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The influence of naturalness of the landscape structure on children's connectedness to Nature in North-eastern Italy

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Abstract

Connectedness to Nature and the ability to perceive the restorativeness value of places characterized by the presence of natural elements are personal characteristics that, when appropriately measured, make it possible to predict an individual's attitude toward pro-environmental behaviors. While these characteristics have an innate basis, they are also shaped by personal experiences and various cognitive, affective, and sociocultural factors. In this exploratory study, we delve into an interdisciplinary field that explores the relationship between the environment of the residential area and its impact on children's attitudes toward Nature. To do so, we conducted a comprehensive questionnaire among schoolchildren in North-eastern Italy to gauge their connectedness to Nature, their perceptions of restorativeness in surrounding natural settings, and their schoolyard environment. Then, drawing from optical satellite imageries, we calculated a combined multispectral index to assess the naturalness degree of participants' residential areas. Significant higher levels of connectedness to Nature were observed among children living in areas with high naturalness, compared to those living in areas with average or low naturalness. Perceived restorativeness scores exhibit a similar to that of connectedness to Nature, reinforcing the importance of natural spaces in fostering positive attitudes towards the environment. However, schoolyards were consistently perceived as less regenerative than natural places, regardless of the naturalness of the neighborhood. These results raise intriguing questions about the potential consequences of inadequate exposure to Nature on children's affiliation to the natural world and its possible subsequent effects on pro-environment behaviors in adulthood. By shedding light on the complex interplay between personal characteristics, environment, and attitudes towards Nature, our study underscores the significance of fostering a deeper connection with natural spaces to nurture a sustainable and environmentally conscious society.

Keywords

Connectedness to Nature, Naturalness Index, Perceived Restorativeness Scale, Children, Pro-environmental behaviors

Introduction

For a long time during the history of their species, humans lived in transitional forests and green environments (Wilson 2002). While they adapted to live in different environments by molding the landscape and the structure of the ecosystem, making them more comfortable and protective, humans maintained their ancestral preference for settling in green and blue areas (Ceola et al. 2015, Campos et al. 2006, Fang et al. 2018). Even in contemporary times, this affinity persists, as evident in our propensity to seek homes and environments nestled amidst natural landscape, especially when characterized by a certain level of "tidy wilderness" (,Ebert et al. 2022,Van den Berg et al. 2014). The higher value of houses built in a green and luxuriant area, or in the nearing of it, also testifies to the preference for such a landscape, where visual contact with vegetation can be granted, attesting to the enduring allure of Nature (Alvarez et al. 2004Morano et al. 2019, Trojanek et al. 2018).

Remarkably, this preference is also detectable in children, as they inherently prefer passing the time outdoors, show an instinctive capability to be fascinated by living beings, and become somehow contemplative in the presence of natural environments (Barbiero et al. 2014, Berto and Barbiero 2014).

A crucial exploration lies in comprehending the developmental underpinnings of this affinity and its potential for transformative impact, especially in nurturing a pro-environmental ethos within society. Central to this inquiry are two pivotal attributes: "connectedness to Nature", and the perception of the "restorativeness value" of natural environments (Berto and Barbiero 2022), meaning with “natural environments” the terrestrial or aquatic areas hosting an ecosystem with most of its processes (IPBES 2019), naturally colonized by vegetation and wildlife. The former attribute entails an individual’s feeling of being related to natural elements, akin to a familial bond, and can be measured by using psychometric scales such as the Connectedness to Nature Scale (Cheng and Monroe 2012, Navarro et al. 2022, Mayer and Frantz 2004) and its validated version for children (Barbiero and Berto 2021, Berto et al. 2015, Pasini 2009). The latter attribute involves the assessment of a place's capacity to induce stress recovery and attention restoration and is empirically measured by tools like the Perceived Restorativeness Scale (Hartig et al. 1991, Korpela and Hartig 1996), which contributes to highlighting the environment contribution to psychophysiological balance (Kaplan 1995, White et al. 2019) and people's well-being.

Matching the connectedness to Nature and the restorativeness value associated with natural environments represents a great opportunity for the study of social-ecological systems, where the entire system's dynamical evolution depends not only on the potential

of the ecosystem to offer resources and ecosystem services but also on the society's choices and collective human behavior (Liu et al. 2007, McGinnis and Ostrom 2014, Ostrom 2009). This convergence gains even more significance considering that fostering a sense of responsibility toward the environment, its status, and its resilience is inherently linked to personal connectedness and to the pleasure an individual feels to be gaining when visiting a natural space, with studies unveiling a heightened pro-environmental disposition among those deeply bonded with the natural world (Mackay and Schmitt 2019, Teixeira et al. 2023).

However, personal connectedness to Nature is not easy to enhance, especially in adolescence and adulthood when it is generally considered to have been established by this time: several studies demonstrated that connectedness to Nature is a stable personality trait that appears very early in childhood (Berto et al. 2015, Kahn 1997), finding it improbable that it can be later influenced by experiences in Nature during adulthood. Yet, the possibility of instilling and enhancing awareness of the importance of Nature remains a promising avenue for fostering a profound sense of ecological responsibility and stewardship. Indeed, connectedness to Nature is supposed to depend on several variables (Hand et al. 2017, Lin et al. 2018, Ulrich 1993) and is far from being considered an innate and immutable instinct (Grinde and Patil 2009, Kahn 1997, Myers 1996, Zhang et al. 2014), suggesting that a well-planned and guided exposure to Nature during the early childhood can be beneficial in fostering Nature connectedness (Barrable and Booth 2020) and, consequently, a positive attitude toward behaviors respectful to the natural environment and its resources.

Unfortunately, as urbanization progresses, the availability and accessibility of spaces where to engage in contact with the natural ecosystems become increasingly variable (UNICEF 2018), potentially affecting children’s affiliation and connectedness to Nature (Clayton and Karazsia 2020).

Despite the recent literature clearly highlights the beneficial effects of natural green and blue landscapes on health and well-being (Beute et al. 2020,De Nocker et al. 2023, Conniff and Craig 2016,Lee et al. 2015, Wood et al. 2017), as well as the positive outcomes of interactions with Nature (Tillmann et al. 2018, Berto et al. 2015), the specific relationship between the structure of the residential environment and inhabitants’ connectedness to Nature remains underexplored, particularly in children and teenagers. Moreover, available studies on the benefits of exposure to natural settings are more focused on the view of a few selected semi-natural landscapes, without a prior assessment of the naturalness of the landscapes.

To address this research gap, we conducted the first study in North-eastern Italy that investigate the relationship between residential area characteristics, connectedness to Nature, and perceived restorativeness of the surrounding areas that school-aged children attend daily. Our aims were to analyze whether and how the environmental structure and distributional features of the place of residence influence young inhabitants’ connectedness to Nature, and if the availability of different degrees of surrounding naturalness is driving

the restorative values they attribute to the places they view and frequent every day, since their early childhood.

In such an interdisciplinary endeavor, we administered a comprehensive questionnaire to schoolchildren living in North-eastern Italy, evaluating their connectedness to Nature, along with the restorativeness value they ascribe to both their favorite natural environment and their schoolyard. Then, we integrated optical satellite imageries to assess the naturalness degree of the residential areas of the participants, unveiling the potential availability of natural environments for the region's youngest inhabitants.

Our primary research question delved into understanding whether the level of naturalness in residential areas influences children's connectedness to Nature. This exploration led us to a parallel question: are children who live in areas exhibiting different levels of naturalness likely to assign different restorativeness scores to natural settings? Therefore, we determined whether the fascination associated with the presence of natural elements remains consistent, regardless of the naturalness of the surrounding residential environment, or if it changes in response to the surrounding landscape structure due to the consistent presence of man-made features.

Material and methods

This interdisciplinary study utilized a questionnaire to gather pertinent information regarding the residential areas and daily habits of the participants. Additionally, two psychometric scales were employed to assess these factors. Simultaneously, a series of satellite images were analysed to determine the natural elements within the residential area, including green and blue spaces.

Participants

A total of 533 primary school children, mean age of 8 years (±1.29 s.d., range 6-11 years) from Friuli-Venezia-Giulia, Trentino-Alto-Adige, and Veneto regions in Italy participated in the study between November 2020 and April 2021. The parents agreed with the informed consent for their children to participate. Among the answers, 527 out of 533 were considered in this study, dropping 6 questionnaires because they were incomplete.

The instrument

The study utilized an online anonymized questionnaire including questions about the age, the attended school, and the place of residence of the respondent. The questions about personal data were followed by the psychometric section, which consisted of the Connectedness to Nature Scale-children (CNS-ch) and the Perceived Restorativeness Scale-children (PRS-ch) to assess the perceived restorativeness value of both the schoolyard and the children’s favorite natural place.

Questionnaire

The dissemination of the questionnaire followed a first meeting with the headmaster of each of the 149 schools invited to participate in the study, during which they were offered a presentation of the project and a copy of the questionnaire. We chose the schools to be invited based on their location within the study area of Friuli-Venezia-Giulia, Trentino-Alto-Adige, and Veneto regions, including only the schools that have a schoolyard that can be used by children during school hours. If the invitation was accepted, the institute proceeded to distribute the online questionnaire through a message containing a link to the webpage, which was accessible from the parents' computers or smartphones. The online format offered a notable advantage in terms of survey dissemination across a broader geographical area. Additionally, it enabled us to circumvent the restrictions related to the Covid-19 pandemic that were still ongoing in Italy during the study period.

Connectedness to Nature

To assess the connectedness to Nature of the participants, we employed the Connectedness to Nature scale for children, CNS-ch (Berto et al. 2015), based on the scale of Mayer and Frantz 2004 and adapted to primary school children, which allows us to evaluate the extent to which a child feels part of the natural world, making it a reliable measurement of the construct "affiliation with Nature" of the biophilia hypothesis (Wilson 2002). The CNS-ch consists of 7 items rated on a 5-point scale, where 0 = never and 4 = always. The average score of the 7 items establishes the measure of the pupil's personal relationship with Nature.

Perceived Restoration

To assess the perceived restoration of the schoolyard and the natural places declared as their favorite natural place by the participating children we used the Perceived Restorativeness Scale for children, PRS-ch (Pasini 2009), a scale designed for school-age pupils based on the Attention Restoration Theory (Kaplan 1995) and the adult version of the PRS (Hartig et al. 1997). The PRS-ch consists of 18 items measuring the perception of four restorative factors (being-away, fascination, coherence, scope). Additional items were included after the PRS-ch items in order to assess preference: *I like that place*. Each item is rated on a 5-point scale where 0 = completely disagree and 4 = completely agree. The restorative value of a place is given by the average of the scores on the whole list of 18 questions.

We first asked the children to respond to the PRS-ch items by considering the schoolyard, since this is one of the environments they are familiar with and should represent a well-known playground. Subsequently, we inquired about their favourite natural place, the frequency of their visits to that place, and the activities they typically engage in while there, aiming to assess their perceptions about what they consider “natural” and somehow wilder

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than the schoolyard. Then, we requested their responses to the PRS-ch items considering the natural place they had mentioned.

Land cover, naturalness, and accessibility indicators

To assess the characteristics of the residential areas we performed a GIS analysis of the land cover and evaluated the greenness of the residential areas, retrieving it from remote sensing data. We acquired a series of 32 multispectral satellite images from the Copernicus portal (https://scihub.copernicus.eu/), choosing among optical images collected by the Sentinel-2 fleet. We selected imageries collected from March and April 2021, applying a filter to limit cloud cover to less than 9.9%.

After the pre-processing for atmospheric correction of the suitable Level 1-C images, we calculated for each of the pre-processed tile two spectral indexes, the Normalized Difference Vegetation Index (NDVI, Rouse et al. 1973) and the Normalized Difference Built-up Index (NDBI, Zha and Gao 2003), using the following equations:

eq. 1 $$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

eq. 2 $$NDBI = \frac{(SWIR - NIR)}{(SWIR + NIR)}$$

where NIR stands for Near Infrared spectral band (central wavelength 833 nm), Red stands for red band (central wavelength 664 nm), and SWIR represents the Short-Wave Infrared band (central wavelength 1613 nm resampled to a 10 meters spatial resolution) for Sentinel-2 sensors.

Then, we combined the resulting indexes to obtain a Naturalness Index (NI) according to the following equation:

eq. 3 $$NI = 2NDVI - NDBI$$

The resulting NI index enhances the bands in which plants are more reflective, while assigning negative values to pixels with non-vegetated, built-up elements, as detected by the NDBI. This calculation allowed us to obtain a proxy for the naturalness degree of the study areas. High values indicate higher vegetation greenness, while bare soils and built-up show negative values; water bodies approach 0, verified using the

Normalized Difference Water Index (NDWI, Gao 1996) on the same imageries.

The advantage of using the proposed NI as a proxy is that it well discriminates the presence of vegetated patches in urban areas (such as parks, gardens, and trees rays), and distinguishes cultivated and non-cultivated croplands within the agricultural lands since the non-cultivated fields result in values between 0.10 and 0.25 whereas cultivated ones have values between 0.25 and 0.59. Conversely, land patches covered by tree canopy results in values higher than 0.60. Moreover, we could discriminate water-covered pixels from bare soil and built-up structures, allowing for considering the areas containing water as a contribution to the naturalness.

Once the NI index was obtained for the study areas, we estimated the average NI value for a 10 km topological buffer around each of the towns mentioned by the participant children.

The width of the buffer was based on the daily traveling habits of children and scholars in Italy, as reported in the transport statistical report of the Veneto Region (Regione Veneto 2012).

The buffer areas were subsequently classified with a multi-criteria approach. An initial rough classification was based on the extension between artificial and natural areas, according to the 2018 Corine Land Cover dataset available at a 100-meters resolution (https://land.copernicus.eu/pan-european/corine-land-cover). Then, to have the most updated and high-resolution information about the naturalness characteristics of the residential areas, we classified the surface included in the 10 km buffer by ranking the NI values and considering the geographical location as well. Therefore, we identified 4 classes that differentiate from each other in terms of proximity to the coastline and the average naturalness index values (Fig. 1), to which we associated the classes "coastal", "low", "average", "high".

Statistical analysis

We assessed the distribution of the collected psychometric data by performing the Shapiro-Wilk test and Bartlett's test. Since data were not normally distributed, we performed a Kruskal-Wallis H test for ranks, followed by multiple comparisons among groups at the post-hoc Dunn test, with a Benjamini-Hochberg adjustment of p-values to address for multiple comparisons (Dunn 1961, Dunn 1964). All the operations concerning satellite imageries and geostatistical computation were performed in QGIS 3.16.2 (QGIS Association: QGIS Geographic Information System, 2022). Statistical computing was carried through R 4.1.2 (R Core team 2022) language within the Rstudio 2021.09.2 integrated development environment (RStudio team 2021).

Results

The classification of the residential areas into 4 classes according to their naturalness level ("coastal", "low", "average", "high") showed that the majority of the participants live in areas with average naturalness, followed by the group or participants who live in residential areas with a high naturalness and the group living within the coastal area; the less numerous group includes children living in areas with a low naturalness (Fig. 2).

The places mentioned by the children as the preferred natural environment were clustered into 8 categories. Table 1reports the relative frequency of each expressed preference.

As shown in Table 1, most participants declared that their favorite environment is represented by park and garden settings, followed by "beach and sea". Most of the participants living in low and average naturalness areas mentioned more frequently favorite places that are located outside the 10 km buffer around their place of residence, while children living in high naturalness area and coastal area select places within their estimated movement area of 10 km radius.

CNS-ch scores

Overall, the mean value of the CNS-ch resulted in 3.25 (±0.62). The CNS-ch scores do not differ significantly between different age groups, nor between different schools. Also, the frequency of visits to natural environments showed no correlation with the CNS scores.

Analyzing CNS-ch average scores among groups living in areas with different NI, the statistical analyses highlighted a significant difference between groups "average" and "high" (adj-p = 0.027) and between "low" and "high" (adj-p = 0.031), with a confidence interval of 95% (Fig. 3).

PRS-ch scores

The comparison between the PRS-ch scores related to the favorite natural place (A), and the one related to the schoolyard (B), showed that the restorativeness value of the natural environments was significantly higher than the schoolyard value for all groups (Fig. 4). The maximum score for the PRS-ch associated to the natural places was shown in the group "high", which is contrasted by the minimum PRS-ch score for the schoolyards. Moreover, a significant difference emerged between the restorativeness value of natural environments between group "average" and group "high", and between groups "low" and "high".

The restorativeness values assigned to the favorite natural environments in groups "high" and "coastal" were significantly higher than the restorativeness value of the favorite natural environments values in groups "average" and "low" (Fig. 4). On the other hand, the schoolyard restorativeness values were different between "high" and "average", as well as between "coastal" and "high", with the restorativeness of the schoolyard in the group "high"

significantly lower than the perceived restorativeness of the schoolyard in other residential areas.

Interestingly, the trend followed among groups by PRS-ch scores for the favorite environment and the CNS-ch scores are similar, even if the variables are only moderately correlated (Spearman's r = 0.49, p = 2.2^{-16}); conversely, a low correlation was found between PRS-ch score for the schoolyard and CNS-ch scores (Spearman's r = 0.36, p = 2.2^{-16}), as well as between PRS-ch score for the favorite environment and the PRS-ch score for the schoolyard (Spearman's r = 0.38, p = 2.2^{-16}).

No significant differences were found between the PRS-ch scores of different favorite natural places (Fig. 5).

However, a slightly higher value in the PRS-ch was found for the group of children who declared reaching the natural places only to play, compared with the group of children who go there to play sports or other structured activities: the mean PRS-ch was respectively 3.46 ± 0.54 for the former and 3.37 ± 0.55 for the latter. An increase in the visit frequency does not correspond to an increase in the PRS scores.

Discussion and conclusions

Recognizing the multifaceted significance of Nature in upholding and enhancing human life (Costanza 2000, Díaz et al. 2015, MEA 2005), scientists and policymakers are intensively seeking strategies to safeguard and augment Nature conservation and achieve sustainable utilization of natural resources and the associated ecosystem services (Lokhorst et al. 2014).

A powerful way to ensure a future in which people are aware of the importance of Nature, and thus are willing to conserve it, could find its basis in enhancing since early childhood a strong connectedness to Nature and the personal ability to perceive restorativeness values in the nearby natural spaces. Indeed, it has been reported that adult individuals possessing a heightened sense of affiliation with Nature avoid behaviors harmful to the environment and exhibit a greater willingness to actively participate in pro-environmental actions (Liu et al. 2019). Given that today's children will become the citizens and the decision-makers of the future, nurturing their sense of connectedness to Nature with the goal of empowering them to find restoration and emotional affiliation in natural contexts (Hartig et al. 1991,Berto et al. 2018) becomes a precursor to the youths' willingness to engage with, appreciate, and respect such settings (Lokhorst et al. 2014, Sella et al. 2023, Tang et al. 2015).

Remarkably, the seeds of sustainable behavior can be sown in early childhood: as Barrera-Hernández et al. 2020 observed, children more connected to Nature tend to exhibit sustainable behaviors from a young age. But connectedness to Nature and the ability to perceive the restorativeness value of a natural environment result from a complex combination of innate factors and a set of learned rules (Barbiero and Berto 2021). Since the involvement of cognitive processes in approaching Nature in early childhood, it is interesting to investigate whether the environmental characteristics of the residential area,

where children spend the first years of life, are among the factors that can influence children's affiliation with Nature, and eventually foster the willingness to engage in pro-environmental behaviors later in adulthood.

This study represents the first scientific multidisciplinary work dwelling on children's connectedness to Nature and assessing the restorativeness values of the residential environments in North-eastern Italy, considering three different Regions. Moreover, it stands for the first attempt to assess the influence on the connectedness to Nature patterns of the naturalness structure of the landscape, to which the participants are exposed since their birth or early childhood. Therefore, it contributes to covering the need to establish empirical and evidence-based recommendations for policymakers and urban planners in the design of cities and nearby areas (Tillmann et al. 2018).

We found in the first place that a different naturalness index value in the residential area in North-eastern Italy was associated with a significant difference in children's connectedness to Nature. In fact, the CNS-ch score results higher where the naturalness of the residential area is higher, whereas, in highly built residential areas, the CNS-ch score testifies for a significantly lower connectedness to Nature.

However, it is interesting to notice that Nature connectedness is not too low in children living in residential areas with average naturalness, dominated by rural landscapes. On the one hand, this confirms the theories according to which children are generally born with a "physiological" affiliation with Nature (Guiney and Oberhauser 2009); on the other hand, it also suggests that even agricultural areas could play a role in molding the biophilic traits of a person in the evolutive age. Although farmlands and croplands do not often guarantee free access and do not ensure the fruition of environmental affordances, outdoor play in a vegetated landscape, even if represented by a rural landscape or by a place dominated by crops, can be helpful in maintaining an acceptable connection to Nature. In this regard, no significant differences have been detected in analyzing the PRS-ch scores by type of preferred natural place, even when comparing fascinating and mysterious mountains, valleys, or riverbanks, with farmlands or urban parks. This may suggest that, provided the child is allowed to play and explore, it is probably enough for the child to have a slightly higher level of naturalness compared to the built environment to benefit from the feeling of "being-away" and all the related traits that result in a more pleasant experience in a natural setting. Such a hypothesis, although deserving of further investigations on Italian children, is in line with the Affordance Theory in Outdoor Play (Waller et al. 2017) and confirms the findings of other authors who reported that outdoor recreation opportunities are still valuable for restoration, even in non-ideal settings (Parry and Gollob 2018, Van den Berg et al. 2014).

Nevertheless, it must be remarked that, in our study, PRS-ch score trend in the four groups living in areas with different levels of naturalness is similar to the respective CNS-ch score trend. This suggests that a low naturalness of the residential area, characterized by less availability of deeply restorative natural settings, may affect the personal connectedness to Nature and the feeling of well-being in a natural setting.

Our study also confirmed that children are inherently capable of perceiving the difference in the restorativeness potential of a natural environment if compared with a built environment, in accordance with previous literature (Astell-Burt et al. 2014, Barbiero and Berto 2021, Barbiero et al. 2014, Berto et al. 2018, Nilsson et al. 2011, Shu and Ma 2018), as testified by the comparison between the PRS-ch scores in natural places to the PRS-ch scores for the schoolyard. However, the group "high" presented the largest gap between the PRS-ch score assigned to the natural place and the PRS-ch score assigned to the schoolyard. This result may suggest that their greater experience in observing and frequenting natural environments, granted by living in high-naturalness residential areas, probably makes them more competent in distinguishing between "truly natural" and semi-natural or artificial environments. Hard to say if the capability to distinguish between different naturalness levels can also shape the future attitude towards sustainable behaviors, therefore we suggest that this could be a good topic deserving further research.

An additional result to reflect on is that children living in areas with low and average naturalness mention more frequently, as favorite natural place, locations among places that stand outside the 10 km buffer around their place of residence and even outside of their municipality. Conversely, children living in high naturalness areas and coastal areas selected places within their municipality, or in very close proximity. Such a result is of particular significance if considering that one of the ways we can foster children's connectedness to Nature and, therefore, indirectly invest in their eventual willingness to assume an environmentally friendly lifestyle in their adulthood, is to improve the viewability, availability, and accessibility of Nature for them.

If confirmations are needed to the intuition that the availability of natural spaces in residential neighborhoods is essential, especially from the point of view of a child whose possibility to engage in frequent trips is limited and develops only at a limited distance from home or from school, almost half of the group of participants in this study declared that their favorite environment is represented by semi-natural environments, namely parks and gardens, a result comparable to that recorded by adults in similar conditions (Barbiero et al. 2023). Of course, family habits might come into play in this (as previously argued also by Tomasso and Chen 2022), but in light of our results, it turns out that accessibility and viewability of genuine natural spaces serve as a compelling factor deserving attention from urban planners, particularly within the context of Northern Italy, which boasts the highest land consumption rate in the country.

In the context of research on natural environments and their benefits to humans, this attempt to couple the physical characteristics of an inhabited place and the results of the inhabitants' psychometric scales proved to be a promising approach to bolstering the body of empirical evidence that demonstrates how natural ecosystems are capable of providing mental health benefits to humans, in a crucial but hitherto underexplored set of ecosystem services (Bratman et al. 2019).

It's important to note that we observed no predictive relationship between an increase in the declared frequency of visits to natural environments and the CNS-ch or PRS-ch scores. This finding aligns with other studies suggesting that, in order to derive the

psychophysiological benefits from increased enjoyment in natural settings and a stronger connection to Nature, children in the developmental age require not only the experience of Nature itself but also the presence of a more experienced guide, with whom they have a personal relationship (King et al. 2003). In this regard, it is noteworthy to notice that the schoolyards always resulted in less restorative potential than natural places, even in the case where the mentioned natural place was mostly frequented to play sports or other activities with rules, which is supposed to prevent free exploration of the place by children.

Given that children spend a significant portion of their daily time in the schoolyard under the guidance of teacher, with whom they establish an educational bond, and considering the existing body of research highlighting the positive outcomes associated with greener schoolyards (Luís et al. 2020, van Dijk-Wesselius et al. 2018) and of biophilic designed classrooms (Barbiero et al. 2021), it could be advisable to make these educational spaces “greener and richer” for the benefit of children. Although the connectedness to Nature may still be influenced by family habits or cultural factors (Teixeira et al. 2023, Wu et al. 2023), the incorporation in the schoolyards of more natural elements, with which the teacher can be made familiar through proper training (Anđić and Šuperina 2021, Barrable and Booth 2020, Ernst and Theimer 2011), not only helps children in having a quality break during school hours but could also make a huge difference in fostering the Nature connectedness of children, nurturing their ability to find relief and restoration also in other natural settings. This becomes of particular relevance in areas characterized by low naturalness, where children lack access and views of green or blue landscapes in the immediate surroundings.

Far to be conclusive, this study suggests also that further research is needed to investigate the accessibility of genuine natural environments for children. In fact, the favorite places where the children participating in this study reported spending their spare time were, in most cases, parks, gardens, and beaches. Such places are easily accessible but present a very limited degree of wilderness and mystery. We must therefore ask if the place declared as the preferred one is really the most favorite one, or whether the choice is strictly related to the places where children have the easiest chance to be admitted or accompanied by parents and relatives. In other words, it is legit to ask whether children, if placed in conditions that empower them to choose their favorite place among the whole catalog of ecosystems, would express the same choice or would instead prefer an environment with different features.

Since our study highlighted that a higher naturalness in the residential area is significantly associated with a higher connectedness to Nature and to a likely higher capability to appreciate natural environments, we conclude by suggesting that, in order to foster both today’s well-being and future sustainability, decision-makers should consider a comprehensive approach encompassing the evaluation, enhancement, and ongoing monitoring of the naturalness within residential areas. This approach, coupled with the enrichment of school environments and teacher training, holds the potential to yield immediate short-term benefits, offering children residing in low naturalness, heavily urbanized residential zones more restorative spaces that rekindle their bond with nature and foster their cognitive development (Bijnens et al. 2020, Van Aart et al. 2018).

Such a multifaceted strategy may enhance children's connectedness to Nature and holds the potential to extend its impact over the long term, by cultivating their capacity to engage, find restoration, and thrive in natural environments through the simple decisions of providing more genuine natural areas and the guidance of experienced educators, skilled in nurturing curiosity and ensuring safety. This way, a resilient framework emerges, leveraging heightened connectedness to Nature to shape a disposition for respectful and protective behaviors towards ecosystems, their irreplaceable services, and their non-human inhabitants.

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Author contributions

Authors' contribution according to the CREDIT taxonomy:

Conceptualization: A.S., C.T., G.B., F.P.; Data curation, formal analysis, investigation: A.S., C.T.; Methodology: A.S., C.T., G.B., F.P.; Software A.S.; Supervision and validation: G.B., F.P.; Writing – original draft: A.S.; writing – review and editing: A.S., C.T., G.B., F.P.

Conflicts of interest

The authors have declared that no competing interests exist.

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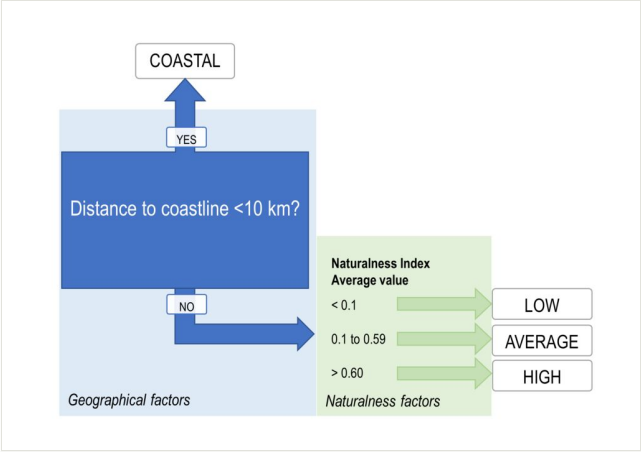

Figure 1.

Classification approach implemented for grouping residential areas into 4 classes.

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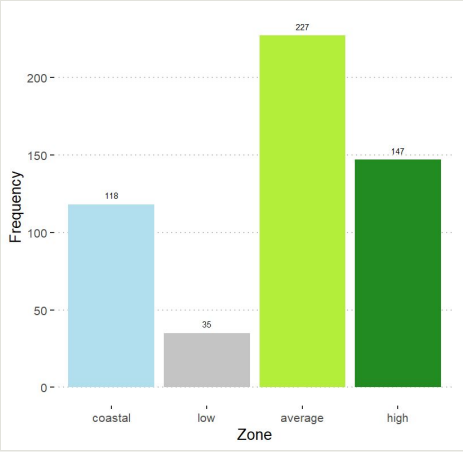

Figure 2.

Number of participants per residential area class

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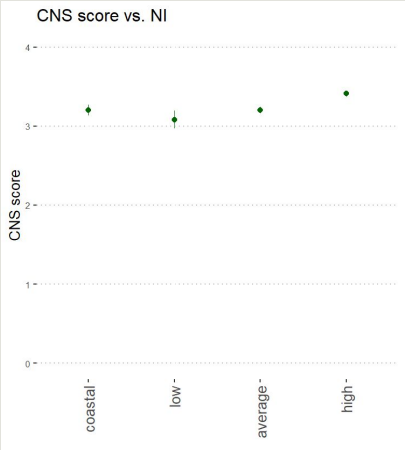

Figure 3.

Scores of the CNS-ch scale in the four groups of participants, grouped according to naturalness index of the residential area. The dot represents the mean CNS-ch value of the group, the bar represents the standard error.

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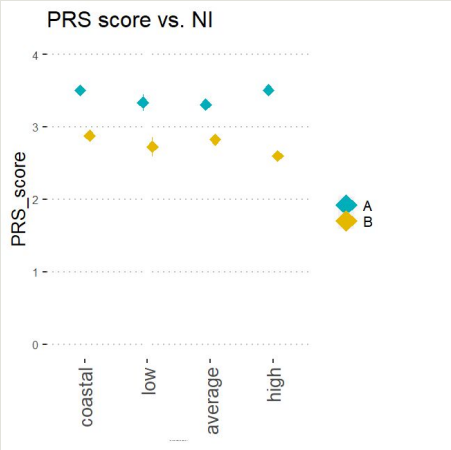

Figure 4.

Restorativeness values of the preferred natural place (A, turquoise) and the schoolyard (B, dark yellow dots) as perceived in the different groups. The dot represents the mean values, and the bar represents the standard error.

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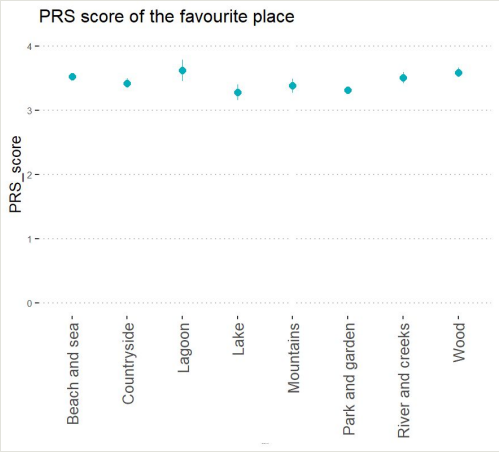

Figure 5.

Perceived restorativeness values of different favorite natural places mentioned by the interviewed children. The dot stands for the mean PRS score for each place, and he bar for the standard error.

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Table 1.

Natural environments indicated by the participants and relative frequency of mentioning.

Natural environment	**Frequency (%)**
Park and gardens	46.5
Beach and sea	22.2
Countryside	10.7
Woodland	8.2
Mountains	4.8
River and creeks	4.6
Lake	2.1
Lagoon	0.8