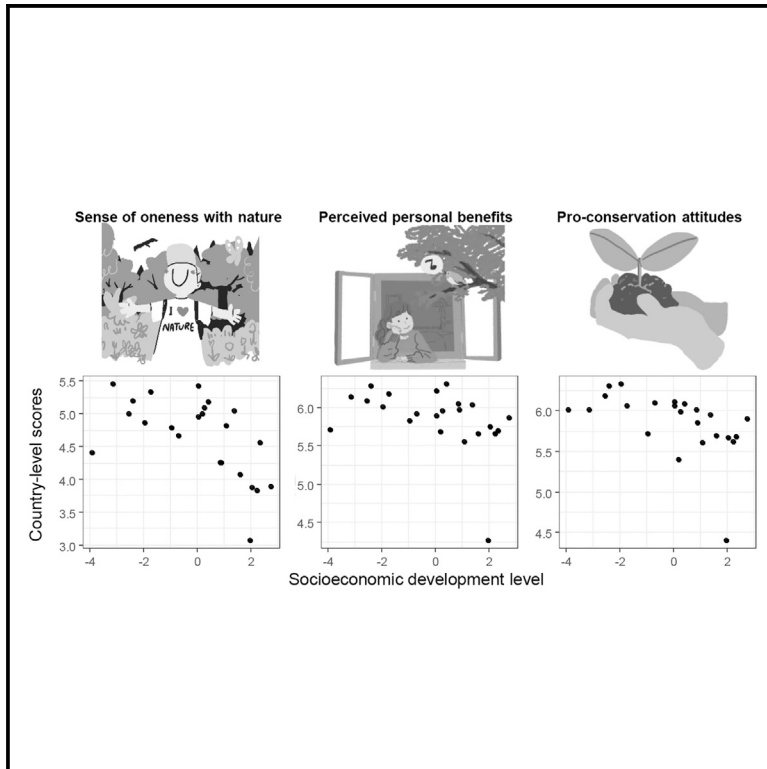


Cross-country variation in people's connection to nature

Graphical abstract



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In brief

By surveying over 22,000 young adults across 23 countries, we found substantial variations in individuals' psychological and physical connections to nature. These differences were explained by country-scale factors such as socioeconomic conditions, cropped land cover, and biodiversity levels. Our findings emphasize the importance of considering country-specific contexts when evaluating people's connection to nature and devising effective enhancement strategies.

Highlights

- We assessed people's connection to nature across 23 countries worldwide
- The strength of connection to nature varies substantially among these countries
- This variation is explained by several country-level factors
- Individual-level factors also play a key role in explaining connection to nature

Article

Cross-country variation in people's connection to nature

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SCIENCE FOR SOCIETY The connection people have with nature is crucial for both human health and environmental sustainability. The strength of this connection is known to be influenced by personal factors, but it can also be shaped by broader country-level factors, as these influence cultural norms, values, and opportunities for interacting with nature. Nevertheless, the significance of country-level factors remains poorly understood due to the scarcity of studies employing a cross-country approach, especially outside the Global North. In this study, we reveal substantial variation in people's connections to nature across countries. This variation is influenced by several country-level factors (socioeconomic development level, biodiversity level, and land use), although individual-level factors (such as education level and social status) still play a key role. Our findings highlight the diversity of people's relationships with nature across societies.

SUMMARY

Enhancing pro-nature behavior across societies is a key sustainability challenge, with people's connection to nature recognized as a primary driver. Understanding how this connection varies across countries and regions and the factors influencing it is, therefore, a crucial step in addressing this challenge. However, this remains poorly understood due to the scarcity of cross-country studies, particularly outside the Global North. Using data from a survey spanning 23 countries worldwide, we identified substantial variations in individuals' psychological (cognitive) and physical (experiential) connections to nature. These differences are influenced by several country-level factors, such as socioeconomic development and the extent of cultivated land, alongside individual-level factors like education level and social status. The broad variation in connection to nature revealed by our study provides valuable insights for predicting large-scale spatial patterns of this connection and identifying regions where targeted efforts are most needed to strengthen it effectively.

INTRODUCTION

The physical and psychological connections people have with nature are crucial for both human well-being and environmental health.^{1–4} From a human well-being perspective, direct interactions with nature have positive impacts on a diverse range of health outcomes, and these benefits are increasingly recognized in public health initiatives and urban greening strategies.^{5–7} An individual's emotional connection to nature is also known to be closely linked to their subjective well-being.^{8,9} From an environmental perspective, fostering such connections also enhances environmental protection efforts.^{10,11} Individuals with knowledge, interest, and active engagement in nature are more likely to support pro-environmental policies and management actions.^{12–14} Consequently, it is increasingly acknowledged that

addressing the ongoing disconnection between humanity and the rest of the natural world is essential for establishing a sustainable and harmonious relationship between the two.^{1–4,11}

With growing recognition of the dual benefits of a connection to nature for both human and environmental health outcomes,^{1–4} it has become increasingly important to understand what shapes the strength of individuals' physical and psychological connections to nature. Research has demonstrated that this strength varies greatly among individuals within specific regions, with a range of environmental and socioeconomic factors identified as key determinants.^{2,15–18} For example, individuals with higher social status, higher educational levels, and greater access to green spaces tend to exhibit a stronger sense of oneness with nature and more frequent direct nature experiences in natural settings.^{2,15–17}

While research has predominantly focused on individual-level factors in explaining connection to nature, it can also be strongly influenced by broader societal influences, such as country-level factors. Indeed, recent studies suggest that individuals' perceptions and attitudes toward nature are linked to the socioeconomic and environmental circumstances of the countries where they live, including levels of urbanization and economic development.^{19–22} Despite this, there is surprisingly limited insight into how connection to nature differs across countries and what factors contribute to this large-scale variation. Previous research has primarily focused on samples from specific regions and countries,²⁰ especially from the Global North, lacking a systematic analysis that includes a diverse range of countries. Although some studies have attempted to address this gap, they have been limited by small sample sizes, restricted country coverage, or a narrow focus on specific aspects of connection to nature (e.g., nature relatedness).^{19–22} Consequently, a key question remains: is an individual's connection to nature primarily shaped by individual-level factors or broader country-level influences, and which of these is more important?

Understanding the extent and drivers of cross-country variation in individuals' connection to nature is crucial for two main reasons. First, it can inform the development of targeted strategies aimed at enhancing connections to nature, tailored to the unique circumstances of various regions. As awareness of the need to transform human behavior toward nature grows,^{23,24} many major environmental policies and strategies increasingly emphasize the importance of deepening people's understanding of, and engagement with, nature and promoting pro-conservation attitudes and behavior. For example, fostering public awareness, encouraging direct experiences of nature, and promoting pro-nature actions make up one of the five key strategic programs of Japan's National Biodiversity Strategy, established in 2023.²⁵ Likewise, the UK's Environmental Improvement Plan 2023 includes goals of halting nature loss and actively recovering nature, improving access to nature, and using natural resources more sustainably.²⁶ Second, this understanding likely improves the ability to predict how people's connection to nature can shift in response to nation-scale environmental, socioeconomic, and cultural changes, such as economic growth and urbanization. Predicting these shifts can help guide proactive strategies and actions to mitigate potential negative consequences associated with reduced connections to nature.

Here, we examine the variation in multiple dimensions of individuals' connections to nature across countries with diverse environmental, socioeconomic, and cultural contexts. Using a questionnaire survey of 22,773 participants aged 20–30 years across 23 nations (Table S2), we collected data on connection to nature,^{10,27,28} along with sociodemographic and personal details. Given the multifaceted character of connection to nature and the variation in its use across fields,¹⁰ we adopted the definition proposed by Ives et al.¹⁰ and incorporated a broad range of psychological and physical dimensions of connection to nature at the individual level (see Table S1 and the next section); some of our measures extend beyond those typically used in psychological studies.²⁹ Based on our analysis, we demonstrate substantial cross-country variation in individuals' connection to nature, explained by several country-level factors. These findings highlight the importance of incorporating broad-scale envi-

ronmental, socioeconomic, and cultural variables when assessing and predicting connection to nature on a global scale.

RESULTS AND DISCUSSION

Variation in people's connection to nature across countries

To assess individuals' psychological (cognitive) and physical (experiential) connection to nature, we used seven measures: five items for psychological connection ("sense of oneness with nature," "perceived personal benefits," "perceived societal benefits," "concern for nature," and "pro-conservation attitudes") and two items for physical connection ("recent nature experiences" and "childhood nature experiences") (see Table S1 for the list of measures used). These measures were assessed on a 5- or 7-point Likert scale, with higher scores indicating stronger connections.

Across the 23 study countries, substantial variations were observed in people's connection to nature, particularly notable in their sense of oneness with nature and the two measures of nature experience (see Figures 1, 2, and S1). The sense of oneness with nature was highest in Egypt, India, the Philippines, and Turkey, with over 70% of participants from these countries reporting a relatively high level (i.e., scoring higher than 5 on the Inclusion of Nature in Self scale³⁰; see Figure 2A). Conversely, this percentage dropped below 40% in Australia, Germany, Japan, the UK, and the US (Figure 2A). Similarly, we observed the highest frequency of both recent and childhood direct experiences of nature in Germany, Russia, and Turkey, with over 70% reporting occurrences more than "weekly" (Figure 1). In contrast, this figure fell below 40% in Ghana and Japan (Figure 1). While the cross-country variation in the four other psychological connection measures was less pronounced compared to other connection measures, some variation still existed, with Japan exhibiting the lowest values across all four measures (Figures 2B–2E).

The seven measures of connection to nature we focused on showed positive associations with each other (Figure 3). The interconnectedness among these variables is not surprising, given that some connection measures likely act as both causes and consequences of others. For example, the sense of oneness with nature is recognized as both a driver and a consequence of direct experiences with nature.² Similarly, experiences with nature are known to enhance people's pro-conservation attitudes and behavior.^{11,14} However, while there were positive correlations between the seven measures of connection to nature overall, these values were not high (Figure 3). This highlights the multifaceted and complex nature of human connection to nature, emphasizing the importance of considering multiple aspects to understand that connection.¹⁰

In the survey, we specifically focused on individuals aged 20–30 years old rather than a representative sample of each country's entire population. This targeted approach offers both limitations and benefits. One significant limitation is that the data may not accurately represent the overall average population-wide level of connection to nature in each country. Different age groups tend to have varying values and degrees of connection to nature. For example, people in their 20s tend to report lower levels of oneness with nature^{31,32} and show less concern for

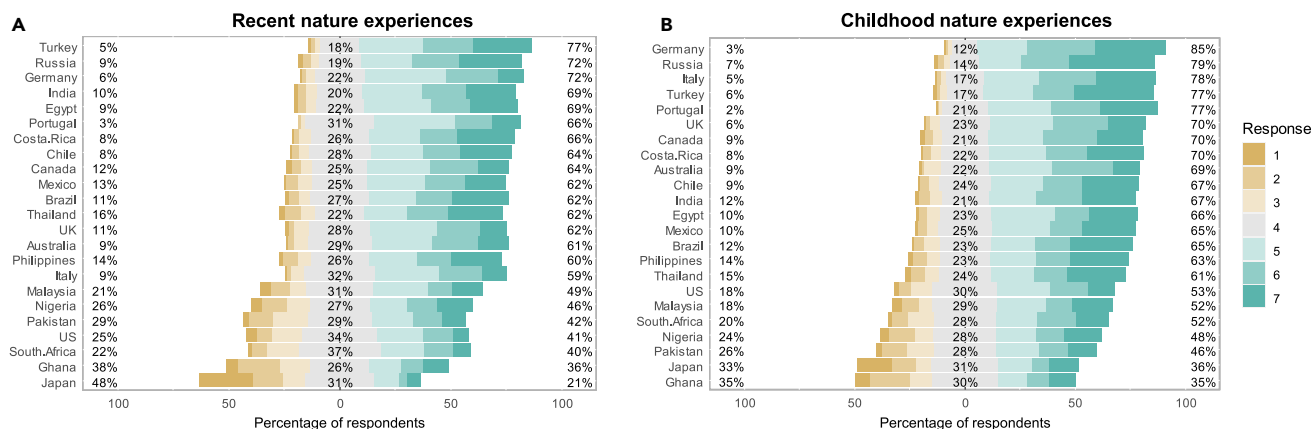


Figure 1. Likert plots for two measures of physical connection to nature across 23 study countries

(A and B) (A) Recent nature experiences and (B) childhood nature experiences. The values shown in the left, middle, and right parts of each image represent the percentages of respondents reporting their engagement with nature at different frequencies: 1 (never) to 3 (once every few months), 4 (monthly), and 5 (weekly) to 7 (five or more times per week), respectively, for each country.

pro-environmental attitudes,³³ which might suggest that our findings underestimate the overall level of connection to nature. However, by standardizing the age of respondents across countries, we can more effectively assess the impact of country-level factors on connection to nature within inevitably limited sample sizes while minimizing the influence of demographic differences across nations (see subsequent sections).

Explaining cross-country variation in connection to nature

Drawing from the framework proposed by Richardson and colleagues,²⁰ we hypothesized that people's connection to nature at the country level is predicted by four primary aspects of a country's conditions: physical proximity to nature, consumption and commerce, utility and dominion, and negativistic (see Richardson and colleagues' paper for a more detailed discussion on the theoretical background for the impacts of each factor on connection to nature). To capture these aspects, we used seven measures, ensuring the inclusion of at least one for each aspect (see Table S2). Due to the significant correlation among the proportion of the population that is urban, the per-capita gross domestic product (GDP), the per-capita material footprint, and the Internet penetration rate ($r > 0.80$), we combined these into a single composite factor termed "socioeconomic development" using principal-component analysis (PCA). Given the structure of our data, we used hierarchical regression models to assess the effects of both individual- and country-level factors on individuals' connection to nature (see methods for details).

The results from regression models indicated that the level of socioeconomic development is a major predictor of connection to nature. Individuals in countries with higher levels of socioeconomic development exhibited reduced psychological connections to nature (sense of oneness with nature, perceived personal benefits, concern for nature, and pro-conservation attitudes) (Figures 4 and S2; detailed statistical information provided in Table S3). This decline can be attributed to two primary factors. First, in these high-income nations, a significant portion of the population lives in highly urbanized areas where natural

environments and wildlife are often limited in quantity and quality.³⁴ This physical detachment from nature may consequently widen the psychological gap individuals feel toward the natural world.³⁵ Second, countries with higher socioeconomic development tend to have increased access to digital entertainment, such as the Internet and television, which could contribute to a decrease in people's interest in and affection for nature (the "videophilia" hypothesis).³⁶ Third, in these high-income nations, consumerism and commercialism likely play a dominant role in shaping societal values, further weakening the connection to nature, as these values typically oppose those that promote a deeper psychological bond with nature.²⁰ However, the frequency of nature experiences during childhood was higher in countries with high socioeconomic development levels (Figure 4). This might be driven by improved safety in local living environments³⁷ and heightened societal motivation to use nature experiences to improve health and well-being ("nature-based health intervention"), especially for urban dwellers.³⁸

Alongside socioeconomic factors, environmental factors also played an important role in explaining individuals' connection to nature. People in less biodiverse countries expressed lower levels of concern about environmental degradation (Figure 4). This may be partly due to shifting baseline syndrome, where people's accepted norms for environmental conditions progressively decline over time.^{39,40} Indeed, these countries have experienced decades, or even more than a century, of large-scale biodiversity loss due to human activities,⁴¹ leading residents to become accustomed to impoverished environmental conditions and potentially diminishing their concern for nature degradation. Interestingly, however, individuals living in countries with lower biodiversity reported higher frequencies of nature experiences (Figure 4). This result may be partly explained by the fact that areas with higher biodiversity often have natural environments that are less managed by humans and may harbor animals potentially harmful to humans,⁴² which could limit people's opportunities and motivation to explore nature.

We also found that individuals in countries with a higher proportion of cultivated land reported lower levels of a sense of

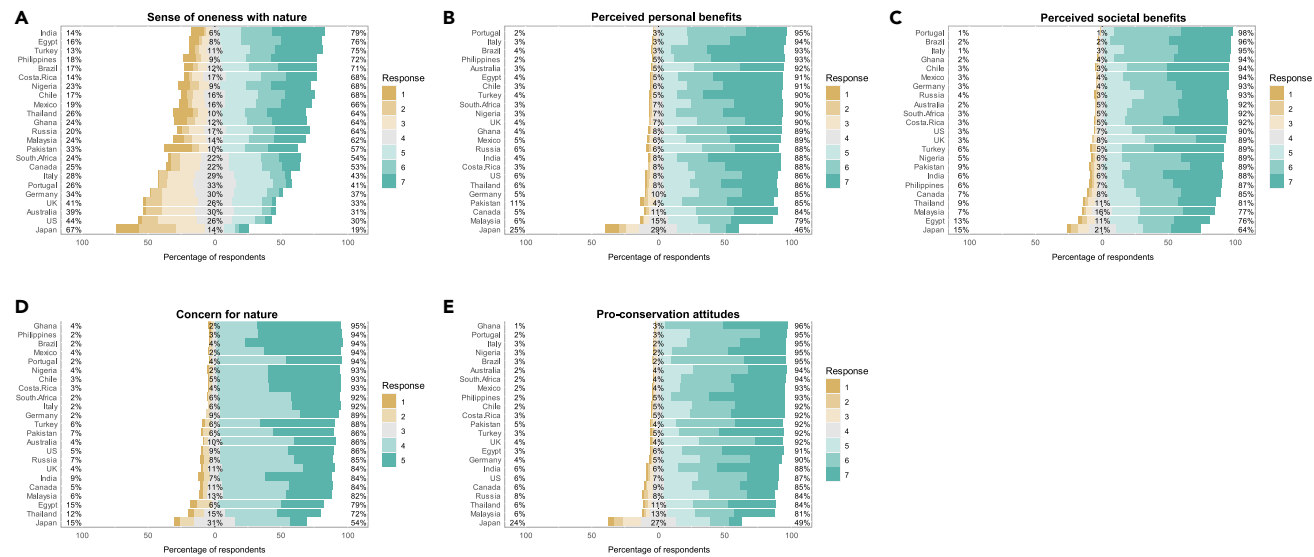


Figure 2. Likert plots for five measures of psychological connection to nature across 23 study countries

(A–E) (A) Sense of oneness with nature, (B) perceived personal benefits, (C) perceived societal benefits, (D) concern for nature, (E) pro-conservation attitudes. The values in the middle section of the images represent the percentage of respondents who provided a neutral response (3 on a 5-point Likert scale and 4 on a 7-point Likert scale), while the values in the left and right sections indicate the percentages of respondents who provided answers lower and higher than neutral, respectively.

oneness with nature (Figure 4). While small-scale, organic farming practices that harmonize with nature do exist, agricultural activities in many modern societies tend to prioritize maximizing profit from natural resources by intensively managing land, often through monoculture farming, the heavy use of chemical inputs, and mechanized processes that can degrade ecosystems.⁴³ This industrial approach likely promotes utilitarian and dominionistic values, which can erode connection to nature by reinforcing a worldview where humans perceive themselves as separate from nature, with the right to control and exploit it.^{20,44}

We found no negative relationship between natural disaster risk and the measures of connection to nature examined (Figure 4). Instead, interestingly, frequencies of childhood and recent nature experiences were higher in countries with higher disaster risk. One potential explanation for this result is that countries at greater risk for natural disasters often have warmer climates and environments that support high-quality nature-based recreational activities, such as mountainous and coastal areas.⁴⁵ These conditions may, in turn, lead to more frequent nature experiences. To fully explore the influence of society's negative beliefs and values toward nature on individuals' connection to nature, a more in-depth, social-science-based approach would be needed.

Clearly, there is likely a bidirectional relationship between country-level socioeconomic and environmental factors and connection to nature. Over the long term, changes in connection to nature can influence country-level socioeconomic and environmental conditions. For instance, a diminished sense of oneness with nature resulting from increased socioeconomic development can lead to decreased participation in pro-conservation behaviors.^{12–15} This, in turn, may impact biodiversity levels within the country.⁴⁶ Similarly, a decline in the sense of oneness with nature could reduce people's inclination to live in

and use areas abundant with green spaces, potentially increasing their physical distance from nature. Understanding the temporal dynamics of human-nature relationships would be an interesting avenue for future research.

Relative importance of individual-level factors

In addition to country-level factors, individual-level characteristics also play an important role in influencing connection to nature (Figure 4). People with higher social status reported stronger connections to nature across all seven measures (Figure 4). This positive correlation between social status (i.e., wealth) and connection to nature can be attributed to the “luxury effect,” where wealthier individuals often have greater opportunities for positive nature experiences.⁴⁷ Indeed, it is well documented that, particularly in urbanized societies, access to natural environments from one's residence is skewed toward groups with a higher social status.^{48,49} Given the various health and well-being benefits that direct experiences with nature offer, ensuring access to natural components in the areas where individuals with lower social status reside seems to be critically important in promoting social equality and environmental justice.⁵⁰

Individuals with higher levels of education exhibited greater connection to nature (Figure 4). Education can influence connections to nature in various ways. For example, it can enhance individuals' knowledge about the natural world, contributing to their “environmental literacy” or “ecological literacy.”⁵¹ This increased knowledge can strengthen the cognitive aspects of their connection to nature, although the effects of information provision are often short lived and limited.⁵² Additionally, certain educational approaches, such as nature-based learning, likely provide more direct experiences in natural settings, which are known to enhance emotional connections to nature.^{52,53} Another explanation for the positive relationship between education and

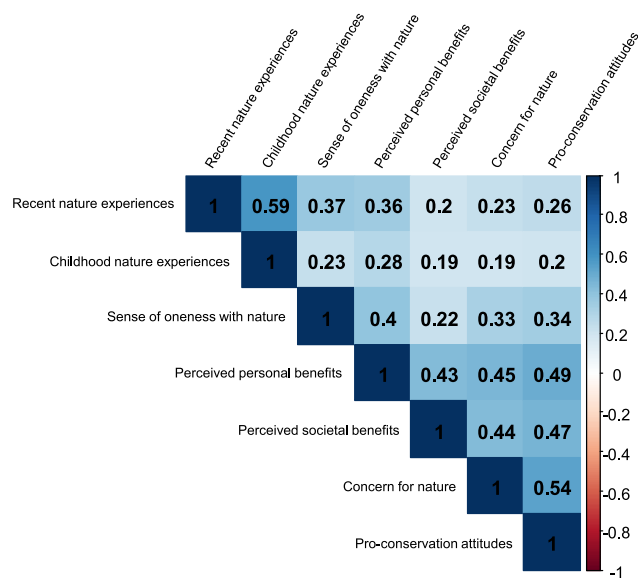


Figure 3. Associations between the scores for each of the seven measures of connection to nature

The data for all participants were aggregated, and Spearman's correlation values are presented.

connection to nature is that individuals with higher education levels often display traits, such as curiosity and a strong motivation to explore, that enhance their understanding and awareness of various subjects, including the natural world.⁵⁴

The level of urbanization in a person's living environment was associated with their connection to nature, though the direction of this association varied (Figure 4). People living in more urbanized areas reported a lower sense of oneness with nature as well as fewer recent and childhood nature experiences (Figure 4). This decline is not surprising, given that urban dwellers often have limited opportunities for direct interactions with nature. Indeed, in highly urbanized areas, a large proportion of people often do not engage directly with nature or do so only to a very limited extent, a phenomenon known as the "extinction of experience."^{33,34} Interestingly, however, those in more urbanized areas reported higher levels of perceived personal and societal benefits, greater concern for nature, and stronger pro-conservation attitudes (Figure 4). One possible explanation for this result is the potential increase in the emphasis on environmental education in urban settings, such as in schools or recreational and educational venues like museums and zoos.⁵⁵ Additionally, interventions and campaigns designed to enhance public engagement with nature and pro-conservation attitudes are often implemented in urban areas.^{56,57} While it is commonly believed that urbanization leads to a decrease in people's connection to nature, their relationship seems to be more complex than previously assumed.

While this study primarily focused on examining the influence of external factors on individuals' connections to nature, we also found that gender is a significant predictor. Female respondents reported a stronger psychological connection to nature (Figure 4). This finding aligns with previous research showing that women tend to exhibit deeper emotional bonds with nature

and demonstrate more pro-environmental attitudes and behavior.^{58,59} These patterns may reflect broader societal norms in which women are often socialized to prioritize traits such as empathy, care, and altruism, whereas men are typically encouraged to emphasize independence and competitiveness. Indeed, environmentalism and conservation, activities that involve caring for and nurturing nature, are often seen as "prototypical" feminine characteristics.⁶⁰ Interestingly, despite this stronger psychological connection, female respondents reported less frequent experiences with nature compared to males (Figure 4). This disparity may be explained by factors such as increased concerns about personal safety, including fears of crime and risks associated with outdoor activities.⁵⁹

Finally, to ensure the robustness of our results, we conducted a sensitivity analysis. In our study, the Japanese displayed a notably lower level of connection to nature compared to the other countries (Figures 1 and 2), raising the possibility that these data might have undue influence. To address this, we performed a reanalysis, excluding responses from Japanese participants and treating them as outliers (see Table S4). Following this adjustment, we found that the factors influencing individuals' connection to nature, both at the country and individual levels, remained largely unchanged. This highlights the overall reliability of our findings.

This study focused solely on major individual-level factors known to influence connection to nature, and there are likely many others deserving further investigation. For instance, social norms have been shown to influence people's engagement with nature,¹⁵ and parental attitudes and behavior toward nature can also have a similar impact.⁶¹ Gaining a more detailed understanding of the role of these personal factors in shaping individuals' connection to nature will yield more practical insights into designing policies and strategies aimed at enhancing this connection, such as urban greening policies and social marketing efforts.

Our findings are based on individuals aged 20–30, and thus it remains unclear whether the predictors of connection to nature identified here apply to other age groups. Further research across a broader age range is needed better to understand these relationships. Nonetheless, our results hold particular importance given the unique characteristics of this age group. Young adults are known to exhibit the lowest levels of connection to nature, particularly in terms of psychological engagement, across the life course.^{31–33} Therefore, these findings offer important insights into how to strengthen connection to nature among those who are highly disconnected from nature. This is particularly important at a time when people's connection to nature is gradually declining in many parts of the world.²⁷

Implications

Using a novel dataset that focusses on a much broader range of geographically and culturally diverse countries than previous studies, we have quantitatively measured the variation in individuals' connection to nature across societies and identified the key predictors underlying these differences. These findings have significant implications from both scientific and practical perspectives. First, they suggest that people's perceptions, attitudes, and engagement with nature are likely to be much more heterogeneous across societies than currently often assumed. To date,

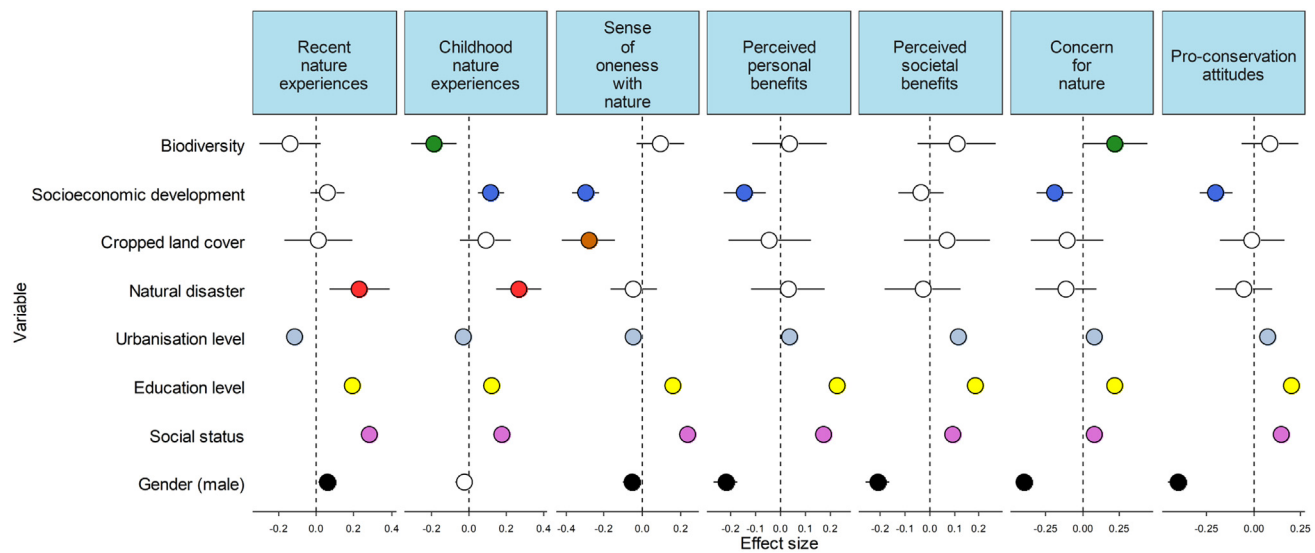


Figure 4. Effect size plot of the effects of predictor variables on the seven measures of connection to nature

All predictor variables, except gender, were scaled to allow direct comparisons. Error bars represent 95% confidence intervals (CIs). Effects are considered significant if their 95% CIs do not intersect the zero-effect line. The circle colors indicate different variables, and unfilled circles denote non-significant results.

studies on connection to nature, particularly within the field of psychology, have predominantly focused on high-income countries, especially in Europe.²⁷ Given the findings of our study, research synthesis based on such skewed research efforts may lead to inaccurate generalized evaluations of human connection to nature. Our research revealed that countries frequently studied (i.e., high-income countries) tended to exhibit lower levels of connection to nature. Therefore, extrapolating findings from these studies to wider populations might underestimate that existing connection.

Second, our results highlight the importance of considering country-specific contexts when examining individuals' connection to nature. As noted earlier, country-level factors have often been overlooked in research on connection to nature. However, our data indicate that these factors can exert as much influence on individuals' connections to nature as the individual-level factors previously identified as important. This highlights the need for theoretical and empirical investigations to understand macro-scale patterns in human connection to nature. While our primary focus was on factors hypothesized to impact connection to nature based on prior studies (see [methods](#)), exploring additional factors, both at the country and individual levels, could provide further valuable insights. For example, cultural factors such as customs and religious beliefs related to nature may profoundly impact individuals' connections to the natural world. While research on connection to nature in psychology and sustainability has largely not explored these factors so far, collaborating with fields like anthropology, which has long considered these influences, could offer valuable insights.

Third, our study emphasizes the importance of implementing actions and strategies aimed at promoting support for nature conservation in economically wealthier countries. These countries wield significant influence over the Earth's natural environment due to heightened economic activities and consumption patterns.⁶² However, our analysis indicates that, overall, these

countries exhibit lower levels of psychological connection to nature, a factor that is known to be a key driver of pro-nature behaviors.^{12,13} Therefore, future conservation strategies and initiatives, such as those from IPBES,²³ would benefit from focusing on enhancing people's positive emotions and attitudes toward nature in high-income countries. Importantly, our data reveal that individual-level factors, possibly associated with people's awareness, knowledge, and engagement with nature, play an equally crucial role as socioeconomic development level. This suggests that mitigating the decline in connection to nature resulting from economic growth may be achievable through appropriate actions and strategies, such as urban greening policies and environmental education.

METHODS

Questionnaire survey

In 2023, we conducted a questionnaire survey across 23 nations using internet survey approaches. We used internet panels provided by a commercial company, SmartSurvey, to recruit study participants. The survey was conducted in the most commonly spoken language for each country, with translations and back translations checked by native speakers familiar with local dialects to ensure accuracy. To mitigate the possible influence of seasonal variations on participants' responses regarding their connection to nature, we conducted the survey during relatively warm seasons for all study countries. To reduce the impact of sociodemographic differences in the sample, we targeted individuals aged 20 to 30 years old and aimed for a gender balance of 50% male and 50% female. We focused on this specific age group for two reasons. First, a primary goal of this study was to explore the relationship between country- and individual-level factors and individuals' connection to nature. Including older age groups could obscure this relationship, as individuals in these groups may have experienced varying (and often greatly

different) environmental and socioeconomic circumstances throughout their life courses. Second, we aimed to examine childhood nature experiences, and younger individuals are less susceptible to recall bias, which allows for more accurate reporting of their past experiences with nature. The sample size was determined using power analysis, aiming for more than 700 participants in each country. Data from respondents who did not complete the survey were excluded from the analysis. All study participants provided informed consent, and the survey protocol was approved by the Ethics Committee of the Graduate School of Agricultural and Life Sciences at the University of Tokyo (permission no. H22-012). Details regarding sample size, survey seasons, and languages used in each country are provided in [Table S5](#).

The questionnaire aimed to gather data on individuals' connections to nature and sociodemographic details (see [Data S1](#) for the list of the variables we collected). Participants were required to provide self-reported responses to seven measures of connection to nature: five items for psychological (cognitive) connection and two items for physical (experiential) connection (see [Table S2](#) for details about items and answer scales used for each item). Where possible, we used psychological scales from previous studies to ensure consistency and comparability with existing research.^{16,30,63} While there are some established psychological scales for measuring the sense of oneness with nature that can be applied across diverse cultural settings,^{30,64} widely applicable scales for other aspects of connection to nature remain limited. Given that this study explores multiple dimensions of both psychological and physical connections to nature, we included questions not yet widely used globally. We acknowledge that some scales may be culturally sensitive, particularly in terms of language differences, which could influence the results. These potential impacts were accounted for in our subsequent analyses (see the [analysis](#) section).

Individual-level factors

We collected four personal and sociodemographic factors in the questionnaire: subjective social status, education level, level of urbanization of the living environment, and gender. Subjective social status was measured by the 10 rungs ladder scale developed by Adler and colleagues.⁶⁵ Education level and level of urbanization of the living environment were evaluated on a four-point Likert scale ([Data S1](#)). Gender was recorded in four categories: “female,” “male,” “other,” and “prefer not to say.”

Country-level factors

Building on the framework proposed by Richardson and colleagues,²⁰ we considered four primary aspects of a country's conditions that could explain people's connection to nature at the country level: physical proximity to nature, consumption and commerce, utility and dominion, and negativistic. To measure these aspects, we employed seven indicators: (1) the proportion of the population that is urban (<https://population.un.org/wup/Download/>) and (2) the biodiversity level (assessed by the National Biodiversity Index, <https://www.cbd.int/gbo1/annex.shtml>) for physical proximity to nature; (3) the per-capita material footprint,⁶⁶ (4) the per-capita GDP (https://databankfiles.worldbank.org/public/ddpext_download/GDP.pdf), and (5) the Internet penetration rate (<https://data.worldbank.org/indicator/IT.NET.USER>

<https://data.worldbank.org/indicator/AG.LND.AGRI.ZS>) for consumption and commerce; (6) the proportion of cropped land cover (<https://data.worldbank.org/indicator/AG.LND.AGRI.ZS>) for utility and dominion; and (7) natural disaster risk (<https://reliefweb.int/report/world/worldriskreport-2022-focus-digitalization>) for negativistic. The distribution of per-capita GDP was highly skewed, so it was log transformed for use in subsequent analyses.

Analysis

To explore the relationship between individuals' connection to nature and factors at both country and individual levels, we employed cumulative link mixed models (CLMMs) using the “ordinal” package⁶⁷ in R (v.4.2.2).⁶⁸ This approach allows for regression analyses similar to linear models while appropriately handling ordered categorical factors, such as the Likert-scale responses used in our measures of connection to nature.

We used scores for the seven measures of connection to nature as response variables ([Table S2](#)). We intended to incorporate seven country-level and four individual-level factors as explanatory variables. However, there was substantial correlation among the proportion of population that is urban, the per-capita GDP, the per-capita material footprint, and the Internet penetration rate ($r > 0.80$). Consequently, we amalgamated these four country-level factors into composite factors using PCA. The PCA produced four axes, with the first axis accounting for the majority of the variance (84%) (see [Table S6](#)). We used only this first axis, which we termed the socioeconomic development level, as an explanatory variable in the CLMMs. This approach allowed us to incorporate all of these socioeconomic factors into the model while avoiding multicollinearity issues. Since the axis originally indicated increasing values with decreasing socioeconomic level, we inverted it for clarity in our analysis. All explanatory variables were treated as continuous except for gender ([Data S1](#)). To facilitate direct comparison across variables, we standardized all continuous explanatory variables to have a mean of zero and a standard deviation of one. Gender was included as a categorical variable. We included only respondents who identified as female or male in the analysis, as those selecting the other two categories accounted for a very small proportion (2%, $n = 460$). Given that respondents were nested within each country, we included country ID as a random effect. Additionally, language was included as a random effect to account for potential influences of linguistic differences on responses. We calculated the mean estimates and 95% confidence intervals (CIs) for each explanatory variable. We plotted our results as effect sizes and interpreted predictors as significant if their 95% CIs did not cross the zero-effect line.

RESOURCE AVAILABILITY

Lead contact

Further information and requests for resources should be directed to and will be fulfilled by the lead contact, Masashi Soga (asoga@g.ecc.u-tokyo.ac.jp).

Materials availability

This study did not generate any new physical materials.

Data and code availability

All data and R code used in this study are available from the authors upon request.

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AUTHOR CONTRIBUTIONS

Conceptualization, M.S. and K.J.G.; data collection, M.S.; analysis, M.S.; writing – original draft, M.S.; writing – review & editing, M.S. and K.J.G.

DECLARATION OF INTERESTS

The authors declare no competing interests.

SUPPLEMENTAL INFORMATION

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REFERENCES

- Soga, M., and Gaston, K.J. (2020). The ecology of human-nature interactions. *Proc. Biol. Sci.* 287, 20191882.
- Soga, M., and Gaston, K.J. (2021). Towards a unified understanding of human-nature interactions. *Nat. Sustain.* 5, 374–383.
- Barragan-Jason, G., de Mazancourt, C., Parmesan, C., Singer, M.C., and Loreau, M. (2022). Human–nature connectedness as a pathway to sustainability: a global meta-analysis. *Conserv. Lett.* 15, e12852.
- Barragan-Jason, G., Loreau, M., de Mazancourt, C., Singer, M.C., and Parmesan, C. (2023). Psychological and physical connections with nature improve both human well-being and nature conservation: a systematic review of meta-analyses. *Biol. Conserv.* 277, 109842.
- Keniger, L.E., Gaston, K.J., Irvine, K.N., and Fuller, R.A. (2013). What are the benefits of interacting with nature? *Int. J. Environ. Res. Publ. Health* 10, 913–935.
- Frumkin, H., Bratman, G.N., Breslow, S.J., Cochran, B., Kahn, P.H., Jr., Lawler, J.J., Levin, P.S., Tandon, P.S., Varanasi, U., Wolf, K.L., and Wood, S.A. (2017). Nature contact and human health: a research agenda. *Environ. Health Perspect.* 125, 075001.
- Bratman, G.N., Anderson, C.B., Berman, M.G., Cochran, B., De Vries, S., Flanders, J., Folke, C., Frumkin, H., Gross, J.J., Hartig, T., et al. (2019). Nature and mental health: an ecosystem service perspective. *Sci. Adv.* 5, eaax0903.
- Capaldi, C.A., Dopko, R.L., and Zelenski, J.M. (2014). The relationship between nature connectedness and happiness: a meta-analysis. *Front. Psychol.* 5, 976.
- Pritchard, A., Richardson, M., Sheffield, D., and McEwan, K. (2020). The relationship between nature connectedness and eudaimonic well-being: a meta-analysis. *J. Happiness Stud.* 21, 1145–1167.
- Ives, C.D., Abson, D.J., von Wehrden, H., Dörninger, C., Klaniecki, K., and Fischer, J. (2018). Reconnecting with nature for sustainability. *Sustain. Sci.* 13, 1389–1397.
- Gaston, K.J., Phillips, B.B., and Soga, M. (2023). Personalised ecology and the future of biodiversity. *Camb. prisms. Extinction* 1, e18.
- Mackay, C.M., and Schmitt, M.T. (2019). Do people who feel connected to nature do more to protect it? A meta-analysis. *J. Environ. Psychol.* 65, 101323.
- Martin, L., White, M.P., Hunt, A., Richardson, M., Pahl, S., and Burt, J. (2020). Nature contact, nature connectedness and associations with health, wellbeing and pro-environmental behaviours. *J. Environ. Psychol.* 68, 101389.
- Soga, M., and Gaston, K.J. (2024). Do people who experience more nature act more to protect it? A meta-analysis. *Biol. Conserv.* 289, 110417.
- Oh, R.R.Y., Fielding, K.S., Nghiem, L.T.P., Chang, C.C., Carrasco, L.R., and Fuller, R.A. (2021). Connection to nature is predicted by family values, social norms and personal experiences of nature. *Glob. Ecol. Conserv.* 28, e01632.
- Soga, M., and Gaston, K.J. (2023). Nature benefit hypothesis: direct experiences of nature predict self-reported pro-biodiversity behaviors. *Conserv. Lett.* 16, e12945.
- Gaston, K.J. (2024). Characterizing personalized ecologies. *J. Zool.* 322, 291–308.
- Gaston, K.J., Soga, M., Duffy, J.P., Garrett, J.K., Gaston, S., and Cox, D.T.C. (2018). Personalised ecology. *Trends Ecol. Evol.* 33, 916–925.
- Zemo, K.H., and Nigus, H.Y. (2021). Does religion promote pro-environmental behaviour? A cross-country investigation. *J. Environ. Econ. Polic.* 10, 90–113.
- Richardson, M., Hamlin, I., Elliott, L.R., and White, M.P. (2022). Country-level factors in a failing relationship with nature: nature connectedness as a key metric for a sustainable future. *Ambio* 51, 2201–2213.
- Kleespies, M.W., and Dierkes, P.W. (2023). Connection to nature of university students in the environmental field—an empirical study in 41 countries. *Biol. Conserv.* 283, 110093.
- Date, M., Fukano, Y., Farkhary, S.I., Uchida, K., and Soga, M. (2024). Beyond bees: a cross-country investigation into public perceptions of insect-mediated crop-pollination services. *Biol. Conserv.* 292, 110524.
- IPBES (2019). In Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, E.S. Brondizio, J. Settele, S. Díaz, and H.T. Ngo, eds. (IPBES secretariat), p. 1148. <https://doi.org/10.5281/zenodo.3831673>.
- Dasgupta, S.P. (2021). The economics of biodiversity the Dasgupta review abridged version (London: HM Treasury).
- Ministry of the Environment (2023). 生物多様性国家戦略 2023-2030. <https://www.env.go.jp/content/000124381.pdf>.
- Department of Environment, Food and Rural Affairs (2023) Environmental Improvement Plan 2023: Executive summary. <https://www.gov.uk/government/publications/environmental-improvement-plan/environmental-improvement-plan-2023-executive-summary#improving-our-use-of-resources>.
- Soga, M., and Gaston, K.J. (2023). Global synthesis reveals heterogeneous changes in connection of humans to nature. *One Earth* 6, 131–138.
- Nisbet, E.K., Zelenski, J.M., and Murphy, S.A. (2009). The nature relatedness scale: Linking individuals' connection with nature to environmental concern and behavior. *Environ. Behav.* 41, 715–740.
- Tam, K.P. (2013). Concepts and measures related to connection to nature: Similarities and differences. *J. Environ. Psychol.* 34, 64–78.
- Schultz, P.W. (2002). Inclusion with nature: the psychology of human-nature relations. In *Psychology of Sustainable Development* (Springer US), pp. 61–78.
- Richardson, M., Hunt, A., Hinds, J., Bragg, R., Fido, D., Petronzi, D., Barbett, L., Clitherow, T., White, M., and White, M. (2019). A measure of nature connectedness for children and adults: validation, performance, and insights. *Sustainability* 11, 3250.
- Hughes, J., Rogerson, M., Barton, J., and Bragg, R. (2019). Age and connection to nature: when is engagement critical? *Front. Ecol. Environ.* 17, 265–269.

33. Twenge, J.M., Campbell, W.K., and Freeman, E.C. (2012). Generational differences in young adults' life goals, concern for others, and civic orientation, 1966–2009. *J. Pers. Soc. Psychol.* **102**, 1045–1062.
34. Miller, J.R. (2005). Biodiversity conservation and the extinction of experience. *Trends Ecol. Evol.* **20**, 430–434.
35. Soga, M., and Gaston, K.J. (2016). Extinction of experience: the loss of human–nature interactions. *Front. Ecol. Environ.* **14**, 94–101.
36. Pergams, O.R.W., and Zaradic, P.A. (2006). Is love of nature in the US becoming love of electronic media? 16-year downtrend in national park visits explained by watching movies, playing video games, internet use, and oil prices. *J. Environ. Manag.* **80**, 387–393.
37. Sallis, J.F., Bowles, H.R., Bauman, A., Ainsworth, B.E., Bull, F.C., Craig, C.L., Sjöström, M., De Bourdeaudhuij, I., Lefevre, J., Matsudo, V., et al. (2009). Neighborhood environments and physical activity among adults in 11 countries. *Am. J. Prev. Med.* **36**, 484–490.
38. Shanahan, D.F., Astell-Burt, T., Barber, E.A., Brymer, E., Cox, D.T.C., Dean, J., Depledge, M., Fuller, R.A., Hartig, T., Irvine, K.N., et al. (2019). Nature-based interventions for improving health and wellbeing: the purpose, the people and the outcomes. *Sports* **7**, 141.
39. Pauly, D. (1995). Anecdotes and the shifting baseline syndrome of fisheries. *Trends Ecol. Evol.* **10**, 430.
40. Soga, M., and Gaston, K.J. (2018). Shifting baseline syndrome: causes, consequences, and implications. *Front. Ecol. Environ.* **16**, 222–230.
41. Pereira, H.M., Martins, I.S., Rosa, I.M.D., Kim, H., Leadley, P., Popp, A., van Vuuren, D.P., Hurtt, G., Quoss, L., Arneth, A., et al. (2024). Global trends and scenarios for terrestrial biodiversity and ecosystem services from 1900 to 2050. *Science* **384**, 458–465.
42. Longbottom, J., Shearer, F.M., Devine, M., Alcoba, G., Chappuis, F., Weiss, D.J., Ray, S.E., Ray, N., Warrell, D.A., Ruiz de Castañeda, R., et al. (2018). Vulnerability to snakebite envenoming: a global mapping of hotspots. *Lancet* **392**, 673–684.
43. Pretty, J. (2008). Agricultural sustainability: concepts, principles and evidence. *Philos. Trans. R. Soc. Lond. B Biol. Sci.* **363**, 447–465.
44. Richardson, M. (2023). *Reconnection: Fixing Our Broken Relationship with Nature* (Pelagic Publishing Ltd).
45. Van Zanten, B.T., Van Berkel, D.B., Meentemeyer, R.K., Smith, J.W., Tieskens, K.F., and Verburg, P.H. (2016). Continental-scale quantification of landscape values using social media data. *Proc. Natl. Acad. Sci. USA* **113**, 12974–12979.
46. Waldron, A., Miller, D.C., Redding, D., Mooers, A., Kuhn, T.S., Nibbelink, N., Roberts, J.T., Tobias, J.A., Gittleman, J.L., and Gittleman, J.L. (2017). Reductions in global biodiversity loss predicted from conservation spending. *Nature* **551**, 364–367.
47. Leong, M., Dunn, R.R., and Trautwein, M.D. (2018). Biodiversity and socio-economics in the city: a review of the luxury effect. *Biol. Lett.* **14**, 20180082.
48. Chen, Y., Yue, W., and La Rosa, D. (2020). Which communities have better accessibility to green space? An investigation into environmental inequality using big data. *Landsc. Urban Plann.* **204**, 103919.
49. Spotswood, E.N., Benjamin, M., Stoneburner, L., Wheeler, M.M., Beller, E.E., Balk, D., McPhearson, T., Kuo, M., McDonald, R.I., and McDonald, R.I. (2021). Nature inequity and higher COVID-19 case rates in less-green neighbourhoods in the United States. *Nat. Sustain.* **4**, 1092–1098.
50. Wu, S., Chen, B., Webster, C., Xu, B., and Gong, P. (2023). Improved human greenspace exposure equality during 21st century urbanization. *Nat. Commun.* **14**, 6460.
51. Scholz, R.W., and Binder, C.R. (2011). *Environmental literacy in science and society: from knowledge to decisions* (Cambridge University Press).
52. Liefänder, A.K., Fröhlich, G., Bogner, F.X., and Schultz, P.W. (2013). Promoting connectedness with nature through environmental education. *Environ. Educ. Res.* **19**, 370–384.
53. Pirchio, S., Passiatore, Y., Panno, A., Cipparone, M., and Carrus, G. (2021). The effects of contact with nature during outdoor environmental education on students' wellbeing, connectedness to nature and pro-sociality. *Front. Psychol.* **12**, 648458.
54. Von Stumm, S., Hell, B., and Chamorro-Premuzic, T. (2011). The hungry mind: Intellectual curiosity is the third pillar of academic performance. *Perspect. Psychol. Sci.* **6**, 574–588.
55. Yu, X. (2014). Is environment 'a city thing' in China? Rural-urban differences in environmental attitudes. *J. Environ. Psychol.* **38**, 39–48.
56. Schwartz, A., Cosquer, A., Jaillon, A., Piron, A., Julliard, R., Raymond, R., Simon, L., Prévot-Julliard, A.C., and Prévot-Julliard, A.C. (2012). Urban biodiversity, city-dwellers and conservation: how does an outdoor activity day affect the human-nature relationship? *PLoS One* **7**, e38642.
57. Richardson, M., and McEwan, K. (2018). 30 days wild and the relationships between engagement with nature's beauty, nature connectedness and well-being. *Front. Psychol.* **9**, 1500.
58. Price, E., Maguire, S., Firth, C., Lumber, R., Richardson, M., and Young, R. (2022). Factors associated with nature connectedness in school-aged children. *Curr. Res. Ecol. Soc. Psychol.* **3**, 100037.
59. Rosa, C.D., Larson, L.R., Collado, S., Cloutier, S., and Profice, C.C. (2023). Gender differences in connection to nature, outdoor preferences, and nature-based recreation among college students in Brazil and the United States. *Leisure Sci.* **45**, 135–155.
60. Liu, T., Geng, L., Ye, L., and Zhou, K. (2019). "Mother Nature" enhances connectedness to nature and pro-environmental behavior. *J. Environ. Psychol.* **61**, 37–45.
61. Truong, M.V., Nakabayashi, M., and Hosaka, T. (2023). Parents' orientation is more important for children's visits to greenspaces than the availability of spaces and time. *Landsc. Urban Plann.* **235**, 104738.
62. Wiedmann, T., Lenzen, M., Keyßer, L.T., and Steinberger, J.K. (2020). Scientists' warning on affluence. *Nat. Commun.* **11**, 3107.
63. Natural England (2020). *The People and Nature Survey for England*. Retrieved December 15th, 2022, from <https://www.gov.uk/government/collections/people-and-nature-survey-forengland>
64. Lambert, L., Lomas, T., van de Weijer, M.P., Passmore, H.A., Joshnloo, M., Harter, J., Ishikawa, Y., Lai, A., Kitagawa, T., Chen, D., et al. (2020). Towards a greater global understanding of wellbeing: A proposal for a more inclusive measure. *Intnl. J. Wellbeing* **10**, 1–18.
65. Adler, N.E., Epel, E.S., Castellazzo, G., and Ickovics, J.R. (2000). Relationship of subjective and objective social status with psychological and physiological functioning: preliminary data in healthy, white women. *Health Psychol.* **19**, 586–592.
66. Wiedmann, T.O., Schandl, H., Lenzen, M., Moran, D., Suh, S., West, J., and Kanemoto, K. (2015). The material footprint of nations. *Proc. Natl. Acad. Sci. USA* **112**, 6271–6276.
67. Christensen, R. H. B. (2018). Cumulative link models for ordinal regression with the R package ordinal. <https://cran.r-project.org/web/packages/ordinal/ordinal.pdf>.
68. R Core Team (2022). *R: A Language and Environment for Statistical Computing* (R Foundation for Statistical Computing). <https://www.R-project.org/>.