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From roots to action: how adolescent nature exposure and adult eco-anxiety foster pro-environmental behavior

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Abstract
Scholars and international agencies have raised alarms about the irreversible destruction of natural habitats, emphasizing the urgent need for action to preserve healthy ecosystems. A promising approach to enhancing pro-environmental behavior and improving human well-being is fostering human-nature connectedness. However, the factors that mediate this relationship remain underexplored and mostly focused on industrialized countries. This study addresses this gap by examining three potential mediators of pro-environmental behavior in populations across various world regions: 1) adolescent exposure to nature, 2) perceived environmental landscape changes, and 3) eco-anxiety. We conducted an online survey involving 222 adults from Africa, Europe, the Americas, and Asia, focusing on nature connectedness, eco-anxiety, pro-environmental behavior dispositions, perceptions of landscape changes, and adolescent experiences with community volunteering. Our analysis revealed that adolescent exposure to nature, particularly through environmental activities and community service, is positively correlated with adult nature connectedness. Additionally, perceived landscape changes are linked to increased eco-anxiety. Multiple regression analysis verified that both nature connectedness and eco-anxiety predict pro-environmental behavior. Encouraging community and environmental volunteering from childhood can thus strengthen connections to nature and enhance resilience against eco-anxiety, ultimately fostering greater pro-environmental awareness and action.

Keywords Pro-environmental behavior · Eco-anxiety · Nature connectedness · Adolescent

Introduction

Nature contributes to physical and psychological dimensions of health, while also supporting identity, inspiration, and learning according to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2019). However, the ongoing environmental crises, particularly climate change, pose an increasing threat to ecosystems, biodiversity, and human livelihoods. The latest report from the Intergovernmental Panel on Climate Change (IPCC, 2023) underscores that climate change has accelerated in severity and impact, affecting not only ecosystems but also human health and well-being. The IPCC calls for urgent climate-resilient development strategies that integrate both adaptation and mitigation measures to achieve sustainable development goals.

In its 2023 report, the IPCC emphasized the need for concerted global action across governments, civil society, and the private sector. Climate change's irreversible impacts demand stronger interventions than previously assessed. However, despite growing awareness of the climate crisis, necessary behavioral changes at both individual and community levels have not kept pace with the urgency of the crisis (Molinario et al., 2020). This disconnect between awareness and action highlights the need to reevaluate current climate mitigation and adaptation strategies, which have largely focused on technological innovations and international policy regulations.

While technological solutions and policy interventions are important, there is growing recognition that sustainable environmental progress will require a deeper focus on individual and community behaviors. According to Beckage et

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al. (2022), the role of adaptive responses from individuals and communities must be emphasized as part of a broader mitigation and adaptation strategy. The biophilia hypothesis, first proposed by Wilson (1994), suggests that humans have an innate affinity for nature rooted in our evolutionary history. This theory suggests that fostering a connection to nature can motivate pro-environmental behaviors, although these behaviors are often mediated by social and cultural contexts (Kellert, 1993). Recent research has increasingly focused on understanding the conditions that drive individuals toward pro-environmental behavior (Jagers et al., 2016), with evidence pointing to the need for behavior-based interventions to complement technological and political efforts.

An increasing number of studies have demonstrated a positive relationship between a sense of connectedness to nature and pro-environmental behavior (PEB), with some research suggesting a causal link (Mackay & Schmitt, 2019; Martin et al., 2020; Otto & Pensini, 2017). However, the existing research predominantly examines these dynamics within Western societies, leaving significant gaps in understanding how nature connectedness and pro-environmental behavior manifest in different regions (Pong & Tam, 2023). Furthermore, little is known about how early life experiences, particularly during adolescence, influence eco-anxiety and pro-environmental behavior in adulthood (Coffey et al., 2021; Křepelková et al., 2020).

This cross-regional study sought to address these gaps by investigating whether adolescent engagement in community and environmental conservation activities influences adult nature connectedness and pro-environmental behavior. Additionally, the study examines how perceptions of landscape changes, often resulting from climate-related environmental degradation, contribute to eco-anxiety in adulthood. Understanding the relationship between perceived environmental changes and eco-anxiety could provide insight into the emotional drivers of pro-environmental behavior.

Pro-environmental behavior (PEB)

Pro-environmental behavior (PEB) encompasses a variety of actions aimed at minimizing harm to the environment and promoting sustainability, which is central to efforts addressing environmental degradation. Common examples of PEB include reducing energy consumption, using sustainable transport methods, recycling, conserving resources, and choosing eco-friendly products (Lange & Dewitte, 2019; Steg & Vlek, 2009). However, PEB is a multifaceted construct, influenced by personal values, beliefs, social norms, and individual circumstances (Stern et al., 1999). Similarly, geographic context significantly influences environmental perceptions and behavioral outcomes (Quintas-Soriano et al., 2018). For one, urban versus rural settings can lead to different motivations and practices related to PEB (Oludoye et al., 2024). Although rural dwellers often have limited access to information and resources (Severin, 2020), their stronger place attachment due to more direct interaction with the natural environment can be a powerful motivation towards pro-environmental choices (Alcock et al., 2020). In contrast, urban areas have more infrastructure, resources, and policies that support PEB (Qing et al., 2022).

While many individuals express pro-environmental attitudes, they often find themselves constrained by socio-economic factors. For instance, the cost of green technologies such as solar panels or electric vehicles may be prohibitive for some, or logistical options such as work-related travel may conflict with environmental concerns. Likewise, adopting a plant-based diet may not always be practical or affordable due to personal or cultural reasons. The Global North is generally seen to have more resources and infrastructure to support PEB. In contrast, the Global South often demonstrates more consistent environmental behaviors rooted in cultural and economic realities (Pisano & Lubell, 2017).

Understanding the drivers and barriers to pro-environmental behavior is crucial for crafting effective interventions that move beyond awareness-raising campaigns to address not only knowledge gaps but also the contextual and personal challenges that may prevent the individual from taking tangible, sustainable action.

Adolescent nature exposure and connectedness

Adolescence is a critical period for the development of identity, social relationships, and personal values, all of which can influence an individual's relationship with nature (Richardson et al., 2019). Numerous studies have highlighted the importance of early-life positive experiences with nature as fostering greater nature connectedness and a stronger pro-environmental orientation in adulthood (Matsuba & Pratt, 2013; Palmer & Suggate, 2004; Pensini et al., 2016).

Nature connectedness reflects the individual's belief about their relationship with the natural world, emotional attachment, and experiences within it (Barragan-Jason et al., 2022; Capaldi et al., 2014; Mayer & Frantz, 2004). Research indicates that nature connectedness is positively correlated with pro-environmental behaviors, but there is also evidence suggesting a decline in environmental concern and connection during adolescence (Krettenauer et al., 2020; Price et al., 2022; Van Heezik et al., 2021). This decline may be driven by developmental factors such as peer influence, self-esteem, and identity formation.

Despite growing efforts to integrate nature into education and promote outdoor activities among young people, such interventions have shown only modest effects on long-term pro-environmental behavior (Green et al., 2019; Otto

& Pensini, 2017; Roczen et al., 2014). Adolescents' sense of control over environmental issues, their social interactions, and hands-on experiences may play a role in mitigating the decline in nature connectedness observed during this life stage (Price et al., 2022). Communities that foster collaboration and collective action often see higher participation in environmental activities, therefore participation in community-based environment initiatives, particularly those involving peer interaction with a sense of agency, may help to strengthen nature connectedness and promote resilience, well-being, and pro-environmental behavior into adulthood (Smith et al., 2021; Whitburn et al., 2019).

Complementing previous research, the present study aims to ascertain whether adults who recall and report participation in community service and environmental conservation activities during adolescence report stronger nature connectedness into adulthood. This leads to the study's first hypothesis:

Hypothesis 1: There is a significant positive relationship between recalled adolescent experience of community and/or environmental conservation activities and nature connectedness in adulthood.

Landscape change perception and eco-anxiety

Nature connectedness is not only influenced by direct interaction with the natural world but also by perceptions of environmental changes. Place-based connections to nature, such as a sense of belonging and responsibility for a specific location, can evoke strong emotional responses when those places are degraded (Devine-Wright, 2013; Keaulana et al., 2021; Riechers et al., 2020). Detrimental landscape changes—whether caused by climate events like droughts, wildfires, or floods—can lead to emotional distress, particularly for individuals who have developed attachments to these environments (Evans, 2019).

Eco-anxiety, a growing area of research, refers to the chronic fear or worry about environmental collapse and its future implications (Pihkala, 2020). As the frequency and intensity of climate-related disasters increase, so too do levels of eco-anxiety, which can manifest as emotional distress and physical symptoms (Ágoston et al., 2022; Clayton & Karazsia, 2020). Exposure to media representations of environmental crises, coupled with personal experiences of landscape changes, is a significant driver of eco-anxiety (Ogunbode et al., 2023).

While eco-anxiety can be debilitating, it also has the potential to motivate pro-environmental behavior. The adaptive response to eco-anxiety—where an individual engages constructively with their fears—can lead to actions that improve both personal well-being and environmental outcomes (Verplanken et al., 2020; Whitmarsh et al., 2022). The present study seeks to explore how perceived landscape changes influence eco-anxiety in adulthood and whether this eco-anxiety is associated with increased pro-environmental behavior.

Hypothesis 2: A significant positive relationship exists between perceived landscape change and eco-anxiety.

Nature connectedness, eco-anxiety, and pro-environmental behavior

The third and final hypothesis of this study addresses the interaction between nature connectedness, eco-anxiety, and pro-environmental behavior. While there is a growing body of evidence linking nature connectedness to pro-environmental behavior (Capaldi et al., 2014; Nisbet et al., 2009; Whitburn et al., 2019), this relationship's strength, direction, and consistency vary. Hogg et al. (2024) present the relationship between eco-anxiety and PEB to be curvilinear, whereby high levels of eco-anxiety contribute to eco-paralysis. However, eco-anxiety can play a mediating role by heightening individuals'awareness of environmental threats and motivating adaptive behavior (Hogg et al., 2024). Low to moderate levels of anxiety, as a general emotional response, influence behavior by triggering future-oriented planning and risk avoidance (Barlow et al., 2018). In the context of eco-anxiety, this future orientation may lead to positive actions toward mitigating environmental risks to improve mental and physical well-being (Ogunbode et al., 2023). By examining the interplay between nature connectedness and eco-anxiety, this study aims to provide a more nuanced understanding of these emotional factors driving pro-environmental behavior.

Hypothesis 3: Greater pro-environmental behavior is predicted by greater nature connectedness and eco-anxiety.

Aims

In summary, this cross-regional study aims to address gaps in the literature investigating the role of nature connectedness and eco-anxiety in fostering pro-environmental behavior and whether adolescent experiences in environmental and community activities, expanded by the influence of perceived landscape changes, contribute to nature connectedness and eco-anxiety in adulthood.

Method

Design

This quantitative, correlational study measured pro-environmental behavior using Markle's (2013) scale, nature connectedness via Mayer and Frantz's (2004) scale, and eco-anxiety using Ágoston et al. (2022) questionnaire. Additionally, single-item measures assessed direct community (e.g., volunteering programs, visiting the elderly or sick in hospitals, fundraising events for the disadvantaged, etc.), and direct environmental (e.g., litter collection, tree planting, animal care, etc.) involvement, perceived landscape change, and nature exposure during adolescence and now (McEwan et al., 2019). The independent variables were nature connectedness and eco-anxiety, and the dependent variable was pro-environmental behavior. Demographic data on age, gender, and residence (both current and childhood) were collected, with particular interest in a wide geographical representation. Power analysis revealed that a sample size of 84 participants was required to achieve an effect size of 0.5, with a p-value of 0.05 and a statistical power of 0.8 (Faul et al., 2007).

Participants

To minimize potential geographic bias (urban–rural, Global North/South, collective/individual societies) identified in prior research (Boeve-de Pauw & Van Petegem, 2013), participants were recruited internationally through United World College alumni networks and social media platforms (Facebook, WhatsApp, Instagram). The survey, hosted online on Qualtrics, outlined the study's aims and objectives, participant rights, and consent requirements in an information sheet. Participants created unique IDs for anonymity and completed the survey in 10–15 min. Ethical approval was obtained from the University of Derby.

A total of 222 responses were collected, with 71 excluded due to incomplete data and one due to age (under 18). The final sample included 151 participants (33% male, 67% female), with an age range of 19–82 (M = 47, SD = 12.9). Participants were geographically diverse, 48% grew up in Africa, 38% in Europe, 5% in North America, 7% in South America, and 2% in Asia. Garden access was reported by 73%, and 75% of participants spent"a lot"of time outdoors during childhood, compared to 33% in the past year. Participant spread from childhood to current residence is depicted in Fig. 1.

Materials

The survey included demographic questions (age, gender, residence during childhood and now), measures of community/environmental involvement during adolescence and now, perceived landscape change, and nature exposure (McEwan et al., 2019). Three validated scales were used:

1) Connectedness to Nature Scale (CNS; Mayer & Frantz, 2004) – a 14-item scale with responses on a 5-point Likert scale. Internal consistency (Cronbach's $\alpha = 0.84$) was replicated in this study ($\alpha = 0.83$).
2) Eco-Anxiety Questionnaire (Ágoston et al., 2022) – a 22-item scale measuring distress and anxiety about climate change, with responses on a 4-point Likert scale. Internal consistency ($\alpha = 0.91$) was confirmed ($\alpha = 0.93$).
3) Pro-Environmental Behavior Scale (PEBS; Markle, 2013) – a 19-item, 4-dimensional scale assessing conservation, environmental citizenship, food consumption, and transportation. Internal consistency varied across dimensions, with α values in this study ranging from 0.46 to 0.79.

Data analysis plan

Data analysis was conducted using SPSS. Preliminary analyses were conducted to ensure the assumptions of normality, linearity, multicollinearity, and homoscedasticity were met. Correlation analyses were conducted on demographic variables, community service, nature exposure,

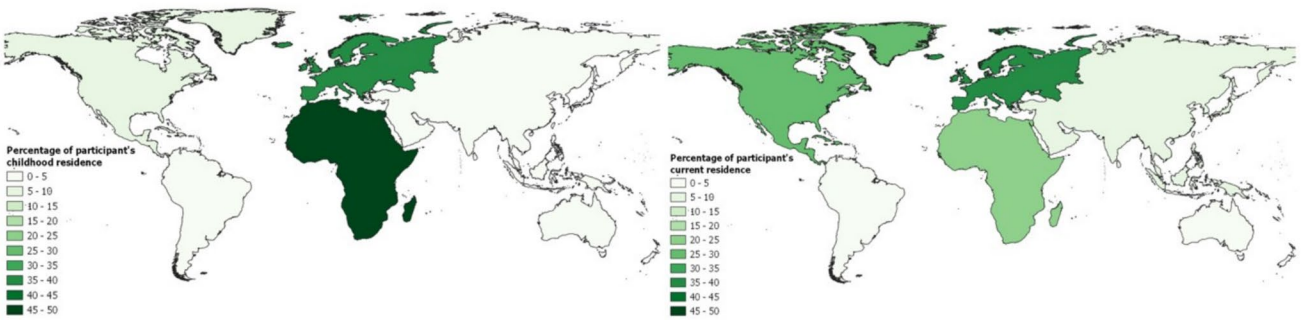

Fig. 1 Participants' childhood and current residence

Table 1 Descriptive statistics

Variable	*N*	Minimum	Maximum	Mean	Std. deviation	95% CI	
						LL	UL
Nature connection	151	30	70	53.87	8.50	0.06	0.41
Eco-anxiety	151	28	86	56.16	11.14	0.18	0.45
PEB	151	37	78	59.49	9.63		

CI confidence interval, *LL* lower limit, *UL* upper limit

Table 2 Pearson correlations for study variables

Variable	1	2	3	4	5	6	7	8	9
1. Nature connection	-	0.41**	0.36**	0.06	0.19*	0.25**	0.14	0.14	0.03
2. Eco-anxiety		-	0.45**	−0.00	0.09	0.37**	−0.02	0.06	−0.10
3. PEB			-	0.02	0.08	0.09	0.13	0.05	−0.13
4. Adolescent community service				-	0.59**	−0.00	0.00	0.01	−0.17*
5. Adolescent environmental conservation					-	−0.02	0.12	0.03	−0.11
6. Perceived landscape change						-	−0.12	0.13	−0.16
7. Time spent outdoors (Childhood)							-	0.23**	0.10
8. Time spent outdoors (Last Year)								-	0.31**
9. Garden access									-

*$p<0.05$, **$p<0.01$

conservation activities, nature connectedness, perceived landscape change, and eco-anxiety. These served as the basis for multiple regression analyses to examine the predictive value of nature connectedness and eco-anxiety on pro-environmental behavior.

The raw data is not publicly available to preserve individuals' privacy; anonymized data is available from the author on request.

Results

Descriptive statistics

The data followed a normal distribution, allowing for Pearson correlation analysis. Table 1 presents the descriptive statistics for key variables: nature connectedness, eco-anxiety, and pro-environmental behavior (PEB).

Correlation analysis

Pearson correlation analysis revealed significant relationships between PEB, eco-anxiety, nature connectedness, perceived landscape change, and time spent outdoors (Table 2).

- Hypothesis 1: There was a small but significant positive correlation between adolescent environmental conservation activities and nature connectedness in adulthood ($r=0.19$, $p<0.05$). Time spent outdoors during childhood and in the past year also showed a small but significant correlation with nature connectedness ($r=0.14$, $p<0.01$).
- Hypothesis 2: Perceived landscape change was significantly positively correlated with eco-anxiety ($r=0.37$, $p<0.01$).
- Hypothesis 3: PEB was positively correlated with both nature connectedness ($r=0.36$, $p<0.01$) and eco-anxiety ($r=0.45$, $p<0.01$).

No significant correlations were found between age, gender, and nature connectedness or eco-anxiety.

Regression analysis

A multiple regression analysis was conducted to predict PEB based on nature connectedness and eco-anxiety. The model explained 24% of the variance in PEB ($R^2=0.24$, $F(2,148)=22.80$, $p<0.001$). Eco-anxiety was the strongest predictor of PEB ($\beta=0.36$, $p<0.05$), accounting for 11% of the variance. Nature connectedness also significantly predicted PEB ($\beta=0.21$, $p<0.05$), contributing 4% of the variance. The moderate correlation between nature connectedness and eco-anxiety ($r=0.41$) indicated shared variance between these variables.

Supplementary analysis

Post-hoc analysis of extreme scores offered additional insights:

- The highest PEB scores were associated with frequent adolescent environmental conservation and community service activities, particularly among participants from Africa. In contrast, the lowest PEB scores were

observed in participants from the EU with little to no adolescent involvement.
- Participants with the highest eco-anxiety scores also reported perceiving human-induced environmental changes, while those with the lowest eco-anxiety perceived no significant changes.

Discussion

The results support all three hypotheses, showing that nature connectedness and eco-anxiety significantly predict pro-environmental behavior. Adolescent involvement in conservation and community service activities positively correlates with adult nature connectedness, while perceptions of landscape change increase eco-anxiety. Together, these findings highlight the importance of early environmental exposure and direct experiences in shaping pro-environmental behavior in adulthood.

Adolescent nature exposure and connectedness

Our study found a positive association between adolescent environmental conservation activities and nature connectedness in adulthood. This reinforces the idea that early experiences in environmental conservation, combined with time spent in nature, are crucial for fostering a lifelong connection to nature, as supported by previous literature (Bixler et al., 2002; Pensini et al., 2016).

The analysis revealed a positive association between childhood environmental conservation activities and nature connectedness. This finding is particularly relevant given prior research indicating that many adolescents exhibit lower levels of nature connectedness (Kahn & Kellert, 2002; Krettenauer et al., 2020; Price et al., 2022; Solano-Pinto et al., 2020). Factors contributing to this trend include adolescents'inclination towards sensation-seeking (Kaplan & Kaplan, 2002) and their developmental stage, characterized by a quest for identity and social interaction (Chawla, 2009). Adolescents often prefer urban environments that facilitate social interaction and recreational activities over natural spaces (Kaplan & Kaplan, 2002; Kahn & Kellert, 2002).

Thus, engaging in environmentally focused activities during adolescence can strengthen connections to nature and establish a foundation for pro-environmental behavior in adulthood. Our findings support the recommendations of Price et al. (2022) for interventions that integrate social interactions to enhance adolescents' sense of control over their environment, potentially mitigating the decline in nature connectedness. Community-based activities can also contribute positively to adolescents' emotional, social, and self-esteem development. Krettenauer et al. (2020) noted that communal contexts and moral expectations influence environmental attitudes, suggesting that nurturing a sense of responsibility toward the environment can drive pro-environmental intentions (Kaiser et al., 1999; Kaiser & Byrka, 2011). Social norms and status can further motivate behavior change, particularly during adolescence (Smith et al., 2021; Steg & Vlek, 2009; Uren et al., 2021).

Notably, our analysis revealed a strong correlation between adolescent community service and environmental conservation activities, underscoring the importance of community engagement in promoting pro-environmental interventions. The lack of significant associations with age or gender suggests that connections to nature can develop throughout life, emphasizing the potential for lifelong engagement (Solano-Pinto et al., 2020; Whitburn et al., 2020).

Landscape change perception and eco-anxiety

We found a significant relationship between nature connectedness and perceived landscape change, aligning with Riechers et al. (2020), who noted that landscape changes can negatively impact individuals' connections to nature. Place attachment—developed through direct interactions with environments—plays a role in how people respond to changes in those environments (Scannell & Gifford, 2010). Drawing on the positive correlation between perceived landscape change, eco-anxiety, and nature connectedness found in this study, we reinforce existing theories on place attachment being an important antecedent of PEB (Daryanto & Song, 2021; Zhang et al., 2023). Consistent with previous research, our results indicate that heightened eco-anxiety due to negative landscape changes could either motivate pro-environmental lifestyles or lead to avoidance behaviors (Gifford et al., 2011; Lutz et al., 2023; Hogg et al., 2024).

Nature connectedness and eco-anxiety as determinants of pro-environmental behavior

Our findings confirm that both nature connectedness and eco-anxiety are significant predictors of pro-environmental behavior. While these emotions can foster engagement and stewardship, they may also trigger feelings of helplessness and denial (Kurth & Pihkala, 2022; Nisbet et al., 2009). Greater direct contact with nature in childhood was shown in this study to result in greater contact and connectedness with nature in adulthood and subsequent PEB. Notably, eco-anxiety emerged as the strongest predictor of PEB, expanding previous research by including a heterogeneous mix of participants across the Global North and South, the latter often being underrepresented in research studies. Our

findings indicate that eco-anxiety, driven by perceived environmental threats, can lead to greater engagement, resulting in pro-environmental actions, as seen in previous literature (Kurth & Pihkala, 2022).

Implications and limitations

This study highlights the importance of adolescent experiences with nature in shaping lifelong connections to the environment and influencing eco-anxiety. Encouraging outdoor activities and community engagement during childhood can counteract declines in nature connectedness and enhance environmental awareness.

There are clear limitations in this study, the first being that self-reported behaviors can be subject to recall bias, as individuals may be inconsistent in their behavioral responses and may also be subject to social desirability bias (Kurth & Pihkala, 2022). Moreover, the responses gathered are reflections of a person's attitude and intention towards environmental protection without reliable impact measures (Arnold et al., 2018; Stern, 2000), and as such, can merely infer a general propensity to engage in PEB. Additionally, this research is correlational, subject to the uncertainty of the validity in memory and accuracy of retrospective self-reports and lacking causal assertions regarding behavior impact (Arnold et al., 2018; Stern, 2000).

Future research should incorporate field studies to observe actual behaviors and outcomes, possibly employing performance-based assessments like the Pro-Environmental Behavior Task (Lange & Dewitte, 2021) to capture tangible PEB patterns. Longitudinal studies may also reveal critical periods for nature connection and provide insights into individual differences in eco-anxiety levels (Lutz et al., 2023).

Environmental behaviors are influenced by numerous factors, including education, income, social status, and cultural context (Steg & Vlek, 2009) or superimposed issues like the debate on climate change as a political or moral issue (Caillaud et al., 2019). Such confounding variables could not be included within the scope of this study but may be central in future research, to further our understanding of ecological attitudes and behaviors.

Conclusion

Our study demonstrates that nature connectedness, cultivated through adolescent exposure to natural environments and childhood conservation activities, along with eco-anxiety related to perceived landscape changes, are key predictors of pro-environmental behavior. As global sustainability challenges intensify, individuals need to embrace ecologically sustainable behaviors.

These findings deepen our understanding of the dynamics of individual-level pro-environmental behavior, highlighting that both a deeper sense of nature connectedness and heightened eco-anxiety are positively linked to environmental action. Moreover, the results underscore the importance of fostering early engagement with nature and community-based activities to alleviate eco-anxiety and bolster environmental stewardship.

To address the complex interconnections between human behavior and ecological challenges ongoing research into the cognitive, motivational, and structural processes that either facilitate or hinder sustainability efforts is essential (Steg & Vlek, 2009). Encouraging individuals and communities to adapt to eco-anxiety while nurturing their bond with the natural world is crucial for achieving environmental goals.

Author contributions Sylvia Kratz- conceptualization; data curation; formal analysis; methodology; validation; and first writing & editing. Kirsten McEwan- conceptualization; supervision; review & editing.

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Declarations

Ethical approval Ethics approval was obtained from the University of Derby Research Ethics Committee; College of Health, Psychology and Social Care, ETH2223-2642.

Competing interest The authors have no competing interests to declare.

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