



## Situation networks: The emotions and activities that are central to nature-connectedness experiences

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### ABSTRACT

Many of the psychological phenomena that are relevant to the environmental crises facing the globe are determined by a complex set of interrelated constructs—that is, they are determined by a network of factors. In recognizing that these factors form a network and do not work in isolation, the need for research that captures the holistic interrelations between variables becomes obvious. As a way of exploring the value of such an approach for other areas of environmental psychology, we tested the utility of treating nature-connectedness experiences as a network using principles adapted from social network analysis. In Study 1, we look at the affective situation network concerning nature-connectedness experiences. In Study 2, we draw upon the pathways to nature framework to investigate the activity situation network for nature connectedness experiences. In Study 1, we find that awe, inspiration, and love are all important and central to nature-connectedness experiences. In Study 2, we find that meaningful (e.g., meaning-making) and deliberate engagement (e.g., noticing) are important and central to nature-connectedness experiences. More importantly, the results from this pair of studies indicate that using this network approach is a useful exploratory tool that is both generative and flexible and can yield important insights that can catalyse novel lines of confirmatory research. Thus, we suggest that research in other areas of environmental psychology consider this approach.

There are many environmental crises facing the globe (Falk et al., 2022). More than ever, it is important to understand the factors that can influence our progress toward a sustainable future. Therefore, catalysing novel and innovative lines of research is likewise more valuable than ever. For example, due to its robust associations with both human (e.g., see Pritchard et al., 2020, for a meta-analysis) and planetary well-being (e.g., see Whitburn et al., 2020, for a meta-analysis), nature connectedness is becoming increasingly recognized as a policy target across the globe (Convention on Biological Diversity, 2022, EEA, 2022; SEI & CEEW, 2022; UNEP, 2021; see Lengieza et al., 2023)—indicating that innovative nature connectedness research should be a priority. Yet, recent research suggests that studies on how to increase nature connectedness have somewhat stagnated (Sheffield et al., 2022). To the extent that this stagnation is real, this body of literature would benefit from generative research that sparks new hypotheses and novel lines of research.

Additionally, many topics of interest in environmental psychology are multiply determined with far more than just a single cause. Again,

considering nature connectedness as an example, research has revealed that there are multiple pathways (i.e., types of activities; e.g., Lumber, Richardson, & Sheffield, 2017), psychological phenomena (e.g., Schutte & Malouff, 2018), situational features (e.g., Wyles et al., 2019) and emotions (e.g., Capaldi et al., 2014) that influence nature connectedness (see Lengieza & Swim, 2021b, for a review). With so many different determinants, looking for a single highly explanatory factor, while valuable, ignores the more holistic picture of a *network* of factors that influence important sustainability outcomes (see Capizzi & Kempton, 2023, or Costantini et al., 2019, for examples of how networks can be useful in psychological research). Thus, this paper aims to explore the utility of thinking about modern environmental challenges as networks of influential factors. We do this using nature connectedness as an exemplar outcome across two content domains: emotions and the pathways to nature connectedness.

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## 1. Situations as networks

The idea behind this approach is that any given situation can be considered a network of factors that influence an outcome of interest. Moreover, these factors not only have the potential to influence the outcome of interest but may also influence each other in a consistent way. To explain why this is useful, consider a *social* network analogy.

If a researcher was interested in whether different members of a community—the town Artist, Florist, Carpenter, Bartender, Librarian, Community Organizer, and City-councillor, etc.—had an important influence on fun community gatherings within a *specific* community, they could track the number of times that each member of the community was present at a community gathering. Let us assume that they (a) found that the Artist, Councillor, and Bartender were found at the notably fun community events more often than the rest of the community members and that they (b) also found that the Councillor and the Carpenter were frequently present at the boring gatherings—whereas the Artist and Bartender were rarely at the boring events. Such a case would indicate (1) that the Artist and Bartender are uniquely important for fun events (i.e., because they were *both* highly present at fun events and notably absent at boring events); (2) that councillors, despite being at many fun events, likely have no influence on the funness of the event (i.e., because they were also notably present at many unfun events, suggesting that they were only present for the fun events because they are involved in all events); and, finally, (3) that the Carpenter has a negative impact on the funness of the event (i.e., because they were only present for boring events). Finally, suppose that the researchers also found that while the Librarian, Florist, and Organizer frequently occurred in both types of events, they almost always appeared together. This would suggest an association between the three—perhaps these individuals often work very closely in this community.

In essence, by noting the presence and absence of certain community members in “fun” and “unfun” contexts, the researchers can formulate a sense of who are the positively influential members of the network, who are the negatively influential members of the network, and who tends to interact with whom for *this* community. However, if they were interested in the more universal pattern across communities, they could collect the same data across many communities and then aggregate it into a higher-level network. Doing so might reveal that, across communities, Bartenders are still notably present at fun events for all communities, whereas Artists are only notably present at fun events for *some* communities, and in other communities, it is the Organizers who are notably present at fun events. Such a pattern would indicate that Bartenders heavily influence fun events across communities, whereas artists and community organizers are positively influential in some contexts, but not always. All of this would be uncovered using social network analysis.

Fortunately, for research in environmental psychology, the same thing can be done with emotions, for example. Just as Person A can appear in different social situations and can be identified as connected to Person B depending on if Person A and Person B frequently appear in the same social setting, Emotion A can appear in different psychological situations and can be identified as connected to Emotion B depending on if Emotion A and Emotion B frequently appear in the same psychological setting. Thus, by noting the presence and absence of certain emotions in nature-connective contexts and non-nature-connective contexts, across people, researchers could formulate a sense of which emotions are the positively influential members of the connectedness network, which emotions are the negatively influential members of the connectedness network, and which emotions tend to interact with which other emotions. This is the essence of the approach furthered in this paper.

Finally, while the frequency of appearance might be one metric for influence in a network, there are other potential ways of conceptualizing influential nodes. For example, some nodes can be more central (i.e., well-connected) to the network and, therefore, more influential (Barrat et al., 2004). To illustrate, in the case of a virus outbreak, the person who

is most central to a social community—that is, has the most connections with other people because they tend to socialize with many individuals—is the one who might be most likely to influence whether the rest of the community gets sick. To use emotions as the easy example in the context of the research here, emotions that tend to be associated with many other emotions could be seen as particularly influential if their presence tends to spark a large number of other, more important emotions. In other words, if one emotion tends to instigate other emotions in the nature-connectedness network, it could be important to investigate further.

## 2. Why nature connectedness?

The approach used here is meant to apply to a variety of topics within environmental psychology—for example, studying motivations or barriers to active travel or understanding the network of stressors contributing to ecoanxiety (see Coffey, Bhullar, Durkin, Islam, & Usher, 2021; Lutz et al., 2023). In particular, it is meant to be *most* useful in contexts where (a) little is already known about the topic or new insights are seen as especially valuable and (b) where there is reason to believe that there is a large network of factors that would influence the outcome of interest. While nature connectedness is already well-researched, we chose it for the following reasons.

First, we selected nature connectedness because it is our area of expertise and, therefore, an area with which we have enough knowledge to judge the soundness of the insights generated from this approach. Second, despite this approach seeming primarily useful for newer areas of study, connectedness was selected explicitly *because* there is a well-established body of literature. This is because, to assess the utility of the approach, it is necessary to have an existing knowledge base against which resulting insights can be judged. Accordingly, the research questions used here are deliberately less novel than they might otherwise be when using this method. Third, even though the literature is relatively well-established, it has stagnated somewhat (see Sheffield et al., 2022) despite a recent surge in references to nature connectedness in international policy (see Lengieza et al., 2023). Fourth, nature connectedness matters in terms of progress towards a more harmonious relationship with the rest of the natural world (see Barragan-Jason et al., 2022). Consequently, any new insights generated from this research should be especially valuable.

To demonstrate the value of this method, we apply it to two content areas related to the determinants of nature-connectedness. First, we consider the emotions that influence nature connectedness, which is a very well-established body of literature (see Capaldi et al., 2014; Lengieza & Swim, 2021b; Nisbet & Zelenski, 2011). Then we consider the pathways to nature connectedness framework, which is comparatively less studied than emotions but still well-established and relevant to the wider systems context beyond the individual level (see Lumber et al., 2017, 2018; Richardson et al., 2020).

## 3. Background on nature connectedness

### 3.1. What is nature connectedness?

Before detailing the associations between nature connectedness and both emotions and the pathways to nature connectedness, it is useful to first define nature connectedness and acknowledge two key theoretical perspectives on the construct. Nature connectedness—which is the extent to which nature is included in one’s sense of self (Schultz, 2002)—emerged as an extension of interpersonal relationship closeness (Schultz, 2002; see Aron et al., 2022) and, therefore, can be seen as an operationalization of our relationship with nature. Indeed, ample research has shown that nature connectedness and interpersonal relationships share many parallels and often operate on similar principles (e.g., Davis, Le, & Coy, 2011). For this reason, nature connectedness has been treated as a form of self-expansion (see Lengieza, 2024). In

addition to being seen as a form of self-expansion, nature connectedness is also seen as a form of self-transcendence—which entails lessened salience of the self and blurring of the distinction between self and others (see Yaden et al., 2017). Like other forms of self-transcendence, nature connectedness involves a blurring of the boundaries between self and nature and often results in pro-collective (i.e., less selfish) behavior (Lengieza et al., 2021). Both of these perspectives are emphasized here as they often prove useful for contextualizing previously unestablished associations between predictors and nature connectedness.

### 3.2. Emotions & nature connectedness

State nature connectedness appears to be highly sensitive to the emotions one is experiencing at any given moment. For example, within the pathways to nature framework, emotions are one of the key pathways to nature connectedness (Lumber et al., 2017). Beyond the pathways framework, a meta-analysis has revealed that positive affect, in general, is a robust positive predictor and outcome of nature connectedness (Capaldi et al., 2014), and it may even be one of the possible mediators between contact with nature and connectedness (Nisbet & Zelenski, 2011). Moreover, like positive affect, negative affect has also been shown in several studies to have an association with individuals' level of nature connectedness, albeit an expectedly negative one (see Lengieza & Swim, 2021b). Thus, in terms of broad brushstrokes, affect plays a clear role in forming nature connectedness: when people feel good in nature, they tend to feel connected to nature; when they feel bad, they tend to feel less connected to nature.

Yet, research and theory also suggest that the *type* of emotion or affect might determine the ultimate effect on nature connectedness. For example, in terms of theory, differential effects of positive affect on nature connectedness are consistent with the tenets of the Broaden and Build Theory (B&BT) of positive emotions (see Fredrickson, 1998, 2004, 2013; Waugh & Fredrickson, 2006). Specifically, B&BT suggests that while all positive emotions work toward broadening the self, specific emotions (e.g., inspiration) are more likely to broaden than others (Fredrickson, 2013). This would imply that some emotions may better connect us to nature (see McEwan, Richardson, Sheffield, Ferguson, & Brindley, 2019).

More importantly, empirical research suggests that some emotions do, indeed, appear to be more potent predictors of nature connectedness than others. For example, awe—largely considered *the* self-transcendent emotion (Haidt, 2006; Shiota et al., 2017) and often associated with pro-social outcomes (e.g., Stellar et al., 2017; Piff et al., 2015) and pro-environmental behaviours (e.g., Yan, Liao, Dale, Arpan, & Raney, 2024; Yang, Hu, Jing, & Nguyen, 2018)—is especially correlated with nature connectedness (Nisbet et al., 2019) which has been conceptualized as a form of self-transcendence (Lengieza, 2024; Lengieza et al., 2021; Lengieza & Swim, 2021b). Other self-transcendent emotions and affective states such as love and compassion (Jacobs & McConnell, 2022) and elevating experiences (Capaldi et al., 2017) are likewise strong predictors of nature connectedness relative to other self-interested positive emotions such as amusement (Jacobs & McConnell, 2022). Further, eudaimonic affect (e.g., introspection and inspiration) is more associated with feeling connected to nature and humanity than hedonic affect (e.g., excitement and amusement; Lengieza et al., 2021) and eudaimonic reflection (e.g., reflecting on meaning and purpose or on growth) has a stronger and more consistent positive influence on nature connectedness than does hedonic reflection (e.g., reflecting on fun; Lengieza, 2024). Finally, interventions that prompt positive affective states have been found to increase nature connectedness, and this specifically involved low arousal/positive valence affect (McEwan et al., 2019). Thus, there is ample reason to believe different emotions will have different effects on nature connectedness.

There is also ample reason to believe that certain emotions would be more likely to occur organically in nature-connecting experiences. For

example, awe is considered a frequent emotion that occurs in nature (e.g., Bai et al., 2017; Shiota, Keltner, & Mossman, 2007; Piff et al., 2015) and is explicitly linked to connecting to others (e.g., Yaden et al., 2019). It would, consequently, be reasonable to wonder, “Is awe a particularly central emotion in nature-connecting experiences?” And, if it is, it would also be reasonable to wonder, “Is awe *the* central emotion (or are other emotions important as well)?”. Knowing which emotions frequently occur during peoples' nature connectedness experiences—and which ones tend to co-occur—can inform our understanding of which emotions are important and central to the experiences that connect people to nature.

Thus, we have three research questions related to emotions and nature connectedness.

1. Which emotions might be most influential in nature-connectedness experiences?
2. Are there emotions that are highly central (i.e., well connected to other emotions) to nature-connectedness experiences?
3. How do the emotions influence each other? Are there sub-groups of emotions that tend to co-occur in nature-connectedness experiences?

### 3.3. The pathways to nature connectedness

The pathways to nature connectedness framework (Lumber et al., 2017, 2018; Richardson et al., 2020) is informed by the values of biophilia (Kellert, 1993) to identify the types of human-nature relationships that predict nature connectedness. Specifically, *emotion* (i.e., considering the thoughts and feelings one has about nature), *sensory contact* with nature (i.e., enjoying nature through the senses, such as watching or smelling nature), *meaning* (i.e., considering the meaning and symbolism one can derive from nature), *compassion* (i.e., taking action to help nature) and engagement with nature's *beauty* (i.e., appreciating the aesthetics of nature, for example, taking in a view from a hilltop) have been identified as key pathways to being connected to nature (Lumber et al., 2017). In the original paper developing this framework, engaging with nature using the pathways—for example emotion, meaning, and compassion (scaffolded upon engagement with nature's beauty)—and pathways were significant predictors of nature connectedness (Lumber et al., 2017). These pathways have provided a popular framework for designing real-world nature engagement activities for individuals and provide a useful perspective for considering nature connectedness at the societal scale through combining with a systems and leverage points perspective (Richardson et al., 2020).

However, while the framework has been well established there is much that remains unanswered. For example, even more so than the emotions reviewed in the previous section, it is unclear which pathways are most likely to occur in nature-connecting experiences and which are most central to those experiences. While some pathways, such as meaning, might be particularly potent but rare in contemporary Western societies, others might be less impactful but more prevalent. Moreover, it is unclear whether some pathways have the potential to lead to other pathways. Take the scientific value of biophilia, for example. This route has not been found to be a significant predictor of nature connectedness in past work (e.g., Lumber et al., 2017). Yet, one may wonder whether scientific nature activities are well-connected or poorly connected to other more impactful pathways; if scientific nature activities are strongly connected to emotional nature experiences, they might still be important even if only stepping-stones to other parts of the network. If they instead frequently occur in isolation, then they may have little value after all. So how does the scientific pathway influence other pathways, for example? This is precisely the type of question that can be answered by looking at the pathways to nature as a network.

Thus, we apply the same research questions to the pathways to nature connectedness.

1. Which pathways might be most influential in nature-connectedness experiences?
2. Are there pathways that are highly central to nature-connectedness experiences?
3. How do the pathways influence each other? Are there sub-groups of pathways that tend to co-occur in nature-connectedness experiences?

#### 4. Networks as generative, exploratory, and flexible

The value of this approach is derived from three key qualities. First and foremost, this approach is useful because it is *generative*. It has a high potential to identify new associations and insights that can be investigated in later confirmatory studies. In other words, it can generate new hypotheses and potentially catalyse new lines of research. Consequently, and secondly, it is an inherently *exploratory* approach. It is not situated to confirm previously unestablished associations. Instead, it is situated to uncover them for future study. For this reason, the explicit use of p-values and inferential statistics should be purposefully kept to a minimum. Introducing p-values and inferential statistics makes it all too easy to view the results as confirmatory and definitive, which they are not; the results of this approach are tentative and explicitly call for further investigation and should always be viewed as such. Finally, this approach, which leans toward data-driven, is highly *flexible* and requires little a-priori knowledge or expectations about the patterns in the data. Again, this approach seems especially useful in areas where little is known about the topic. Thus, the flexibility and low need for a *priori* expectations are particularly valuable qualities.

In sum, the outputs from this approach are not a set of confirmed associations, as is typical in quantitative environmental psychology. Instead, the outputs are a series of potentially novel hypotheses that can and should be tested in future studies.

#### 5. The present research

The purpose of this paper is to explore the utility of treating situations as networks using the context of nature connectedness as an exemplar. Thus, the primary goal is to evaluate whether the insights generated here are consistent with the extant literature to assess this approach's utility in other, less-researched contexts. Still, given this approach's flexibility and generativity, new insights will likely emerge as well.

To test this approach, two surveys were conducted (in separate samples) focusing on (a) three of the participants' notably positive nature-connectedness experiences and (b) one of their notably underwhelming nature-connectedness experiences. In each of the studies, participants indicated which of the closed set of network members was or was not present in each of their experiences and rated how connected to nature that experience made them feel. The data was then analysed as a network to answer our three recurring research questions.

#### 6. Methods

This methods section is structured slightly differently than most multi-study methods sections. For the most part, the information about each study is presented in tandem, given the high degree of methodological similarity across studies. However, despite describing the general methods in a separate section, each study has a brief methodological subsection of its own to clarify some of the unique considerations, namely item choice.

##### 6.1. Participants

As this is a new approach, there was no guidance on sample size. Thus, an intended final sample of 200 participants was selected. However, to account for the possibility of exclusions (allowing for a 20%

exclusion rate), 250 UK participants were recruited from Prolific for each sample (see supplemental materials for sample characteristics). In Studies 1 ( $N_{\text{final}} = 205$ ) and 2 ( $N_{\text{final}} = 216$ ), participants were excluded following the procedures of Lengieza, Aviste, and Swim (2023). Specifically, participants were excluded for reporting that they rushed, were distracted, or did not take the survey seriously (12 in Study 1, 13 in Study 2). Participants were also excluded for taking too long on the survey (13 in Study 1, 13 in Study 2). Additionally, some participants experienced unsalvageable glitches on the sorting task (20 in Study 1 and 8 in Study 2).

#### 7. Materials and procedure

##### 7.1. Experience selection

After providing informed consent, as per institutional ethics approval, participants first selected the four experiences they would reference later during the card-sorting task. On the initial page, participants were presented with the instructions displayed in Fig. 1. After taking as much time as needed on this page, participants advanced to a second page, which asked them to specify an experience for each category. The page included several text boxes—with reminders—that participants used to supply a short title for their experiences (see Fig. 2). Three connective experiences were selected to increase the variety and richness of the resulting network. The express purpose of including the underwhelming experience was to get a comparison context that still included nature but was not particularly impactful on the participants' sense of nature connectedness. This allowed us to separate items directly related to nature connectedness from items simply related to nature.

##### 7.1.1. Card Sorting Task

After selecting their experiences, participants completed a drag-and-drop card-sorting task. In this task, they were presented with a series of cards reflecting the network factors of interest in the given study (i.e., the items they sorted differed between studies; see Tables 1 and 2). They were asked to drag each item into one of four categories depending on its degree of presence in each of their experiences. Prior to starting this task, participants were presented with the instructions depicted in Fig. 3.

The appearance of the actual task page can be found in Fig. 4. The experience order was randomized, as was the item order. The item pool only displayed a portion of the entire set at a time—to accommodate different-sized devices this depended on participant screen size.<sup>1</sup> The drop-bins were coded from 0 ("not at all present") to 3 ("very present").

##### 7.1.2. Emotions

In Study 1, emotions (see Table 1) were selected based on those frequently encountered in the relevant literature (e.g., awe). For example, awe (Piff et al., 2015; Shiota et al., 2007; Yang et al., 2018), inspiration (Fredrickson, 2013; Lengieza et al., 2021; Oliver & Raney, 2011), joy (Jacobs & McConnell, 2022), and compassion (Adventure-Heart & Proeve, 2017; Lumber et al., 2017), have all appeared relatively frequently in the literature. Other emotions were included based upon interest in their effects despite being previously unexplored (e.g., boredom, curiosity, nostalgia)—again, this approach seems most useful for exploratory research. We attempted to keep the emotions relatively balanced and under thirty items to avoid overburdening participants (more explicit justification for each emotion can be found in the supplemental materials).

##### 7.1.3. Pathways

In Study 2, pathways (see Table 2) were selected as informed by the items used in the original pathways publication (Lumber et al., 2017).

<sup>1</sup> Given the underlying code for the task, participants were required to complete the task on non-mobile devices.



Help us understand people's experiences.

Please consider the experiences within the last year that have **made you feel connected to nature and the earth**, we will ask you to pick four of them:

1. One that was especially **SIGNIFICANT or IMPACTFUL**  
(i.e., made you feel the most connected to nature)
2. One that was especially **ORDINARY or COMMON**  
(i.e., best fits how you most commonly connect to nature)
3. One that was especially **PREFERRED or IDEAL**  
(i.e., best fits the way you typically prefer to connect with nature)
4. One that was especially **LAME or UNDERWHELMING**  
(i.e., an ordinary nature experience that didn't make you feel any more connected to nature than you usually feel)

We ask that you please select four DIFFERENT experiences (i.e., do not use an experience more than once).

If there is an experience that fits more than one category, use it for the one it fits best and then pick the next best one for the other category.

*You do not have to pick the experiences just yet. You will do that on the next page.*

Fig. 1. Experience selection instructions.

**For your benefit, provide a short description or "title" for each experience you choose. This will help to make them a bit more concrete in your memory and the titles you give will be used as a label later in the survey.**

Provide a **short description** or "**title**" for the experience you have chosen that was especially **SIGNIFICANT or IMPACTFUL** (i.e., made you feel the most connected to nature).

Again, this experience should:

1. have made an **ABOVE AVERAGE** impact on your sense of connection to nature or the earth
2. have occurred **within the last year** or so
3. have been especially **SIGNIFICANT or IMPACTFUL** (i.e., made you feel the most connected to nature)
4. be DIFFERENT from the other experiences

Fig. 2. Experience selection title input example.

However, to increase applicability to many people across multiple situations, the items were re-designed to capture the spirit of an activity (e.g., "Keeping nature where it belongs" to reflect the dominionistic pathway) rather than a concrete activity (e.g., "gardening" or "weeding"). Moreover, to get at the spirit of the activity from multiple angles, three slightly different framings were used for each pathway (e.g., "Keeping nature where it belongs" plus "Altering nature to fit my preferences" and "Controlling nature" were all used for the dominionistic pathway). We also included a non-engagement pathway (i.e., "To do", "Conversation", and "Music") as activities that should be relatively common in everyday life (i.e., analogous to the Councilor described in the introduction) to use as a potential point of reference.

#### 7.1.4. Nature connectedness

After each card-sorting task for a given experience, participants completed a sliding-scale version of the Inclusion of Nature in Self scale (INS; Schultz, 2002), following the procedure used in past research (i.e., Lengieza, Aviste, & Swim, 2023b; Lengieza & Swim, 2021a). This scale presents two circles; one labelled self and the other nature, with a slider that could be used to move them closer together. Participants were asked to use the slider to indicate how connected to nature they felt during the specific experience.

#### 7.1.5. Exit items

We also included several exit items at the end of the survey to assess

**Table 1**  
Emotion items used in study 1.

Item	Importance	Standardized Centrality
Joy	0.48	0.64
Awe	0.47	0.76
Inspiration	0.46	1.80
Excitement	0.45	1.15
Gratitude	0.41	0.62
Love	0.38	1.29
Belonging	0.37	0.89
Interest	0.37	0.98
Pride	0.34	0.67
Calmness	0.34	0.55
Hopefulness	0.32	0.64
Curiosity	0.30	0.91
Desire	0.29	0.20
Nostalgia	0.26	0.20
Compassion	0.24	0.06
Relief	0.24	0.21
Fear	-0.07	-0.88
Guilt	-0.11	-0.93
Embarrassment	-0.15	-0.92
Anxiety	-0.18	-1.17
Sadness	-0.19	-0.78
Anger	-0.21	-1.27
Disgust	-0.23	-1.64
Discomfort	-0.23	-1.32
Irritation	-0.35	-1.24
Boredom	-0.36	-1.22

data quality (see Lengieza et al., 2023b). These items asked participants to self-report whether they rushed, were distracted, or did not take the survey seriously and were used to exclude low-quality responses, as noted above. Prior to answering these questions, participants were explicitly informed that their answers would not affect their credit.

**Table 2**  
Pathway items used in study 2.

Item	Node Label	Importance	Standardized Centrality
Noticing nature’s beauty	Noticing	0.40	1.08
Having meaningful interaction with nature	Interactions	0.40	1.09
Appreciating nature’s beauty	Appreciating	0.39	0.83
Capturing or depicting nature’s beauty	Capturing	0.36	0.86
Making sense of life through nature	Meaning Making	0.33	1.51
Having deep thoughts about nature	Thoughts	0.33	0.87
Having strong feelings about nature	Feelings	0.31	1.26
Watching nature	Watching	0.28	1.22
Listening to nature	Listening	0.28	1.16
Learning about nature	Learning	0.26	0.92
Smelling nature	Smelling	0.24	0.10
Thinking about natural icons (e.g., mother earth)	Icons	0.24	0.10
Using my knowledge of nature	Knowledge	0.22	0.10
Using nature for personal benefits	Personal Gain	0.21	0.05
Objectively documenting nature	Documenting	0.21	0.25
Thinking about how people should treat nature	Moral Thinking	0.18	0.01
Caring about how people treat nature	Moral Caring	0.18	-0.07
Keeping nature where it belongs	Confining	0.18	-0.67
Using natural metaphors or analogies	Metaphors	0.17	0.38
Using resources from nature	Resource Use	0.13	0.35
Gathering resources from nature	Gathering	0.13	0.02
Doing something about how people treat nature	Moral Action	0.08	-0.45
Talking with other people	Conversation	0.08	-0.67
Altering nature to fit my preferences	Altering	-0.02	-0.76
Listening to music	Music	-0.03	-1.11
Using social media	Social Media	-0.04	-0.71
Controlling nature	Controlling	-0.06	-0.76
Avoiding unpleasant parts of nature	Avoiding	-0.13	-1.40
Preparing for unpleasant parts of nature	Preparing	-0.16	-2.13
Thinking about what I needed to do later	To do	-0.20	-0.73
Being uncomfortable because of unpleasant parts of nature	Discomfort	-0.22	-2.55

7.1.6. Analytic approach

7.1.6.1. *Node importance.* Node importance was based upon the proportional frequency of presence across the three connective experiences (weighted by the degree of presence and accounting for the frequency of presence in the non-connective experiences; see supplemental materials for validation of this approach). Table 3 outlines the procedure for calculating these values using “Joy” as an example. The resulting values (which ranged from -1 to 1) were used to determine node size and color in the network. Specifically, the absolute value was used to determine the size of the node. Larger nodes indicate that the presence (or absence) of a given item was further from 0—suggesting that they are important. The sign of the proportional frequency was used to determine the color of the node. Items that were more often absent than present (i.e., negative values) from nature-connective experiences were colored red; items that were more often present than absent (i.e., positive values) were colored green. To make it easier to visually parse the graph, nodes in the top third of their color group were assigned a triangle, those in the middle third were assigned a square, and those in the lower third were assigned a circle (and also colored a slightly darker shade).

7.1.6.2. *Edge calculations.* The recommended approach to calculating connection strength in networks, at least within psychology (Capizzi & Kempton, 2023; Costantini et al., 2019) to calculate partial correlations between all members of the network using the Extended BIC graphical lasso methodology (EBIC GLASSO; see Costantini et al., 2019). The partial correlations indicate which items still have a relationship after accounting for all the other items in the network. However, given the nature of the approach used here, there was a possibility that some items might end up being aliased (e.g., “Noticing Beauty”, “Appreciating Beauty”, and “Capturing Beauty” might be measuring the same thing). If these items were, indeed, aliased, testing for the “Noticing–Smelling” association, when controlling for “Appreciating” and “Capturing”, would be similar to testing for the “Noticing–Smelling” association when

On the next pages, you will be asked to drag and drop items based on whether they were part of your experience.

- Some of the items will have been **very present** (i.e., very obvious and strong). You should place them in the **green category**.
- Some items will have been **sort of present** (i.e., less noticeable or less strong) You should place them in the **brown category**.
- Some items will have been only **barely present**, (i.e., only briefly or very weakly). You should place them in the **orange category**.
- Some items have been **not at all present** (i.e., not there at all). You should place them in the **red category**.

Fig. 3. Pre-instructions for the sorting task.

Tell us about your "**my SIGNIFICANT or IMPACTFUL experience**" experience.

Drag and drop the items below based on whether they were part of your experience.

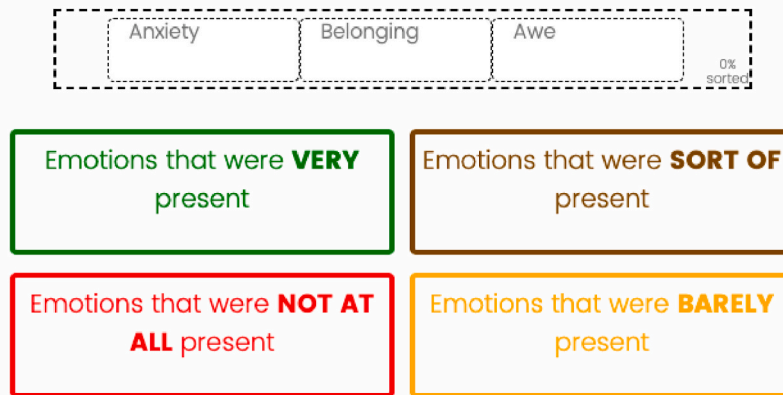


Fig. 4. Presentation of the card sorting task.

controlling for “Noticing” itself. To address this, we used what we call the “twinned-node approach” (see supplemental materials for justification and consideration of alternatives). Table 4 outlines the steps for this approach. When visualizing the network, we made sure to indicate potential aliasing using a thick grey edge.

**7.1.6.3. Thresholding.** A common practice in network analysis, especially for dense networks with few perfectly null connections, is to use thresholding (see Neuman et al., 2022). While the EBIC GLASSO procedure partially attempts to make the network sparser, for the purposes of this project, we also used a threshold of  $|r_{\text{pseudo-partial}}| < .10$ ; all edges below this value were deleted from the network. We did this because thresholding prevents networks from being unnecessarily dense (i.e., filled with trivial connections; see Neuman et al., 2022). Using  $|r_{\text{pseudo-partial}}| < .10$  as an additional threshold further ensures that non-meaningful connections in the network are removed.

**7.1.6.4. Centrality.** One of the key questions in these analyses is which network-members are most influential. There are, however, multiple ways in which a node can be considered influential. While nodes in the network that are more frequent can be considered more influential, nodes that are more central—more well-connected—can be seen as influential as well. There are a number of metrics of centrality, but one such metric that is easily conceptualized and directly applicable to the

questions here is strength. Strength, as generated by *strength()* in the package *igraph* (Csardi, 2013), is calculated by summing all of the weighted connections that a given node shares with other nodes in the network. Nodes with a greater number of strong connections have higher values, indicating that they are, quite literally, more strongly connected to the network.

We used an adaptation of this principle to calculate strength here. Specifically, we not only accounted for the weight of the association between two nodes (which ranged from  $-1$  to  $1$ ), but we also accounted for the importance of the other node in the pair (which also ranged from  $-1$  to  $1$ ). Using the adapted strength calculation, nodes that were strongly connected to a greater number of positively important nodes in the network would be properly categorized as positively central (i.e., strongly connected to positive parts of the network), and nodes that were strongly connected to a greater number of negatively important nodes would be properly categorized as negatively central. Table 5 outlines the steps for calculating “Valanced Strength” (see supplemental materials for more information).

**7.1.6.5. Clusters.** *Cluster\_optimal()* from the *igraph* package was used to identify clusters in the data based on the weighted connections between each node. Such clustering procedures are used to identify communities in networks based on the ties between them (Neuman et al., 2022). This function only accepts positive values for weights. Since the weights in our network could range from  $-1$  to  $1$ , we temporarily shifted these

**Table 3**  
Steps for calculating node importance using Joy as an example.

Step Number	Description
Step 1	For each participant, the degree of presence for “Joy” was coded individually for each of the three nature-connective experiences. This resulted in three values, one for each experience type. All three scores could range from 0 to 3.
Step 2	The values from Step 1 were summed across the three experiences to get the total number of appearances of “Joy” for each participant and then divided by the maximum possible degree of presence (9) to get the proportional appearance of “Joy” across all experiences with scores ranging from 0 (“Joy” never occurred) to 1 (“Joy” occurred in every experience).
Step 3	Then, for each participant, the degree of “Joy” present in the control experiences was coded, and proportionalized (similar to Step 2) of “Joy” was calculated across participants by dividing each participant’s score by the maximum possible presence of “Joy” in the control experiences (3).
Step 4	Then, for each participant, this most recent value from Step 3 was subtracted from the value calculated in Step 2 to account for the baseline presence of “Joy” <sup>a</sup> . Values could range between –1 and 1. <i>Negative values</i> indicated that “Joy” was present in non-connective experiences more often than it was in connective experiences; <i>Positive values</i> indicated that “Joy” was present in connective experiences more often than it was in non-connective experiences; a <i>value of 0</i> indicated that the “Joy” occurred equally in both types of experiences.
Step 5	Finally, the values calculated in Step 4 for each participant were averaged to create a sample-level proportional frequency, which was used to indicate node importance.

Notes.

<sup>a</sup> This is important because some items might have a high frequency in daily life, making them likely to appear in any experience.

**Table 4**  
Steps for the twinned node approach and calculating pseudo-partial correlations.

Step Number	Description
Step 1	First, we calculated the raw correlations between variables and identified the ones that might have been aliased using the threshold of $ r  \geq .70$
Step 2	We then calculated the EBIC GLASSO partial correlations as normal—using EBICglasso from the qgraph package in R (Epskamp et al., 2012)
Step 3	After this step, we went through all of the potentially-aliased pairs and replaced the existing value with the value from a recalculated EBIC GLASSO matrix after excluding any aliases with either member of the pair

values by adding the absolute of the minimum value in the dataset (i.e., so that the most negative value was shifted to 0).

**Simplified Networks Based on Clusters.** Because the clusters themselves represent particularly interesting groups of network members and offer a way to potentially simplify the network by aggregating common nodes, we also generated networks based on aggregated nodes from the same cluster. Since we were recalculating a network, it was necessary to account for potential aliasing at the aggregate level—we did this as described for the edges above. Since this network was (a) much smaller and (b) we were not interested in clustering at this stage, no thresholding was done for edges.

In calculating the influence of the aggregate nodes, we opted to calculate the partial correlations between the aggregate values for a node cluster and nature connectedness. Here, when creating the aggregate values for clusters, we followed a similar approach to handling aliasing as with centrality. That is, if multiple aliased nodes were included in the same cluster, their presence in a given nature experience was first averaged among themselves. That single value was then used when computing the average for the whole cluster. While we could have simply used these aggregate values for node size, we decided

**Table 5**  
Steps for calculating Valanced Strength using Joy as an example.

Step Number	Description
Step 1	All of the nodes that shared a connection with “Joy” were identified
Step 2	The weighted connections between “Joy” and the identified nodes were collected, as were the node-importance values for those nodes.
Step 3	To account for aliasing, all aliases found in the subset of nodes identified in Step 1 were collapsed into a single value. For example, if “Awe” and “Inspiration” were potentially-aliased and both were connected to “Joy”, their edge weights would be averaged into a single value, and their importance would be averaged into a single value.
Step 4	After accounting for aliasing, both sets of values were divided by their maximum absolute value so that all values were put on roughly the same scale (i.e., on a scale of “relative to the maximum for the given attribute”). <sup>a</sup>
Step 5	The edge-importance pairs were then multiplied together and summed.

Notes.

<sup>a</sup> This was done to ensure that the two values were afforded similar weight in Step 5.

to calculate the semi-partial association between these values and nature connectedness so that we could determine which clusters of nodes had unique associations above and beyond the other clusters. This was done using the standardized coefficients for the within-subjects effect for each cluster value derived from a multi-level regression predicting nature connectedness from the cluster values simultaneously (see Supplemental Materials for more information).

## 8. Results & discussions

### 8.1. Study 1 results & discussion

Table 6 provides a summary of the insights generated from Study 1.

#### 8.1.1. Influential members

**Positive Influence.** In the emotion network (displayed in Fig. 5), few emotions were distinctly un-influential (in contrast to the forthcoming pathway network). In other words, all emotions, especially the positive ones, seemed to have at least some degree of influence on nature connectedness. The most noteworthy positively influential emotions (i.e., the biggest and greenest nodes) were awe, joy, inspiration, excitement, love, and gratitude. These positive emotions were highly and distinctly present in peoples’ nature-connection experiences.

The prominence of awe (Bai et al., 2017; Lengieza & Swim, 2021b; Piff et al., 2015; Shiota et al., 2007; Sturm et al., 2022; Yang et al., 2018) and joy (Capaldi et al., 2014; Lengieza, 2024; Lengieza & Swim, 2021b), in particular, are very consistent with a great deal of the extant literature on nature connectedness (and related constructs), suggesting that this approach is capable of capturing important insights. However, the approach also revealed that a handful of understudied emotions are important, several of which are supported by empirical research, even if limited. For example, inspiration, which is not frequently studied in the context of connection to nature, was also one of the major influences on the network. This insight is consistent with work linking eudaimonic affect—which includes inspiration—and nature connectedness (e.g., Lengieza et al., 2021) as well as B&BT, which suggests that the primary functional purpose of inspiration is to grow and expand the self specifically (Fredrickson, 2013). Relatedly, the prominence of excitement is likewise more novel but still consistent with the broader literature, especially from a nature-connectedness-as-a-relationship perspective (see Lengieza et al., 2023). Specifically, excitement is one of the key ingredients for self-expansion (see Aron, Aron, Tudor, & Nelson, 1991, 1992, 2013, 2022; Aron & Nardone, 2012), which, in this case, just happens to be expanding the self to include nature (Lengieza, 2024).



**Table 6**  
Generated insights from study 1.

Insight	Consistent Extant Evidence	Novelty in the NC literature
Awe—which is considered <i>the</i> self-transcendent emotion (Haidt, 2006)—is a highly influential emotion in the nature-connection emotion network.	Bai et al., 2017; Lengieza & Swim, 2021b; Piff et al., 2015; Shiota et al., 2007; Sturm et al., 2022; Yang et al., 2018	Validating Insight
Joy (and other hedonic emotions) is a highly influential emotion in the nature-connection emotion network.	Capaldi et al., 2014; Jacobs & McConnell, 2022; Lengieza, 2024; Nisbet & Zelenski, 2011	Validating Insight
Positive emotions have a positive effect on nature connection	Capaldi et al., 2014; Crawford, Holder, & O'Connor, 2017; Fredrickson, 2013; Jacobs & McConnell, 2022; Lengieza, 2024; Nisbet & Zelenski, 2011	Validating Insight
Negative emotions have a negative effect on nature connection	Dopko, Capaldi, & Zelenski, 2019; Lengieza & Swim, 2021b; Mayer et al., 2009; Nisbet & Zelenski, 2011; Nisbet, Zelenski, & Murphy, 2011	Validating Insight
Different emotions have differential effects on nature connectedness	Jacobs & McConnell, 2022; Lengieza, 2024; Lengieza et al., 2021; Lengieza & Swim, 2021b	Validating Insight
Nature-relevant emotions cluster into drive, contentment, and threat	Richardson et al. (2016)	Validating But Mostly Novel Insight
Inspiration—which is a key part of eudaimonic affect (e.g., Oliver & Raney, 2011)—is both important and central to nature-connection experiences. It might be an important topic for future research.	Fredrickson, 2013; Lengieza et al., 2021	Mostly Novel But Corroborated Insight
Love was central and influential, which is especially consistent with theories of positive emotions but not often considered in the nature connection literature.	Adventure-Heart & Proeve, 2017; Fredrickson, 2013	Mostly Novel But Corroborated Insight
Gratitude might be an important emotion in the nature-connection emotion network.	McEwan et al., 2020	Mostly Novel But Corroborated Insight
Disgust & irritation (but not fear) might be key negatively influential emotions in the nature connectedness network.	Beery et al. (2023)	Mostly Novel But Corroborated Insight
Boredom was one of the majorly influential negative members of the network and may even serve as a barrier to the positive sub-networks.	None	Very Novel
Nostalgia, Curiosity, Interest, Hope, etc, have been relatively understudied but seem like they might have some influence. They might be theoretically valuable to research further.	None	Very Novel
Ecoanxiety-relevant emotions—sadness, guilt, and fear—had a relatively weak influence in the network, suggesting that they may be non-obstacles to nature connection.	None	Very Novel

Additionally, it is worth noting that love—and compassion—were positively influential, albeit only slightly, which is consistent with research showing that activities such as loving-kindness meditation can increase nature connectedness (Adventure-Heart & Proeve, 2017). Similarly, gratitude was also noted as a positively influential emotion and has been tentatively linked to a connection with nature in more recent research (Chen, Liu, Fu, Guo, & Chen, 2022). Nostalgia was likewise identified here and has been explicitly linked to social connectedness (Hepper et al., 2012; Reid et al., 2015; Routledge et al., 2011; Wildschut et al., 2010). Interest and curiosity, hope, belonging, calmness, and pride also seem to be important emotions, but little research has considered them.

**Negative Influence.** The most note-worthy negatively influential emotions (i.e., the biggest and reddest nodes) were boredom, irritation, and disgust. These negative emotions were highly and distinctly absent from peoples' nature-connection experiences. The emotions that had the lowest degree of influence were fear and guilt. Both Fear (Frequency<sub>connective</sub> = 9.4%; Frequency<sub>control</sub> = 16.4%) and Guilt (Frequency<sub>connective</sub> = 6%; Frequency<sub>control</sub> = 17%) occurred largely infrequently in both types of experiences compared to the average for all emotions (Frequency<sub>connective</sub> = 29.1%; Frequency<sub>control</sub> = 30.2%)

In terms of negative emotions, the most notably negative emotion was disgust, followed by irritation and boredom. While it is rather intuitive that these emotions would negatively impact nature connectedness, they have, until now, been largely missing from the literature, at least on a nuanced level. It is, however, interesting to note that boredom—a seemingly innocuous emotion—appears at least as important as irritation. While it is intuitive to suggest that nature connectedness will suffer when one experiences nature as causing them noticeable distress, it likely would not have been our first prediction that the mere experience of disinterest would be so influential. Moreover, the findings here also highlight a perhaps less intuitive finding: it is disgust, irritation, and boredom, *not* fear and anxiety that seem to be most impactful for nature connectedness. This, in particular, is especially novel in that it

highlights the possibility that more anticipatory negative emotions like fear and anxiety might not be a key barrier to nature connectedness whereas the more experiential negative emotions such as disgust or irritation might be.

### 8.1.2. Central members

The three most positively central emotions were inspiration, love, and excitement. The most apparent interpretation of this is that when inspiration, love, and excitement are present, many other positively influential emotions are likely to be present, and few negatively influential emotions are likely to be present. This is largely consistent with what one would expect from the literature. For example, of the positive emotions, love is supposed to be the emotion that is felt when an individual experiences any other positive emotion in reference to interpersonal relationships and social connections (Fredrickson, 2013). This would suggest that love, in particular, would have connections with many other emotions, consistent with the trends here. One additional observation worth noting about the positively central nodes is that, despite the potential aliasing between awe and inspiration, inspiration's (1.80) centrality was more than a full standard deviation away from awe's (0.77), suggesting that Inspiration and Awe have far from identical associations with the other members of the network. This is not necessarily surprising given the broader literature on emotions. The distinction between awe and inspiration drawn by prominent emotion researchers seems to largely rest on the fact that awe is evoked by a limited set of stimuli (i.e., those perceived as notably vast in some manner) and results in a limited set of motivations (i.e., the motivation to accommodate new information into existing schemas) whereas inspiration is seen as an emotional state that is elicited by a wide range of stimuli and resulting in *some* form of intense approach motivation (Shiota et al., 2017). Thus, on this logic, one would expect inspiration to be connected to a wider variety of elicitors, some of which might evoke other emotions. This would result in inspiration co-occurring with a greater number of other emotions relative to awe. This re-affirms our

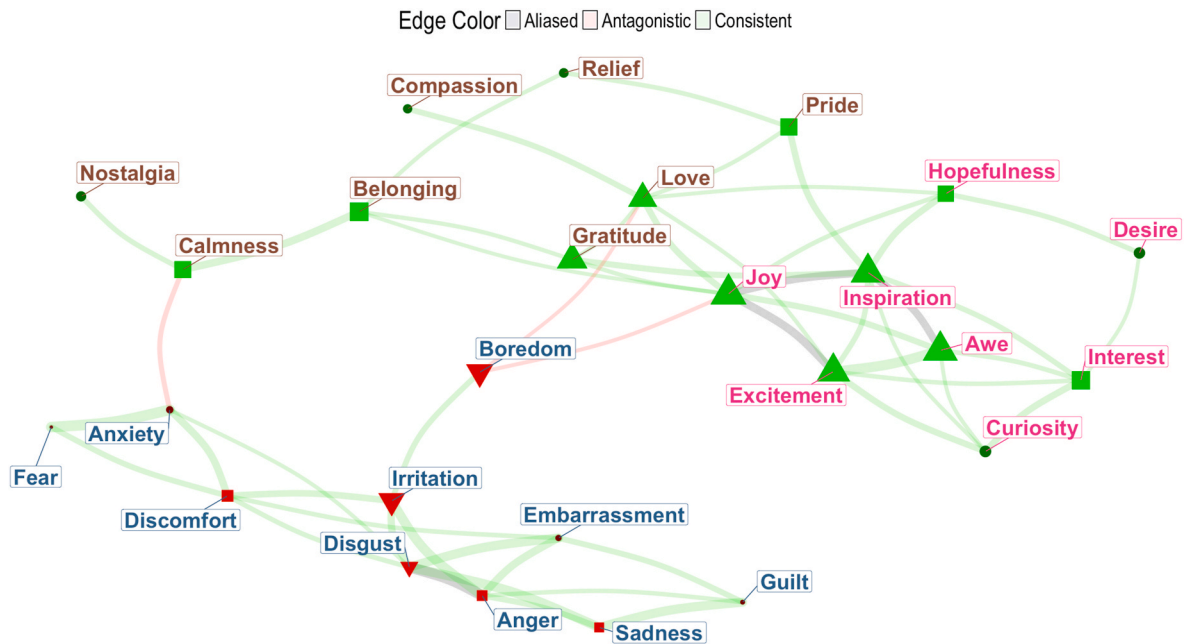


Fig. 5. The detailed nature-connectedness emotion network.

Note. The following information explains how to interpret the network visualization. **Nodes:** Larger nodes are implied to be more influential (based on presence); Green nodes had a positive influence on nature connection; Red nodes had a negative influence on nature connection. The top third, middle third, and bottom third of the positive and negative nodes are indicated with a triangle, square, or circle, respectively. **Edges:** Thicker bands indicate a strong relationship between two nodes after accounting for all the other nodes (i.e., the unique association) except for potential aliases; No bands indicate no relationship ( $|r_{\text{pseudo-partial}}| < .10$ ) after controlling for the association between other nodes; Green bands indicate a positive association between two nodes; Red bands indicate a negative relationship between two nodes; Grey bands indicate that two nodes shared 50% of their variance or more and might be aliased. **Label color:** The color of labels was determined by the cluster assignment derived from the network community structure, indicating clusters of Emotions.

decision to use the twinned-node approach.

The three most negative central emotions were disgust, discomfort, and anger. When these emotions were present, many other negatively influential emotions were also likely to be present, and few positively influential emotions were likely to be present. In sum, these members of the network are potentially influential because of their *relationships* with other members of the network.

**Radiating vs. Converging Centrality.** Given the cross-sectional nature of this data, it is difficult to determine the causality of the relationships behind the centrality of the identified nodes. On the one hand, it could be, for example, that when someone feels inspired, they are likely to subsequently feel a variety of other emotions, although, not necessarily all at once; in other words, becoming inspired could make it more likely that at least one of several other influential emotions will occur. Such a case would be appropriate to describe as a radiating effect (inspiration  $\rightarrow$  many other emotions) and would be somewhat consistent with the notion that inspiration is an emotional state that has many elicitors, including other emotions (Shiota et al., 2017). On the other hand, it could be that when someone feels any strong emotion, they are more likely to become subsequently inspired; in other words, becoming inspired could be the most likely result of multiple other emotions. Such a case would be appropriate to describe as a converging effect (many other emotions  $\rightarrow$  inspiration). Only with more research would we be able to determine which case it is.

Either way, however, it is still clear that Inspiration is an important emotion upon which to focus. In the radiating case, reflective prompting (e.g., Lengieza et al., 2021), which focuses on inducing inspiration, would likely create many other important emotions, potentially making it more potent in terms of practical effect. In the converging case, reflective prompting focusing on inducing inspiration would likely be accessible to more people (because it could arise from many different avenues), potentially making it more likely to resonate with a wide audience. Consequently, researchers may want to consider studying the

effects of feeling inspired by nature as a way of promoting nature connectedness and perhaps even other pro-environmental phenomena.

In contrast, Love might be more likely to be the convergence type of relationship, given the assertions of B&BT (Fredrickson, 2013). As noted above, love should arise when someone experiences another positive emotion in the context of social connections or relationships. Thus, many other emotions  $\rightarrow$  love would seem to be the theoretical prediction. However, despite the theory, it is still possible that when someone feels love, they become more likely to feel joy, gratitude, compassion, excitement, and so on (i.e., many other emotions), suggesting that love  $\rightarrow$  many other emotions is also possible. Future research could test this—granted, it might be of more interest outside of environmental psychology. But, like inspiration, which case it turns out to be does not detract from the fact that the centrality of love clearly indicates its importance. Future research may want to consider the effects of manipulations of love (e.g., “Reflect on what you love most about nature”).

While the radiating versus converging nature of central positive emotions was too ambiguous to draw a conclusion, the case of disgust seems more obvious. It seems more likely than the alternative that when an individual feels disgusted while in nature, they are subsequently more likely to experience other negatively influential emotions (e.g., irritation, sadness, discomfort). If it is the case that disgust is likely to incite other influential negative emotions, it would suggest that finding ways to inoculate against nature-based disgust may be especially important for maximizing the connective effect of spending time in nature (perhaps especially for those not already inclined to spend time in nature). Research should investigate whether disgust causes a cascade of other negative emotions and focus on confirming the negative direct influence of disgust.

### 8.1.3. Clusters

Three distinct clusters emerged in this network, which appeared to be structured into two distinct sub-networks: A positive sub-network

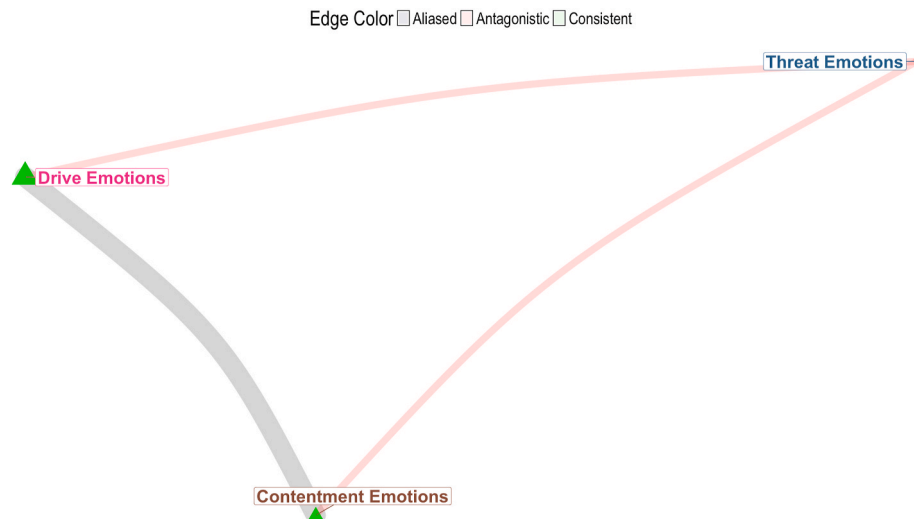


Fig. 6. The simplified nature-connectedness emotion network.

Note. The only differences in interpretation of this simplified graph versus the detailed graph are (a) that larger nodes are implied to be more influential after controlling for the influence of other clusters (this is based upon the standardized within-subjects effect from a multi-level model) (b) no bands indicate no relationship at all (i.e., there was no thresholding for these networks), and (c) label color is determined by the cluster assignment used in the simplified network. Additionally, for this graph only, bands did not account for aliasing aside from coloring potentially-aliased bands grey. Otherwise, the remaining components of interpreting the graph remain the same as those noted for the detailed networks.

and a negative sub-network, which, incidentally, mapped strongly onto extant accounts of nature-based emotions in the literature (Richardson, 2019b; Richardson, McEwan, Maratos, & Sheffield, 2016). That is, the positive sub-network was comprised of a “drive emotions” cluster (joy, inspiration, hopefulness, excitement, awe, interest, curiosity, and desire) and a “contentment emotions” cluster (love, gratitude, pride, relief, compassion, belonging, calmness, and nostalgia).<sup>2</sup> The drive emotions generally seemed to be the type of emotion characterized by high pleasure and arousal. These stimulating and activating emotions are linked to the sympathetic nervous system (Gilbert, 2014). The contentment emotions generally seemed to be the type of emotion characterized by “fuzzier and warmer” feelings characterized by high pleasure and low arousal (Richardson et al., 2016). These calming and soothing emotions are linked to the parasympathetic nervous system and thereby regulating, toning down the sympathetic drive and threat system (Gilbert, 2014). This system is focused on affiliation and restoration and it can be seen to reflect a mindful ‘being’ mode, rather than ‘doing’ mode (i.e., the mode associated with drive). The negative sub-network, which was consistent with “Threat emotions” identified in past research (Richardson et al., 2016), was comprised of all the negative emotions. One notable feature of this cluster was that Boredom and Anxiety were the only two emotions with a direct (antagonistic) relationship with the positive sub-networks. In essence, while most negative emotions were neither more nor less likely to co-occur with any specific positive emotion when Boredom was present, participants were less likely to experience love or joy. When Anxiety was present, participants were less likely to experience calmness.

**Aggregate Network.** The simplified aggregate network is shown in Fig. 6. Despite the drive emotions and contentment emotions likely being aliased, it did not make sense to account for aliasing as we had intended because there were only three clusters. Consequently, for these results, and these results only, standard partial associations were

<sup>2</sup> While pride might not seem like a particularly peaceful emotion, its connection to relief suggests it may have been capturing a “whoop, finally” type of pride (e.g., the type of pride one often feels upon reaching the top of the mountain) rather than the “Hooray, I did it” type of pride (e.g., the type of pride stereotypical of graduation ceremonies). The remainder of the emotions in this cluster were quite obviously more peaceful emotions.

calculated for the edges (but the aliasing was still indicated in the graph).

Above and beyond the other aggregated clusters in the network, each cluster had a meaningful influence on the connectivity of the experience. Both positive emotion clusters had a positive effect, consistent with a great deal of research showing an association between positive affect and nature connection (e.g., Capaldi et al., 2014; Jacobs & McConnell, 2022; Lengieza, 2024; Nisbet & Zelenski, 2011). The negative emotion cluster had a negative effect (Lengieza & Swim, 2021b), which appeared potentially weaker than the effect of the two types of positive emotions.

## 8.2. Study 2 results & discussion

Table 7 provides a summary of the insights generated from Study 2.

### 8.2.1. Important members

In the pathways network (Fig. 7), the most notable positive members of the network (i.e., the biggest and greenest) were the aesthetic pathway (noticing, appreciating, and capturing), the emotive pathway (meaningful interactions, deep feelings, and deep thoughts), the sensory pathway (watching nature, in particular, along with listening to and smelling it), and the symbolic pathway (meaning-making, in particular, along with thinking about natural icons and using natural metaphors), largely consistent with the initial work on the pathways framework (Lumber et al., 2017). In essence, these pathways were highly and uniquely present in peoples’ nature-connection experiences. The scientific pathway (learning about nature, documenting nature, and using knowledge of nature) and moral pathway (moral thinking, moral caring, moral action) were also positive members of the network, but their influence was notably weaker than the aforementioned items, which is also consistent with the original pathways work.

The most notable negative members of the network were the non-pathways (thinking about your to-do list, in particular, along with listening to music and using social media) and the negativistic pathway (avoiding, preparing for, and being uncomfortable with the negative parts of nature). In essence, these features were highly and uniquely absent from peoples’ nature-connection experiences. This is consistent with the original pathways work (Lumber et al., 2017) and with more recent work highlighting the key (antagonistic) role of negativism in the

**Table 7**  
Insights generated from study 2.

Insight	Consistent Extant Evidence	Novelty In The NC Literature
Emotions are an important pathway	Capaldi et al., 2014; Crawford et al., 2017; Fredrickson, 2013; Jacobs & McConnell, 2022; Lengieza, 2024; Lengieza et al., 2021; Lengieza & Swim, 2021b; Nisbet & Zelenski, 2011	Validating Insight
Meaning is an important pathway	Lengieza, 2024; Lengieza et al., 2021; Lumber et al., 2017; Pritchard et al., 2020	Validating Insight
Senses are an important pathway	Harvey, Oskins, McCarter, & Baker, 2016; Lumber et al., 2017; Rickard & White, 2021	Validating Insight
Noticing nature's beauty is an important pathway	Passmore & Holder, 2017; Richardson, Hamlin, Butler, et al., 2022; Richardson & Sheffield, 2017	Validating Insight
Negativism is an important—albeit negative—pathway. It may also preclude the presence of other more positive pathway activities.	Lumber, Richardson, & Sheffield, 2017; Richardson et al., 2022	Validating Insight
Scientific engagement was not an important pathway (at least not directly)	Barragan-Jason et al., 2022; Lumber et al., 2017	Validating Insight
Basic engagement with nature is necessary but not sufficient to increase nature connectedness—it needs to be deliberate and meaningful.	Lengieza et al., 2023; Passmore & Holder, 2017; Sheffield et al., 2022	Validating Insight But Under-Recognized In The Field
The scientific pathway, despite not directly influencing nature connectedness, is strongly connected to the two most influential forms of engagement and, therefore, might have utility as a stepping stone to more important forms of engagement.	Butler et al., 2024	Mostly Novel Insight
Several of the original pathways were clearly captured (e.g., a distinct moral pathway, scientific pathway, and negativistic pathway). However, others formed blended pathways, suggesting that there could be an opportunity to further refine or extend the framework.	Lumber et al., 2017; Richardson et al., 2020	Mostly Novel Insight
Discomfort (c.f., irritation in Study 1) and being distracted by what one needs to do later (c.f., boredom in Study 1) may be two of the biggest barriers to nature connectedness.		Very Novel
Dis-engagement and non-engagement might represent two distinct problem areas. Reducing avoidance of nature <i>and</i> also reducing distracted engagement with nature are likely both important.		Very Novel
Stewardship engagement and social engagement might be two distinct pathways worth investigating further.		Very Novel

human–nature relationship (Richardson, Hamlin, Elliott, & White, 2022).

In contrast to expectations and the literature (e.g., Richardson, Hamlin, Elliott, & White, 2022), the utilitarian pathway (resource use, personal benefit, and gathering) appeared to have a non-negative influence in the network; however, the degree of its positive influence was rather limited. The dominionistic pathway (altering, controlling, and, separately, confining) had a more ambiguous and fragmented influence: Altering and controlling had a weak negative influence, and confining had a comparatively stronger positive influence. The latter, in particular, seems to suggest that confining might be tapping a qualitatively different form of engagement than altering and controlling. It is possible that the former represents engaging with nature from a more benevolent motivation (e.g., what gardening is to our relationship with nature as looking out for our children is to our relationship with them) whereas the latter two represent engaging with nature in a more malignant manner (e.g., what excessive lawn care is to engage with nature as nit-picking children's appearance is to our relationship with them).

### 8.2.2. Central members

The three most central components of the network were meaning-making through nature, having strong feelings about nature, and watching nature, respectively. In other words, more so than other parts of the network, when people made meaning through, had emotional experiences with, or watched nature, the greatest number of other *important* positive activities—and the fewest number of negative activities—were likely to be present.

Just like the positively central emotions, whether meaning-making,

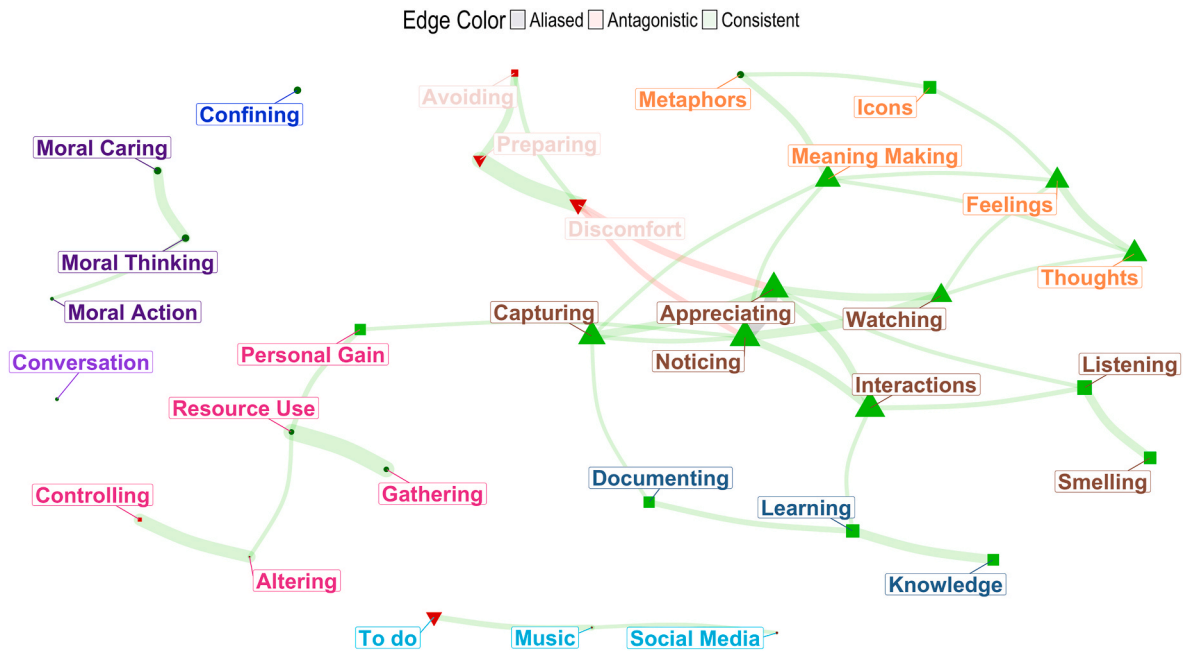
strong feelings, and watching are central because they radiate or are points of convergence is unclear. It could be that through the process of meaning-making, for example, individuals are forced to engage in other important activities (e.g., forced to have deep thoughts, forced to acknowledge feelings, etc.). Or, it could be that when people engage in other important activities, it results in a sense of meaning through nature. Yet, just as before, whichever case it turns out to be does not negate the fact that meaning, strong feelings, and watching nature are all hubs in the network and likely deserve further/continued attention.

The three most negatively central features were the three members of the negativistic pathway. These items were all largely connected to themselves *and* discomfort and had a strikingly antagonistic association with appreciating and noticing nature's beauty, both of which were among the network's three most positively influential members. In other words, not only is it the case that when one negativistic activity is present, the rest are present as well, but that the presence of one likely prevents the presence of other, more positive, members. Overall, this pattern suggests that the negativistic pathway to nature might be an active barrier to more positive pathways. This is also largely consistent with one of the major conclusions from the emotion network: aversion (whether it be aversive emotions or negativistic activities) has an influence on nature connectedness.

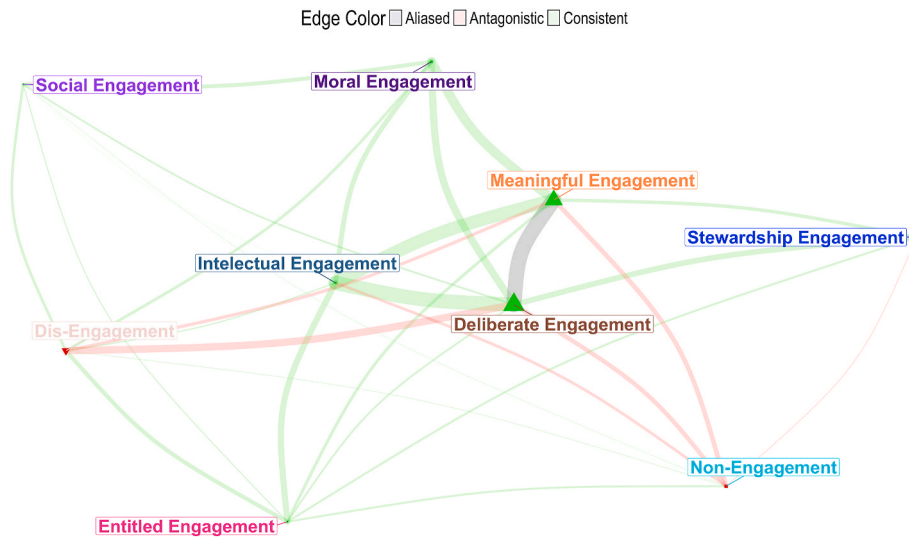
### 8.2.3. Clusters

Several distinct clusters emerged in this network, which appeared to be structured as a well-connected network converging on a central hub with only two fully-disconnected arms. What is most interesting about these clusters is that, on the whole, they reflect the pathways from the





**Fig. 7.** The detailed nature-connectedness emotion network.  
 Note. The following information explains how to interpret the network visualization. **Nodes:** Larger nodes are implied to be more influential (based on presence); Green nodes had a positive influence on nature connection; Red nodes had a negative influence on nature connection. The top third, middle third, and bottom third of the positive and negative nodes are indicated with a triangle, square, or circle, respectively. **Edges:** Thicker bands indicate a strong relationship between two nodes after accounting for all the other nodes (i.e., the unique association) except for potential aliases; No bands indicate no relationship ( $|r_{\text{pseudo-partial}}| < .10$ ) after controlling for the association between other nodes; Green bands indicate a positive association between two nodes; Red bands indicate a negative relationship between two nodes; Grey bands indicate that two nodes shared 50% of their variance or more and might be aliased. **Label color:** The color of labels was determined by the cluster assignment derived from the network community structure, indicating clusters of pathways.



**Fig. 8.** The simplified nature-connectedness emotion network.  
 Note. The only differences in interpretation of this simplified graph versus the detailed graph are (a) that larger nodes are implied to be more influential after controlling for the influence of other clusters (this is based upon the standardized within-subjects effect from a multi-level model) (b) no bands indicate no relationship at all (i.e., there was no thresholding for these networks), and (c) label color is determined by the cluster assignment used in the detailed network.

framework. However, several of them are blended.  
 The most seemingly influential cluster was a “deliberate engagement” pathway, which was comprised of a combination of all three

members of the aesthetic pathway, all three members of the sensory pathway, and a lone member of the emotive pathway (meaningful interactions with nature), corroborating recent work highlighting the

importance of deliberate engagement (Lengieza, Aviste, & Richardson, 2023; Sheffield, Butler, & Richardson, 2022).<sup>3</sup> This cluster was the cluster upon which the rest of the pathways seemed to converge. The next most clearly influential cluster was a “meaningful Engagement” pathway, which was comprised of a combination of the symbolic pathway (meaning-making, thinking about natural icons, using natural metaphors) and the remaining emotive pathway (i.e., deep thoughts and feelings). This arm was singularly connected to the “deliberate engagement” cluster. The final blended cluster was an “entitled engagement” pathway, which was comprised of all three members of the utilitarian pathway and two of the members of the dominionistic pathway (altering and controlling nature). This cluster was only connected to the “deliberate engagement” cluster. There were also distinct arms for the scientific pathway (dubbed “intellectual engagement” for label consistency) and the negativistic pathway (dubbed “dis-engagement”), which, again, both only connected to the deliberate engagement cluster.

Finally, two “floating” arms were not connected to the rest of the network, along with two “floating” nodes. One arm was the moral pathway (“moral engagement”), which was comprised of all three members of the moral pathway outlined in the original pathways work. The other arm was a “non-engagement” cluster (to do, music, and social media). Both confining nature and conversation were not connected to any other nodes in the network. This could be a random artefact in the data, or it could be because they inadvertently tapped two additional ways of engaging with nature not captured by the original pathways. To highlight this possibility, we have labelled them “stewardship engagement” and “social engagement”. The reason for the former label is that confining nature, which was meant to tap the same underlying pathway as altering and controlling, was both unrelated to the other dominionistic nodes and had the opposite effect (i.e., a positive one). The most readily available explanation is that this item inadvertently tapped the type of activity one might find in the context of gardening (e.g., weeding). This, of course, is a tentative possibility and should be investigated in future research with more carefully pointed items. Yet, if a stewardship pathway emerges as an additional pathway that is distinct from dominion in future confirmatory work, it would suggest researchers and practitioners might need to make careful distinctions between activities that appear, on the surface, to entail controlling nature.

**Aggregate Network.** This study’s clustering and subsequent network analyses proved especially fruitful (the simplified aggregate network is shown in Fig. 8). Their most notable implication follows from three observations. First, above and beyond the other aggregated clusters in the network, deliberate engagement and meaningful engagement each had a strong positive influence on the network. This is consistent with a great deal of work suggesting that deliberate engagement, for example, actively noticing nature, is important for nature connection (e.g., Passmore & Holder, 2017; Richardson, Hamlin, Butler, Thomas, & Hunt, 2022; Richardson & Sheffield, 2017), and the large body of work linking meaningful engagement and nature connectedness—especially vis-à-vis meaning and purpose or eudaimonia—(e.g., Ives et al., 2017; Lengieza, 2024; Lengieza et al., 2021; Pritchard et al., 2020; Richardson et al., 2020). It also re-affirms the importance of promoting more-than-just-contact (Lengieza et al., 2023). It is also noteworthy that the analyses revealed that both forms of impactful engagement were potentially aliased. However, despite this aliasing—and thanks to the twinned approach—the network revealed (a) that both nodes have a unique influence on nature connectedness when controlling for the other and (b) that dis-engagement has a more antagonistic association

with deliberate engagement than with meaningful engagement.

Second, dis-engagement and non-engagement both negatively influenced the network, with active dis-engagement potentially being more problematic than non-engagement. This highlights that repairing the growing disconnection between people and nature likely necessitates efforts to increase basic levels of engagement with nature, as can be found in recent policy (Lengieza et al., 2023). Interestingly, the two problematic forms of engagement were not associated with each other—suggesting that they represent two *distinct* problem areas. This pattern seems to be somewhat consistent with the findings in the emotion network. Namely, while boredom ultimately fell into the same cluster as the other negative emotions, it only had a strong tie with irritation—and no ties with fear or anxiety. In other words, both networks loosely imply a distinction between avoidance and aversion and this more disinterested and bored engagement. This finding is quite intriguing. In particular, it would imply that it is *not* simply a case of people who do not like nature (dis-engagement) are also the ones who do not take an interest in it (non-engagement). Instead, it seems that the experience of not liking nature is one problematic experience and finding nature uninteresting is another problematic experience. Again, if we recognize the parallel between nature connectedness and interpersonal relationship closeness (see Lengieza et al., 2023), this makes some sense. There is, indeed, a distinction between active dislike for another person and the mere lack of interest in them. Both, however, would logically seem to influence how close of a relationship we will form with them. While intuitive, this would suggest that future research could benefit from deliberately and separately considering what things lead to experiencing nature as aversive and what things lead to experiencing nature as boring and uninteresting.

Third, both types of problematic engagement had antagonistic associations with the two most important forms of positive engagement. Suggesting that even when people are spending time around nature, if they are non-engaged (e.g., distracted or not paying attention to nature) or dis-engaged (e.g., avoiding nature or uncomfortable in nature), they will not only be unlikely to engage in the actual important activities needed to connect to nature but will also actively feel less connected to nature. Together, these three insights lead to a similar conclusion as past conceptual work (Lengieza et al., 2023): increasing basic engagement with nature is *necessary* but not *sufficient* to promote nature connectedness—promoting active and meaningful engagement is necessary as well.

Intellectual engagement (reflecting the scientific pathway) had only a small influence on nature connectedness—which shows yet another consistency with extant work (Lumber et al., 2017)—but did show strong positive ties with active and meaningful engagement. In contrast, moral engagement has a similarly small influence on nature connectedness but has comparatively weaker ties to the two keystone forms of engagement. Similarly, neither stewardship engagement nor social engagement had a noticeable effect on this aggregate network. However, this non-effect may be owed to an unfair comparison. Both of these rogue forms of engagement in the network ended up with only a single item, as their measurement was not intended a-priori, whereas the other forms of engagement had multiple items. If stewardship and social engagement do represent distinct forms of engagement—something future research should investigate—it would mean that they may not have been adequately captured in the present data. Thus, it seems unwise to draw conclusions based on an analysis pitting a single-item indicator against several multi-item indicators without further research.

Lastly, the cluster analyses also provide general support for the pathways framework, with several of the pathways forming largely distinct clusters. However, it also suggests that there may be some room to re-organize the pathways as several of the clusters seemed to reflect a blend of more than one pathway. This suggests that future research may wish to consider extending or refining the original framework.

<sup>3</sup> By deliberate, we mean engaging with nature in a way that inherently entails noticing or perceiving it (as opposed to passively spending time in nature without nature being a focal part of the experience—e.g., consciously noticing nature while on your way to work vs. merely exercising in nature because that is where the best running trail is).

## 9. Discussion

There is growing global recognition of the need to renew the human relationship with the rest of nature, a complex relationship that includes individual, organisational, and societal values, behaviours, and interactions (see Lengieza et al., 2023). The literature on nature connectedness has managed to capture and conceptualise the individual relationship with nature, and subsequently identify many notable antecedents of nature connectedness (see Lengieza & Swim, 2021b), including important emotions (e.g., Jacobs & McConnell, 2022) and distinct pathways to nature connectedness (Lumber et al., 2017). While these insights, especially those generated from the pathways framework, have helped with successful intervention design and systems approaches considered at the societal scale (e.g., Richardson et al., 2020), as with any body of literature, it does not capture the complete picture. Critically, there is a need to consider the interplay between these antecedents of nature connectedness and bring new analytical methods to explore the human–nature relationship in our efforts to address the environmental crises. Importantly, the results here show that the situation network approach can do just this by generating useful exploratory insights that account for the network of influences more holistically.

First and foremost, the network approach was shown to validate findings from previous research (see Tables 6 and 7). That is, the results here were consistent with many key findings already established in the field, as was the hope by selecting an already well-studied topic such as nature connectedness. This would suggest that had this approach come before the extant literature had been solidified, it would have provided many essential exploratory insights. Second, despite the well-established nature of the topics studied here, the network approach also demonstrated the potential to produce new insights and directions for both research and practice. This further reinforces the generativity of this approach as an exploratory method, suggesting that it would even be useful to apply to established topic areas.

## 10. Summary of key insights

### 10.1. Emotions

The validated insights corroborate the key role of emotions in the human–nature relationship. The results corroborate the importance of positive emotions such as awe and joy (see Lengieza & Swim, 2021b), but also the problematic role of negative emotions such as disgust and boredom (c.f. Beery et al., 2023). Although emotions are central to nature connectedness, they feature little in policy, yet clearly, for some experiences, disgust, boredom, and irritation seem to get in the way of nature connectedness. Therefore, there is likely a need to allay these negative emotions before positive emotions can be built. This suggests nuanced approaches to policy and practice around access and nature engagement programmes, but also education, upbringing, and culture that are likely to play a role in creating and overcoming negativity—nature may rarely be boring for the lifelong birder and rarely disgusting to the person who grew up catching frogs.

While discussing positive and negative emotions, the relatively small role of feelings of sadness, guilt, and fear should be noted. Although many non-connective experiences may contain disgust, irritation, and boredom, fear does not feature strongly, suggesting that fear of nature is (a) not a large barrier to nature connectedness and (b) distinct from other aversive emotions. Moreover, as interest in ecoanxiety increases, it is interesting that sadness and guilt seem to have little to do with connection to nature, although this may reflect the lack of awareness of the decline of biodiversity and the depleted state of the natural world. Additionally, given the notably antagonistic association between anxiety and contentment emotions in the network, it is still possible that high enough levels of anxiety could preclude important positive emotional experiences.

A key novel insight is how the nature-relevant emotions were found

to cluster into drive, contentment, and threat suggesting a possible link between nature connectedness, emotion regulation, and physiological responses to nature. Critically, these three emotion clusters map strongly onto the three-circle model, which connects the function of our nervous system onto the emotion regulation system (Gilbert, 2005, 2014). In brief, the model suggests that threat emotions (i.e., emotions that initiate our fight-or-flight response and result in greater inhibitory processes; e.g., anxiety) activate our sympathetic nervous system; contentment emotions (i.e., emotions that signal safety and result in affiliative motivations; e.g., calmness) activate our parasympathetic nervous system; and drive emotions (i.e., emotions that result in strong approach motivations to seek out rewards; e.g., joy) activates our sympathetic nervous system and our dopaminergic system (Gilbert, 2014).

Conceptual work has shown that this model might explain how nature helps play a role in affect regulation and well-being (Richardson, 2019b). Re-analysis of nature exposure research (Richardson et al., 2016) showed that changes in physiological measures as a result of nature exposure were consistent with the three-circle model (Richardson, 2019). That is, nature exposure known to be relaxing, such as forest bathing, resulted in greater contentment physiological responses and lower threat responses for most individuals (Richardson, 2019). Accordingly, the fact the emotions in nature connectedness experiences clustered in a way that mirrors this model of emotion regulation, suggests a novel point of convergence between nature-connectedness, emotion regulation in nature, and physiological responses to nature. While this is somewhat speculative, it is corroborated by other research showing that affect regulation mediates the relationship between nature connectedness and well-being (Richardson & McEwan, 2018) and that both nature exposure and connectedness increase adaptive emotion regulation, decrease emotion regulation difficulties and thereby improve psychological well-being and reducing stress perception (Vitale & Bonaiuto, 2024). Further, recent research has found that nature connectedness mediated the link between nature contact and emotional regulation strategies (Gu et al., 2023).

Also novel was the role of nostalgia. Many nature connectedness interventions focus on mindfulness, an approach centered on being ‘in the moment’ (Barragan-Jason et al., 2022). There is far less work that considers time and looking back. Such ‘beyond the moment’ narratives and traditions—such as those more that feature more prominently in the more harmonious Indigenous relationships with nature—are likely to have a role in negating emotions such as disgust and boredom and generating positive emotions, together with interest, curiosity, and hope from reflecting on the bigger picture. At the very least, the evident role of nostalgia here may give reason to broaden our scope beyond in-the-moment and mindfulness-based interventions to consider narrative and remembering-the-past based interventions.

Finally, the importance and particularly the centrality of inspiration and love suggest that research may want to turn a careful eye toward both of these emotions as a means of connecting individuals to nature. These emotions were both highlighted specifically because of their connections to many other influential emotions. While, as noted above, it is difficult to know the causal direction of this relationship, the centrality of these emotions suggests that they may be particularly interesting emotions for future research.

Inspiration, in particular, seems to have potential as a key emotion for nature connection. In B&BT, it is considered to be uniquely associated with a motivation for growth (Fredrickson, 2013), which, itself, has been associated with nature connectedness (Lengieza, 2024). Furthermore, inspiration has unique ties with self-transcendence (Dai & Jiang, 2024), of which nature connectedness is one form (Lengieza et al., 2021; Lengieza & Swim, 2021b). Thus, there is tentative evidence to support the association between inspiration and nature connectedness. Thus, inspiration might be worth considering as the target for nature connection interventions, especially since it is believed to be elicited by a wide range of antecedents (Shiota et al., 2017) and might, therefore, be especially easy to evoke. For example, one could easily imagine an

intervention where individuals journal about one thing from nature that inspired them today.

Similarly, love might be an especially useful target for interventions. Love of nature is among the most frequently felt types of love (Rinne et al., 2023) and it shares some fundamental neural mechanisms as interpersonal love (Rinne et al., 2024). As noted in the introduction, nature connectedness is ultimately an extension of interpersonal relationship closeness to our relationship with nature (Schultz, 2002). This makes it rather intuitive that an emotion like love would impact nature connectedness. Moreover, like inspiration, the emotion literature gives us reason to believe love might be especially potent as an intervention. Namely, B&BT emphasizes love as being the result of experiencing any other positive emotion in the context of social relationships. Thus, having individuals reflect on 'Something they love about nature' is not only likely to be intuitively accessible to many but also quite likely to evoke any number of other positive emotions (all of which generally seem to promote nature connectedness, here, and in the literature; see Lengieza & Swim, 2021b) and to even potentially prime people with a receptivity to forming social connections.

## 10.2. Pathways

The pathways to nature connectedness (Lumber et al., 2017) network also provided many useful insights. First and foremost, it reaffirmed the importance of meaning, emotions, sensory contact, and noticing nature's beauty as important pathways. The analysis also suggested that the negativistic and scientific relationships are not helpful pathways to nature connectedness, the former being actively detrimental and the latter having little effect. While consistent with the original pathways work (Lumber et al., 2017) and recent meta-analyses (Barragan-Jason et al., 2022), the lack of effect for scientific engagement might seem counter to expectations, especially given the amount of research focusing on the impact of environmental education on nature connectedness (see Lengieza, Aviste, & Swim, 2023a). One possible reason that scientific engagement with nature might not be associated with nature connectedness is that it may focus too much on objective knowledge. For example, in interpersonal relationships, sharing of mundane information between potential relationship partners does not predict including relationship partners in one's sense of self whereas sharing more intimate self-revealing knowledge does (Slatcher, 2010; Sprecher, 2020). Thus, to the extent that nature connectedness follows a similar principle, it makes sense that a more objective way of engaging with nature might not be the best way to connect with it. However, while the network and the literature suggest scientific engagement with nature might not have the most influential direct impact on nature connectedness, the results do suggest that the scientific relationship could be a stepping stone towards a pathway through tapping into important forms of relationships such as emotion and meaning. Recent explorations around the emotional aspects of citizen science help confirm this notion (Pocock, Hamlin, Christelow, Passmore, & Richardson, 2023). Thus, to the extent that scientific engagement can be used as a vehicle for promoting meaning-making or strong emotions, for example, it may still have value as a means of promoting nature connectedness.

More novel findings suggest blending between the pathways to nature connectedness. The original research purposefully controlled and isolated the pathways to test them and provided accessible guidance. However, the results provide a reminder that, in reality, everything is related, and there is potential for research and practice to explore this further. For example, the aggregate network implies that the meaningful and deliberate engagement clusters might be aliased (although, they do have different associations with other clusters and unique influences on nature connectedness). Future research could consider whether a single 'deep engagement' umbrella pathway, for example, captures reality well enough to provide a more parsimonious framework for understanding the routes to nature connectedness than keeping separate the four underlying pathways captured by the meaningful and deliberate

engagement clusters (i.e., senses, beauty, emotions, and meaning).

A further novel finding important for practice is that the negativistic pathway may prevent positive pathways. So, as seen with negative emotions, there is a need to lessen feelings of irritation and discomfort—together with disgust and boredom—before embarking on building a more positive relationship. In essence, there may be value in identifying how to inoculate against these barriers to nature connectedness in addition to the vast majority of research tending to focus on the promoters of nature connectedness. Relatedly, perhaps the most cross-cutting finding between the two networks was that disinterest (boredom as an emotion, non-engagement as a pathway) was especially problematic in both networks. Given that little research has considered *disinterest* in nature (as opposed to aversion and avoidance) as important for nature connectedness, this finding is particularly novel, and also likely important. For example, it implies that there is a potential risk to forcing individuals to engage with nature against their natural inclinations, at least to the extent that an individual who would not voluntarily choose to engage with nature would find such an experience boring.

## 11. Evaluation of the network approach

Overall, the two applications of this situation network approach yielded promising results. First, the networks were able to correctly identify many of the key findings found in the extant literature, suggesting that, as a generatively exploratory approach, these analyses have value. In particular, it seems likely that this approach would similarly produce many important insights if it were to be applied to other content areas with less established bodies of literature. Second, the networks were also able to generate several new and exciting topics for future research, for example, further investigation into the role of boredom in the human–nature relationship or considering how scientific engagement with nature can be deliberately forged into a stepping-stone to the other parts of the network. Finally, by treating these situations as networks, we were able to operationalize influence in two ways: importance and centrality. The latter, in particular, revealed the possibility that emotions such as love or activities such as meaning-making might be important expressly because they are uniquely connected to many other nodes in the network.

### 11.1. Limitations

It is worth noting some of the primary limitations of this approach. First, although somewhat obvious, it should be emphasized that this is not a causal approach. As implied by the ambiguity around radiating centrality or converging centrality, the associations between nodes are not directional (there are ways to model directed networks, they would simply require causal data). Additionally, inferences around node importance—which was based upon presence or absence—cannot determine whether it was the presence of the emotions that made the experience connective or if it was the sense of connection created by the experience that elicited emotions. Fortunately, as this approach seems primarily useful as exploratory and generative, this simply means that potential causal associations should be seen as just that, potential causal associations.

Second, this approach, ultimately being data-driven, suffers the same issues as other data-driven approaches (e.g., exploratory factor analyses). This is especially true for the clustering. Like exploratory factor analysis, there is the risk that resulting clusters reflect nonsense categories that researchers then attempt to make sense of after the fact. This, of course, is best addressed using a combination of data-driven insights (i.e., what the data tells us), theory (i.e., what the literature tells us), and critical thinking (i.e., what common sense tells us).

Third, without p-values or other inferential statistics, it is considerably more ambiguous where to draw the line between influential and non-influential. In theory, one can easily incorporate some form of



inferential statistics into the approach (as we have done for the aggregated network). However, we would like to reiterate that our non-reliance on inferential statistics is purposeful as the hope is for this approach to serve as exploratory and generative. Still, generativity comes with the heightened potential for false positives, hence our repeated emphasis on following up insights generated here with confirmatory work. To address this issue, we feel it is generally wise to ensure that the potential network members not only include items that researchers feel should have a clear influence on the phenomena of interest but should also deliberately include items expected to have no effect (or can at least serve as valuable points of reference). For example, it was our intention that including items like ‘To do’ and ‘music’ would serve as good points of reference—granted, they ended up having more influence than we would have anticipated.

Fourth, while not exactly a limitation, it should be noted that the insights are only as good as the network members. If a large enough proportion of node items are not well thought out, it is likely that the resulting network will produce unreliable insights. This is especially true if two or more qualitatively different kinds of network members are included. For example, had we included both emotions and pathways in Study 1, it would have essentially been comparing apples and oranges and this could have, in theory, hindered the clustering’s ability to differentiate between the important subclasses (i.e., when looking at apples and oranges it is easy for the type-of-fruit distinction to overshadow the type-of-apple distinction).

## 12. Next steps

One of the most unique perspectives offered by taking this network approach is recognizing the potential importance of centrality. The idea of some phenomena being important *because* it is connected to many influential phenomena is not one that is readily captured by existing paradigms (e.g., regression and regression-esque approaches). When considering phenomena as a network, however, it becomes easier to recognize the importance of things like centrality. Yet, what this centrality implies in this context and whether it is meaningful is still unclear. In order to advance this approach, it will be necessary to determine how to make sense of centrality along with determining how it can be reconciled and studied with existing paradigms. For example, how can we determine whether inspiration is central because it radiates or because it is a point of convergence?

Additionally, the topics studied here are most applicable at the individual scale. However, for transformative change, there is a need to consider community and societal scales from a systems and cross-disciplinary perspective (Ives et al., 2017; Richardson et al., 2020), yet little research has endeavoured to do this. Fundamentally, network analysis recognises that behaviours take place within a system at various levels (Knoke & Kuklinski, 1991) and, therefore, can contribute to much-needed efforts to understand systems-level nature connectedness with a great deal of potential to generate novel and valuable insights. Future research interested in this approach should consider the ways it can adopt a systems-level perspective, potentially by studying community-level networks to help uncover influential elements of the system. For example, one could, in theory, use the methodology here cross-culturally to gauge whether the pathways networks for some cultures differ from others—perhaps in western cultures, the dominionistic pathway is a more frequent part of nature connection experiences than other cultures.

## 13. Conclusion

At a time when it is vital to address the looming environmental crises, including the deteriorating human–nature relationship, it is useful to have new research methodologies to further understand and suggest new approaches to policy and practice around these issues. Here, we have demonstrated the utility of the situation network. Its validity was

supported by its ability to corroborate existing research findings, such as the importance of key positive emotions (e.g., awe and joy) and key pathways to nature connectedness (e.g., meaning and beauty). Further, the generativity of the approach, even within a well-established body of literature, was supported by its ability to identify novel findings that should be of interest for both further research and practice. Thus, this research suggests that we may be able to catalyse new lines of research within environmental psychology if we begin to adopt a more holistic network perspective. Here, by adopting this more holistic network perspective, we have illuminated several key findings of interest for both further research and practice, which are needed to prevent stagnation in approaches to nature connection. Most notably, this approach has highlighted the need for policy and practice to move beyond limited notions of access to include active and meaningful engagement with nature, perhaps through targeting key emotions such as inspiration from or love for nature and combating irritation and boredom.

## CRedit authorship contribution statement

**Michael L. Lengieza:** Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Miles Richardson:** Writing – review & editing. **Rosemary Aviste:** Writing – review & editing, Conceptualization.

## Compliance of ethical standard & informed consent statement

This research was conducted with approval from institutional ethics boards, and informed consent was received from participants prior to their participation.

## Conflict of interest statement

The author has no conflicts of interest to report.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jenvp.2024.102491>.

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