta-analysis. *Journal of Environmental Psychology*, 36, 257–269. <https://doi.org/10.1016/j.jenvp.2013.09.003>
- IBM Corp. (2019). *IBM SPSS Statistics for Windows* (26.0). Armonk, NY: IBM Corp.
- Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services [IPBES]. (2019). *Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. <https://doi.org/10.2750/arp.36.13>

- Ipsos. (2021). *Ipsos Issues Monitor February 2021* (Issue February).
https://www.ipsos.com/sites/default/files/ct/publication/documents/2021-03/im_national_feb21_v1.pdf
- Ives, C. D., Abson, D. J., von Wehrden, H., Dorninger, C., Klaniecki, K., & Fischer, J. (2018). Reconnecting with nature for sustainability. *Sustainability Science*, 13(5), 1–9.
<https://doi.org/10.1007/s11625-018-0542-9>
- Ives, C. D., Freeth, R., & Fischer, J. (2019). Inside-out sustainability: The neglect of inner worlds. *Ambio*, 1–10. <https://doi.org/10.1007/s13280-019-01187-w>
- Ives, C. D., Giusti, M., Fischer, J., Abson, D. J., Klaniecki, K., Dorninger, C., Laudan, J., Barthel, S., Abernethy, P., Martín-López, B., Raymond, C. M., Kendal, D., & von Wehrden, H. (2017). Human-nature connection: A multidisciplinary review. *Current Opinion in Environmental Sustainability*, 26–27(May), 106–113. <https://doi.org/10.1016/j.cosust.2017.05.005>
- Jepson, P., & Ladle, R. J. (2015). Nature apps: Waiting for the revolution. *Ambio*, 44(8), 827–832.
<https://doi.org/10.1007/s13280-015-0712-2>
- Jordan, K., & Kristjánsson, K. (2017). Sustainability, virtue ethics, and the virtue of harmony with nature. *Environmental Education Research*, 23(9), 1205–1229.
<https://doi.org/10.1080/13504622.2016.1157681>
- Kaiser, F. G., Brügger, A., Hartig, T., Bogner, F. X., & Gutscher, H. (2014). Appreciation of nature and appreciation of environmental protection: How stable are these attitudes and which comes first? *Revue Européenne de Psychologie Appliquée*, 64(6), 269–277.
<https://doi.org/10.1016/j.erap.2014.09.001>
- Kals, E., Schumacher, D., & Montada, L. (1999). Emotional affinity toward nature as a motivational basis to protect nature. *Environment and Behavior*, 31(2), 178–202.
<https://doi.org/10.1177/00139169921972056>
- Kellert, S. R. (1993). The biological basis for human values of nature. In S. R. Kellert & E. O. Wilson (Eds.), *The Biophilia Hypothesis* (pp. 42–69). Island Press.
- Kellert, S. R., & Wilson, E. O. (Eds.). (1993). *The Biophilia Hypothesis*. Island Press.
- Keniger, L. E., Gaston, K. J., Irvine, K. N., & Fuller, R. A. (2013). What are the benefits of interacting with nature? *International Journal of Environmental Research and Public Health*, 10(3), 913–935. <https://doi.org/10.3390/ijerph10030913>
- Kesebir, S., & Kesebir, P. (2017). A growing disconnection from nature is evident in cultural products. *Perspectives on Psychological Science*, 12(2), 258–269.
<https://doi.org/10.1177/1745691616662473>
- Keulartz, J., van der Windt, H., & Swart, J. (2004). Concepts of nature as communicative devices: The case of Dutch nature policy. *Environmental Values*, 13(1), 81–99.
- Kidd, L. R., Garrard, G. E., Bekessy, S. A., Mills, M., Camilleri, A. R., Fidler, F., Fielding, K. S., Gordon, A., Gregg, E. A., Kusmanoff, A. M., Louis, W., Moon, K., Robinson, J. A., Selinske, M. J., Shanahan, D., & Adams, V. M. (2019). Messaging matters: A systematic review of the

- conservation messaging literature. *Biological Conservation*, 236(April), 92–99.
<https://doi.org/10.1016/j.biocon.2019.05.020>
- Kiesling, F. M., & Manning, C. M. (2010). How green is your thumb? Environmental gardening identity and ecological gardening practices. *Journal of Environmental Psychology*, 30(3), 315–327. <https://doi.org/http://dx.doi.org/10.1016/j.jenvp.2010.02.004>
- Kiley, H. M., Ainsworth, G. B., & Weston, M. A. (2018). Modest levels of interpretability of the term "biodiversity", mediated by educational level, among the Australian public. *Pacific Conservation Biology*, 2017–2019. <https://doi.org/10.1071/PC18056>
- Kingsley, J., Egerer, M., Nuttman, S., Keniger, L., Pettitt, P., Frantzeskaki, N., Gray, T., Ossola, A., Lin, B., Bailey, A., Tracey, D., Barron, S., & Marsh, P. (2021). Urban agriculture as a nature-based solution to address socio-ecological challenges in Australian cities. *Urban Forestry and Urban Greening*, 60(November 2020), 127059. <https://doi.org/10.1016/j.ufug.2021.127059>
- Kingsley, J., Foenander, E., & Bailey, A. (2019). "You feel like you're part of something bigger": Exploring motivations for community garden participation in Melbourne, Australia. *BMC Public Health*, 19(1), 1–12. <https://doi.org/10.1186/s12889-019-7108-3>
- Klaniecki, K., Leventon, J., & Abson, D. J. (2018). Human-nature connectedness as a 'treatment' for pro-environmental behavior: Making the case for spatial considerations. *Sustainability Science*, 1–14. <https://doi.org/10.1007/s11625-018-0578-x>
- Kleespies, M. W., Braun, T., Dierkes, P. W., & Wenzel, V. (2021). Measuring connection to nature - A illustrated extension of the Inclusion of Nature in Self Scale. *Sustainability*, 13(4), 1761. <https://doi.org/10.3390/su13041761>
- Klein, S. A., & Hilbig, B. E. (2018). How virtual nature experiences can promote pro-environmental behavior. *Journal of Environmental Psychology*, 60(February), 41–47. <https://doi.org/10.1016/j.jenvp.2018.10.001>
- Klöckner, C. A. (2013). A comprehensive model of the psychology of environmental behaviour: A meta-analysis. *Global Environmental Change*, 23(5), 1028–1038. <https://doi.org/10.1016/j.gloenvcha.2013.05.014>
- Kloek, M. E., Buijs, A. E., Boersema, J. J., & Schouten, M. G. C. (2018). Cultural echoes in Dutch immigrants' and non-immigrants' understandings and values of nature. *Journal of Environmental Planning and Management*, 61(5–6), 818–840. <https://doi.org/10.1080/09640568.2017.1319803>
- Knepple Carney, A. (2018). *How connectedness to nature relates to well-being over time* [Dissertation - Eberly College of Arts and Sciences, West Virginia University]. <https://researchrepository.wvu.edu/etd/5992/>
- Kollmuss, A., & Agyeman, J. (2002). Mind the Gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental Education Research*, 8(3), 239–260. <https://doi.org/10.1080/13504620220145401>
- Korach, J., & McConnell, A. R. (2021). The Triadic Framework: Integrating nature, communities,

- and belief systems into the self-concept for sustained conservation action. *Sustainability*, 13(15), 8348. <https://doi.org/10.3390/su13158348>
- Kunchambo, V., Lee, C. K. C., & Brace-Govan, J. (2021). Cultivating nature identity and ecological worldviews: A pathway to alter the prevailing dominant social paradigm. *Journal of Macromarketing*, 41(3), 484–505. <https://doi.org/10.1177/0276146721997540>
- Kuo, H.-M., Su, J.-Y., Wang, C.-H., Kiatsakared, P., & Chen, K.-Y. (2021). Place attachment and environmentally responsible behavior: The mediating role of destination psychological ownership. *Sustainability*, 13(12), 6809. <https://doi.org/10.3390/su13126809>
- Kuo, M., Barnes, M., & Jordan, C. (2019). Do experiences with nature promote learning? Converging evidence of a cause-and-effect relationship. *Frontiers in Psychology*, 10(February), 1–9. <https://doi.org/10.3389/fpsyg.2019.00305>
- Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics*, 33(1), 159–174.
- Lengieza, M. L., & Swim, J. K. (2021). Diminished public self-awareness in nature contributes to the positive effects of contact with nature on connectedness to nature. *Ecopsychology*, 13(3), 210–218. <https://doi.org/10.1089/eco.2020.0047>
- Lerner, J. S., Li, Y., Valdesolo, P., & Kassam, K. S. (2015). Emotion and decision making. *Annual Review of Psychology*, 66(1), 799–823. <https://doi.org/10.1146/annurev-psych-010213-115043>
- Lev, E., Kahn, P. H., Chen, H., & Esperum, G. (2020). Relatively wild urban parks can promote human resilience and flourishing: A case study of Discovery Park, Seattle, Washington. *Frontiers in Sustainable Cities*, 2(January), 1–12. <https://doi.org/10.3389/frsc.2020.00002>
- Levé, M., Colléony, A., Conversy, P., Torres, A.-C., Truong, M.-X., Vuillot, C., & Prévot, A.-C. (2019). Convergences and divergences in understanding the word biodiversity among citizens: A French case study. *Biological Conservation*, 236, 332–339. <https://doi.org/10.1016/j.biocon.2019.05.021>
- Light, A. (2006). Ecological citizenship: The democratic promise of restoration. In R. H. Pratt (Ed.), *The Human Metropolis: People and Nature in the 21st-Century City* (pp. 169–181). University of Massachusetts Press. https://stevenreedjohnson.com/~stevenr1/stevenreedjohnson/GCMore2_files/humaneMetropolis.pdf#page=183
- Lin, B. B., Egerer, M. H., & Ossola, A. (2018). Urban gardens as a space to engender biophilia: Evidence and ways forward. *Frontiers in Built Environment*, 4(December), 1–10. <https://doi.org/10.3389/fbuil.2018.00079>
- Lin, B. B., Fuller, R. A., Bush, R., Gaston, K. J., & Shanahan, D. F. (2014). Opportunity or orientation? Who uses urban parks and why. *PLoS ONE*, 9(1), 1–7. <https://doi.org/10.1371/journal.pone.0087422>
- Lin, B. B., Gaston, K. J., Fuller, R. A., Wu, D., Bush, R., & Shanahan, D. F. (2017). How green is

your garden?: Urban form and socio-demographic factors influence yard vegetation, visitation, and ecosystem service benefits. *Landscape and Urban Planning*, 157, 239–246.

<https://doi.org/10.1016/j.landurbplan.2016.07.007>

Lokhorst, A. M., Hoon, C., le Rutte, R., & de Snoo, G. (2014). There is an I in nature: The crucial role of the self in nature conservation. *Land Use Policy*, 39, 121–126.

<https://doi.org/10.1016/j.landusepol.2014.03.005>

Lumber, R., Richardson, M., & Sheffield, D. (2017). Beyond knowing nature: Contact, emotion, compassion, meaning, and beauty are pathways to nature connection. *PLoS ONE*, 12(5), 1–24. <https://doi.org/10.1371/journal.pone.0177186>

Macaulay, R., Lee, K., Johnson, K., & Williams, K. (2022). Mindful engagement, psychological restoration, and connection with nature in constrained nature experiences. *Landscape and Urban Planning*, 217, 104263. <https://doi.org/10.1016/j.landurbplan.2021.104263>

MacDonald, E., Harbrow, M., Jack, S., Kidd, J., Wright, A., Tuinder, P., Balanovic, J., Medvecky, F., & Poutasi, M. (2019). Segmenting urban populations for greater conservation gains: A new approach targeting cobenefits is required. *Conservation Science and Practice*, 1(10), 1–12. <https://doi.org/10.1111/csp2.101>

Mace, B. G. M. (2014). Whose conservation? *Science*, 345(6204), 1558–1560.

<https://doi.org/10.1126/science.1254704>

Mackay, C. M. L., & Schmitt, M. T. (2019). Do people who feel more connected to nature do more to protect it? A meta-analysis. *Journal of Environmental Psychology*, 65(101323), 1–9.

<https://doi.org/10.1016/j.jenvp.2019.101323>

Maloney, P., Grawitch, M. J., & Barber, L. K. (2011). Strategic item selection to reduce survey length: Reduction in validity? *Consulting Psychology Journal*, 63(3), 162–175.

<https://doi.org/10.1037/a0025604>

Marais-Potgieter, A., & Thatcher, A. (2020). Identification of six emergent types based on cognitive and affective constructs that explain individuals' relationship with the biosphere. *Sustainability (Switzerland)*, 12(18). <https://doi.org/10.3390/su12187614>

Marcus, B., Bosnjak, M., Lindner, S., Pilischenko, S., & Schütz, A. (2007). Compensating for low topic interest and long surveys: A field experiment on nonresponse in web surveys. *Social Science Computer Review*, 25(3), 372–383. <https://doi.org/10.1177/0894439307297606>

Marczak, M., & Sorokowski, P. (2018). Emotional connectedness to nature is meaningfully related to modernization. Evidence from the Meru of Kenya. *Frontiers in Psychology*, 9(SEP), 1–7.

<https://doi.org/10.3389/fpsyg.2018.01789>

Martin, C., & Czellar, S. (2016). The extended Inclusion of Nature in Self scale. *Journal of Environmental Psychology*, 47, 181–194. <https://doi.org/10.1016/j.jenvp.2016.05.006>

Martin, C., & Czellar, S. (2017). Where do biospheric values come from? A connectedness to nature perspective. *Journal of Environmental Psychology*, 52, 56–68.

<https://doi.org/10.1016/j.jenvp.2017.04.009>

- Martin, L., White, M. P., Hunt, A., Richardson, M., Pahl, S., & Burt, J. (2020). Nature contact, nature connectedness and associations with health, wellbeing and pro-environmental behaviours. *Journal of Environmental Psychology*, 68(January), 101389. <https://doi.org/10.1016/j.jenvp.2020.101389>
- Mata, L., Garrard, G. E., Fidler, F., Ives, C. D., Maller, C., Wilson, J., Thomas, F., & Bekessy, S. A. (2019). Punching above their weight: the ecological and social benefits of pop-up parks. *Frontiers in Ecology and the Environment*, 17(6), 341–347. <https://doi.org/10.1002/fee.2060>
- Mattijssen, T. J. M., Ganzevoort, W., van den Born, R. J. G., Arts, B. J. M., Breman, B. C., Buijs, A. E., van Dam, R. I., Elands, B. H. M., de Groot, W. T., & Knippenberg, L. W. J. (2020). Relational values of nature: leverage points for nature policy in Europe. *Ecosystems and People*, 16(1), 402–410. <https://doi.org/10.1080/26395916.2020.1848926>
- Maund, P. R., Irvine, K. N., Lawson, B., Steadman, J., Risely, K., Cunningham, A. A., & Davies, Z. G. (2020). What motivates the masses: Understanding why people contribute to conservation citizen science projects. *Biological Conservation*, 246(March), 108587. <https://doi.org/10.1016/j.biocon.2020.108587>
- Mausner, C. (1996). A kaleidoscope model: Defining natural environments. *Journal of Environmental Psychology*, 16, 335–348.
- Mayer, F. S., Frantz, C. M., Bruehlman-Senecal, E., & Dolliver, K. (2009). Why is nature beneficial? The role of connectedness to nature. *Environment and Behavior*, 41(5), 607–643. <https://doi.org/10.1177/0013916508319745>
- Mayer, F. S., & Frantz, C. M. P. (2004). The connectedness to nature scale: A measure of individuals' feeling in community with nature. *Journal of Environmental Psychology*, 24(4), 503–515. <https://doi.org/10.1016/j.jenvp.2004.10.001>
- Maynard, L., Monroe, M. C., Jacobson, S. K., & Savage, A. (2020). Maximizing biodiversity conservation through behavior change strategies. *Conservation Science and Practice*, February, 1–11. <https://doi.org/10.1111/csp2.193>
- McConnell, A. R., & Jacobs, T. P. (2020). Self-nature representations: On the unique consequences of nature-self size on pro-environmental action. *Journal of Environmental Psychology*, 71(101471), 1–13. <https://doi.org/10.1016/j.jenvp.2020.101471>
- McConnell, A. R., Shoda, T. M., & Skulborstad, H. M. (2012). The self as a collection of multiple self-aspects: Structure, development, operation, and implications. *Social Cognition*, 30(4), 380–395. <https://doi.org/10.1521/soco.2012.30.4.380>
- McDugle, L. M., Greenspan, I., & Handy, F. (2011). Generation green: understanding the motivations and mechanisms influencing young adults' environmental volunteering. *International Journal of Nonprofit and Voluntary Sector Marketing*, 16(4), 325–341. <https://doi.org/10.1002/nvsm.431>
- McEwan, K., Ferguson, F. J., Richardson, M., & Cameron, R. (2020). The good things in urban nature: A thematic framework for optimising urban planning for nature connectedness.

- Landscape and Urban Planning*, 194(October 2019), 103687.
<https://doi.org/10.1016/j.landurbplan.2019.103687>
- McEwan, K., Richardson, M., Sheffield, D., Ferguson, F. J., & Brindley, P. (2019). A smartphone app for improving mental health through connecting with urban nature. *International Journal of Environmental Research and Public Health*, 16(18), 1–15.
<https://doi.org/10.3390/ijerph16183373>
- McMahan, E. A., Cloud, J. M., Josh, P., & Scott, M. (2016). Nature with a human touch: Human-induced alteration negatively impacts perceived naturalness and preferences for natural environments. *Ecopsychology*, 8(1), 54–63. <https://doi.org/10.1089/eco.2015.0068>
- Mcphie, J., & Clarke, D. A. G. (2018). Nature matters: diffracting a keystone concept of environmental education research—just for kicks. *Environmental Education Research*, 26(9–10), 1509–1526. <https://doi.org/10.1080/13504622.2018.1531387>
- Millenium Ecosystem Assessment [MEA]. (2005). *Living beyond our means: Natural assets and human well-being*. <https://www.millenniumassessment.org/documents/document.429.aspx.pdf>
- Mears, M., Brindley, P., Barrows, P., Richardson, M., & Maheswaran, R. (2021). Mapping urban greenspace use from mobile phone GPS data. *PLoS One*, 16(7), 1–30.
<https://doi.org/10.1371/journal.pone.0248622>
- Measham, T. G., & Barnett, G. B. (2008). Environmental volunteering: Motivations, modes and outcomes. *Australian Geographer*, 39(4), 537–552.
<https://doi.org/10.1080/00049180802419237>
- Meis-Harris, J., Saeri, A., Boulet, M., Borg, K., Faulkner, N., & Jorgensen, B. (2019). *Victorians Value Nature: Survey Results*. <https://www.ari.vic.gov.au/research/people-and-nature/victorians-value-nature>
- Mena-García, A., Olivos, P., Loureiro, A., & Navarro, O. (2020). Effects of contact with nature on connectedness, environmental identity and evoked contents / Efectos del contacto con la naturaleza en conectividad, identidad ambiental y contenidos evocados. *Psyecology*, 11(1), 21–36. <https://doi.org/10.1080/21711976.2019.1643663>
- Merenlender, A. M., Crall, A. W., Drill, S., Prysby, M., & Ballard, H. (2016). Evaluating environmental education, citizen science, and stewardship through naturalist programs. *Conservation Biology*, 30(6), 1255–1265. <https://doi.org/10.1111/cobi.12737>
- Merino, A., Valor, C., & Redondo, R. (2020). Connectedness is in my character: The relationship between nature relatedness and character strengths. *Environmental Education Research*, 0(0), 1–22. <https://doi.org/10.1080/13504622.2020.1825630>
- Milfont, T. L., & Duckitt, J. (2010). The environmental attitudes inventory: A valid and reliable measure to assess the structure of environmental attitudes. *Journal of Environmental Psychology*, 30(1), 80–94. <https://doi.org/10.1016/j.jenvp.2009.09.001>
- Milligan, C., & Bingley, A. (2007). Restorative places or scary spaces? The impact of woodland on the mental well-being of young adults. *Health and Place*, 13(4), 799–811.

<https://doi.org/10.1016/j.healthplace.2007.01.005>

- Milton, K. (2002). *Loving Nature: Towards an Ecology of Emotion*. Taylor & Francis Group.
- Ministry of Natural Resources and Environment. (2016). *National Policy on Biological Diversity 2016-2025*. <https://www.cbd.int/doc/world/my/my-nbsap-v2-en.pdf>
- Moon, K., & Blackman, D. (2014). A guide to understanding social science research for natural scientists. *Conservation Biology*, 28(5), 1167–1177. <https://doi.org/10.1111/cobi.12326>
- Muhar, A., Raymond, C. M., van den Born, R. J. G. G., Bauer, N., Böck, K., Braitto, M., Buijs, A., Flint, C., de Groot, W. T., Ives, C. D., Mitrofanenko, T., Plieninger, T., Tucker, C., & van Riper, C. J. (2018). A model integrating social-cultural concepts of nature into frameworks of interaction between social and natural systems. *Journal of Environmental Planning and Management*, 61(5–6), 756–777. <https://doi.org/10.1080/09640568.2017.1327424>
- Muhr, M. M. (2020). Beyond words—the potential of arts-based research on human-nature connectedness. *Ecosystems and People*, 16(1), 249–257. <https://doi.org/10.1080/26395916.2020.1811379>
- Mullenbach, L. E., Baker, B. L., Benfield, J., Hickerson, B., & Mowen, A. J. (2019). Assessing the relationship between community engagement and perceived ownership of an urban park in Philadelphia. *Journal of Leisure Research*, 50(3), 201–219. <https://doi.org/10.1080/00222216.2019.1581719>
- Mundaca, E. A., Lazzaro-Salazar, M., Pujol-Cols, L., & Muñoz-Quezada, M. T. (2021). The Emotional and Cognitive Scale of the Human–Nature Relationship (ECS-HNR). *SAGE Open*, 11(1). <https://doi.org/10.1177/21582440211004142>
- Naess, A. (1973). The shallow and the deep, long-range ecology movement: A summary. *Inquiry (United Kingdom)*, 16(1–4), 95–100. <https://doi.org/10.1080/00201747308601682>
- Nielsen, K. S., Marteau, T. M., Bauer, J. M., Bradbury, R. B., Broad, S., Burgess, G., Burgman, M., Byerly, H., Clayton, S., Espelosin, D., Ferraro, P. J., Fisher, B., Garnett, E. E., Jones, J. P. G., Otieno, M., Polasky, S., Ricketts, T. H., Trevelyan, R., van der Linden, S., ... Balmford, A. (2021). Biodiversity conservation as a promising frontier for behavioural science. *Nature Human Behaviour*, 5(5), 550–556. <https://doi.org/10.1038/s41562-021-01109-5>
- Nigbur, D., Lyons, E., & Uzzell, D. (2010). Attitudes, norms, identity and environmental behaviour: Using an expanded theory of planned behaviour to predict participation in a kerbside recycling programme. *British Journal of Social Psychology*, 49(2), 259–284. <https://doi.org/10.1016/B978-0-12-374279-7.04007-8>
- Nisbet, E. K., & Zelenski, J. M. (2013). The NR-6: A new brief measure of nature relatedness. *Frontiers in Psychology*, 4, 1–11. <https://doi.org/10.3389/fpsyg.2013.00813>
- Nisbet, E. K., Zelenski, J. M., & Grandpierre, Z. (2019). Mindfulness in nature enhances connectedness and mood. *Ecopsychology*, 11(2), 81–91. <https://doi.org/10.1089/eco.2018.0061>
- Nisbet, E. K., Zelenski, J. M., & Murphy, S. A. (2009). The Nature Relatedness Scale: Linking

- individuals' connection with nature to environmental concern and behavior. *Environment and Behavior*, 41(5), 715–740. <https://doi.org/10.1177/0013916508318748>
- Nisbet, E. K., Zelenski, J. M., & Murphy, S. A. (2011). Happiness is in our nature: Exploring Nature Relatedness as a contributor to subjective well-being. *Journal of Happiness Studies*, 12(2), 303–322. <https://doi.org/10.1007/s10902-010-9197-7>
- Novacek, M. J. (2008). Engaging the public in biodiversity issues. *Proceedings of the National Academy of Sciences*, 105(Supplement 1), 11571–11578. <https://doi.org/10.1073/pnas.0802599105>
- O'Brien, K. (2015). Political agency: The key to tackling climate change. *Science*, 350(6265), 1170–1171. <https://doi.org/10.1126/science.aad0267>
- Oh, R. R. Y., Fielding, K. S., Nghiem, L. T. P., Chang, C. C., Carrasco, L. R., & Fuller, R. A. (2021). Connection to nature is predicted by family values, social norms and personal experiences of nature. *Global Ecology and Conservation*, 28, e01632. <https://doi.org/10.1016/j.gecco.2021.e01632>
- Oh, R. Y. R., Fielding, K. S., Nghiem, T. P. Le, Chang, C., Shanahan, D. F., Gaston, K. J., Carrasco, R. L., & Fuller, R. A. (2021). Factors influencing nature interactions vary between cities and types of nature interactions. *People and Nature*, 3, 405–417. <https://doi.org/10.1002/pan3.10181>
- Olivos-Jara, P., Aragonés, J. I., & Navarro-Carrascal, O. (2013). Environmental education: Itineraries in nature and their relationship with connectedness, environmental concerns and behavior. *Revista Latinoamericana de Psicología*, 45(3), 501–511. <https://doi.org/10.14349/rlp.v45i3.1490>
- Olivos-Jara, P., Segura-Fernández, R., Rubio-Pérez, C., & Felipe-García, B. (2020). Biophilia and biophobia as emotional attribution to nature in children of 5 years old. *Frontiers in Psychology*, 11(March), 1–14. <https://doi.org/10.3389/fpsyg.2020.00511>
- Olivos, P., & Aragonés, J.-I. (2011). Psychometric properties of the Environmental Identity Scale (EID). *Psychology*, 2(1), 65–74. <https://doi.org/10.1174/217119711794394653>
- Olivos, P., Aragonés, J. I., & Amérigo, M. (2011). The Connectedness to Nature Scale and its relationship with environmental beliefs and identity. *International Journal of Hispanic Psychology*, 4(1), 5–19.
- Ong, M., Baker, A., Aguilar, A., & Stanley, M. (2019). The meanings attributed to community gardening: A qualitative study. *Health and Place*, 59(August), 102190. <https://doi.org/10.1016/j.healthplace.2019.102190>
- Otto, S., & Pensini, P. (2017). Nature-based environmental education of children: Environmental knowledge and connectedness to nature, together, are related to ecological behaviour. *Global Environmental Change*, 47(September), 88–94. <https://doi.org/10.1016/j.gloenvcha.2017.09.009>
- Özgüner, H. (2011). Cultural differences in attitudes towards urban parks and green spaces.

- Landscape Research*, 36(5), 599–620. <https://doi.org/10.1080/01426397.2011.560474>
- Pacheco, P., Mo, K., Dudley, N., Shapiro, A., Aguilar-Amuchastegui, N., Ling, P. Y., Anderson, C., & Marx, A. (2021). *Deforestation Fronts: Drivers and Responses in a Changing World*. https://wwfint.awsassets.panda.org/downloads/deforestation_fronts___drivers_and_responses_in_a_changing_world___full_report_1.pdf
- Palliwoda, J., Kowarik, I., & von der Lippe, M. (2017). Human-biodiversity interactions in urban parks: The species level matters. *Landscape and Urban Planning*, 157, 394–406. <https://doi.org/10.1016/j.landurbplan.2016.09.003>
- Pan, Y. T., Yang, K. K., Wilson, K., Hong, Z. R., & Lin, H. shyang. (2020). The impact of museum interpretation tour on visitors' engagement and post-visit conservation intentions and behaviours. *International Journal of Tourism Research*, 22(5), 593–603. <https://doi.org/10.1002/jtr.2358>
- Pasca, L., Aragonés, J. I., & Fraijo-Sing, B. (2020). Categorizing landscapes: Approaching the concept of nature (Categorizando paisajes: una aproximación al concepto de naturaleza). *Psycology*, 11(3), 342–362. <https://doi.org/10.1080/21711976.2019.1659029>
- Pascoe, B. (2018). *Dark Emu* (2nd ed.). Magabala Books Aboriginal Corporation.
- Passmore, H. A., & Holder, M. D. (2017). Noticing nature: Individual and social benefits of a two-week intervention. *Journal of Positive Psychology*, 12(6), 537–546. <https://doi.org/10.1080/17439760.2016.1221126>
- Peck, J., Kirk, C. P., Luangrath, A. W., & Shu, S. B. (2021). Caring for the commons: Using psychological ownership to enhance stewardship behavior for public goods. *Journal of Marketing*, 85(2), 33–49. <https://doi.org/10.1177/0022242920952084>
- Pennay, D. W., Neiger, D., Lavrakas, P. J., & Borg, K. (2018). The Online Panels Benchmarking Study: A total survey error comparison of findings from probability-based surveys and nonprobability online panel surveys in Australia. In *CSRM & SRC Methods Paper No. 2/2018*. <http://csrm.cass.anu.edu.au/research/publications/online-panels-benchmarking-study-total-survey-error-comparison-findings>
- Pennisi, L., Lackey, N. Q., & Holland, S. M. (2017). Can an immersion exhibit inspire connection to nature and environmentally responsible behavior? *Journal of Interpretation Research*, 22(2), 35–49. <https://doi.org/10.1177/109258721702200204>
- Pensini, P., Horn, E., & Caltabiano, N. J. (2016). An exploration of the relationships between adults' childhood and current nature exposure and their mental well-being. *Children, Youth and Environments*, 26(1), 125. <https://doi.org/10.7721/chilyoutenvi.26.1.0125>
- Pérez-López, R., Eugenio-Gozalbo, M., Zuazagoitia, D., & Ruiz-González, A. (2020). Organic learning gardens in higher education: Do they improve kindergarten pre-service teachers' connectedness to and conception of nature? *Frontiers in Psychology*, 11(March), 1–6. <https://doi.org/10.3389/fpsyg.2020.00282>
- Pérez-Ramírez, I., García-Llorente, M., Saban de la Portilla, C., Benito, A., & Castro, A. J. (2021).

Participatory collective farming as a leverage point for fostering human-nature connectedness. *Ecosystems and People*, 17(1), 222–234.

<https://doi.org/10.1080/26395916.2021.1912185>

Perkins, H. E. (2010). Measuring love and care for nature. *Journal of Environmental Psychology*, 30(4), 455–463. <https://doi.org/10.1016/J.JENVP.2010.05.004>

Perrin, J. L., & Benassi, V. A. (2009). The connectedness to nature scale: A measure of emotional connection to nature? *Journal of Environmental Psychology*, 29(4), 434–440.

<https://doi.org/10.1016/j.jenvp.2009.03.003>

Petersen, E., Fiske, A. P., & Schubert, T. W. (2019). The role of social relational emotions for human-nature connectedness. *Frontiers in Psychology*, 10(December).

<https://doi.org/10.3389/fpsyg.2019.02759>

Petersen, E., & Martin, A. J. (2020). Kama muta (\approx being moved) helps connect people in and to nature: A photo elicitation approach. *Ecopsychology*, 13(1), 37–47.

<https://doi.org/10.1089/eco.2020.0032>

Phelps, E. A. (2006). Emotion and cognition: Insights from studies of the human amygdala. *Annual Review of Psychology*, 57(1), 27–53.

<https://doi.org/10.1146/annurev.psych.56.091103.070234>

Phillis, C. C., O'Regan, S. M., Green, S. J., Bruce, J. E. B., Anderson, S. C., Linton, J. N., & Favaro, B. (2013). Multiple pathways to conservation success. *Conservation Letters*, 6(2), 98–106. <https://doi.org/10.1111/j.1755-263X.2012.00294.x>

Piff, P. K., Dietze, P., Feinberg, M., Stancato, D. M., & Keltner, D. (2015). Awe, the small self, and prosocial behavior. *Journal of Personality and Social Psychology*, 108(6), 883–899.

<https://doi.org/10.1037/pspi0000018>

Pirchio, S., Passiatore, Y., Panno, A., Cipparone, M., & Carrus, G. (2021). The effects of contact with nature during outdoor environmental education on students' wellbeing, connectedness to nature and pro-sociality. *Frontiers in Psychology*, 12(May), 1–9.

<https://doi.org/10.3389/fpsyg.2021.648458>

Platto, S., Zhou, J., Wang, Y., Wang, H., & Carafoli, E. (2021). Biodiversity loss and COVID-19 pandemic: The role of bats in the origin and the spreading of the disease. *Biochemical and Biophysical Research Communications*, 538, 2–13.

Pogrebna, G., Renaud, K., & Kovaleva, M. (2021). *The Big Bad Bias Book*. Behavioural Data Science. <https://www.bigbadbiasbook.com/>

Pointon, P. (2014). "The city snuffs out nature": Young people's conceptions of and relationship with nature. *Environmental Education Research*, 20(6), 776–794.

<https://doi.org/10.1080/13504622.2013.833595>

Preston, S. D., & Gelman, S. A. (2020). This land is my land: Psychological ownership increases willingness to protect the natural world more than legal ownership. *Journal of Environmental Psychology*, 70(June), 101443. <https://doi.org/10.1016/j.jenvp.2020.101443>

- Prévot, A. C., Cheval, H., Raymond, R., & Cosquer, A. (2018). Routine experiences of nature in cities can increase personal commitment toward biodiversity conservation. *Biological Conservation*, 226(June), 1–8. <https://doi.org/10.1016/j.biocon.2018.07.008>
- Prévot, A. C., Clayton, S., & Mathevet, R. (2018). The relationship of childhood upbringing and university degree program to environmental identity: Experience in nature matters. *Environmental Education Research*, 24(2), 263–279. <https://doi.org/10.1080/13504622.2016.1249456>
- Pritchard, A., Richardson, M., Sheffield, D., & McEwan, K. (2019). The relationship between nature connectedness and eudaimonic well-being: A meta-analysis. *Journal of Happiness Studies*, 1–23. <https://doi.org/10.1007/s10902-019-00118-6>
- Profice, C. (2018). Nature as a living presence: Drawings by Tupinambá and New York Children. *PLoS ONE*, 13(10), 1–15. <https://doi.org/10.1371/journal.pone.0203870>
- Pyle, R. M. (2003). Nature matrix: Reconnecting people and nature. *Oryx*, 37(2), 206–214. <https://doi.org/10.1017/S0030605303000383>
- Raatikainen, K. J., Juhola, K., Huhmarniemi, M., & Peña-Lagos, H. (2020). "Face the cow": reconnecting to nature and increasing capacities for pro-environmental agency. *Ecosystems and People*, 16(1), 273–289. <https://doi.org/10.1080/26395916.2020.1817151>
- Ramkissoon, H., Smith, L. D. G., & Weiler, B. (2013). Testing the dimensionality of place attachment and its relationships with place satisfaction and pro-environmental behaviours: A structural equation modelling approach. *Tourism Management*, 36(0), 552–566. <https://doi.org/http://dx.doi.org/10.1016/j.tourman.2012.09.003>
- Rare and The Behavioural Insights Team [BIT]. (2019). *Behavior Change for Nature: A Behavioral Science Toolkit for Practitioners*. <https://www.bi.team/publications/behavior-change-for-nature-a-behavioral-science-toolkit-for-practitioners/>
- Reddy, S. M. W., Montambault, J., Masuda, Y. J., Keenan, E., Butler, W., Fisher, J. R. B., Asah, S. T., & Gneezy, A. (2017). Advancing conservation by understanding and influencing human behavior. *Conservation Letters*, 10(2), 248–256. <https://doi.org/10.1111/conl.12252>
- Restall, B., & Conrad, E. (2015). A literature review of connectedness to nature and its potential for environmental management. *Journal of Environmental Management*, 159, 264–278. <https://doi.org/10.1016/j.jenvman.2015.05.022>
- Restall, B., Conrad, E., & Cop, C. (2021). Connectedness to nature: Mapping the role of protected areas. *Journal of Environmental Management*, 293(April), 112771. <https://doi.org/10.1016/j.jenvman.2021.112771>
- Rice, C. S., & Torquati, J. C. (2013). Assessing connections between young children's affinity for nature and their experiences in natural outdoor settings in preschools. *Children, Youth and Environments*, 23(2), 78. <https://doi.org/10.7721/chilyoutenvi.23.2.0078>
- Richards, D. R., Fung, T. K., Leong, R. A. T., Sachidhanandam, U., Drillet, Z., & Edwards, P. J. (2020). Demographic biases in engagement with nature in a tropical Asian city. *Plos One*,

15(4), e0231576. <https://doi.org/10.1371/journal.pone.0231576>

Richardson, M. (2021). *The Dasgupta Review and Nature Connectedness*. Finding Nature.

<https://findingnature.org.uk/2021/07/16/the-dasgupta-review/>

Richardson, M., Cormack, A., McRobert, L., & Underhill, R. (2016). 30 days wild: Development and evaluation of a large-scale nature engagement campaign to improve well-being. *PLoS ONE*, 11(2), 1–13. <https://doi.org/10.1371/journal.pone.0149777>

Richardson, M., Dobson, J., Abson, D. J., Lumber, R., Hunt, A., Young, R., & Moorhouse, B. (2020). Applying the pathways to nature connectedness at a societal scale: a leverage points perspective. *Ecosystems and People*, 16(1), 387–401.

<https://doi.org/10.1080/26395916.2020.1844296>

Richardson, M., Hallam, J., & Lumber, R. (2015). One thousand good things in nature: Aspects of nearby nature associated with improved connection to nature. *Environmental Values*, 24(5), 603–619. <https://doi.org/10.3197/096327115X14384223590131>

Richardson, M., & Hamlin, I. (2021). Nature engagement for human and nature's wellbeing during the Corona pandemic. *Journal of Public Mental Health*, 1–11. <https://doi.org/10.1108/JPMH-02-2021-0016>

Richardson, M., Hamlin, I., Butler, C. W., Thomas, R., & Hunt, A. (2021). Actively noticing nature (not just time in nature) helps promote nature connectedness. *Ecopsychology*, 1–9.

<https://doi.org/10.1089/eco.2021.0023>

Richardson, M., Hunt, A., Hinds, J., Bragg, R., Fido, D., Petronzi, D., Barbett, L., Clitherow, T., & White, M. (2019). A measure of nature connectedness for children and adults: Validation, performance, and insights. *Sustainability*, 11(12), 3250. <https://doi.org/10.3390/su11123250>

Richardson, M., & McEwan, K. (2018). 30 Days Wild and the relationships between engagement with nature's beauty, nature connectedness and well-being. *Frontiers in Psychology*, 9(SEP), 1–9. <https://doi.org/10.3389/fpsyg.2018.01500>

Richardson, M., Passmore, H.-A., Lumber, R., Thomas, R., & Hunt, A. (2021). Moments, not minutes: The nature-wellbeing relationship. *International Journal of Wellbeing*, 11(1), 8–33.

<https://doi.org/10.5502/ijw.v11i1.1267>

Richardson, M., Passmore, H., Barbett, L., Lumber, R., Thomas, R., & Hunt, A. (2020). The green care code: How nature connectedness and simple activities help explain pro-nature conservation behaviours. *People and Nature*, January, 1–19.

<https://doi.org/10.1002/pan3.10117>

Richardson, M., & Sheffield, D. (2015). Reflective self-attention: A more stable predictor of connection to nature than mindful attention. *Ecopsychology*, 7(3), 166–175.

<https://doi.org/10.1089/eco.2015.0010>

Richardson, M., & Sheffield, D. (2017). Three good things in nature: Noticing nearby nature brings sustained increases in connection with nature. *Psychology*, 8(1), 1–32.

<https://doi.org/10.1080/21711976.2016.1267136>

- Riechers, M., Balázsi, Á., Abson, D. J., & Fischer, J. (2020). The influence of landscape change on multiple dimensions of human–nature connectedness. *Ecology and Society*, 25(3), 1–12. <https://doi.org/10.5751/ES-11651-250303>
- Riechers, M., Balázsi, Á., García-Llorente, M., & Loos, J. (2021). Human-nature connectedness as leverage point. *Ecosystems and People*, 17(1), 215–221. <https://doi.org/10.1080/26395916.2021.1912830>
- Roczen, N., Duvier, C., Bogner, F. X., & Kaiser, F. G. (2012). The search for potential origins of a favorable attitude toward nature. *Psychology*, 3(3), 341–352. <https://doi.org/10.1174/217119712802845750>
- Rogerson, M., Barton, J., Bragg, R., & Pretty, J. (2017). *The health and wellbeing impacts of volunteering with The Wildlife Trusts*. <https://t.co/cKHqgKXI72>
- Rosa, C. D., & Collado, S. (2019). Experiences in nature and environmental attitudes and behaviors: Setting the ground for future research. *Frontiers in Psychology*, 10(763), 1–9. <https://doi.org/10.3389/fpsyg.2019.00763>
- Rosa, C. D., Profice, C. C., & Collado, S. (2018). Nature experiences and adults' self-reported pro-environmental behaviors: The role of connectedness to nature and childhood nature experiences. *Frontiers in Psychology*, 9(1055), 1–10. <https://doi.org/10.3389/fpsyg.2018.01055>
- Roszak, T. (1992). *The Voice of the Earth*. Simon & Schuster Inc.
- Rousseau, S., & Deschacht, N. (2020). Public awareness of nature and the environment during the COVID-19 crisis. *Environmental and Resource Economics*, 76(4), 1149–1159. <https://doi.org/10.1007/s10640-020-00445-w>
- Russell, R., Guerry, A. D., Balvanera, P., Gould, R. K., Basurto, X., Chan, K. M. A., Klain, S., Levine, J., & Tam, J. (2013). Humans and nature: How knowing and experiencing nature affect well-being. In *Annual Review of Environment and Resources* (Vol. 38). <https://doi.org/10.1146/annurev-environ-012312-110838>
- Sachs, N. A., Rakow, D. A., Shepley, M. M. C., & Peditto, K. (2020). The potential correlation between nature engagement in middle childhood years and college undergraduates' nature engagement, proenvironmental attitudes, and stress. *Frontiers in Psychology*, 11(October), 1–14. <https://doi.org/10.3389/fpsyg.2020.540872>
- Salazar, G., Kunkle, K., & Monroe, M. (2020). *Practitioner Guide to Assessing Connection to Nature*. https://cdn.naaee.org/sites/default/files/assessing_connection_to_nature.7.23.20.pdf
- Salazar, G., Monroe, M. C., Jordan, C., Ardoin, N. M., & Beery, T. H. (2021). Improving assessments of connection to nature: A participatory approach. *Frontiers in Ecology and Evolution*, 8(January), 1–7. <https://doi.org/10.3389/fevo.2020.609104>
- Salmón, E. (2000). Kincentric ecology: Indigenous perceptions of the human-nature relationship. *Ecological Applications*, 10(5), 1327–1332.
- Sangha, K. K., Russell-Smith, J., & Costanza, R. (2019). Mainstreaming indigenous and local

- communities' connections with nature for policy decision-making. *Global Ecology and Conservation*, 19(e00668), 1–13. <https://doi.org/10.1016/j.gecco.2019.e00668>
- Sato, M., Aoshima, I., & Chang, Y. (2021). Connectedness to nature and the conservation of the urban ecosystem: Perspectives from the valuation of urban forests. *Forest Policy and Economics*, 125(102396), 1–11. <https://doi.org/10.1016/j.forpol.2021.102396>
- Schermerle-Engel, K., Müller, H., & Moosbrugger, H. (2003). Evaluating the fit of structural equation models. *Methods of Psychological Research*, 8(2), 23–74.
- Schild, R. (2018). Fostering environmental citizenship: The motivations and outcomes of civic recreation. *Journal of Environmental Planning and Management*, 61(5–6), 924–949. <https://doi.org/10.1080/09640568.2017.1350144>
- Schmithüsen, F., & Wild-Eck, S. (2000). Uses and perceptions of forests by people living in urban areas findings from selected empirical studies. *Forstwissenschaftliches Centralblatt*, 119(1), 395–408. <https://doi.org/10.1007/BF02769152>
- Schmitt, M. T., Mackay, C. M. L., Droogendyk, L. M., & Payne, D. (2019). What predicts environmental activism? The roles of identification with nature and politicized environmental identity. *Journal of Environmental Psychology*, 61, 20–29. <https://doi.org/10.1016/j.jenvp.2018.11.003>
- Schroeder, H. W. (1991). Preference and meaning of arboretum landscapes: Combining quantitative and qualitative data. *Journal of Environmental Psychology*, 11(3), 231–248. [https://doi.org/10.1016/S0272-4944\(05\)80185-9](https://doi.org/10.1016/S0272-4944(05)80185-9)
- Schroeder, H. W. (2002). Experiencing nature in special places: Surveys in the north-central region. *Journal of Forestry*, 100(5), 8–14. <https://doi.org/10.1093/jof/100.5.8>
- Schroeder, H. W. (2007). Place experience, gestalt, and the human-nature relationship. *Journal of Environmental Psychology*, 27(4), 293–309. <https://doi.org/10.1016/j.jenvp.2007.07.001>
- Schultz, P. W. (2000). Empathizing with nature: The effects of perspective taking on concern for environmental issues. *Journal of Social Issues*, 56(3), 391–406. <https://doi.org/10.1111/0022-4537.00174>
- Schultz, P. W. (2001). The structure of environmental concern: Concern for self, other people, and the biosphere. *Journal of Environmental Psychology*, 21(4), 327–339. <https://doi.org/10.1006/jev.2001.0227>
- Schultz, P. W. (2002). Inclusion with nature: The psychology of human-nature relations. In P. Schmuck & W. P. Schultz (Eds.), *Psychology of Sustainable Development* (pp. 61–78). Springer Science and Business Media. https://doi.org/10.1007/978-1-4615-0995-0_4
- Schultz, P. W. (2011). Conservation means behavior. *Conservation Biology*, 25(6), 1080–1083. <https://doi.org/10.1111/j.1523-1739.2011.01766.x>
- Schultz, P. W., Gouveia, V. V., Cameron, L. D., Tankha, G., Schmuck, P., & Franek, M. (2005). Values and their relationship to environmental concern and conservation behavior. *Journal of Cross-Cultural Psychology*, 36(4), 457–475. <https://doi.org/10.1177/0022022105275962>

- Schultz, P. W., Shriver, C., Tabanico, J. J., & Khazian, A. M. (2004). Implicit connections with nature. *Journal of Environmental Psychology*, 24(1), 31–42. [https://doi.org/10.1016/S0272-4944\(03\)00022-7](https://doi.org/10.1016/S0272-4944(03)00022-7)
- Schultz, P. W., & Tabanico, J. J. (2007). Self, identity, and the natural environment: Exploring implicit connections with nature. *Journal of Applied Social Psychology*, 37(6), 1219–1247.
- Schunko, C., & Brandner, A. (2021). Urban nature at the fingertips: Investigating wild food foraging to enable nature interactions of urban dwellers. *Ambio*, 1–11. <https://doi.org/10.1007/s13280-021-01648-1>
- Schutte, N. S., & Malouff, J. M. (2018). Mindfulness and connectedness to nature: A meta-analytic investigation. *Personality and Individual Differences*, 127, 10–14. <https://doi.org/10.1016/j.paid.2018.01.034>
- Schuttler, S. G., Sorensen, A. E., Jordan, R. C., Cooper, C., & Schwartz, A. (2018). Bridging the nature gap: can citizen science reverse the extinction of experience? *Frontiers in Ecology and the Environment*, 16(7), 405–411. <https://doi.org/10.1002/fee.1826>
- Schwartz, M. W. (2020). A social movement for conservation. *Stanford Social Innovation Review*, May 14, 1–7. https://ssir.org/articles/entry/a_social_movement_for_conservation#
- Schwartz, S. H. (1994). Are there universal aspects in the content and structure of values? *Journal of Social Issues*, 50(4), 19–45.
- Scopelliti, M., Carrus, G., Adinolfi, C., Suarez, G., Colangelo, G., Laforzezza, R., Panno, A., & Sanesi, G. (2016). Staying in touch with nature and well-being in different income groups: The experience of urban parks in Bogotá. *Landscape and Urban Planning*, 148, 139–148. <https://doi.org/10.1016/j.landurbplan.2015.11.002>
- Sedawi, W., Assaraf, O. B. Z., & Reiss, M. J. (2020). Indigenous children's connectedness to nature: The potential influence of culture, gender and exposure to a contaminated environment. *Cultural Studies of Science Education*, 0123456789. <https://doi.org/10.1007/s11422-020-09982-8>
- Sedawi, W., Assaraf, O. B. Z., & Reiss, M. J. (2021). Challenges in measuring "connectedness to nature" among indigenous children: Lessons from the Negev Bedouin. *Cultural Studies of Science Education*, 0123456789, 1–37. <https://doi.org/10.1007/s11422-020-09995-3>
- Selinske, M. J., Bekessy, S. A., Geary, W. L., Faulkner, R., Hames, F., Fletcher, C., Squires, Z. E., & Garrard, G. E. (2021). Projecting biodiversity benefits of conservation behavior-change programs. *Conservation Biology*. <https://doi.org/10.1111/cobi.13845>
- Selinske, M. J., Garrard, G. E., Bekessy, S. A., Gordon, A., Kusmanoff, A. M., & Fidler, F. (2018). Revisiting the promise of conservation psychology. *Conservation Biology*, 32(6), 1464–1468. <https://doi.org/10.1111/cobi.13106>
- Selinske, M. J., Garrard, G. E., Gregg, E. A., Kusmanoff, A. M., Kidd, L. R., Cullen, M. T., Cooper, M., Geary, W. L., Hatty, M. A., Hames, F., Kneebone, S., McLeod, E. M., Ritchie, E. G., Squires, Z. E., Thomas, J., Willcock, M. A. W., Blair, S., & Bekessy, S. A. (2020). Identifying

- and prioritizing human behaviors that benefit biodiversity. *Conservation Science and Practice*, e249, 1–19. <https://doi.org/10.1111/csp2.249>
- Seppelt, R., & Cumming, G. S. (2016). Humanity's distance to nature: Time for environmental austerity? *Landscape Ecology*, 31(8), 1645–1651. <https://doi.org/10.1007/s10980-016-0423-5>
- Shanahan, D. F., Cox, D. T. C., Fuller, R. A., Hancock, S., Lin, B. B., Anderson, K., Bush, R., & Gaston, K. J. (2017). Variation in experiences of nature across gradients of tree cover in compact and sprawling cities. *Landscape and Urban Planning*, 157, 231–238. <https://doi.org/10.1016/j.landurbplan.2016.07.004>
- Shaw, A., Miller, K., & Wescott, G. (2013). Wildlife gardening and connectedness to nature: Engaging the unengaged. *Environmental Values*, 22(4), 483–502. <https://doi.org/10.3197/096327113X13690717320748>
- Sheldon, K. M. (2011). Integrating behavioral-motive and experiential-requirement perspectives on psychological needs: A two process model. *Psychological Review*, 118(4), 552–569. <https://doi.org/10.1037/a0024758>
- Simberloff, D. (2014). The "balance of nature" - evolution of a panchreston. *PLoS Biology*, 12(10), 10–13. <https://doi.org/10.1371/journal.pbio.1001963>
- Smith, G. T., McCarthy, D. M., & Anderson, K. G. (2000). On the sins of short-form development. *Psychological Assessment*, 12(1), 102–111. <https://doi.org/10.1037/1040-3590.12.1.102>
- Sobko, T., Jia, Z., & Brown, G. (2018). Measuring connectedness to nature in preschool children in an urban setting and its relation to psychological functioning. *PLoS ONE*, 13(11), 1–17. <https://doi.org/10.1371/journal.pone.0207057>
- Soga, M., & Akasaka, M. (2019). Multiple landscape-management and social-policy approaches are essential to mitigate the extinction of experience. *Landscape and Urban Planning*, 191(August), 103634. <https://doi.org/10.1016/j.landurbplan.2019.103634>
- Soga, M., & Gaston, K. J. (2016). Extinction of experience: The loss of human-nature interactions. *Frontiers in Ecology and the Environment*, 14(2), 94–101. <https://doi.org/10.1002/fee.1225>
- Soga, M., & Gaston, K. J. (2020). The ecology of human-nature interactions. *Proceedings of the Royal Society B: Biological Sciences*, 287(20191882), 1–10. <https://doi.org/10.1098/rspb.2019.1882>
- Soga, M., Yamanoi, T., Tsuchiya, K., Koyanagi, T. F., & Kanai, T. (2018). What are the drivers of and barriers to children's direct experiences of nature? *Landscape and Urban Planning*, 180(April), 114–120. <https://doi.org/10.1016/j.landurbplan.2018.08.015>
- Soliman, M., Peetz, J., & Davydenko, M. (2017). The impact of immersive technology on nature relatedness and pro-environmental behavior. *Journal of Media Psychology*, 29(1), 8–17. <https://doi.org/10.1027/1864-1105/a000213>
- Souter-Brown, G. (2015). *Landscape and urban design for health and well-being: Using healing, sensory and therapeutic gardens*. Routledge.
- St John, D., & MacDonald, D. A. (2007). Development and initial validation of a measure of

- ecopsychological self. *The Journal of Transpersonal Psychology*, 39(1), 48–67.
- Steg, L., & Vlek, C. (2009). Encouraging pro-environmental behaviour: An integrative review and research agenda. *Journal of Environmental Psychology*, 29(3), 309–317.
<https://doi.org/10.1016/j.jenvp.2008.10.004>
- Stern, P. C., & Dietz, T. (1994). The value basis of environmental concern. *Journal of Social Issues*, 50(3), 65–84.
- Stets, J. E., & Biga, C. F. (2003). Bringing identity theory into environmental sociology. *Sociological Theory*, 21(4), 398–423.
- Sturgis, P., & Allum, N. (2004). Science in society: Re-evaluating the deficit model of public attitudes. *Public Understanding of Science*, 13(1), 55–74.
<https://doi.org/10.1177/0963662504042690>
- Tabachnick, B. G., & Fidell, L. S. (2007). *Using Multivariate Statistics* (5th ed.). Pearson Education Inc.
- Talebpour, L. M., Busk, P. L., Heimlich, J. E., & Ardoin, N. M. (2020). Children's connection to nature as fostered through residential environmental education programs: Key variables explored through surveys and field journals. *Environmental Education Research*, 26(1), 95–114. <https://doi.org/10.1080/13504622.2019.1707778>
- Tam, K. P. (2013). Concepts and measures related to connection to nature: Similarities and differences. *Journal of Environmental Psychology*, 34, 64–78.
<https://doi.org/10.1016/j.jenvp.2013.01.004>
- Tang, I. C., Sullivan, W. C., & Chang, C. Y. (2015). Perceptual evaluation of natural landscapes: The role of the individual connection to nature. *Environment and Behavior*, 47(6), 595–617.
<https://doi.org/10.1177/0013916513520604>
- Taylor, D. E. (2018). Racial and ethnic differences in connectedness to nature and landscape preferences among college students. *Environmental Justice*, 11(3), 118–136.
<https://doi.org/10.1089/env.2017.0040>
- Taylor, D. E. (2019). College students and nature: Differing thoughts of fear, danger, disconnection, and loathing. *Environmental Management*, 64, 79–96.
<https://doi.org/10.1007/s00267-019-01172-9>
- Taylor, D. E. (2021). Understanding Black, Asian, Latinx, and White college students' views of nature: Frequent thoughts about wild, remote, rural, and urban landscapes. *American Behavioral Scientist*, 1–43. <https://doi.org/10.1177/00027642211013403>
- Tomasso, L. P., Cedeño Laurent, J. G., Chen, J. T., Catalano, P. J., & Spengler, J. D. (2021). Cultural sets shape adult conceptualizations and relationships to nature. *Sustainability*, 13(20), 11266. <https://doi.org/10.3390/su132011266>
- Toomey, A. H., & Domroese, M. C. (2013). Can citizen science lead to positive conservation attitudes and behaviors? *Human Ecology Review*, 20(1), 50–62,67.
http://www.academia.edu/6128458/Can_citizen_science_lead_to_positive_conservation_attitu

- Travers, H., Walsh, J., Vogt, S., Clements, T., & Milner-Gulland, E. J. (2021). Delivering behavioural change at scale: What conservation can learn from other fields. *Biological Conservation*, 257(April), 109092. <https://doi.org/10.1016/j.biocon.2021.109092>
- Trigwell, J. L., Francis, A. J. P., & Bagot, K. L. (2014). Nature connectedness and eudaimonic well-being: spirituality as a potential mediator. *Ecopsychology*, 6(4), 241–251. <https://doi.org/10.1089/eco.2014.0025>
- Truong, M., Bonnefoy, B., & Prévot, A.-C. (2020). About smells and nature: An exploratory study on the links between environmental identity, smell sensitivity, and sensory uses of natural spaces. *PsyEcology*, 11(1), 7–20. <https://doi.org/10.1080/21711976.2019.1643987>
- Ulrich, R. (1993). Biophilia, biophobia, and natural landscapes. In S. R. Kellert & E. O. Wilson (Eds.), *The Biophilia Hypothesis* (pp. 73–137). Island Press.
- United Nations. (1992). *Convention on Biological Diversity*. <https://doi.org/10.1016/B978-0-12-384719-5.00418-4>
- United Nations Department of Economic and Social Affairs. (2019). World Urbanization Prospects. In *The 2018 Revision (ST/ESA/SER.A/420)*. <https://population.un.org/wup/Publications/Files/WUP2018-Report.pdf>
- Uren, H. V., Dzidic, P. L., Roberts, L. D., Leviston, Z., & Bishop, B. J. (2019). Green-tinted glasses: How do pro-environmental citizens conceptualize environmental sustainability? *Environmental Communication*, 13(3), 395–411. <https://doi.org/10.1080/17524032.2017.1397042>
- van den Born, R. J. G., Lenders, R. H. J., de Groot, W. T., & Huijsman, E. (2001). The new biophilia: An exploration of visions of nature in Western countries. *Environmental Conservation*, 28(1), 65–75. <https://doi.org/10.1017/S0376892901000066>
- van der Linden, S., Maibach, E., & Leiserowitz, A. (2015). Improving public engagement with climate change: Five "best practice" insights from psychological science. *Perspectives on Psychological Science*, 10(6), 758–763. <https://doi.org/10.1177/1745691615598516>
- van der Werff, E., Steg, L., & Keizer, K. (2014). Follow the signal: When past pro-environmental actions signal who you are. *Journal of Environmental Psychology*, 40, 273–282. <https://doi.org/10.1016/j.jenvp.2014.07.004>
- Victorian Association of Forest Industries. (2017). *Annual Industry Review 2017*. <http://www.vafi.org.au/industry-review/>
- Vining, J., Merrick, M. S., & Price, E. A. (2008). The distinction between humans and nature: Human perceptions of connectedness to nature and elements of the natural and unnatural. *Human Ecology Review*, 15(1), 1–11.
- Wallace, H. D. (2019). Transdisciplinary learning in a kitchen garden: Connecting to nature and constructing a path to ecoliteracy? *International Research in Geographical and Environmental Education*, 28(4), 309–323. <https://doi.org/10.1080/10382046.2019.1646013>
- Walton, T. N., & Jones, R. E. (2018). Ecological identity: The development and assessment of a

measurement scale. *Environment and Behavior*, 50(6), 657–689.

<https://doi.org/10.1177/0013916517710310>

Ward Thompson, C., Aspinall, P., & Montarzino, A. (2008). The childhood factor: Adult visits to green places and the significance of childhood experience. *Environment And Behavior*, 40(1), 111–143.

Watson, J. E. M., Venter, O., Lee, J., Jones, K. R., Robinson, J. G., Possingham, H. P., & Allan, J. R. (2018). Protect the last of the wild. *Nature*, 563(7729), 27–30.

<https://doi.org/10.1038/d41586-018-07183-6>

Wells, N. M., & Lekies, K. S. (2006). Nature and the life course: Pathways from childhood nature experiences to adult environmentalism. *Children, Youth and Environments*, 16(1), 1–25.

<https://doi.org/Available online: www.colorado.edu/journals/cye>

Wesselmann, E. D., Boyd, S. W., Arellanes, J. A., Driskell, A., & Hesson-McInnis, M. S. (2021). Manipulating environmental commitment: A replication and extension. *Psychological Reports*.

<https://doi.org/10.1177/00332941211012621>

Whitburn, J., Linklater, W., & Abrahamse, W. (2019). Meta-analysis of human connection to nature and proenvironmental behavior. *Conservation Biology*, 34(1), 180–193.

<https://doi.org/10.1111/cobi.13381>

Whitburn, J., Linklater, W. L., & Milfont, T. L. (2019). Exposure to urban nature and tree planting are related to pro-environmental behavior via connection to nature, the use of nature for psychological restoration, and environmental attitudes. *Environment and Behavior*, 51(7), 787–810. <https://doi.org/10.1177/0013916517751009>

White, M. P., Alcock, I., Grellier, J., Wheeler, B. W., Hartig, T., Warber, S. L., Bone, A., Depledge, M. H., & Fleming, L. E. (2019). Spending at least 120 minutes a week in nature is associated with good health and wellbeing. *Scientific Reports*, 9(7730), 1–11.

<https://doi.org/10.1038/s41598-019-44097-3>

Whitmarsh, L., & O'Neill, S. (2010). Green identity, green living? The role of pro-environmental self-identity in determining consistency across diverse pro-environmental behaviours. *Journal of Environmental Psychology*, 30(3), 305–314.

<https://doi.org/http://dx.doi.org/10.1016/j.jenvp.2010.01.003>

World Health Organization and Convention on Biological Diversity [WHO and CBD]. (2015).

Connecting Global Priorities: Biodiversity and Human Health, A State of Knowledge Review.

<https://doi.org/10.13140/RG.2.1.3679.6565>

World Health Organization Regional Office for Europe. (2021). *Nature, biodiversity and health: an overview of interconnections.*

<https://apps.who.int/iris/bitstream/handle/10665/341376/9789289055581-eng.pdf>

Wilson, E. O. (1984). *Biophilia*. Harvard University Press.

Wilson, E. O. (1993). Biophilia and the conservation ethic. In Stephen R Kellert & E. O. Wilson (Eds.), *The Biophilia Hypothesis* (pp. 31–41). Island Press.

- Winch, K., Stafford, R., Gillingham, P., Thorsen, E., & Diaz, A. (2020). Diversifying environmental volunteers by engaging with online communities. *People and Nature*, January, 1–15.
<https://doi.org/10.1002/pan3.10147>
- Woinarski, J. C. Z., Burbidge, A. A., & Harrison, P. L. (2015). Ongoing unraveling of a continental fauna: Decline and extinction of Australian mammals since European settlement. *Proceedings of the National Academy of Sciences*, 112(15), 4531–4540.
<https://doi.org/10.1073/pnas.1417301112>
- World Economic Forum. (2020). *The Global Risks Report* (Vol. 15). <http://wef.ch/risks2019>
- Wright, P. A., & Matthews, C. (2015). Building a culture of conservation: Research findings and research priorities on connecting people to nature in parks. *Parks*, 21(2), 11–24.
- WWF. (2020). *Living Planet Report 2020: Bending the curve of biodiversity loss*.
<https://f.hubspotusercontent20.net/hubfs/4783129/LPR/PDFs/ENGLISH-FULL.pdf>
- WWF Australia. (2018). *Backyard barometer summary report: Australian attitudes to nature*.
<https://www.wwf.org.au/ArticleDocuments/353/pub-summary-backyard-barometer-australian-attitudes-to-nature-23may18.pdf.aspx?Embed=Y>
- Wyles, K. J., Pahl, S., Holland, M., & Thompson, R. C. (2017). Can beach cleans do more than clean-up litter ? Comparing beach cleans to other coastal activities. *Environment and Behavior*, 49(5), 509–535. <https://doi.org/10.1177/0013916516649412>
- Wyles, K. J., White, M. P., Hattam, C., Pahl, S., King, H., & Austen, M. (2019). Are some natural environments more psychologically beneficial than others? The importance of type and quality on connectedness to nature and psychological restoration. *Environment and Behavior*, 51(2), 111–143. <https://doi.org/10.1177/0013916517738312>
- Yaden, D. B., Kaufman, S. B., Hyde, E., Chirico, A., Zhang, J. W., & Keltner, D. (2019). The development of the Awe Experience Scale (AWE-S): A multifactorial measure for a complex emotion. *The Journal of Positive Psychology*, 14(4), 474–488.
<https://doi.org/10.1080/17439760.2018.1484940>
- Yang, Y., Hu, J., Jing, F., & Nguyen, B. (2018). From awe to ecological behavior: The mediating role of connectedness to nature. *Sustainability (Switzerland)*, 10(7).
<https://doi.org/10.3390/su10072477>
- Zelenski, J. M., & Desrochers, J. E. (2021). Can positive and self-transcendent emotions promote pro-environmental behavior? *Current Opinion in Psychology*, 42, 31–35.
<https://doi.org/10.1016/j.copsyc.2021.02.009>
- Zelenski, J. M., Dopko, R. L., & Capaldi, C. A. (2015). Cooperation is in our nature: Nature exposure may promote cooperative and environmentally sustainable behavior. *Journal of Environmental Psychology*, 42, 24–31. <https://doi.org/10.1016/j.jenvp.2015.01.005>
- Zhang, J. W., Howell, R. T., & Iyer, R. (2014). Engagement with natural beauty moderates the positive relation between connectedness with nature and psychological well-being. *Journal of Environmental Psychology*, 38, 55–63. <https://doi.org/10.1016/j.jenvp.2013.12.013>

- Zhang, J. W., Piff, P. K., Iyer, R., Koleva, S., & Keltner, D. (2014). An occasion for unselfing: Beautiful nature leads to prosociality. *Journal of Environmental Psychology*, 37, 61–72. <https://doi.org/10.1016/j.jenvp.2013.11.008>
- Zhao, X., Lynch, J. G., & Chen, Q. (2010). Reconsidering Baron and Kenny: Myths and truths about mediation analysis. *Journal of Consumer Research*, 37(2), 197–206. <https://doi.org/10.1086/651257>
- Zylstra, M. J., Knight, A. T., Esler, K. J., & Le Grange, L. L. L. (2014). Connectedness as a core conservation concern: An interdisciplinary review of theory and a call for practice. *Springer Science Reviews*, 2, 119–143. <https://doi.org/10.1007/s40362-014-0021-3>

Appendix A

Table A1: Conditional effects of CN-Identity and CN-Experience (X) on picking up litter (Y) for the four concepts of nature categories (n = 3012).

	Concepts of nature category	Effect	SE	t	p
CN-Identity (X)	Experiential	0.069	0.107	0.642	0.521
	Normative	0.304	0.132	2.307	0.021
	Descriptive	0.333	0.018	18.302	< 0.001
	Complex	0.368	0.040	9.300	< 0.001
CN-Experience (X)	Experiential	0.016	0.115	0.139	0.889
	Normative	0.357	0.153	2.331	0.020
	Descriptive	0.325	0.021	15.711	< 0.001
	Complex	0.402	0.047	8.629	< 0.001

Table A2: Conditional effects of picking up litter (X) on CN-Total, CN-Identity, and CN-Experience (Y) for the four concepts of nature categories (n = 3012).

	Concepts of nature category	Effect	SE	t	p
CN-Total (Y)	Experiential	0.036	0.084	0.427	0.669
	Normative	0.223	0.111	2.001	0.045
	Descriptive	0.306	0.017	17.896	< 0.001
	Complex	0.277	0.034	8.240	< 0.001
CN-Identity (Y)	Experiential	0.056	0.102	0.551	0.582
	Normative	0.286	0.135	2.124	0.034
	Descriptive	0.388	0.021	18.776	< 0.001
	Complex	0.351	0.041	8.626	< 0.001
CN-Experience (Y)	Experiential	0.012	0.092	0.127	0.899
	Normative	0.256	0.121	2.113	0.035
	Descriptive	0.302	0.019	16.182	< 0.001
	Complex	0.284	0.037	7.759	< 0.001

Table A3: Conditional effects of environmental volunteering and community gardening (X) on CN-Experience (Y) for the four concepts of nature categories (n = 3012).

	Concepts of nature category	Effect	SE	t	p
Environmental volunteering (X)	Experiential	0.026	0.092	0.278	0.781
	Normative	0.186	0.132	1.414	0.157
	Descriptive	0.271	0.022	12.069	< 0.001
	Complex	0.235	0.045	5.249	< 0.001
Community gardening (X)	Experiential	-0.010	0.089	-0.113	0.910
	Normative	0.083	0.155	0.537	0.592
	Descriptive	0.197	0.024	8.047	< 0.001
	Complex	0.124	0.045	2.741	0.006

Appendix B

Table B1: Spearman correlations between CN total and dimension scores (N = 3090), all $p < 0.001$.

	1	2	3	4
1 CN-Total	-			
2 CN-Identity	0.94	-		
3 CN-Experience	0.93	0.82	-	
4 CN-Philosophy	0.78	0.64	0.61	-

Table B2: Spearman correlations between the CN-12, Nature Relatedness Scale, and Environmental Identity Scale (total and dimension scores) (N = 1069), with corresponding dimensions shown in bold (all $p < .001$).

	CN- Total	CN- Identity	CN- Experience	CN- Philosophy
NR-Total	0.80	0.75	0.73	0.68
NR-Self	0.83	0.82	0.72	0.68
NR-Experience	0.72	0.67	0.74	0.45
NR-Perspective	0.43	0.37	0.35	0.52
EID-Total	0.82	0.81	0.74	0.62
EID-Identity	0.75	0.77	0.64	0.59
EID-Enjoying nature (experience)	0.60	0.60	0.62	0.32
EID-Philosophy	0.75	0.68	0.71	0.63
EID-Appreciation of nature	0.65	0.65	0.58	0.50

Appendix C

Descriptive statistics for connection with nature (CN: total and dimensions) at Time 1 ($N = 3090$) and Time 2 ($N = 1069$).

		Mean	SD	Skew	SE Skew.	Kurtosis	SE Kurtosis
Time 1 (2018)	CN-Total	5.234	1.031	-0.478	0.044	0.266	0.088
	CN-Identity	4.791	1.248	-0.335	0.044	-0.077	0.088
	CN-Experience	5.335	1.112	-0.685	0.044	0.744	0.088
	CN-Philosophy	5.656	1.069	-0.862	0.044	1.008	0.088
Time 2 (2019)	CN-Total	5.253	1.044	-0.601	0.075	0.842	0.149
	CN-Identity	4.842	1.239	-0.319	0.075	-0.055	0.149
	CN-Experience	5.329	1.134	-0.809	0.075	1.317	0.149
	CN-Philosophy	5.676	1.068	-0.961	0.075	1.583	0.149

Appendix D

Appendices for Study 2

STUDY 2, APPENDIX 1: Questionnaire

Demographics

Please specify your age:

1. _____ years

Please specify your gender:

1. Female
2. Male
3. Other (specify): _____

And what is the postcode of your main residence? _____

Nature definition

What comes to mind when you think of ‘nature’? Please describe in your own words.

-----PAGE BREAK-----

In this survey, we would like you to think about nature as everything that is not made by humans. This includes all the *animals*, *plants*, and *vegetation* in *land* and *water* habitats, located in *urban* and *rural* areas, and including *highly modified landscapes* through to *pristine wilderness* areas on land and in the water.

Connection with nature [†]

Please rate the extent to which you agree or disagree with the following statements:

	Strongly disagree (1)	(2)	(3)	Neither agree nor disagree (4)	(5)	(6)	Strongly agree (7)
1. I think of myself as an 'environmentalist'							
2. I think of myself as someone who is very concerned about taking care of nature							
3. Protecting nature is an important part of who I am							
4. My relationship to nature is a big part of how I think about myself							
5. I feel uneasy if I am away from nature for too long							
6. I feel right at home when I am in nature							
7. Feeling connected to nature helps me deal with everyday stress							
8. I feel a strong emotional connection to nature							
9. I enjoy spending time in nature							
10. I like to get outdoors whenever I get the chance							
11. Being in nature allows me to do the things I like doing most							
12. Getting away on an overnight trip in nature is something I do as often as I can							
13. Forests are valuable mostly because they produce wood products, jobs and income for people							
14. Meeting the needs of people requires sacrificing some natural areas							
15. In order to provide us with the goods and services we need we can't avoid nature being degraded.							
16. Natural areas are important to people because we use them for recreation							
17. My connection to nature is something I would describe as "spiritual"							
18. Everything in nature is connected (e.g. animals, plants, humans, water, air, land, fire, etc.)							
19. Human beings and nature are connected by the same 'energy' or 'life-force'							
20. Human wellbeing depends upon living in harmony with nature							

[†] Items included in the CN-12 are in bold

Pro-environmental behaviour

In the last year, how often have you done each of the following activities?

	Never (1)	Rarely (2)	Sometimes (3)	Often (4)	Always (5)
1. Controlled the movements of your pets to keep them away from native birds and animals i.e. keep my cat inside at night					
2. Chosen native plant species when planting/gardening					
3. Reduced energy use (e.g. electricity/gas) in the home					
4. Chosen sustainable seafood					
5. Used public transport rather than driving					
6. Volunteered time for activities that take care of the environment (e.g. planting trees, clearing weeds)					
7. Collected information on the natural environment for scientific projects or databases (citizen science)					
8. Donated money to organisations that take care of the environment					
9. Advocated for the environment (by, for example, contacting businesses or politicians about environmental issues, signing pro-environment petitions, attending rallies etc.)					
10. Cleaned up litter in a public space, park or forest					
11. Been involved in a local community garden or community composting activity					

STUDY 2, APPENDIX 2: Sample responses and initial coding themes for the question *what comes to mind when you think about nature?*

Coding themes (round 1 coding)	Sample responses			
	The environment -- flora and fauna, landscape, seas, rivers.	the wetlands & walking tracks in my local area	Greenery fresh air	Forest
Flora, plants, shrubs, bushes	1			
Trees				
Bush, bushland, forest, woods, woodlands, rainforest				1
Parks, national parks, marine parks, reserves				
Gardens, urban parks				
Grass, grasslands, lawns				
Vegetation, foliage, leaves				
Flowers, flowering plants				
Native, local, endemic, indigenous				
Fauna, animals, wildlife, wild animals, water creatures, marine life	1			
Birds				
Insects				
Fish				
People, humans				
Wilderness, wild, not domesticated				
Outdoors, outside				
Air, fresh air, oxygen, clean air			1	
Water, clean water, running water				
Waterways and bodies of water (rivers, lakes, waterfalls, streams, wetlands)	1	1		

Coding themes (round 1 coding)	Sample responses			
	The environment -- flora and fauna, landscape, seas, rivers.	the wetlands & walking tracks in my local area	Greenery fresh air	Forest
Ocean, seas, coast, beach, mangroves	1			
Land, plains, fields, paddocks, mountains, hills, valleys, landscape, scenery, views	1			
Desert, outback				
Environment, surroundings, topography				
Rural, regional, out of the city, non-urban, countryside, the country				
Open spaces, space, spacious				
Habitat				
Green, greenery, green space			1	
Beauty, elegance				
Tranquility, peacefulness, solace, calm, relaxed, quiet, serenity				
Solitude, few people, no people				
Balance, in harmony, natural cycles and systems, interconnectivity				
positive emotions (awe, wonder, happiness, enjoyment, fulfilment, fun)				
negative emotions (boredom, dead, sickness, distress)				
vast, huge, unpredictable, lethal, rugged, uncontrollable, powerful, unknown, expansive				
spiritual phenomena (e.g. Gods creation, Mother nature, essence)				

Coding themes (round 1 coding)	Sample responses			
	The environment -- flora and fauna, landscape, seas, rivers.	the wetlands & walking tracks in my local area	Greenery fresh air	Forest
what keeps us alive, important, necessary, precious, our future				
Life, living things, growth				
Nature, everything, total, whole				
Natural, original, untouched, undisturbed, unspoiled, fresh, raw, pure, clean, pristine, organic, real				
Not human, not touched by humans, not controlled by humans, not produced by humans, not controlled by humans, undeveloped/uninhabited by humans (specific reference to humans and the impacts of human activities)				
Specific location (e.g. Tasmania, Africa, Great Ocean Road)				
Sky, blue sky, stars, clouds				
Earth, world, planet, products of earth, dirt, sand, soil, rocks, geology. Also universe, atmosphere				
Weather or climate related (snow, rain, sun, sunshine, wind), seasons, sunsets				
Local place, where I live, where we live, my back yard, my garden		1		
Activities and related (e.g. walking tracks, bush walking, hiking, camping, gardening; also exploring, play, adventure, visit)		1		
Human characteristics				
In need of protection, conservation, respect, conservation issues,				

Coding themes (round 1 coding)	Sample responses
	<div>The environment</div> <div>-- flora and fauna, landscape, seas, rivers.</div> <div>the wetlands & walking tracks in my local area</div> <div>Greenery fresh air</div> <div>Forest</div>
sustainability, human impacts, also conservationists, landcare	
climate change, natural disasters	
Free, freedom	
Health, healthy, flourishing, thriving, wellbeing (human or environmental)	
Aesthetic qualities (e.g. color, smells, sounds)	
Evolution	
Ecosystems, biodiversity, ecological, the laws of nature, biological	
The journal	
Food and related	
Natural resources, minerals	
Waste, pollution, recycling	
Energy related	
Human endeavors (science, history, art, culture, nature vs nurture)	
Nudity, simplicity	

STUDY 2, APPENDIX 3: Data screening

Table A3.1 Descriptive statistics for connection with nature (CN) variables, by concept of nature category ($n = 2975$)[†].

	Concept of nature category	<i>n</i>	<i>m</i> (95% <i>CI</i>)	<i>SD</i>	Skewness (<i>SE</i>)	Kurtosis (<i>SE</i>)
CN-12 total score	Descriptive	2226	5.19 (5.15, 5.23)	0.98	-0.15 (0.05)	-0.52 (0.10)
	Normative	55	5.47 (5.20, 5.73)	0.99	-0.43 (0.32)	-0.97 (0.63)
	Experiential	110	5.67 (5.51, 5.83)	0.85	-0.31 (0.23)	-0.28 (0.46)
	Complex	584	5.53 (5.45, 5.60)	0.87	-0.40 (0.10)	-0.22 (0.20)
CN-12 identity dimension	Descriptive	2226	4.73 (4.68, 4.78)	1.22	-0.16 (0.05)	-0.28 (0.10)
	Normative	55	5.19 (4.89, 5.50)	1.13	-0.28 (0.32)	-0.94 (0.63)
	Experiential	110	5.35 (5.17, 5.53)	0.98	-0.06 (0.23)	-0.38 (0.46)
	Complex	584	5.10 (5.01, 5.19)	1.11	-0.38 (0.10)	-0.16 (0.20)
CN-12 experience dimension	Descriptive	2226	5.30 (5.26, 5.34)	1.06	-0.35 (0.05)	-0.25 (0.10)
	Normative	55	5.49 (5.22, 5.75)	0.98	-0.32 (0.32)	-0.99 (0.63)
	Experiential	110	5.75 (5.58, 5.93)	0.92	-0.60 (0.23)	-0.06 (0.46)
	Complex	584	5.63 (5.55, 5.71)	0.94	-0.55 (0.10)	0.14 (0.20)
CN-12 philosophy dimension	Descriptive	2226	5.63 (5.58, 5.67)	1.01	-0.48 (0.05)	-0.30 (0.10)
	Normative	55	5.79 (5.47, 6.12)	1.20	-0.82 (0.32)	-0.39 (0.63)
	Experiential	110	5.95 (5.76, 6.13)	0.96	-0.84 (0.23)	0.42 (0.46)
	Complex	584	5.92 (5.85, 5.99)	0.89	-0.83 (0.10)	0.66 (0.20)

[†] $n = 42$ outliers removed; $n = 78$ mentioned none of the concepts of nature categories
m = mean; *CI* = confidence interval; *SD* = standard deviation; *SE* = standard error

Table A3.2 Levene's test of homogeneity of variances for connection with nature scores (CN-12: total and dimensions).

		Levene statistic	<i>df</i> 1	<i>df</i> 2	<i>p</i>
CN-12 total score	Based on Mean	7.167	3	2971	< 0.000
	Based on Median	6.764	3	2971	< 0.000
	Based on Median and with adjusted <i>df</i>	6.764	3	2948.794	< 0.000
	Based on trimmed mean	7.135	3	2971	< 0.000
CN-12 identity dimension	Based on Mean	3.886	3	2971	0.009
	Based on Median	3.948	3	2971	0.008
	Based on Median and with adjusted <i>df</i>	3.948	3	2947.946	0.008
	Based on trimmed mean	3.783	3	2971	0.010
CN-12 experience dimension	Based on Mean	5.524	3	2971	0.001
	Based on Median	5.454	3	2971	0.001
	Based on Median and with adjusted <i>df</i>	5.454	3	2951.833	0.001
	Based on trimmed mean	5.462	3	2971	0.001
CN-12 philosophy dimension	Based on Mean	9.481	3	2971	< 0.000
	Based on Median	9.078	3	2971	< 0.000
	Based on Median and with adjusted <i>df</i>	9.078	3	2946.684	< 0.000
	Based on trimmed mean	9.384	3	2971	< 0.000

df = degrees of freedom

Table A3.3 Descriptive statistics and Shapiro-Wilk test of normality (W) for the four nature-based pro-biodiversity behaviors ($n = 3012$)[†]

	Mean (95% <i>CI</i>)	Median	SD	Var.	Skewness (<i>SE</i>)	Kurtosis (<i>SE</i>)
Volunteering $W(3012) =$ $0.770, p < 0.001$	1.797 (1.762, 1.833)	1.000	1.000	0.999	1.126 (0.045)	0.535 (0.089)
Citizen science $W(3012) =$ $0.667, p < 0.001$	1.599 (1.564, 1.633)	1.000	0.963	0.928	1.590 (0.045)	1.778 (0.089)
Picking up litter $W(3012) =$ $0.907, p < 0.001$	2.697 (2.655, 2.739)	3.000	1.168	1.364	0.150 (0.045)	-0.743 (0.089)
Community gardening $W(3012) =$ $0.669, p < 0.001$	1.594 (1.560, 1.628)	1.000	0.952	0.906	1.583 (0.045)	1.734 (0.089)

[†] $n = 78$ excluded due to mentioning none of the concepts of nature categories

CI = confidence interval; *SD* = standard deviation; *Var.* = variance; *SE* = standard error

STUDY 2, APPENDIX 4: Games-Howell post-hoc tests comparing connection with nature scores (CN-12: total and dimensions) across concepts of nature categories ($n = 2975$)[†]

Concepts of nature category			Mean Diff.	SE	p	95% CI	
						Lower Bound	Upper Bound
CN-12 total score	Descriptive	Normative	-0.274	0.135	0.188	-0.631	0.083
		Experience	-0.476	0.084	< 0.000	-0.694	-0.258
		Complex	-0.335	0.042	0.000	-0.442	-0.228
	Normative	Descriptive	0.274	0.135	0.188	-0.083	0.631
		Experience	-0.202	0.156	0.571	-0.610	0.207
		Complex	-0.061	0.138	0.972	-0.425	0.304
	Experience	Descriptive	0.476	0.084	< 0.000	0.258	0.694
		Normative	0.202	0.156	0.571	-0.207	0.610
		Complex	0.141	0.089	0.388	-0.089	0.371
	Complex	Descriptive	0.335	0.042	< 0.000	0.228	0.442
		Normative	0.061	0.138	0.972	-0.304	0.425
		Experience	-0.141	0.089	0.388	-0.371	0.089
CN-12 identity dimension	Descriptive	Normative	-0.463	0.154	0.020	-0.870	-0.055
		Experience	-0.622	0.097	< 0.000	-0.874	-0.370
		Complex	-0.371	0.053	< 0.000	-0.507	-0.235
	Normative	Descriptive	0.463	0.154	0.020	0.055	0.870
		Experience	-0.159	0.178	0.809	-0.625	0.307
		Complex	0.092	0.159	0.939	-0.327	0.510
	Experience	Descriptive	0.622	0.097	< 0.000	0.370	0.874
		Normative	0.159	0.178	0.809	-0.307	0.625
		Complex	0.251	0.104	0.079	-0.019	0.521
	Complex	Descriptive	0.371	0.053	< 0.000	0.235	0.507
		Normative	-0.092	0.159	0.939	-0.510	0.327
		Experience	-0.251	0.104	0.079	-0.521	0.019

(continued over)

Concepts of nature category			Mean Diff.	<i>SE</i>	<i>p</i>	95% <i>CI</i>	
						Lower Bound	Upper Bound
CN-12 experience dimension	Descriptive	Normative	-0.188	0.135	0.509	-0.544	0.169
		Experience	-0.453	0.091	< 0.000	-0.689	-0.217
		Complex	-0.329	0.045	<0.000	-0.445	-0.213
	Normative	Descriptive	0.188	0.135	0.509	-0.169	0.544
		Experience	-0.265	0.159	0.346	-0.681	0.150
		Complex	-0.141	0.138	0.737	-0.506	0.223
	Experience	Descriptive	0.453	0.091	< 0.000	0.217	0.689
		Normative	0.265	0.159	0.346	-0.150	0.681
		Complex	0.124	0.096	0.571	-0.126	0.374
	Complex	Descriptive	0.329	0.045	< 0.000	0.213	0.445
		Normative	0.141	0.138	0.737	-0.223	0.506
		Experience	-0.124	0.096	0.571	-0.374	0.126
CN-12 philosophy dimension	Descriptive	Normative	-0.168	0.163	0.734	-0.600	0.265
		Experience	-0.319	0.094	0.005	-0.564	-0.075
		Complex	-0.296	0.042	< 0.000	-0.406	-0.187
	Normative	Descriptive	0.168	0.163	0.734	-0.265	0.600
		Experience	-0.152	0.186	0.847	-0.638	0.335
		Complex	-0.128	0.166	0.866	-0.567	0.310
	Experience	Descriptive	0.319	0.094	0.005	0.075	0.564
		Normative	0.152	0.186	0.847	-0.335	0.638
		Complex	0.023	0.098	0.995	-0.233	0.279
	Complex	Descriptive	0.296	0.042	< 0.000	0.187	0.406
		Normative	0.128	0.166	0.866	-0.310	0.567
		Experience	-0.023	0.098	0.995	-0.279	0.233

[†] *n* = 42 outliers removed; *n* = 78 mentioned none of the concepts of nature categories
SE = standard error; *CI* = confidence interval

STUDY 2, APPENDIX 5: Regression models estimating frequency of participating in each nature-based pro-biodiversity behavior (Y) from connection with nature (X) and concepts of nature (W) after mean centering connection with nature ($n = 3012$).

		Coefficient	SE	<i>t</i>	<i>p</i>
Environmental volunteering $R^2 = 0.080$, $MSE = 0.922$					
	Constant	2.183	0.102	21.318	< 0.001
	CN	0.190	0.108	1.759	0.079
	W1	-0.323	0.168	-1.927	0.054
	W2	-0.390	0.104	-3.733	< 0.001
	W3	-0.454	0.110	-4.114	< 0.001
	CN x W1	0.031	0.171	0.180	0.857
	CN x W2	0.067	0.110	0.610	0.542
	CN x W3	0.116	0.117	0.997	0.319
Citizen science $R^2 = 0.047$, $MSE = 0.887$					
	Constant	1.905	0.100	18.971	< 0.001
	CN	0.245	0.106	2.312	0.021
	W1	-0.157	0.164	-0.955	0.340
	W2	-0.320	0.102	-3.123	0.002
	W3	-0.341	0.108	-3.151	0.002
	CN x W1	-0.094	0.167	-0.559	0.576
	CN x W2	-0.065	0.108	-0.607	0.544
	CN x W3	-0.029	0.115	-0.250	0.802
Picking up litter $R^2 = 0.121$, $MSE = 1.201$					
	Constant	3.030	0.117	25.918	< 0.001
	CN	0.058	0.123	0.471	0.638
	W1	-0.153	0.191	-0.799	0.424
	W2	-0.344	0.119	-2.884	0.004
	W3	-0.366	0.126	-2.904	0.004
	CN x W1	0.249	0.195	1.279	0.201
	CN x W2	0.325	0.125	2.589	0.010
	CN x W3	0.414	0.133	3.103	0.002
Community gardening $R^2 = 0.042$, $MSE = 0.870$					
	Constant	2.015	0.099	20.256	< 0.001
	CN	0.115	0.105	1.097	0.273
	W1	-0.278	0.163	-1.708	0.088
	W2	-0.433	0.101	-4.270	< 0.001
	W3	-0.463	0.107	-4.313	< 0.001
	CN x W1	-0.075	0.166	-0.455	0.649
	CN x W2	0.055	0.107	0.513	0.608
	CN x W3	0.068	0.114	0.603	0.546

CN = connection with nature; SE = standard error; W1 = normative concepts of nature category; W2 = descriptive concepts of nature category; W3 = complex concepts of nature category; Reference group: experiential concepts of nature category

STUDY 2, APPENDIX 6: Number of participants speaking a language other than English at home by concepts of nature categories ($n = 288$)[†]

Language (other than English)	Concepts of nature category			
	Descriptive	Normative	Experience	Complex
Arabic	3			1
Cantonese	14		1	9
Croatian	4			3
French	1		3	3
German	1	1		3
Greek	17	1	1	3
Hindi	1	3	5	7
Indonesian	4			
Italian	11	1		7
Japanese	6			2
Khmer	2			2
Macedonian	4			
Malayalam	6	1		1
Maltese	4			
Mandarin Chinese	33		2	1
Polish	6	1		3
Russian	4			2
Serbian	4			
Sinhalese	4		1	
Tagalog	6			2
Urdu	6			
Vietnamese	16			6
Other	36	3	6	10

[†] $n = 62$ mentioned none of the concepts of nature categories

Appendix E

Appendices for Study 3

STUDY 3, APPENDIX A: Questionnaires

Questionnaires used at Time 1 and Time 2 were almost identical. Items appearing in the questionnaire at Time 1 (QT1) and questionnaire at Time 2 (QT2) are indicated.

Please specify your age (QT1 and QT2)
_____ years

Please specify your gender (QT1 and QT2)

1. Female
2. Male
3. Other (specify): _____

And what is the postcode of your main residence? (QT1 and QT2)

-----PAGE BREAK-----

What comes to mind when you think of ‘nature’? Please describe in your own words* (QT1 and QT2)

** Note: responses to this question were coded to capture concepts of nature*

-----PAGE BREAK-----

In this survey, we would like you to think about nature as everything that is not made by humans. This includes all the *animals*, *plants*, and *vegetation* in *land* and *water* habitats, located in *urban* and *rural* areas, and including *highly modified landscapes* through to *pristine wilderness* areas on land and in the water.
(QT1 and QT2)

-----PAGE BREAK-----

Connection with nature* (QT1 and QT2)

Please rate the extent to which you agree or disagree with the following statements
(1=*strongly disagree*, 7=*strongly agree*)

1. I think of myself as an ‘environmentalist’
2. **I think of myself as someone who is very concerned about taking care of nature**
3. Protecting nature is an important part of who I am
4. **My relationship to nature is a big part of how I think about myself**
5. **I feel uneasy if I am away from nature for too long**
6. **I feel right at home when I am in nature**

7. **Feeling connected to nature helps me deal with everyday stress**
8. **I feel a strong emotional connection to nature**
9. **I enjoy spending time in nature**
10. **I like to get outdoors whenever I get the chance**
11. **Being in nature allows me to do the things I like doing most**
12. Getting away on an overnight trip in nature is something I do as often as I can
13. Forests are valuable mostly because they produce wood products, jobs and income for people
14. Meeting the needs of people requires sacrificing some natural areas
15. In order to provide us with the goods and services we need we can't avoid nature being degraded.
16. Natural areas are important to people because we use them for recreation
17. My connection to nature is something I would describe as "spiritual"
18. **Everything in nature is connected (e.g. animals, plants, humans, water, air, land, fire, etc.)**
19. **Human beings and nature are connected by the same 'energy' or 'life-force'**
20. **Human wellbeing depends upon living in harmony with nature**

* NB: Items included in the CN-12 are in bold

-----PAGE BREAK-----

In the last year, about how often have you generally spent time in nature? (QT1 and QT2)

1. Never
2. Less than once a year
3. At least once a year
4. At least twice a year
5. At least once a month
6. At least once a fortnight
7. At least once a week
8. Every other day
9. Every day

-----PAGE BREAK-----

In the last year, about how often did you spend time in/at the following places? (QT2 only)

(1=never; 2=rarely (e.g. 1-2 times per year); 3=sometimes (e.g. monthly or every few months); 4=often (e.g. weekly or fortnightly); 4=very often (e.g. daily or every other day))

1. A protected or wilderness area (e.g. national park)
2. The beach or coastal areas
3. A lake, river or other waterway
4. A zoo, wildlife park, or botanical garden
5. An urban or suburban park (e.g. with grass and trees)
6. Your garden at home, or the garden of a friend, neighbour or family member

-----PAGE BREAK-----

Pro-environmental behaviour

In the last year, how often have you done each of the following activities? (QT2 only)

(1=never, 2=rarely, 3=sometimes, 4=often, 5=very often)

1. Controlled the movements of your pets to keep them away from native birds and animals (i.e. keep my cat inside at night)
2. Chosen native plant species when planting/gardening
3. Reduced energy use (e.g. electricity/gas) in the home
4. Chosen sustainable seafood
5. Used public transport rather than driving
6. Volunteered time for activities that take care of the environment (e.g. planting trees, clearing weeds)
7. Collected information on the natural environment for scientific projects or databases (citizen science)
8. Donated money to organisations that take care of the environment
9. Advocated for the environment (by, for example, contacting businesses or politicians about environmental issues, signing pro-environment petitions, attending rallies etc.)
10. Cleaned up litter in a public space, park or forest
11. Been involved in a local community garden or community composting activity

STUDY 3, Appendix B: Descriptive statistics and correlations

Table B1: Demographics (n=1053)

Age	n	%
18-29	74	7.0
30-39	164	15.6
40-49	183	17.4
50-59	226	21.5
60-69	269	25.5
70+	137	13.0
Gender		
Male	538	50.1
Female	515	48.9
Other	0	0

Table B2: Time spent in nature (n=1053)

	n	%
Never	29	2.8
Rarely (e.g. 1-2 times per year)	238	22.6
Sometimes (e.g. monthly)	206	19.6
Often (e.g. weekly or fortnightly)	340	32.3
Very often (e.g. daily or every other day)	240	22.8

Figure B1: Time spent in six different types of nature (n=1053)

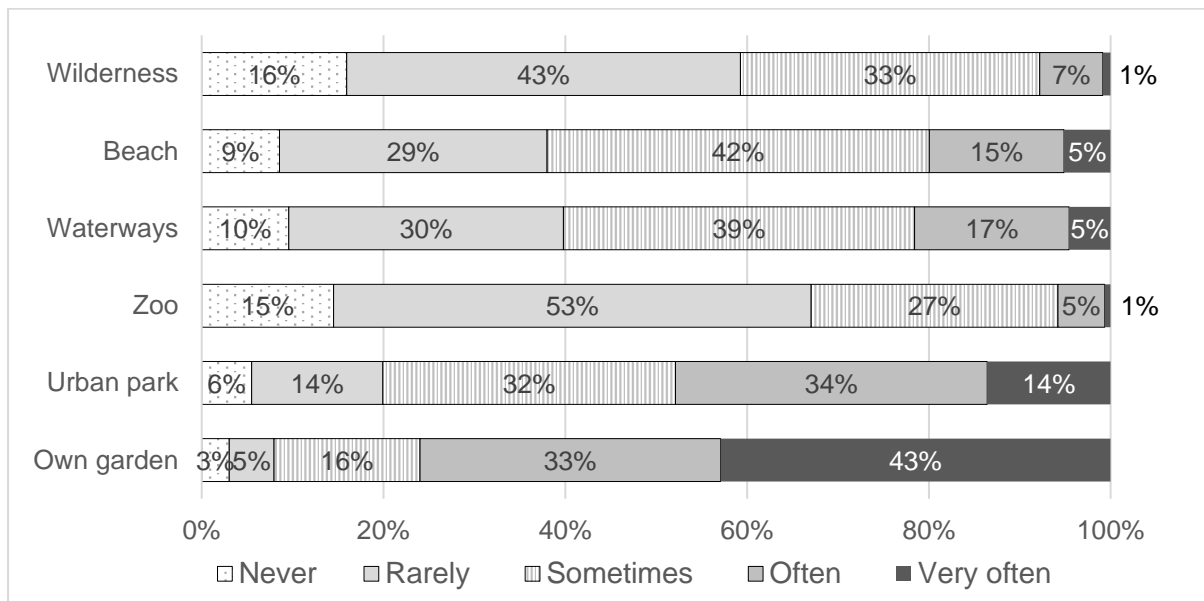


Figure B2: Participation in four nature-based pro-biodiversity behaviours (n=1053)

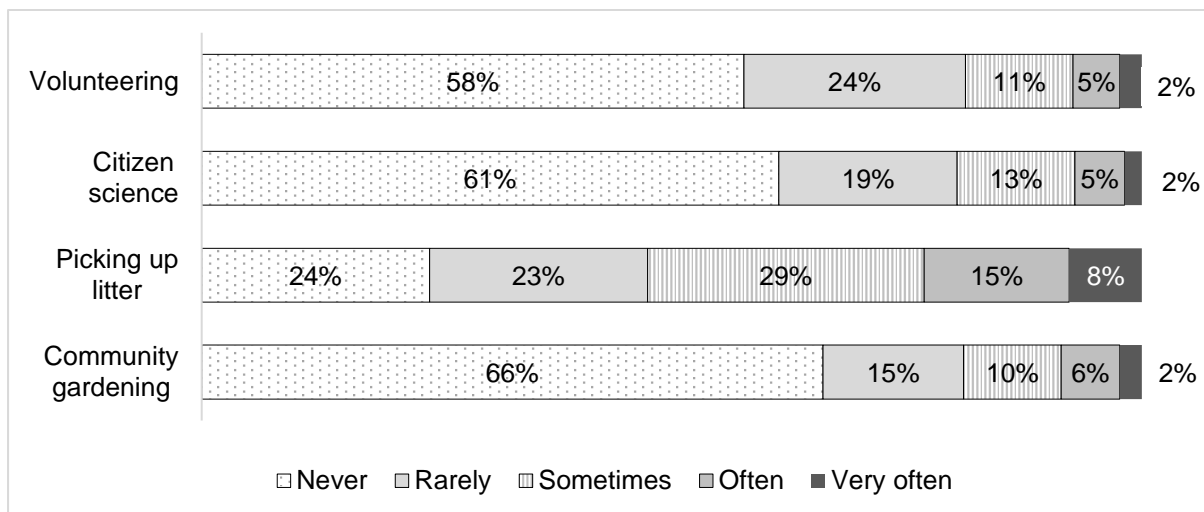


Table B3: Spearman correlations between connection with nature, time spent in nature, and the four pro-biodiversity behaviours (n=1053)

	1	2	3	4	5	6	7	8	9	10	11	12
1 CN at Time 1	--											
2 CN at Time 2	0.802**	--										
3 TIN past year	0.383**	0.431**	--									
4 TIN wilderness	0.313**	0.349**	0.330**	--								
5 TIN beach	0.203**	0.233**	0.244**	0.391**	--							
6 TIN waterway	0.267**	0.323**	0.419**	0.475**	0.436**	--						
7 TIN zoo	0.193**	0.227**	0.217**	0.449**	0.350**	0.374**	--					
8 TIN urban park	0.220**	0.285**	0.369**	0.324**	0.311**	0.373**	0.362**	--				
9 TIN own garden	0.318**	0.336**	0.423**	0.143**	0.139**	0.252**	0.104**	0.240**	--			
10 Volunteer	0.223**	0.256**	0.172**	0.350**	0.231**	0.316**	0.355**	0.190**	0.109**	--		
12 Citizen science	0.231**	0.245**	0.141**	0.405**	0.254**	0.290**	0.351**	0.160**	0.045 ^{ns}	0.584**	--	
13 Litter	0.349**	0.374**	0.257**	0.361**	0.259**	0.325**	0.287**	0.237**	0.187**	0.420**	0.389**	--
14 Community gardening	0.167**	0.164**	0.094**	0.342**	0.231**	0.244**	0.323**	0.121**	0.028 ^{ns}	0.642**	0.621**	0.357**

Note. CN = connection with nature; TIN = time spent in nature; **p<0.001, ^{ns}=not significant (p>0.05)