Hatty, M., D. Goodwin, L. Smith, and F. Mavondo. 2022. Speaking of nature: Relationships between how people think about, connect with, and act to protect nature. Ecology and Society 27(3):17. https://doi.org/10.5751/ES-13369-270317

*Research*

# Speaking of nature: Relationships between how people think about, connect with, and act to protect nature

*Melissa Hatty* [1], *Denise Goodwin* [1], *Liam Smith* [1] *and Felix Mavondo* [2]

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 the 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.

Key Words: *Concepts of nature; connection with nature; conservation behavior; conservation psychology; human-nature relationships; thoughts about 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: 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: 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 Opotow 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

[1]BehaviourWorks Australia, Monash Sustainable Development Institute, Monash University, [2]Department of Marketing, Faculty of Business and Economics, Monash University

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 person (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).

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, compare 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 categorized. 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 participation in citizen science, and other environmental volunteering activities, is 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-

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

| Themes and example terms | Authors |
|---|---|
| What nature is | |
| 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) | |
| Relationships within nature | |
| Ecosystems, biodiversity | Collado et al. 2016, Keulartz et al. 2004, Pointon 2014, Taylor 2019 |
| Landscapes | |
| Growing, living | |
| Human interactions with natural systems | |
| Experiences in nature, emotional experiences related to nature | |
| 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) | |
| Human relationships with nature, values of nature | |
| 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 | |
| How nature should be managed | |
| Moral status of nature, informing management actions | Buijs and Elands 2013, Keulartz et al. 2004, Pointon 2014, Taylor 2019 |
| In need of protection | |
| Delicate, fragile, important | |
| Unspoiled, free from human interference | |
| Human productions and impacts on nature, non-natural elements | |
| Pollution, noise | Bolzan-de-Campos et al. 2018, Collado et al. 2016, Mausner 1996 |
| Human-built structures (cities, cars) | |
| Human productions (parks) | |
| Industries, smoke | |

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 that 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.

## METHODS

### 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 organizations 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 semantic 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"; 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 was 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

**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 |
| 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

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, $\alpha = 0.758$).

### 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).

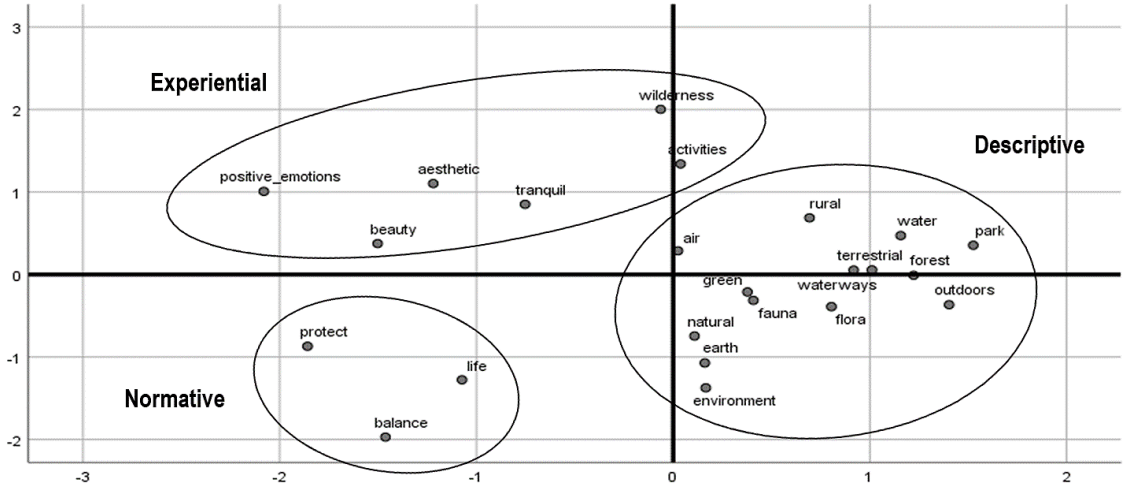
## RESULTS

### 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 labeled them "descriptive", "normative", and "experiential" (Fig. 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

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




of nature categories ($n$ = 3012) to compare differences in CN and PBB across concepts of nature categories.

**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).

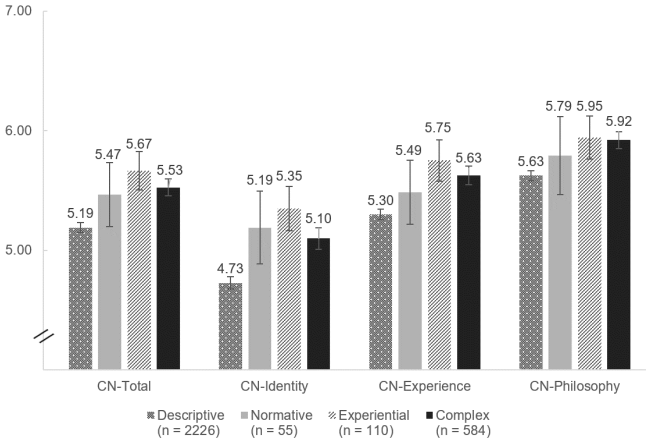
ANOVA results suggested that participants who described nature in purely experiential or in more complex terms had higher CN scores (total and dimensions) than participants who described nature in purely descriptive terms. Further, participants who described nature in purely normative terms scored higher on the CN-Identity dimension than participants who described nature in purely descriptive terms (Table 3, Fig. 2, and Appendix 4).

**Table 3**. One-way analyses of variance comparing connection with nature (total and dimension scores) across the four concepts of nature categories (n = 2975[†]).

| | *df* | Welch's *F* | $\eta^2$ |
|---|---|---|---|
| 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
*** $p < 0.001$

**Fig. 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).

**Concepts of nature as moderator between CN and PBB**

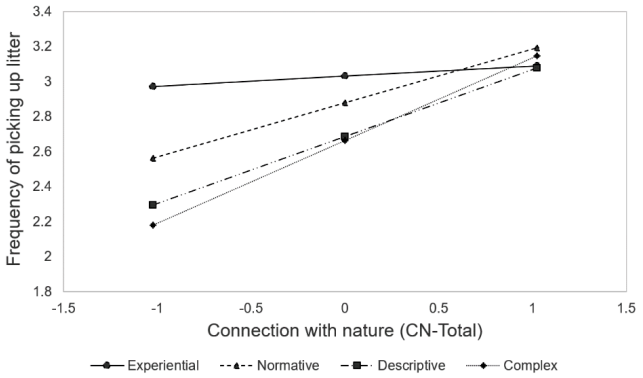
As the experiential concepts of nature category appeared to have different relationships with CN and PBB than most other concepts of nature categories, we used the experiential category as the reference group for indicator coding of the concepts of nature variable (Hayes 2018). CN variables were mean-centered 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]; Fig. 3). Moderation effects for environmental volunteering, citizen science, and community gardening were not significant (Appendix 5).

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

| | Kruskall-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 |

**Fig. 3**. Visual representation of the moderation effect of connection with nature (X) on frequency of participating in picking up litter (Y) as a function of the four concepts of nature categories.




## DISCUSSION

This research sought to investigate and statistically categorize concepts of nature, consider differences in CN scores and participation in nature-based PBB across concepts of nature categories, and 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 Opotow 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 dimensions 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 represent 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: 10). Thus, people who perceive themselves as having a stronger emotional connection to nature and 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 PEB 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 influencing 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 antecedent 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 from 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 encouraging behaviors that protect the natural environment.

*Responses to this article can be read online at:*
https://www.ecologyandsociety.org/issues/responses.php/13369

---

**Author Contributions:**

*Melissa Hatty: Conceptualization, methodology, validation, formal analysis, writing - original draft, writing - review and editing, visualization; Denise Goodwin: conceptualization, formal analysis, writing - review and editing, supervision; Liam Smith:*

*conceptualization, methodology, writing - review and editing, supervision; Felix Mavondo: conceptualization, methodology, formal analysis, writing - review and editing, supervision.*

**Acknowledgments:**

*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. Thank you to Kim Lowe, Fern Hames, and the DELWP Victorians Value Nature team for their input into this research. Thank you also to two anonymous reviewers whose feedback improved the clarity and presentation of this research.*

**Data Availability:**

*The data/code for this research are available at Open Science Framework https://osf.io/zugdj/?view_only=e3e109fa17934042be-a3d5f183442474. Ethical approval for this research was granted by the Monash University Human Research Ethics Committee (Project ID: 14010).*

---

**LITERATURE CITED**

Aaron, R. F., and P. A. Witt. 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

Adams, S., and S. Savahl. 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., M. P. White, S. Pahl, R. Duarte-Davidson, and L. E. Fleming. 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., C. Manning, B. Scott, and S. Koger. 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

Asah, S. T., M. M. Lenentine, and D. J. Blahna. 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

Biodivcanada. 2015. 2020 Biodiversity Goals and Targets for Canada. https://publications.gc.ca/collections/collection_2016/eccc/CW66-524-2016-eng.pdf.

Bolzan-de-Campos, C., B. Fedrizzi, and C. R. Santos-Almeida. 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/10.1080/217119-76.2018.1432526

Braun, V., and V. Clarke. 2006. Using thematic analysis in psychology. Qualitative Research in Psychology 3(2):77-101. https://doi.org/10.1191/1478088706qp063oa

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/10.1080/08941-920801901335

Buijs, A. E., and B. H. M. Elands. 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., A. Fischer, D. Rink, and J. C. Young. 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.4.2:1

Cameron, R. W. F., P. Brindley, M. Mears, K. McEwan, F. Ferguson, D. Sheffield, A. Jorgensen, J. Riley, J. Goodrick, L. Ballard, and M. Richardson. 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

Chase, S. K., and A. Levine. 2017. Citizen science: Exploring the potential of natural resource monitoring programs to influence environmental attitudes and behaviors. Conservation Letters 11 (April):1-10. http://doi.wiley.com/10.1111/conl.12382

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

Clayton, S. 2003. Environmental identity: A conceptual and operational definition. Pages 45-66 in S. D. Clayton and S. Opotow, editors. Identity and the Natural Environment: The Psychological Significance of Nature. MIT Press, Cambridge, MA, USA. https://doi.org/10.7551/mitpress/3644.001.0001

Clayton, S., and S. Opotow. 2003. Introduction: Identity and the natural environment. Pages 1-24 in S. D. Clayton and S. Opotow, editors. Identity and the Natural environment: The Psychological Significance of Nature. MIT Press, Cambridge, MA, USA. https://doi.org/10.7551/mitpress/3644.001.0001

Clayton, S., and G. Myers. 2009. Conservation Psychology: Understanding and Promoting Human Care for Nature. Wiley-Blackwell, Ltd., Chichester, UK.

Cohen, J. 1977. Statistical Power Analysis for the Behavioral Sciences. Elsevier Science & Technology. Academic Press Inc., New York, NY, USA. https://doi.org/10.4324/9780203771587

Colding, J., M. Giusti, A. Haga, M. Wallhagen, and S. Barthel. 2020. Enabling relationships with nature in cities. Sustainability (Switzerland) 12(11):1-16. https://doi.org/10.3390/su12114394

Collado, S., L. Íñiguez-Rueda, and J. A. Corraliza. 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

Colléony, A., R. Cohen-Seffer, and A. Shwartz. 2020a. Unpacking the causes and consequences of the extinction of experience. Biological Conservation 251:108788. https://doi.org/10.1016/j.biocon.2020.108788

Colléony, A., L. Levontin, and A. Shwartz. 2020b. Promoting meaningful and positive nature interactions for visitors to green spaces. Conservation Biology 34(6):1373-1382. https://doi.org/10.1111/cobi.13624

Coscieme, L., H. da Silva Hyldmo, Á. Fernández-Llamazares, I. Palomo, T. H. Mwampamba, O. Selomane, N. Sitas, P. Jaureguiberry, Y. Takahashi, M. Lim, M. P. Barral, J. S. Farinaci, J. Diaz-José, S. Ghosh, J. Ojino, A. Alassaf, B. N. Baatuuwie, L. Balint, Z. Basher, F. Boeraeve, S. Budiharta, R. Chen, M. Desrousseaux, G. Dowo, C. Febria, H. Ghazi, Z. V. Harmáčková, R. Jaffe, M. M. Kalemba, C. K. Lambini, F. P. S. Lasmana, A. A. A. Mohamed, A. Niamir, P. Pliscoff, R. Sabyrbekov, U. B. Shrestha, A. Samakov, A. A. Sidorovich, L. Thompson, and M. Valle. 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., R. Raymond, and A. C. Prevot-Julliard. 2012. Observations of everyday biodiversity: A new perspective for conservation? Ecology and Society 17(4):2. https://doi.org/10.5751/ES-04955-170402

Crocetti, E. 2016. Systematic reviews with meta-analysis. Emerging Adulthood 4(1):3-18. https://doi.org/10.5751/ES-04955-170402

Department of Environment, Land, Water and Planning. 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 Conservation. 2020. Aotearoa New Zealand Biodiversity Strategy. Wellington, New Zealand. https://doi.org/10.4135/9781412952453.n56

Diduck, A. P., C. M. Raymond, R. Rodela, R. Moquin, and M. Boerchers. 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

Ducarme, F., and D. Couvet. 2020. What does "nature" mean? Palgrave Communications 6(1):1-8. https://doi.org/10.1057/s41599-020-0390-y

Field, A. 2013. Discovering Statistics using IBM SPSS Statistics. M. Carmichael, editor. 4th edition. Sage Publications Ltd, London, UK.

Fischer, A., and J. C. Young. 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

Flint, C. G., I. Kunze, A. Muhar, Y. Yoshida, and M. Penker. 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

Fraijo-Sing, B. S., N. I. Beltrán Sierra, C. Tapia-Fonllem, and R. Valenzuela Peñúñuri. 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

Frumkin, H., G. N. Bratman, S. J. Breslow, B. Cochran, P. H. K. Jr, J. J. Lawler, P. S. Levin, P. S. Tandon, U. Varanasi, K. L. Wolf, and S. A. Wood. 2016. Nature contact and human health: A research agenda. Environmental Health Perspectives 125(7):1-18. https://doi.org/10.1289/EHP1663

Ganzevoort, W., and R. J. G. van den Born. 2020. Understanding citizens' action for nature: The profile, motivations and experiences of Dutch nature volunteers. Journal for Nature Conservation 55:125824. https://doi.org/10.1016/j.jnc.2020.125824

Gould, R. K., N. M. Ardoin, M. Biggar, A. E. Cravens, and D. Wojcik. 2016. Environmental behavior's dirty secret: The prevalence of waste management in discussions of environmental concern and action. Environmental Management 58(2):268–282. https://doi.org/10.1007/s00267-016-0710-6

Guiney, M. S., and K. S. Oberhauser 2010. Conservation volunteers' connection to nature. Ecopsychology, 1(4):187-197. https://doi.org/10.1089/eco.2009.0030

Hair, J. F., W. C. Black, B. J. Babin, and R. E. Anderson. 2014. Multivariate Data Analysis. 7th edition. Pearson, Harlow, Essex, UK.

Hamlin, I., and M. Richardson. 2021. Visible garden biodiversity leads to an increase in noticing nature, which in turn leads to an increase in nature connectedness. https://psyarxiv.com/uamwg.

Hatty, M. A., L. D. G. Smith, D. Goodwin, and F. T. Mavondo. 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 edition. Methodology in the social sciences. Guilford Publications Inc., New York, NY, USA.

IBM Corp. 2019. IBM SPSS Statistics for Windows. IBM Corp., Armonk, NY, USA.

Ives, C. D., D. J. Abson, H. von Wehrden, C. Dorninger, K. Klaniecki, and J. Fischer. 2018. Reconnecting with nature for sustainability. Sustainability Science 13(5):1-9. https://doi.org/10.1007/s11625-018-0542-9

Ives, C. D., R. Freeth, and J. Fischer. 2019. Inside-out sustainability: The neglect of inner worlds. Ambio 49:208–217. https://doi.org/10.1007/s13280-019-01187-w

Ives, C. D., M. Giusti, J. Fischer, D. J. Abson, K. Klaniecki, C. Dorninger, J. Laudan, S. Barthel, P. Abernethy, B. Martín-López, C. M. Raymond, D. Kendal, and H. von Wehrden. 2017. Human-

nature connection: A multidisciplinary review. Current Opinion in Environmental Sustainability 26-27:106-113. https://doi.org/10.1016/j.cosust.2017.05.005

Keniger, L. E., K. J. Gaston, K. N. Irvine, and R. A. Fuller. 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

Keulartz, J., H. van der Windt, and J. Swart. 2004. Concepts of nature as communicative devices: The case of Dutch nature policy. Environmental Values 13(1):81-99. https://doi.org/10.3197/096327104772444785

Kingsley, J., E. Foenander, and A. Bailey. 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

Kloek, M. E., A. E. Buijs, J. J. Boersema, and M. G. C. Schouten. 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

Landis, J. R., and G. G. Koch. 1977. The measurement of observer agreement for categorical data. Biometrics 33(1):159-174. https://doi.org/10.2307/2529310

Levé, M., A. Colléony, P. Conversy, A.-C. Torres, M.-X. Truong, C. Vuillot, and A.-C. Prévot. 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

Lin, B. B., M. H. Egerer, and A. Ossola. 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

Lumber, R., M. Richardson, and D. Sheffield. 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

MacDonald, E., M. Harbrow, S. Jack, J. Kidd, A. Wright, P. Tuinder, J. Balanovic, F. Medvecky, and M. Poutasi. 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

Mackay, C. M. L., and M. T. Schmitt. 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

Marais-Potgieter, A., and A. Thatcher. 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

Martin, C., and S. Czellar. 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., M. P. White, A. Hunt, M. Richardson, S. Pahl, and J. Burt. 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

Maund, P. R., K. N. Irvine, B. Lawson, J. Steadman, K. Risely, A. A. Cunningham, and Z. G. Davies. 2020. What motivates the masses: Understanding why people contribute to conservation citizen science projects. Biological Conservation 246:108587. 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. https://doi.org/10.1006/jevp.1996.0028

Mayer, F. S., and C. M. P. Frantz. 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

McEwan, K., M. Richardson, D. Sheffield, F. J. Ferguson, and P. Brindley. 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

Measham, T. G., and G. B. Barnett. 2008. Environmental volunteering: Motivations, modes and outcomes. Australian Geographer 39(4):537-552. https://doi.org/10.1080/00049180802419237

Meis-Harris, J., A. Saeri, M. Boulet, K. Borg, N. Faulkner, and B. Jorgensen. 2019. Victorians Value Nature: Survey Results. Melbourne, Australia. https://www.ari.vic.gov.au/research/people-and-nature/victorians-value-nature

Mena-García, A., P. Olivos, A. Loureiro, and O. Navarro. 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/10.1080/2171-1976.2019.1643663

Merenlender, A. M., A. W. Crall, S. Drill, M. Prysby, and H. Ballard. 2016. Evaluating environmental education, citizen science, and stewardship through naturalist programs. Conservation Biology 30(6):1255-1265. https://doi.org/10.1111/cobi.12737

Nisbet, E. K., J. M. Zelenski, and S. A. Murphy. 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

Olivos-Jara, P., J. I. Aragonés, and O. Navarro-Carrascal. 2013. Environmental education: Itineraries in nature and their relationship with connectedness, environmental concerns and behavior. Revista Latinoamericana de Psicologia 45(3):501-511. http://www.scielo.org.co/pdf/rlps/v45n3/v45n3a14.pdf

Pan, Y. T., K. K. Yang, K. Wilson, Z. R. Hong, and H. shyang Lin. 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., J. I. Aragonés, and B. Fraijo-Sing. 2020. Categorizing landscapes: Approaching the concept of Nature (Categorizando paisajes: Una aproximación al concepto de naturaleza). Psyecology 11(3):342-362. https://doi.org/10.1080/21711976.2019.1659029

Pennisi, L., N. Q. Lackey, and S. M. Holland. 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

Pérez-López, R., M. Eugenio-Gozalbo, D. Zuazagoitia, and A. Ruiz-González. 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

Pointon, P. 2014. "The city snuffs out nature": Young people's conceptions of and relationship with nature relationship with nature. Environmental Education Research 20(6):776-794. https://doi.org/10.1080/13504622.2013.833595

Restall, B., and E. Conrad. 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

Richardson, M., A. Cormack, L. McRobert, and R. Underhill. 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., J. Dobson, D. J. Abson, R. Lumber, A. Hunt, R. Young, and B. Moorhouse. 2020a. 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., and K. McEwan. 2018. 30 Days Wild and the relationships between engagement with nature's beauty, nature connectedness and well-being. Frontiers in Psychology 9:1-9. https://doi.org/10.3389/fpsyg.2018.01500

Richardson, M., H. Passmore, L. Barbett, R. Lumber, R. Thomas, and A. Hunt. 2020b. The green care code: How nature connectedness and simple activities help explain pro-nature conservation behaviours. People and Nature 2(3):821-839. https://doi.org/10.1002/pan3.10117

Richardson, M., and D. Sheffield. 2017. Three good things in nature: Noticing nearby nature brings sustained increases in connection with nature. Psyecology 8(1):1-32. https://doi.org/10.1080/21711976.2016.1267136

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

Schroeder, H. W. 2002. Experiencing nature in special places: Surveys in the north-central region. Journal of Forestry 100 (5):8-14. https://www.nrs.fs.fed.us/pubs/jrnl/2002/nc_2002_Schroeder_001.pdf

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

Schutte, N. S., and J. M. Malouff. 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

Sobko, T., Z. Jia, and G. Brown. 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

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

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

The Behavioural Insights Team. 2014. EAST: Four simple ways to apply behavioural insights. https://www.bi.team/wp-content/uploads/2015/07/BIT-Publication-EAST_FA_WEB.pdf

van den Born, R. J. G., R. H. J. Lenders, W. T. de Groot, and E. Huijsman. 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

Vining, J., M. S. Merrick, and E. A. Price. 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.

Waldispühl, J., A. Szantner, R. Knight, S. Caisse, and R. Pitchford. 2020. Leveling up citizen science. Nature Biotechnology 38(10):1123-1126. https://doi.org/10.1038/s41587-020-0694-x

Whitburn, J., W. Linklater, and W. Abrahamse. 2019a. 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., W. L. Linklater, and T. L. Milfont. 2019b. 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

Zent, E. L. 2015. Unfurling western notions of nature and Amerindian alternatives. Ethics in Science and Environmental Politics 15(2):105-123. https://doi.org/10.3354/esep00159

Zylstra, M. J., A. T. Knight, K. J. Esler, and L. L. L. Le Grange. 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 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 | | | | | |

**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 | | | | |

| 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 |
| Waterways and bodies of water (rivers, lakes, waterfalls, streams, wetlands) | 1 | 1 | | |
| 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) | | | | |

| 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 |
| vast, huge, unpredictable, lethal, rugged, uncontrollable, powerful, unknown, expansive | | | | |
| spiritual phenomena (e.g. Gods creation, Mother nature, essence) | | | | |
| 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 | | |

| 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 |
| 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, 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 | | | | |

**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 | *n* | *m* (95% *CI*) | *SD* | Skewness (*SE*) | Kurtosis (*SE*) |
|---|---|---|---|---|---|---|
| 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 | *df*1 | *df*2 | *p* |
|---|---|---|---|---|---|
| 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 *df* | 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 *df* | 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 *df* | 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 *df* | 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% *CI*) | Median | SD | Var. | Skewness (*SE*) | Kurtosis (*SE*) |
|---|---|---|---|---|---|---|
| Volunteering<br>$W(3012) = 0.770$, $p < 0.001$ | 1.797<br>(1.762, 1.833) | 1.000 | 1.000 | 0.999 | 1.126<br>(0.045) | 0.535<br>(0.089) |
| Citizen science<br>$W(3012) = 0.667$, $p < 0.001$ | 1.599<br>(1.564, 1.633) | 1.000 | 0.963 | 0.928 | 1.590<br>(0.045) | 1.778<br>(0.089) |
| Picking up litter<br>$W(3012) = 0.907$, $p < 0.001$ | 2.697<br>(2.655, 2.739) | 3.000 | 1.168 | 1.364 | 0.150<br>(0.045) | -0.743<br>(0.089) |
| Community gardening<br>$W(3012) = 0.669$, $p < 0.001$ | 1.594<br>(1.560, 1.628) | 1.000 | 0.952 | 0.906 | 1.583<br>(0.045) | 1.734<br>(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

**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. | *SE* | *p* | *95% CI* | |
|---|---|---|---|---|---|---|---|
| | | | | | | 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

**APPENDIX 5**: Moderation analyses

**Table A5.1** 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* | *t* | *p* |
|---|---|---|---|---|---|
| Environmental volunteering | Constant | 2.183 | 0.102 | 21.318 | < 0.001 |
| $R^2$ = 0.080, *MSE* = 0.922 | CN | 0.190 | 0.108 | 1.759 | 0.079 |
| $F_{(7, 3004)}$ = 37.088, $p$ < 0.001 | 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 | Constant | 1.905 | 0.100 | 18.971 | < 0.001 |
| $R^2$ = 0.047, *MSE* = 0.887 | CN | 0.245 | 0.106 | 2.312 | 0.021 |
| $F_{(7, 3004)}$ = 21.027, $p$ < 0.001 | 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 | Constant | 3.030 | 0.117 | 25.918 | < 0.001 |
| $R^2$ = 0.121, *MSE* = 1.201 | CN | 0.058 | 0.123 | 0.471 | 0.638 |
| $F_{(7, 3004)}$ = 59.294, $p$ < 0.001 | 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 | Constant | 2.015 | 0.099 | 20.256 | < 0.001 |
| $R^2$ = 0.042, *MSE* = 0.870 | CN | 0.115 | 0.105 | 1.097 | 0.273 |
| $F_{(7, 3004)}$ = 18.970, $p$ < 0.001 | 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

**Figure A5.1** Visual representation of the relationship between connection with nature (X) and frequency of participating in environmental volunteering (Y) as a function of concepts of nature ($n$ = 3012). The moderation effect of concepts of nature was not significant (see Table A5.1).

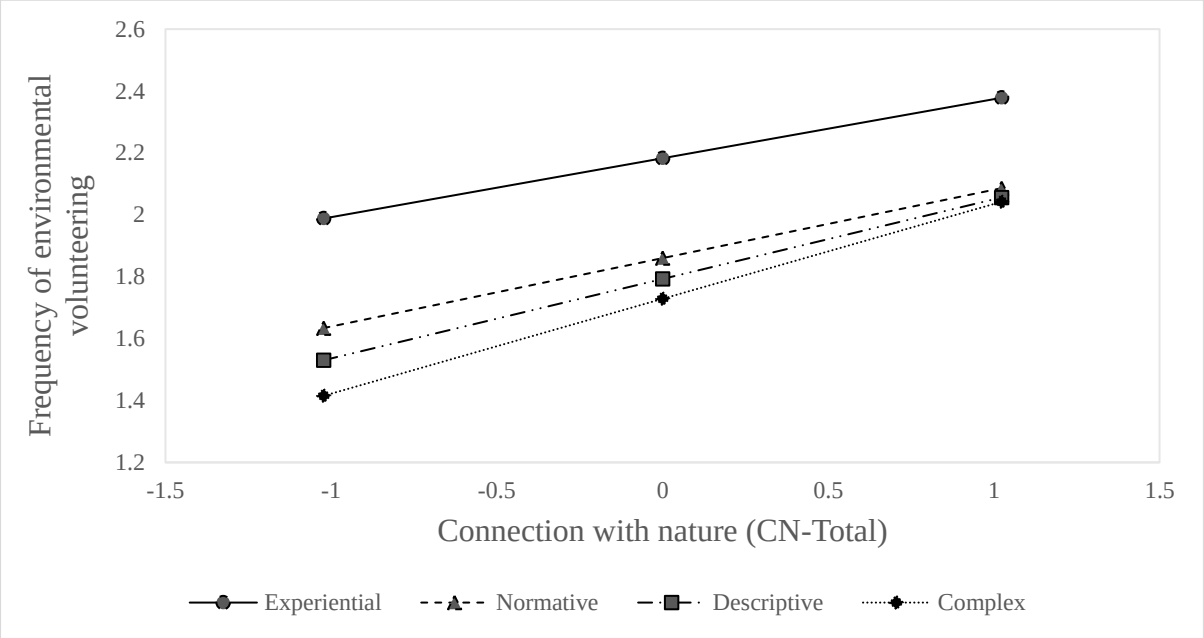


**Figure A5.2** Visual representation of the relationship between connection with nature (X) and frequency of participating in citizen science (Y) as a function of concepts of nature ($n$ = 3012). The moderation effect of concepts of nature was not significant (see Table A5.1).

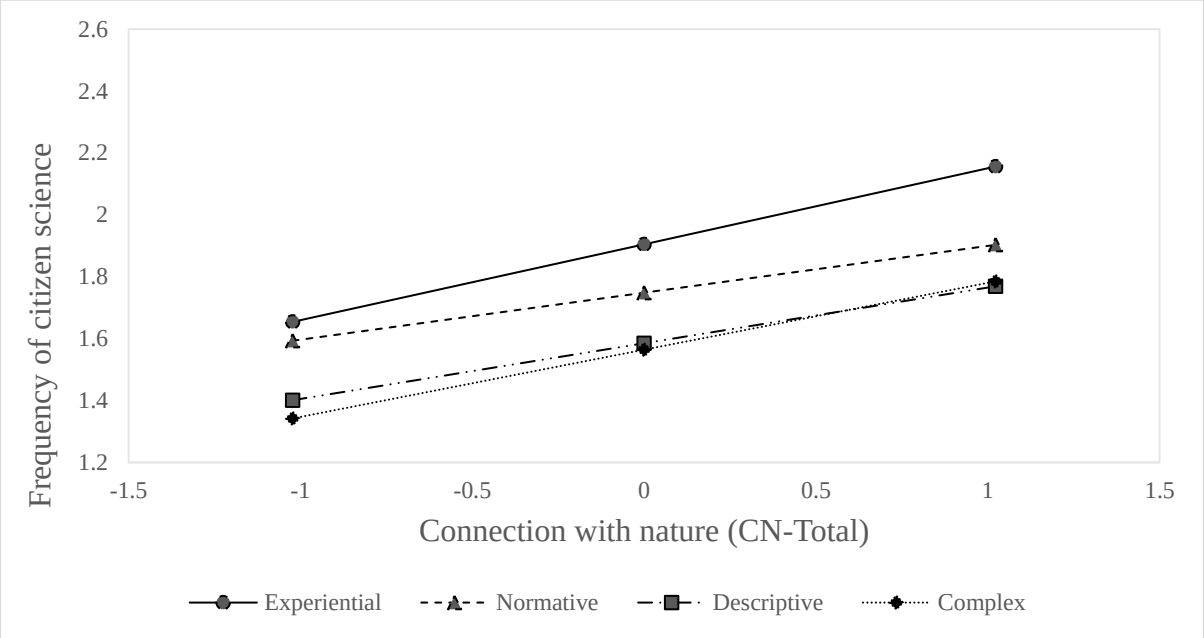
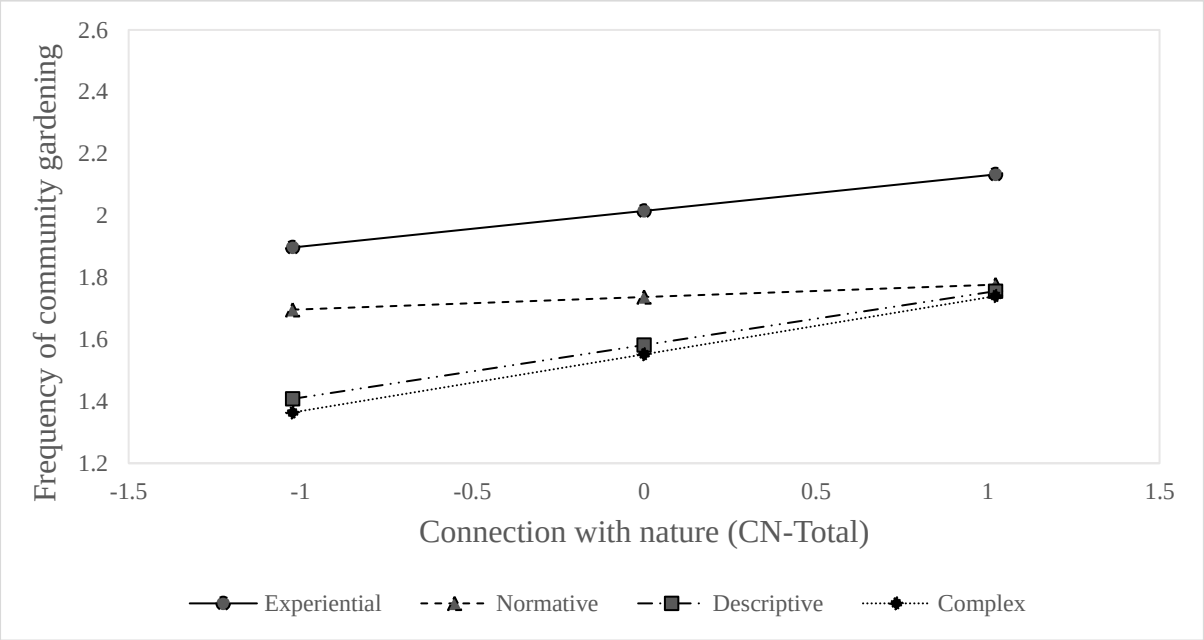


**Figure A5.3** Visual representation of the relationship between connection with nature (X) and frequency of participating in community gardening (Y) as a function of concepts of nature ($n$ = 3012). The moderation effect of concepts of nature was not significant (see Table A5.1).



**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