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RESEARCH ARTICLE

Elucidating human–nature connectedness in three EU countries: A pro-environmental behaviour perspective

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Abstract

1. Strengthening positive human–nature relationships is seen as a way to more pro-environmental behaviour and leads to a greater environmental sustainability. Therefore, understanding human–nature relationships has attracted increasing attention among researchers. Nature connectedness is a concept developed to measure such relationships. Since nature connectedness is complex and context dependent phenomenon, more research comparing sociocultural and environmental factors within societies in different countries is needed to understand its determinants.
2. In this study, we explored how sociodemographic and socioeconomic characteristics and value orientation of respondents and environmental variables affected nature connectedness across different contexts in the European Union. We used 11 sociodemographic, socioeconomic and personal value factors from the computer-assisted web interview (CAWI) and six environmental variables characterizing the local environments of 1054 respondents as independent variables to explain the nature connectedness of the respondents in Greece, Poland and Sweden. The individual level of nature connectedness (response variable) was expressed by an additive index (NC-index) based on a 5-item scale originating from CAWI. The general additive model was applied to link NC-index to sociodemographic, value orientation and selected environmental variables.
3. We found that the sociodemographic characteristics of the respondents and their value orientation were substantially more important in explaining the individual level of nature connectedness than environmental variables. The NC-index was positively correlated with the frequency of visits to the natural environment and biospheric values of the respondents, and was higher for women and the most prosperous respondents. Moreover, we observed several country-wise differences in associations between explanatory variables and NC-index. For example, altruistic orientation was positively related to the level of nature connectedness only in Greece, but not in two other countries, and residence during childhood was important to nature connectedness only in Sweden.

4. Our findings that some sociodemographic, socioeconomic and value orientation variables affect the level of individual nature connectedness across studied countries are encouraging. They indicate that some universally applied educational actions may elevate the level of nature connectedness. We argue that exploration of nature connectedness from a cross-country perspective may provide significant insights into the environmental debate in national and international contexts.

KEYWORDS
biospheric orientation, human–nature connection, pro-environmental behaviour, sustainability

1 | INTRODUCTION

1.1 | Human–nature relationships and pro-environmental behaviour

Humanity has undermined its safe operating space by closely approaching or breaching planetary boundaries (Rockström et al., 2009; Steffen et al., 2015). Increasing environmental degradation (Lelieveld et al., 2015; Schwarzenbach et al., 2010), biodiversity crisis (Pecl et al., 2017), climate change (Wise et al., 2014) and human population growth (Godfray et al., 2010) underscore the importance of transitions towards a more sustainable way of life (IPBES, 2019). This transformation requires, among other things, a change in people's behaviour to become more environmentally friendly (Blok et al., 2015; Uzzell & Rathzel, 2009).

Evidence suggests that the development of positive human–nature relationships and, in consequence, pro-environmental behaviour has relevance for attaining sustainability (e.g. Alcock et al., 2020; Martin et al., 2020; Saunders, 2003; Whitburn et al., 2020). Departing from the notion that humanity has been largely detached from the natural world and this fact is one of the main causes of the current environmental crisis, several scholars proposed the urgent need of 'reconnection' with nature as a way to deal with this issue (e.g. Folke et al., 2011; Ives et al., 2018; Pyle, 2003). Furthermore, the impact of the human–nature relationship on health and well-being has been pointed out (Russell et al., 2013; Seymour, 2016). Here, the 'biophilia hypothesis' (Wilson, 1984), assuming that humans have an innate need to connect with nature based on their evolutionary past, is proposed as one of the explanations. The focus on reducing everyday nature experiences due to urbanization has led to further development of the biophilia paradigm with, for example, 'Nature deficit disorder' or 'Extinction of experience' ideas (Louv, 2005; Soga & Gaston, 2016). However, human–nature relationships, pro-environmental behaviour and sustainability are all complex, and not always strictly defined phenomena. In this work, we focus on positive human–nature relationships, described as human–nature connectedness, and explore this phenomenon in three European countries—Sweden, Poland and Greece. Based on other studies (Barragan-Jason et al., 2022; Iwińska et al., 2023; Rosa et al., 2018; Whitburn et al., 2020), we assume that human-–nature connectedness has the potential to strengthen pro-environmental behaviours at individual and societal levels and thereby assist in the quest for a more sustainable future.

1.2 | The concept of human–nature connectedness

Human–nature connectedness (HNC) is a wide and not always clearly defined concept (Restall & Conrad, 2015; Zylstra et al., 2014). For example, it has been defined as a sense of belonging to the wider natural world, that is, as being part of a larger community of nature (Martin et al., 2020; Mayer et al., 2009) and also the degree to how much an individual includes nature within his/her cognitive representation of self (Schultz, 2002). Ives et al. (2018) proposed a conceptual framework that included five different types of HNC: material, experiential, cognitive, emotional and philosophical. These five types represent a spectrum ranging from connections with the outer world (e.g. physical interactions) to connections with the inner world (e.g. emotions or worldviews). Moreover, they suggested that all types could be considered at the individual level and some of them could be aggregated to the societal scale. Zylstra et al. (2014) proposed a different framework based on four components embodying connectedness with nature: information about nature (mind), experience in nature (mind–body), connectedness with nature (mind–body–spirit) and committed connectedness with nature (mind–body–spirit–willpower).

Barragan-Jason et al. (2022) argued that HNC can be instrumental in improving sustainability and, as such, should be integrated into conservation policy. Barrows et al. (2022) demonstrated, for instance, that HNC was a significant predictor of pro-nature conservation behaviour. Richardson, Dobson, et al. (2020) recommended HNC as a measurable target for improving the human–nature relationship and, therefore, helping fight the current environmental crisis. Moreover, they proposed that this could be achieved through sensory contact, emotion, meaning, beauty and compassion, thereby using a number of pathways that are based on different types of HNC.

The use of HNC as a construct that assists in environmental conservation requires assessment methods. Several scales of HNC measurement have been proposed to encompass various types of this phenomenon (Restall & Conrad, 2015). For example, Mayer and Frantz (2004) created the Connectedness to Nature Scale with 14 items that measure the extent to which respondents feel a part of the

natural world and how emotionally connected they are to it. Nisbet et al. (2009) proposed the Nature Relatedness Scale, a 21-item measure focused on the affective, cognitive and experiential aspects of an individual's connection to nature and a sense of appreciation and understanding of the interconnectedness of life in the world. More recently, Richardson et al. (2019) used Nature Connection Index with six items encompassing emotional, aesthetical, experiential and ethical dimensions of human–nature connectedness.

The individual level of nature connectedness and different types of this phenomenon are formed by different factors related to the natural, economic, social and cultural contexts (Arendt & Matthes, 2016; Gosling & Williams, 2010; Haluza et al., 2014). Moreover, nature connectedness apparently influences many aspects of broadly understood human well-being. It develops at a young age (up to the early 20s) and appears to remain the same on the plateau throughout the rest of an individual's life (Hughes et al., 2019; but see Richardson et al., 2019). According to a survey by Windhorst and Williams (2015), the self-reported pleasant childhood nature experiences of Canadian students correlate favourably and significantly with a sense of nature connectedness, which was found to be related to higher levels of emotional and psychological well-being. Their research shows that having positive childhood experiences in natural places may be good for your mental health in the long run by making you more 'eco-friendly'. However, Krettenauer et al. (2020) found that older adolescents showed a lower connectedness to nature in China and Canada, while pro-environmental behaviour was inversely associated with age only in Canada, but not in China. In addition, the individual level of nature connectedness may moderate the influence of nature on human health. For example, Oh et al. (2021) established that people with stronger connectedness were less likely to be depressed, stressed and anxious when interacting with natural environments whereas for those with weaker connection to nature, spending more time in nature was associated with being more depressed, stressed and anxious. Additionally, self-esteem influences the association between nature connection and body admiration in women (Swami et al., 2016). Within the studies of women–nature associations, some studies show that women are more connected to nature than males (Pinder, 2011; Reynolds & Haslam, 2011). For example, gender socialization theory says that girls are taught to be caring, cooperative and empathetic, and as adults, they are expected to take on the role of a nurturing caregiver (Liu et al., 2019; Mayer & Frantz, 2004; Zelezny et al., 2000). Additionally, parenting also makes mothers more concerned about their children's health, safety and the environment. Thus, given that the women–nature association enhances human–nature connectedness, it is assumed that people who have strong HNC are more likely to engage in environmentally friendly activities (Liu et al., 2019). A better understanding of how different factors and contexts relate to individual connectedness to nature would potentially assist the transformation processes towards more sustainable societies.

People's values, which can be defined as reflecting relatively stable, general and desirable goals that are significant and guide people's lives (Schwartz, 1994; Weber, 1905), are among the potential predictors of HNC. Understanding human behaviour towards the environment requires an understanding of various value orientations. According to Value Belief Norms theorists, egoistic, altruistic and biospheric values are particularly relevant to environmentally significant behaviour (de Groot & Steg, 2008; Stern et al., 1993, 1995). Biospheric values reflect the significance that people place on nature and the environment, and have also been shown to have a positive association with HNC levels (Martin & Czellar, 2017). Although biospheric values advocate for environmental benefits, altruistic values emphasize benefits for other individuals and global communities. Also, although egoistic values are presented as environmental insensitivity, their objective is to experience functional and emotional benefits (such as self-enhancement and self-welfare) (Steg, Bolderdijk et al., 2014; Steg, Perlaviciute et al., 2014).

1.3 | Environmental factors, national context and human–nature connectedness

Not only social and economic factors drive individual HNC, but also the quality of the local environment in the sense of its perceived naturalness, sense of place and visual attractiveness may have an impact on the level of nature connectedness. For example, rapid landscape change or landscape simplification measured by different proportions of land use types can negatively influence multiple dimensions of HNC (Riechers et al., 2020, 2021). Additionally, deeper personal connections to nature are associated with greater perceptual experiences of natural landscapes (Tang et al., 2015). According to Restall et al. (2021), especially high levels of nature connectedness were experienced within or near Natura 2000 sites (the European Union network of areas valuable for biodiversity conservation) in Malta, indicating the importance of proximity to natural areas in developing a positive relationship with nature. Alternatively, this relationship could be explained by the fact that people with a high level of HNC select sites with nearby natural areas for living. Such relationships have rarely been investigated; thus, the link between HNC and the surrounding environment is poorly understood.

The associations between social, economic and environmental contexts and HNC may also vary in different countries. First of all, countries may differ in their general environmental attitudes following differences in the wealth of the nations, national environmental policies or the level of environmental education (Franzen & Vogl, 2013). Some studies show that the level of individual income has a significant positive effect on environmental attitudes (Fairbrother, 2013; Pampel, 2014), while Ficko and Boncina (2019) demonstrated that at high levels of economic development, environmental concern decreases. The level of ecocentrism (admitting intrinsic value of all living organisms and their natural environment) in 14 countries was predicted by universalism (implying that it is possible to apply generalized norms, values or concepts to all people and cultures; positive relationship), power (negative relationship) and tradition (negative relationship) and these factors were consistent across the countries (Schultz & Zelezny, 1999). Sarigöllü (2009)

investigated environmental attitudes in a cross-country context using cultural, sociodemographic and contextual factors and found that environmental attitudes differ significantly between cultures. Mayerl (2017) concluded that although there are some remarkable differences in environmentalism between different regions (countries and continents) with a tendency (but not a strong trend) to higher ranks in northern and western countries, more data are needed to get a deeper understanding of worldwide environmentalism. In the case of HNC, we may expect similar interrelations, though generalizations may not always be easy using simple indices. Unfortunately, there are only very few studies examining nature connectedness from a cross-country perspective despite the contextual differences between countries being important to account for shaping environmental policies at the national level (Richardson et al., 2022; Ziegler, 2017).

1.4 | This study

In this paper, we aim to relate self-reported HNC to both sociodemographic factors, such as age, gender, education, environment of living, economic status and value orientation, as well as environmental factors, including the share of natural areas and areas under high anthropogenic pressure. To ensure sufficient spatial replication and a wide cross-country perspective, we surveyed three European countries: Nordic Sweden, Central European Poland and Mediterranean Greece. We focus on the following research questions: (1) What are the common and specific sociodemographic characteristics associated with HNC across different contexts in the EU? (2) How does the value orientation correlate with the HNC? (3) What environmental characteristics are associated with HNC? We selected three European countries that vary in many aspects that potentially might influence human–nature connectedness. Acknowledging the complexity of human relationships to nature deliberated above, we look for factors universally affecting self-reported nature connectedness and discern dimensions where those factors differ between countries.

2 | MATERIALS AND METHODS

2.1 | Greece, Poland and Sweden as case studies

In the ongoing process of integration and Europeanization (Featherstone & Radaelli, 2003), the member states of the European Union have shared some common policies, agriculture and regional development. However, countries maintain a broad spectrum of cultural, social, economic and political physiognomies linked to their natural conditions, history, geopolitical location and other factors. This variation is also discernible in environmental attitudes and the levels of pro-environmental behaviour in particular member states (e.g. Liobikienė & Minelgaite, 2021; Telešiene & Gross, 2017). Effective cross-country comparisons require a meaningful interpretation of the results that often require local knowledge. We selected three countries, Greece (access to EEC/EU in 1981), Poland (access to EU in 2004) and Sweden (access to EU in 1996). These three countries represent northern, central and southern Europe, and the differences in their environmental and sociocultural profiles are expected to influence the perceived level of nature connectedness.

2.2 | The survey

The empirical base is a July 2020 Kantar Millward-Brown survey using the computer-assisted web interview (CAWI) methodology. The survey adheres to the ethical requirements of the universities involved, specifically the project leader, Collegium Civitas, maintains adherence to the Code of Ethics for Researchers (https://instytucja.pan.pl/images/2021/CodeofEthicsForResearchersThirdEdition.pdf) throughout the research process, including the conceptualization stage. The research agency, Kantar, was chosen based on ethical standards in survey implementation, ensuring respondent confidentiality by not disclosing any identifying information.

Kantar complies with all applicable laws, and follows the International Code of Marketing and Social Research Practice—ICC/ESOMAR and ISO 20252 guidelines in all countries. ICC/ESOMAR, which is a benchmark for the market research industry, sets the standard of ethical and professional conduct for the global data, research and insights community. The sample was drawn from Kantar's internet panel and profiled for demographics such as gender, age and place of residence in each country. All survey participants gave their informed consent, as the panel is carried out following Regulation (EU) 2016/679 of the European Parliament and of the Council, also known as the General Data Protection Regulation (GDPR). In particular, every participant voluntarily entered the internet panel and, before starting the online questionnaire, signed the e-agreement, which says: 'Participation in the Kantar Club, as well as all other forms of research conducted by Kantar, is entirely voluntary. Each Kantar Club participant can resign from further participation in the Kantar Club at any time and have his/her data deleted from the Kantar (country) database'.[1]

The complete questionnaire from which data were extracted for the current study is presented in the appendix. All data received from Kantar were fully anonymized without the possibility of tracing individual respondents. The sample initially consisted of approximately 500 respondents aged 18–45 years in each country. The age of the respondents was restricted to people who are potential targets in the university education system due to the goals of the founding project. The complete data (also including respondents from Portugal and the United Kingdom) were used in two other studies focused on pro-environmental behaviour (Iwińska et al., 2023) and the use of green infrastructure (Elbakidze et al., submitted). In this study, we used data from three countries (Greece, Poland and Sweden) for which we were able to obtain relevant environmental variables and link them spatially with the reported postal codes of the respondents ($N = 1054$; for more details, see Section 2.3).

To measure the perceived level of HNC, we created a response variable originating from the above survey data. From many different scales available to measure HNC, we used five questions selected from the connectedness to nature scale provided by Mayer and Frantz (2004) and based on the level of acceptance of the respondent for the following statements: (1) 'I think of the natural world as a community to which I belong'; (2) 'I often feel a sense of oneness with the natural world around me'; (3) 'I recognize and appreciate the intelligence of other living organisms'; (4) 'I often feel a kinship with animals and plants'; (5) 'I have a deep understanding of how my actions affect the natural world'. Respondents responded on a five-point scale where 1 means 'strongly disagree' and 5 means 'strongly agree'. Based on Ives et al. (2018), the above statements could be classified as encompassing the following types of HNC: philosophical (statement 1); emotional (statements 2 and 4); and cognitive (statements 3 and 5). Since this study was part of a larger project sharing different parts of the same questionnaire with limited capacity (see Iwińska et al., 2023), we decided to select those five questions from the original scale. As a response variable, we generated an additive index of HNC (hereafter NC-index) by summing up the points for each respondent assuming that low to high numbers correspond to a gradient in nature connectedness (from low to high).

The survey data provided the input to the model in the form of 11 explanatory variables (Table 1). Seven of them were sociodemographic and socioeconomic variables, and four additional were value orientation scores based on the Environmental Portrait Value Questionnaire (E-PVQ) scale originating from the value-belief-norm (VBN) theory (Steg, Bolderdijk, et al., 2014; Steg, Perlaviciute, et al., 2014; Stern et al., 1998). The choice of sociodemographic variables was based on literature-based knowledge about factors that could affect HNC (see Section 1.2). Sociodemographic and socioeconomic variables included age, sex, economic status, education, community of living, and childhood environment. Although the first four variables are standard factors commonly used in social studies due to their importance in various aspects of people's lives, such as socioeconomic disparities, the latter two are of particular relevance. These variables might directly influence the development and level of HNC by shaping the past and current settings of the living environments of individuals. Additionally, the frequency of visits to the natural environment may be both the expression of HNC and also a pathway to its increase. Value orientation scores, in turn, attempt to present the general psychological attitude of respondents to life. Some orientations (e.g. biospheric) are expected to be positively related to HNC, but some others (e.g. altruistic), as mentioned above, could have more complex relations with HNC.

2.3 | Deriving spatial data

As discussed in Section 1.3, environmental conditions in place of living may have a bearing on the individual level of HNC. Taking this into account, we created a number of potentially relevant variables describing the local environment of the respondents. This included land cover information and area (at three spatial scales) and distance to Natura 2000 sites (Table 1). We assumed that the level of transformation of the local area of the respondents may affect their perceptions and emotions related to nature. Specifically, our variables that described the intensity of anthropogenic pressure (based on land use composition) relate to ideas of 'Nature deficit disorder' or 'Extinction of experience' (Louv, 2005; Soga & Gaston, 2016). The distance from and also the presence of Natura 2000 sites and the proximity to the coast were selected as a measure of the existence of natural areas in the local environments of the respondents. As mentioned above, for example, Restall et al. (2021) found high levels of nature connectedness within or near Natura 2000 sites. We are aware that the local environment of the respondents may affect several types of HNC, possibly exceeding what was directly addressed by our NC-index (e.g. experiential and physical HNC—sensu Ives et al. (2018)). However, we treat our NC-index as a general assessment of the HNC.

To spatially locate the respondents, we used the country zip codes. In ArcGIS (ESRI Inc., 2019) first, for each country's zip code polygon, we calculated the X and Y coordinates of its centroid. Not all respondents provided zip codes, and some of the codes turned out to be incorrect. For Poland and Sweden, respondent records with incorrect zip codes (5 and 18, respectively) were removed, causing 423 (Poland) and 336 (Sweden) records to remain (Figure 1). For Greece, we removed respondent data from zip codes composed of multiple polygons (12 respondents, 56 polygons), and with incorrect zip codes (79); thus, we retained a total of 295 respondent records (Figure 1).

We created 5, 10, and 15 km buffers around each centroid, retaining the identification of the respondents. We overlay these buffers with the Corine Land Cover (Copernicus Land Monitoring Service, 2018) and Natura 2000 (European Environment Agency, 2020) to calculate the area of land cover classes and Natura 2000 within the buffers. Also, we calculated the distance from the centroids to the nearest Natura 2000 site.

2.4 | Statistical modelling

On the basis of the survey and environmental data, we selected relatively uncorrelated independent variables for further statistical analyses. Initially, we considered 19 sociodemographic and value orientation characteristics of the respondents and six environmental variables characterizing sites settled by the respondents (given in Table 1), to explain the NC-index. Independent sociodemographic and socioeconomic variables included age, gender, habits, education, type of place of residence and self-reported financial situation of respondents. In a group of variables describing the value orientation of respondents, we used four scores adhering to value orientations (biospheric, altruistic, hedonistic and egoistic). Environmental characteristics included distance to, and share of Natura 2000 areas in buffer zones (different sizes), presence of sea shore and four continuous variables indicating area of land under different anthropogenic

TABLE 1 Set of 19 sociodemographic and socioeconomic variables, value orientation, land-use and geographic characteristics used as explanatory variables in statistical models explaining self-reported nature connectedness in 1054 respondents from Greece, Poland and Sweden.

	Variable	Description
Sociodemographic and socioeconomic variables		
1	Birth	Year of birth, 1975 to 2002, continuous fitted with spline
2	Gender	Male ($n = 530$) or female ($n = 524$), categorical fitted as fixed factor
3	Visits	Number of visits in natural environment, from 1 (everyday) to 6 (never), continuous
4	Childhood	Environment of a childhood of a person, from 1 (large city) to 3 (countryside), continuous
5	Education	Education, from 1 (primary) to 5 (PhD and more), continuous
6	Community	Community of living, from 1 (big city) to 5 (countryside), continuous
7	EconomicStatus	Economic status, from 1 (prosperous) to 6 (very poor), continuous
Value orientation		
8	Biospheric	Value orientations score, from 4 (least biospheric) to 24 (most), continuous fitted with spline
9	Altruistic	Value orientations score, from 5 (least altruistic) to 30 (most), continuous fitted with spline
10	Hedonistic	Value orientations score, from 3 (least hedonistic) to 18 (most), continuous fitted with spline
11	Egoistic	Value orientations score, from 5 (least egoistic) to 30 (most), continuous fitted with spline
Environmental variables and country		
12	DistanceNatura2000	Distance to nearest Natura 2000 site; 0.0–21.1 km, continuous fitted with spline
13	AreaNatura2000	Area covered by Natura 2000 sites, calculated for 5, 10 and 15 km buffers, continuous fitted with spline
14	SeaShore	Presence of sea shore within 15 km buffer, categorical
15	ExsStrongPressure	Area of land under excessively strong anthropogenic pressure, Corine Land Cover classes: 111, 121, 122, 123, 124, continuous fitted with spline
16	VeryStrongPressure	Area of land under very strong anthropogenic pressure, CLC classes: 112, 131, 132, 133, continuous fitted with spline
17	StrongPressurePooled	Area of land under strong anthropogenic pressure: excessively strong and very strong pooled, continuous fitted with spline
18	LowPressure	Area of land under low anthropogenic pressure, CLC classes: 311, 312, 313, 321, 322, 323, 324, 333, 411, 412, 421, 422, 423; continuous fitted with spline
19	Country	Country (Gre vs. Pol vs. Swe), categorical variable fitted as fixed factor

pressure, as defined by Szilassi et al. (2017). Also, the country was used as a categorical factor.

We used a general additive model (GAM) implemented in the library 'mgcv' (Wood, 2017) in R 4.0.5. (R Core Team, 2021) to link NC-index to sociodemographic, value orientation and selected environmental variables. We decided to use GAMs because they allow to test nonlinear relationships between explanatory and response variables with help of splines (see below), and shape of the relationship does not have to be predefined and is directly estimated from data (Wood, 2017). In the GAM, each respondent ($n = 1054$) was used as a separate data record, while the characteristics summarized in Table 1 were considered explanatory variables. In the GAM, continuous variables were fitted with thin plate regression splines. Here, we used these continuous variables that ensured enough variation ($n = 11$), while continuous variables having only a few levels ($n = 5$ variables) were fitted with a parametric linear fit. We used splines to allow for possible nonlinear fit, with the parameter 'k' set to 4 that is rather low value, which keeps the fit relatively smoothed. We use the 'k.check' function of the 'mgcv' library to verify whether the choices of basis dimensions are adequate (Wood, 2017).

In the GAM, we originally considered interactions between each explanatory variable and the country because the effects of the characteristics studied may differ between the three countries. We considered the parametric interaction or, in the case of splines, we used the option 'by = country' within the function 's'. To check if a given interaction has support in the data and improve the model fit, we compared the AIC score for GAM with and without this interaction, and in the final model, we left only those interactions that were improving the fit (i.e. those that reduce the AIC score).

Similarly, we selected the optimal spatial scale (from 5, 10 or 15 km buffer) for a given environmental variable by comparing AIC scores for GAMs using these three buffers, separately for each variable. As an effect, for each variable, we selected the 'best' buffer. As the three variables concerning anthropogenic pressure were describing similar processes and thus were strongly correlated (i.e. ExsStrong, VeryStrong, StrongPooled), we selected only one among these three, which had the highest support in data, based on AIC. Based on this procedure, we selected the final set of 17 explanatory variables (with or without interaction with country and on different

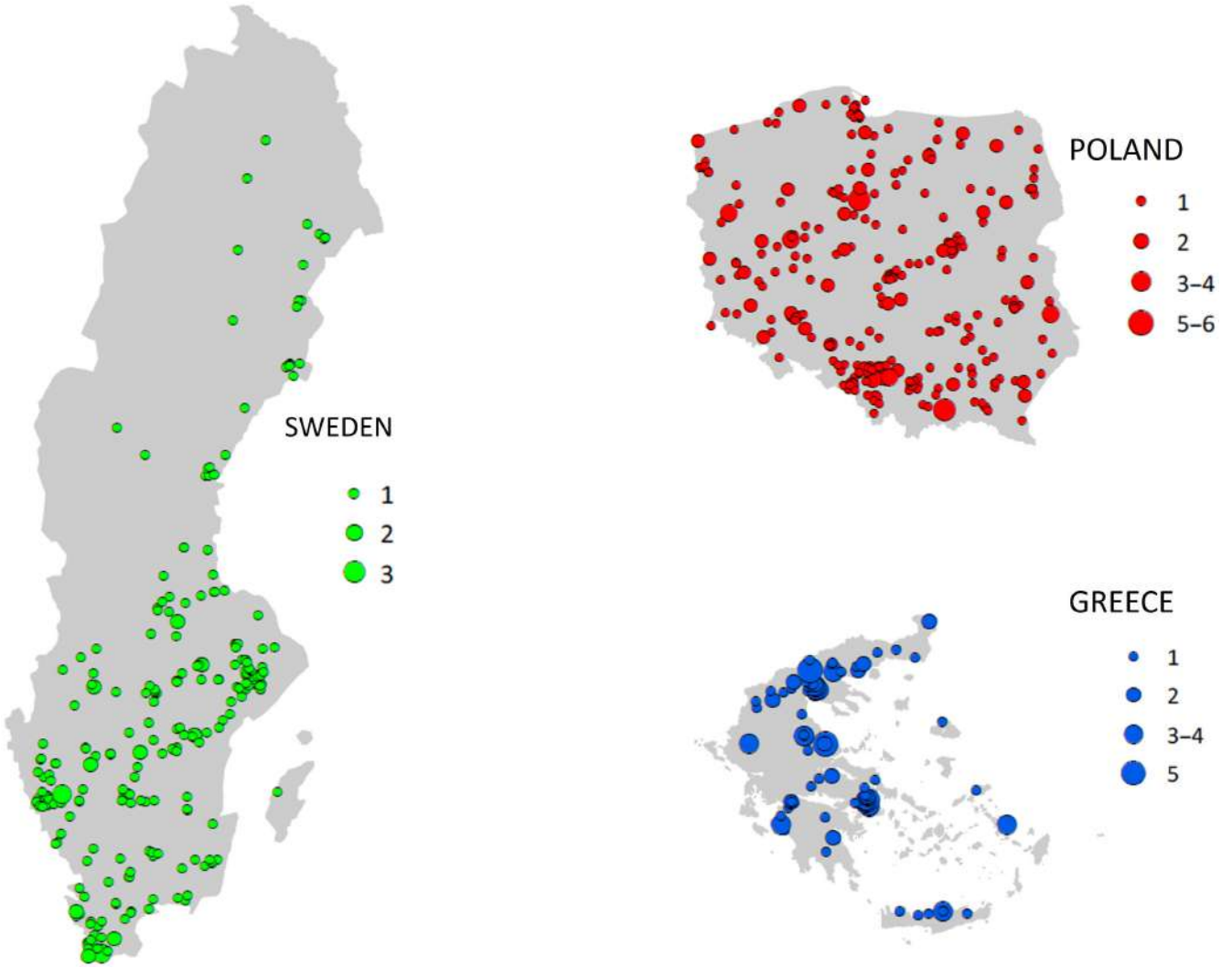

FIGURE 1 Spatial distribution of respondents in Greece, Poland and Sweden. Circles' positions are linked to the location (centroids) of zip-code areas and their size corresponds to the number of respondents.

spatial scales), and we present parameter estimates from the full model as the final result.

In the GAM, 'REML' was used as a smoothing parameter estimation method and Gaussian error distribution; we inspected the residual of the model with the Shapiro–Wilk normality test (no significant deviation from normality recorded). The highest variance inflation factor (VIF) of the final set of explanatory variables (but with all spline fits replaced by linear fits) did not exceed 3.3 for all explanatory variables, thus indicating that there were no problems with their collinearity. GAM residuals were checked for spatial autocorrelation with the help of spline correlograms implemented in the 'ncf' package (Bjørnstad, 2020) and did not show problems with spatial dependency of residuals.

3 | RESULTS

A total of 1054 respondents ($N = 295$ in Greece, $N = 423$ in Poland and $N = 336$ in Sweden) completed the survey (Table 2). The gender of the respondents was relatively balanced in each country, with a slightly higher proportion of men (51%–52%) in Greece and Poland and women (53%) in Sweden. The mean age of the respondents was between 32 and 33 years and was similar in all three countries. Respondents with a university degree were overrepresented in Greece and Poland (56% and 61% of respondents, respectively). In Sweden, respondents with secondary education were overrepresented (41% of respondents).

The GAM that analysed the variation in the NC-index between 1054 respondents in relation to 17 variables explained 45.3% of the deviation and was substantially better than the intercept only model ($\Delta AIC > 500$) thus indicating that the explanatory variables considered are useful for predicting the NC-index (Table 3). NC-index values, as predicted by GAM, were strongly positively correlated with observed NC-index values ($r = 0.67$; $p < 0.0001$) thus showing a generally good fit to the model.

For the entire sample, the NC-index ranged from 5 to 25 and was 18.4 on average (SD = 3.94). The means of the NC-index in the three countries were quite similar (Greece = 18.3; Poland = 19.0;

TABLE 2 Characteristics of the respondents.

	Males, %	Females, %	Mean age in years (SD)	Education, % of responders				
				Primary	Secondary	Technical/vocational	University	PhD
Greece, $n=295$	51.2	48.8	32.6 (7.34)	0.68	21.36	17.63	55.93	4.41
Poland, $n=423$	52.0	48.0	32.4 (7.21)	1.89	20.80	15.13	60.52	1.65
Sweden, $n=336$	47.3	52.7	32.2 (7.72)	6.55	40.77	14.58	36.31	1.79

TABLE 3 Results of general additive model analysing variation in self-reported nature connectedness among 1054 participants/responders in relation to 17 explanatory variables.

Explanatory variables	Effect	SE	*t*-value	*p*-value
Intercept	19.24	0.70	27.5	**<0.001**
Sociodemographic and socioeconomic variables				
Gender: female	0.47	0.19	2.5	**0.014**
Visits	−0.31	0.09	3.5	**0.001**
Childhood	0.20	0.20	1.0	0.320
Education	0.01	0.11	0.1	0.918
Community	−0.15	0.12	1.2	0.219
EconomicStatus	−0.26	0.11	2.4	**0.016**
Country GREECE	1.25	0.61	2.0	**0.043**
Country SWEDEN	1.14	0.63	1.8	0.071
Country GREECE: Childhood	−0.15	0.31	0.5	0.643
Country SWEDEN: Childhood	−0.85	0.29	2.9	**0.004**
s(birth)	2.04	2.44	2.0	0.190
s(Biospheric): Country POLAND	2.34	2.68	55.0	**<0.001**
s(Biospheric): Country GREECE	1.00	1.00	28.0	**<0.001**
s(Biospheric): Country SWEDEN	1.00	1.00	157.3	**<0.001**
s(Altruistic): Country POLAND	2.12	2.47	2.2	0.095
s(Altruistic): Country GREECE	1.02	1.05	11.9	**0.001**
s(Altruistic): Country SWEDEN	1.00	1.00	1.2	0.269
s(Hedonistic)	2.23	2.61	4.9	**0.003**
s(Egoistic)	1.00	1.01	1.5	0.225
Environmental variables				
SeaShore: yes	0.6	0.26	2.6	**0.008**
s(log(DistanceNatura2000 + 1))	1.00	1.00	1.1	0.301
s(log(AreaNatura2000 within15km + 1))	1.00	1.00	0.8	0.369
s(log(StrongPressurePooled within15km + 1))	2.38	2.74	3.6	**0.019**
s(LowPressure)	1.51	1.84	1.7	0.259

Note: Significant effects ($p < 0.05$) are marked in bold.

Sweden = 17.2). The NC-index ranged from 5 to 25 and was 18.4 on average (SD = 3.94).

Several sociodemographic and socioeconomic variables were correlated with the NC-index. We found that the NC-index was higher for women than for men and was also positively correlated with an increased frequency of visits to the natural environment. Furthermore, perceived economic status was positively associated with the NC-index, with the NC-index of the most prosperous respondents being higher than the poorest (Figure 2). Among other sociodemographic variables, we found no clear association of NC-index with age, education and community of living. Childhood residence place was recorded as important only in Sweden (value of NC-index was 1.3 lower for people who spent childhood in a village/countryside as compared to those spending childhood in a large city), but not in Greece nor Poland (Figure 2).

Value orientation scores were also important predictors of the level of NC-index. The biospheric, altruistic and hedonistic value orientations of the respondents were associated with the NC-index,

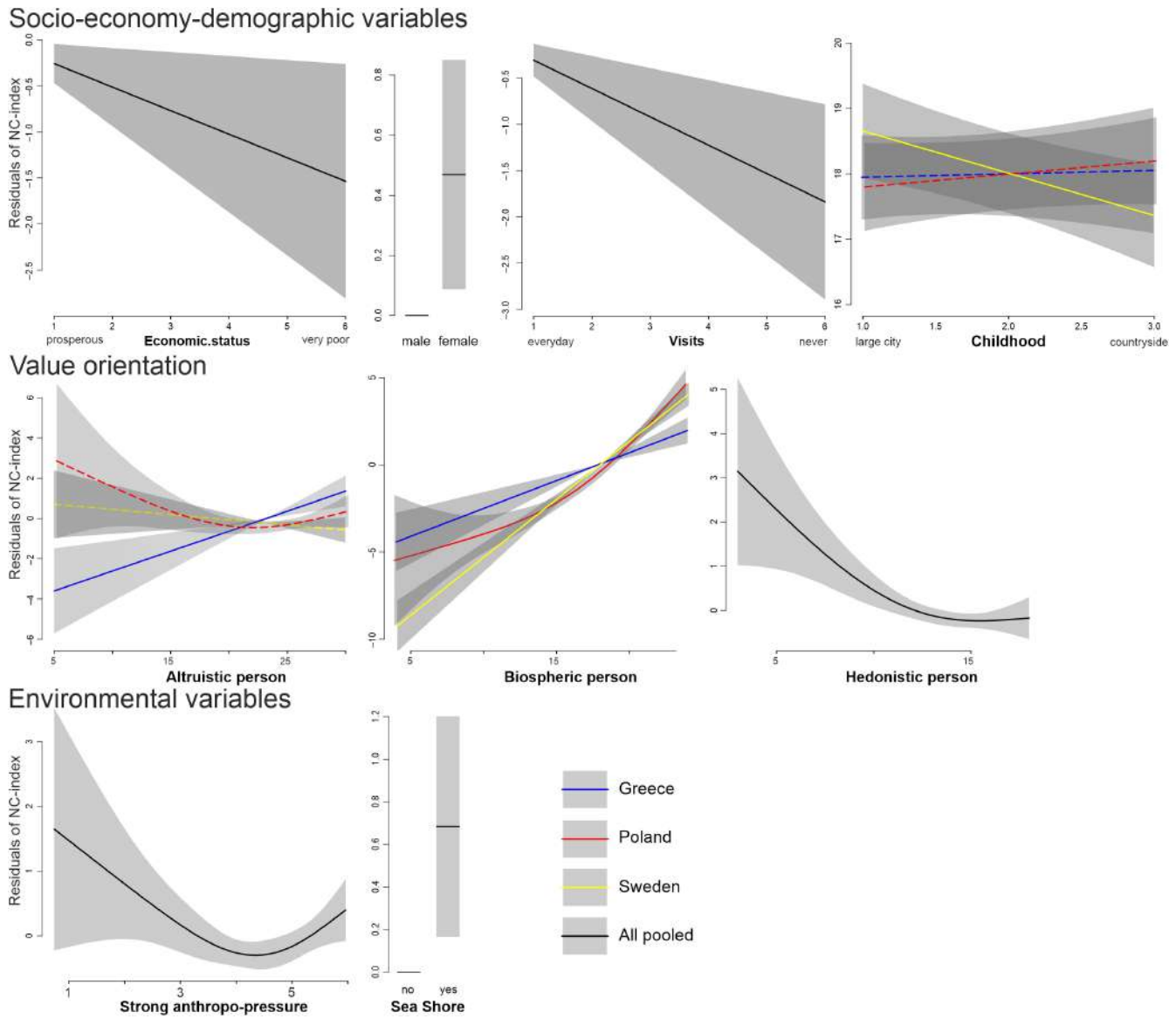

FIGURE 2 Nature connectedness index (*y*-axis, expressed as residuals) as predicted by general additive model summarized in Table 3, in relation to selected explanatory variables. Solid curves indicate statistical significance summarized Table 3.

but in two cases (biospheric and altruistic), the associations were different in the three countries considered (Figure 2). The biospheric score was positively linked with the NC-index and this association was strongest for Sweden and weakest (but still significant) and slightly nonlinear for Poland (clear correlation only for biospheric score values exceeding ca. 10). A linear positive association was recorded between the altruistic score and the NC-index for Greece, but not for Poland nor Sweden. With increasing hedonistic score, NC-index was declining sharply in all three countries but only up to a point—there was no visible association between the two for the score above 15. In turn, egoistic value orientation did not correlate with NC-index.

The environmental characteristic of the local area of the respondents only to a limited extent was related to the NC-index with two variables significantly correlated with the NC-index. The presence of the coast in the vicinity of the place of residence of the respondents was positively correlated with the NC-index and at sites with the coast near the NC-index was 0.7 higher (Figure 2). The area of land under strong anthropogenic pressure was significantly linked with the NC-index but in a nonlinear way: for low to moderate share of areas under strong anthropogenic pressure, the relationship was rather negative (the higher the area, the lower the NC-index) but further increase in the area with strong anthropogenic pressure was linked with the increase in the NC-index. Distance to and share of Natura 2000 that represented the biodiversity values of the local area did not correlate with NC-index.

4 | DISCUSSION

Our results confirm the complexity of relationships between HNC and sociodemographics, personal value orientation and

environmental variables. Several of the considered explanatory variables appeared to be statistically valid predictors of HNC across the case studies and explained a substantial proportion of the variation in our response variable, that is, NC-index. Moreover, the sociodemographic dimension and value orientation of respondents appeared to be substantially more important for explaining HNC than the environment. Based on the above, we may carefully conclude that HNC can effectively be predicted on the basis of personal (internal) and environmental (external) characteristics. However, our results demonstrate several instances where the same explanatory variables relate to HNC in a different mode in different countries, indicating the importance of the broader social context affecting personal HNC.

4.1 | Common factors affecting HNC

Among sociodemographic variables, gender and self-reported financial situation were common factors that affected the level of HNC in the studied countries. A gender effect was evident in all countries, with women generally expressing higher levels of HNC. This result is in line with earlier studies from several countries, for example, Australia (Dean et al., 2018), the United Kingdom (Hughes et al., 2019), Brazil and the United States (Rosa et al., 2020), Canada (Anderson & Krettenauer, 2021) or Spain (Perez-Ramirez et al., 2021). The findings that women are more linked to nature than men, and that this association leads to more pro-environmental behavioural intentions, have important implications for the study of gender–nature connections. We believe that more research is needed to study the younger group of males and females (aged around university level), as well as more complex variables connected to gender dimensions (i.e. personality characteristics, socialization and culture). Interestingly, our study shows that no matter the context of the country (the cultures of the three countries of Europe), the HNC was positively correlated with females and nature visits. It might suggest that traditional socialization of girls has an impact on their further attitudes towards people and nature, as well as environmental care. Also, when we add the association of HNC with altruistic values with the gender–nature relation, it becomes consistent with previous research (Anderson & Krettenauer, 2021; Liu et al., 2019; Reynolds & Haslam, 2011). It has practical implications for environmental campaigners and educators, who can explore the introduction of anthropomorphic narratives of nature into school curricula and public service announcements, particularly by including images or films featuring women. Furthermore, educators must emphasize the links of men to nature through positive experiences in nature by building in them a more ecological self, according to studies (Windhorst & Williams, 2015; Zelenski & Nisbet, 2012).

Respondents who assessed themselves as in a better economic condition indicated a higher HNC than those who perceived themselves as in an inferior economic situation. It aligns with previous findings (Richardson et al., 2022; Scopelliti et al., 2016). An interpretation of this, based on relevant research, could be that in a wider frame, in western culture, income affects consumption that goes further than just purchasing goods, towards personal improvement and achieving personal happiness. A side issue of this path to personal fulfilment is consumers' detachment from nature and the neglect of the HNC as a way to personal contentment (Eckersley, 2000; Hamilton, 2002; Wiedmann et al., 2020).

This study shows that value orientations among respondents were among the most important factors related to HNC in the three studied countries—Greece, Poland and Sweden. In particular, respondents with highly biospheric orientation coincided with a high level of HNC. Martin and Czellar (2017) proposed that HNC facilitates the development of biospheric orientation and suggested that individuals who have integrated nature into their self-concepts may possibly adopt biospheric value orientations. Moreover, Oh et al. (2021) found that the relationship between biospheric values and different dimensions of connection to nature was mediated through social norms of family and friends and experiences of nature. HNC and biospheric orientation in our study were apparently strongly related, but in other studies, these two individual characteristics are often considered separately and, in parallel, affect pro-environmental behaviour. For example, in a recent study on restaurant customers' intention to reduce food leftovers, Kim et al. (2023) demonstrated that HNC and biospheric orientation had a significant positive influence on environmental self-identity and intentions for pro-environmental behaviour. Interestingly, there was also an interaction between the two constructs (HNC and biospheric values) moderated by gender; the HNC of male customers increased their biospheric values more strongly than in the case of female customers. Both biospheric orientation and HNC are linked to self-transcendent emotions that, in turn, lead to more pro-environmental behaviour (Jacobs & MacConnell, 2022). Human value orientation and its interactions with HNC will certainly be the scope of future studies aiming at unravelling the complexity of factors behind pro-environmental behaviour.

We found that people who visited natural environments more frequently had higher levels of HNC. Such a pattern is described in several other studies, particularly in educational studies (e.g. Braun & Dierkes, 2017; Fränkel et al., 2019). Recently, Elbakidze et al. (2022) found that nature connectedness was among the most significant factors that explained the frequency of urban greenspace use in Sweden. People with a higher level of nature connectedness were more likely to visit urban nature more frequently than those with a lower level. Furthermore, Fränkel et al. (2019) identified that visits to the natural environment (forest) were most important in the development of HNC of children in Germany, while the cultural background was not. However, it is hard to judge whether frequent visits to the natural environment cause high HNC or whether high HNC leads a person to visit the natural environment more often. Nevertheless, several scholars claim that intentional and indirect nature contact affect positively nature connectedness, which in turn increases well-being and pro-environmental behaviours (see, e.g. Mayer et al., 2009; Whitburn et al., 2019). Contact with nature may

be considered one of the most important activities to reduce 'nature deficit disorder' or 'extinction of experience' (Louv, 2005; Soga & Gaston, 2016), and may deliver a specific pathway to improve the human–nature relationship, particularly in the urban environment (Richardson, Passmore, et al., 2020).

Contrary to our expectations, we recorded rather weak correlation between the presence of natural areas, including Natura 2000 sites or areas under anthropogenic pressure, and HNC. The presence of the sea shore was the only exception, but this variable hardly reflects the naturalness of the landscape. In a large study from the United Kingdom, respondents recalled a particularly high level of nature connectedness after visits to coastal areas (Wyles et al., 2019). Living near the coast appears to have general beneficial effects on the well-being of people (White et al., 2013). An additional interesting finding is a universal (based on three countries) nonlinear relationship of HNC with the amount of areas under strong anthropogenic pressure; both the landscapes with little and with a great level of anthropogenic pressure were linked to high HNC, whereas intermediate situations relate to low level of HNC. Possibly, both 'extreme' situations stimulate the development of HNC based on different premises; high appreciation of nature where it is not affected and missing the pristine nature where it is very strongly affected. A similar curvilinear relationship could possibly be expected in the gradient from serene rural landscape to production rural landscape and urban landscape. Dorninger et al. (2017) suggest that biophysical HNC at the regional scale, in contrast to 'disconnectedness', may provide renewed opportunities for inhabitants to develop an awareness of their impacts and fundamental reliance on ecosystems. However, to better understand the causes and consequences of biophysical disconnectedness and the ways of 'reconnection', new quantitative methods are needed to assess the extent of regional biophysical human–nature connection.

4.2 | Cross-country differences in HNC

Altruistic orientation in our study was positively related to the level of nature connectedness in Greece, but not in two other countries. In the case of Greece, a clearly similar result was presented by Gkargkavouzi et al. (2021). Altruistic orientation, similar to biospheric orientation, is linked to self-transcendent emotions, and therefore, we expected that it would be correlated positively with HNC (Jacobs & MacConnell, 2022). We do not have a clear explanation why that was not the case for Poland and Sweden, but apparently the country context is of importance. De Groot and Steg (2007) found, in a study on personal value orientations in five European countries in environmental behaviour perspective, that altruistic value orientation of Swedish respondents, unlike in four other countries, was very strongly related to both personal norms and awareness of consequences. In another study, in contrast to biospheric value orientation, altruistic value orientation was not at all related to pro-environmental behaviour in Poland (Caniels et al., 2021). Even if the above findings do not explain the weak association between altruistic orientation and HNC in Sweden and Poland in our study, they clearly illustrate the differences between countries.

Interestingly, residence during childhood was important to nature connectedness only in Sweden and in a rather unexpected manner, that is, respondents originating from the countryside generally have a lower level of nature connectedness. Sweden is one of the most forested countries in Europe and with many other natural environments (e.g. mires, lakes, alpine and coastal areas) being easily available to the people, particularly for those living in the countryside. Perhaps people originating from the countryside have a relationship with nature that is based more often on its utilitarian values realized through forestry, livestock keeping, fishing, hunting, or berry and mushroom picking, while respondents originating from urban areas see nature as something connected with leisure time allowing for the development of more emotional and spiritual bonds. But this relationship could be more complex. For example, Anderson and Krettenauer (2021) demonstrated that the strength of the rural children's relationship with nature was context dependent, with children living in the wilderness displaying the strongest relationship with nature, while children in rural agricultural settings displaying the weakest.

Regarding some sociodemographic variables, such as age and education, our study differs from many previous studies. For example, in Canada ($N = 1251$), adults showed significantly higher levels of emotional connectedness to nature compared to adolescents (Anderson & Krettenauer, 2021). We guess that our focal age group (18 and 45 years) included mostly people with already developed level of HNC and before possible changes in older age observed in some studies (e.g. Krettenauer et al., 2020). We also found that the level of education was not related to nature connectedness. Children's education, particularly based on visits to the natural environment, has been identified as important in developing a high level of nature connectedness (Barrable & Booth, 2020; Liefländer et al., 2013; Otto & Pensini, 2017). Passmore et al. (2021) show that parental connection to nature better predicts children's nature connectedness than visits or area-level characteristics. However, specially designed education or participation in creative activities (e.g. habitat restoration) can enhance nature connectedness also among adults (Down et al., 2022; Furness, 2021; Renowden et al., 2022; Richardson, Passmore, et al., 2020). We believe that more research is needed to study the younger group of males and females (college age), as well as more complex variables connected to gender dimensions (i.e. personality characteristics, socialization and culture).

While HNC can be considered a relatively stable trait that can contribute to understanding the motivational basis of environmental behaviour (Kals & Müller, 2012; Mayer & Frantz, 2004), individual orientations (i.e. altruistic, hedonistic, biospheric and egoistic) are more multifaceted and interacting personal traits that may affect personal behaviour and environmental action in different ways (e.g. Gkargkavouzi et al., 2021). The compliance between HNC and pro-environmental behaviour is attributed to personal values, specifically the notion that people who declared biospheric (or altruistic)

values want to protect nature, themselves and all other beings. As a result, people who have fewer experiences with engaging in conservational behaviours might have more difficulty implementing other related behaviours, such as habit change. Richardson et al. (2022) examined in 14 European countries how country-level indicators of technology, affluence and consumption relate to the average level of HNC, and concluded that HNC is a critical indicator of human and nature well-being needed to inform the transition to a sustainable future. We agree that HNC can, at the country level, be related to many different metrics, also including well-being indicators (e.g. antidepressant consumption, frequency of mental health issues in the population, etc.), but direct use of HNC scales is possibly a useful shortcut for evaluating the progress towards 'greener' societies (Cerda Planas, 2018).

5 | CONCLUSIONS

In summary, we argue that understanding factors that affect HNC is crucial for developing a pathway towards sustainability. People in industrialized nations are becoming less physically and psychologically connected to nature (Shepard, 1996). A continuing trend in creating a nature disconnection could lead to a decline in people's connectedness across generations and create 'environmental generational amnesia' that would bring physical and psychological costs (Kahn et al., 2009). Additionally, recent global assessments (e.g. IPBES, 2019) recognized that the failing human relationship with nature is an underlying cause of environmental crises. The HNC is indeed a key metric for a sustainable future (Richardson, Dobson, et al., 2020). Assuming that HNC is an important pathway to attaining sustainability, our study demonstrates that people with perceived better economic status, often visiting natural environments and with biospheric value orientation, are more prone to adopt a high level of HNC. Furthermore, some factors examined in our study had a context-dependent effect on HNC, differing between countries. Statistical models that identify citizens prone to high HNC may substantially assist sustainable development policy. Therefore, empirical studies exploring these associations are needed. The increase in the level of nature connectedness may be achieved through directed education, increasing visitation and activities in natural environments and generally improving psychological connections of people to natural environments. As recently demonstrated by Pocock et al. (2023), also the engagement in nature-based citizen science, in addition to gathering important data, clearly benefits well-being and nature connectedness of participants and their pro-nature conservation behaviours.

We urge that more cross-country comparative research would reveal contextual differences that mediate the relationship between HNC, underlying factors and pro-environmental behaviour. We argue that exploration of nature connectedness from a cross-country perspective may provide significant insights into the environmental debate in both the national, international and global context.

AUTHOR CONTRIBUTIONS

Grzegorz Mikusiński, Marine Elbakidze, Ioanna Skaltsa and Katarzyna Iwińska conceptually conceived and developed the study. Michał Żmihorski performed all statistical analyses and Ewa H. Orlikowska performed spatial analyses. Grzegorz Mikusiński wrote the first, incomplete draft of the manuscript, and all the coauthors contributed equally to finalize the manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflict of interest.

DATA AVAILABILITY STATEMENT

The survey data used in this paper originated from the international project PASSION funded by NAWA. Data collection was performed by Kantar Millward-Brown using the computer-assisted web interview (CAWI) methodology. Geographic data on distribution of zip-code polygons were purchased from official establishments in the three countries. Other geographic data used in this paper were publicly available. All data used in statistical analyses are available in Open Forest Data Repository https://doi.org/10.48370/OFD/SSIITB (Mikusiński et al., 2023).

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ENDNOTE

[1] Quoted passage from Regulations is translated from the Polish site: https://klubkantar.pl/regulamin/ (viewed 18/07/23).

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