Position Paper

Affective Ecology as development of biophilia hypothesis

Giuseppe Barbiero

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Correspondence: g.barbiero@univda.it

Extended author information available at the end of the article

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Abstract. *Affective ecology is the branch of ecology that deals with the cognitive and emotional relationships that humanity and Gaia establish between themselves. In the last ten years, affective ecology has engaged above all in the experimental verification of the biophilia hypothesis and in defining the two fundamental constructs of biophilia: fascination and affiliation. The definition of such constructs allows us to estimate more precisely the psychological effects of biophilia. Fascination for Nature triggers the restoration of cognitive skills after mental fatigue, while the feeling of affiliation for Nature has a stress-reducing effect. The experimental outcomes allow us to design an ideal biophilic environment, able to stimulate fascination and affiliation for Nature. A biophilic environment is the ideal environment for developing naturalist intelligence. The future perspectives of affective ecology concern the search for high biophilic quality environments, which can be both inner environments, as in the case of Green Mindfulness in ecopsychology, and outer environments as in the case of Biophilic Design in architecture.*

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1. Introduction

My love for Nature[1] is not rational. I am attracted to life. It was obvious to me to choose Life Sciences at university. The knowledge of biology allowed me to love Nature even more. However, as a university student I had great difficulty accepting a science that rejected my love for Nature. This rejection by the mainstream aroused in me a desire to integrate my emotional side into science. This is how *affective ecology* was born.

It was not an easy path. But on my journey, I met many other scientists "on the road", including researchers from the L-TER Network (Long-Term Ecological Research Network) who reflect on topics and goals of science and explore new ways of doing research and communicating ecology. The questions posed by researchers of the L-TER Network are at the basis of research in affective

[1] In this article I will use the word "Nature" with a capital "N" to indicate the biosphere and abiotic matrices (soil, air, water) where it thrives. In addition to being a gesture of respect towards an entity that transcends us as human beings, this will avoid confusion with "nature" (with the lowercase "n") understood as the intrinsic quality of a certain creature or a certain phenomenon.

ecology. Can we integrate science with other forms of description of the world? Are we aware of the role that emotions play in building bonds with Nature? The meeting at Feudozzo, Italy (12-16 September 2019) organized by the Italy L-TER Network was a moment of reflection on the last ten years of research. It provided a stimulus to look for new ways of doing science that consider emotions that Nature gives us, respecting the tradition that goes from Darwin (1872) to the present day (Longo, 2014).

2. Affective ecology ten years ago

Affective ecology is ten years old. The first time I spoke publicly about "affective ecology" was at the workshop «I linguaggi della sostenibilità. Il museo scientifico per un dialogo nuovo con, dentro e a proposito della Natura»[2], which took place from 24 to 27 February 2011 at the Civic Museum of Zoology in Rome and at Villa Adriana (Tivoli, Rome). For ten years I have dedicated myself to this branch of ecology, which deals with the emotional bond that ties up humanity to Nature (Barbiero, 2017). I have studied (Colucci-Gray et al., 2006), undertaken research (Barbiero, 2009), conducted experimental tests (Barbiero 2011; 2014) and suggested hypothesis (Barbiero and Berto, 2021). After ten years, perhaps the time has come to take stock of the situation, starting from the two scientific hypotheses on which the affective ecology is founded: the Gaia hypothesis and the biophilia hypothesis. Over the span of ten years these two hypotheses have evolved, enriched with data, their explanatory power has been clarified and connected to other theories and models, such as the Stress Recovery Theory (Ulrich, 1991) the Attention Restoration Theory (Kaplan, 1995) and naturalistic intelligence in Multiple Intelligence Theory (Gardner, 1999).

2.1 The Gaia hypothesis

Gaia is the system of living organisms (biosphere) interacting with air (atmosphere), water (hydrosphere) and soil (pedosphere). Gaia is the biosphere and the matrices in which it thrives (Volk, 1997, pp. 99-124) that evolve over time (Lovelock, 1988). Although Gaia and Nature are often used interchangeably, Gaia does not coincide with Nature. Nature emerges from the coupling of the metabolism of living organisms with the outer environment, which *continually* reshapes the habitability conditions of Gaia (Lenton, Dutreuil and Latour, 2020). Nature is Gaia at a certain time in the history of life on the planet. Nature belongs to Gaia

[2] "Sustainability languages. The scientific museum for a new dialogue with, within and about Nature"

as a frame belongs to a film. The history of Gaia is full of events that reduced the size of the biosphere. In the Phanerozoic alone, there are at least five major mass extinction events - not surprisingly called transitions - from which Gaia has always recovered, even if the Nature of that era has completely disappeared. This distinction helps us to understand that *Homo sapiens* can modify the environment and harm Nature as we know it, but it cannot harm Gaia. For example, Gaia has not always been hospitable to aerobic organisms. Gaia today (Nature during Cenozoic) is hospitable to respirators, but originally (Nature during Archean) was not. In the future, Gaia may no longer be hospitable to aerobic organisms. Gaia is Gaia. Nature is the epiphany of Gaia at a certain moment in her evolutionary history.

Life on Earth has been flourishing continuously and seamlessly for 3,800 million years. Since liquid water is essential for life, we can deduce that in all this time the planet's mean surface temperature has always remained between 0° C and 100° C, which, at a surface pressure of about 1 bar, has allowed the presence of liquid water (Schwartzman, 1999). And this happened in a situation of progressive increase in the radiant power of the Sun (Watson and Lovelock, 1983). Geophysiology, literally the 'Gaia physiology', was born from this simple empirical datum. The experience gained by this young science has been essential in evaluating the possibility of life in exoplanets, that is, the planets that orbit outside the solar system and about which today we can have information with the aid of new telescopes (Schwieterman, 2018).

A frequent mistake is to think of Gaia as a living organism like us. Gaia is a living organism, but *sui generis*. In fact, living organisms are thermodynamically open systems, that is, they are crossed by energy flows and are characterized by exchanges of matter. Gaia, on the other hand, is a thermodynamically *closed* system and is crossed by energy flows (mainly the Sun) but cannot exchange matter with the surrounding environment. This forces Gaia's creatures to continuously recycle matter and this characteristic of Gaia has become a part of the great debate on sustainability (Volk, 1997). In the long term, only a system able to use the energy flows that cross the planet (renewable energy sources) and recirculating matter (recyclable materials) is sustainable, thus influencing many techno-industrial fields (Schlesinger and Bernhardt, 2013).

We still do not know many details on how Gaia works. However, we know the main laws that determine its general functioning (Kump, Kasting, and Crane, 2011). The study of Gaia and its laws proposes once again the theme of contemplation of Mother Earth, a powerful archetype able to inspire human behaviour (Liu et al., 2019). Perhaps today we no longer need to anthropomorphize Gaia in

Mother Earth. Perhaps today contemplation of it is enough, as in the case of the Apollo 8 astronauts who in December 1968 took the first photograph of the Earth from space (**Figure 1)**.

Figure 1. The first photograph of the Earth with a view from space taken by the Apollo 8 crew (Frank Borman, James Lovell and William Anders) in December 1968.

The beauty of this blue jewel, immersed in dark and cold space, is now an icon of our era, whose psychic function for many is no different from the one that traditional icons have for Orthodox Christian monks. For some scientists, Gaia's iconic function continues to be a problem. For others it is becoming a resource for psychological (Fellows, 2019) and spiritual (Christie, 2013) research, on a track already traced by ecopsychology (Roszak, Gomes, and Kanner, 1995) and by the ecology of mind (Bateson, 1972). To me Gaia has been a profound and primitive psychological experience (Barbiero, Gasparotti, and Baruzzi, 2015).

In the same way as ten years ago, I continue to think that Gaia is a resource for biophilia and the development of naturalist intelligence (Barbiero, 2011).

2.2. The Biophilia hypothesis

Biophilia is our emotional bond with life. Biophilia is the combination of two Greek words: love (*philia*) for life (*bio*). It was coined twice, independently, by the German psychologist Erich Fromm (1964) and the American biologist Edward O. Wilson (1984). Fromm uses the term biophilia to describe the *psychological* orientation to be attracted to all that is alive and vital (Fromm, 1964). Wilson uses the term biophilia to describe the *evolutionarily* adaptive trait of being attracted to what is alive and vital (Wilson, 1984). Biophilia is innate, but it is not instinctive. Being innate, biophilia is the manifestation of a genomic structure that has overcome the screening of natural selection and can therefore be studied from an evolutionary (phylogenetic) perspective. However, not being instinctive, biophilia must be stimulated in order to develop its full potential and can therefore be studied from a psycho-pedagogical (ontogenetic) perspective. The two perspectives, phylogenetic and ontogenetic, complement each other and offer a theoretical horizon for the experimental verification of the biophilia hypothesis (Barbiero and Berto, 2021).

3. Theoretical biophilia

Biophilia is an innate predisposition to learn from the living world. In other words, we are genetically predisposed to interaction with Nature. Predispositions to learn are very important for *Homo sapiens*. Babies are extraordinarily inept at birth and spend a very long inculturation phase, during which they learn the necessary behaviours to survive. Being quick and effective in learning confers an evolutionary advantage, which is still rewarded in school systems all over the world. We can consider biophilia a construct of the human temperament that contributes, together with character, to form personality. Temperament represents a series of innate aspects of personality, derived directly from our evolutionary history and not mediated by culture (Cloninger, Svrakic, and Przybeck, 1993). Although some researchers show resistance to fully understanding the evolutionary heritage of biophilia (Joye and van den Berg, 2011; Patuano, 2020). But an honest analysis cannot leave out the reconstruction of human evolutionary history. Studying biophilia in its phylogenetic (evolutionary) traits will help us better understand biophilia in its ontogenetic (psychological) traits.

3.1 Biophilia phylogeny

Biophilia has been defined as "our innate tendency to focus upon life and life-like forms and, in some instances, to affiliate with them emotionally" (Wilson 2002, p. 132). According to E.O. Wilson, "biophilia is not a single instinct but a complex of learning rules that can be teased apart and analyzed individually. The feelings molded by the learning rules fall along several emotional spectra: from attraction to aversion, from awe to indifference, from peacefulness to fear-driven anxiety" (Wilson, 1993, p. 31). Attraction to Nature is biophilia, aversion to Nature is biophobia (Ulrich, 1993). Over the course of evolution, humanity has had to face the hostile forces of wild Nature. The rules of learning biophilia and biophobia are rooted in the genetic heritage of our species in relation to their contribution to improving human efficiency in the search for resources and shelter. Wild environments trigger two basic types of physiological reaction: (1) the 'fight-or-flight' response, which results in hyperactivity of one of the two branches of the autonomic nervous system, usually an over-stimulation of the sympathetic nervous system (Shimuzu and Okabe, 2007), which is related to the concept of biophobia (Ulrich, 1993); and (2) the 'rest-and-digest' response, which manifests itself as the cooperation of the two branches of the autonomic nervous system, with a prevalent influence of the parasympathetic nervous system. The balance of the two branches of the autonomic nervous system ensures a better long-term resilience of the individual (Harvard Medical School, 2018).

Biophilia evolved in the Palaeolithic era. For about 95% of our evolutionary history, humans have survived by adopting the hunter-gatherer lifestyle. Human beings have thus perfected a set of adaptive responses to different wild environments - mainly the savannah (Orians and Heerwagen, 1992) - aimed at recognizing the quality of an environment in terms of resources and shelters. Some environmental preferences are based on innate learning rules derived from the struggle for the survival of our ancestors and today they form the primary and deepest core of our biophilia (Berto et al., 2015). After the invention of agriculture and breeding about 14,000 years ago (Arranz-Otaegui, et al. 2018), most of the human population became progressively sedentary (Tattersal, 2008, pp. 125-164). Shelters became increasingly permanent, and the first villages were formed (Diamond, 1997). Farmers were forced to protect their crops and farm animals from predators present in wildlife, including other humans (Spinney, 2020). The food supplies accumulated in the village could tempt attackers and this led to the need to protect the villages (Spinney, 2021). Neolithic farmers began to distinguish between rural (good) and wild (bad) Nature. The male archetype also changed. To highlight their fitness, young males were increasingly driven to abandon the

'hunter' lifestyle, to take on that of the 'warrior' (Gimbutas, 1989). In the Neolithic period, which covers approximately 5% of humanity's evolutionary history, biophilia was partially adapted to new cultural demands. An example is proxemics. In the Paleolithic period, the bands of *Homo sapiens* were numerically few, and encounters outside one's clan were rare and sporadic. During the Neolithic period, village life needed a level of socialization that required hitherto unknown physical proximity, to which we are still not fully adapted (Larsen et al., 2019). This could explain, for example, why many people look for outdoor spaces in Nature where human presence is rare.

Finally, only in the last 250 years - a period irrelevant from an evolutionary point of view: less than 0.2% of the evolutionary history of humanity - humans have developed their inclination to transform the environment permanently and irreversibly (Crutzen, 2006). During this period, urban agglomerations gradually become larger and more densely populated. Compared to the wild Nature in which humans evolved, the countries and cities now inhabited by 55% of the world population (Worldbank, 2019) are characterized by an increase in population density and a decrease in green spaces (Beatley, 2011). Since biophilia is a predisposition to learn, if natural stimuli are lacking, this tends to atrophy (Wilson, 1993; Clements, 2004).

The biological evolution of humanity took place in the wilderness. Our genetic predisposition to quickly recognize environments rich in resources and suitable for survival, has favoured the psychological preference for such environments, which are perceived as "restorative" (Barbiero, 2011; Barbiero, 2014). Humans may have learned that resource-rich environments are reassuring (biophilic) and can help restore from mental fatigue more than others (Berto, 2014). Furthermore, restoring attention in shorter time spans may have conferred some evolutionary advantage (Kaplan, R. and Kaplan S., 1989, p. 181). From this point of view, the perceived restoration capacity, understood as the (measurable) ability of people to focus on the restorative characteristics of the environment, could be one of the innate learning rules of biophilia (Wilson, 1993). Although the first break of the Neolithic and above all the second break of the Industrial Revolution had a strong influence on inculturation processes, the predisposition to learn from Nature has probably remained the same. But the kind of Nature from which to learn has changed. There are many indications that wilderness has remained in depths of the human psyche (Pinkola Estés, 1992).

3.2 Biophilia ontogeny

E.O. Wilson (2002, p.132) identifies two conditions/constructs that are necessary for biophilia recognition. The first condition is that life has the power to shift the focus (*fascination*). The second condition is that, in certain circumstances, an emotional bond is created with a life form (*affiliation*).

Before going into the merits of the experimental verification of the constructs of love for life (biophilia), it is necessary to clarify that life (the *life*) does not coincide with Nature (*Life*). In the first case, life is the class of property that is common to all living things. Nature (*Life*) is life *plus* the abiotic environment in which it thrives. Nature emerges from the coupling of the metabolism of living organisms with the outer environment, which continually reshapes the habitability conditions of Gaia (Lenton, Dutreuil and Latour, 2020). Gaia's living conditions vary over time. In the Archean, for example, Gaia's Nature was totally unsuitable for the life of plants and animals. It took billions of years before the coupling of the metabolism of living organisms with the outer environment managed to create a Nature where plants and animals could thrive.

Life can thrive in totally artificial environments, such as a zoo or a laboratory. However, the psychic effects are very different. Environmental psychology distinguishes three types of contact: direct, indirect, and symbolic. The *direct* contact with Nature is the encounter with animals and plants in their natural habitat. The *indirect* contact with Nature is the encounter with animals and plants in artificial environments (farms, zoos, botanical gardens). The *symbolic* contact with Nature is the virtual encounter with animals and plants (books, documentaries, videos, audio). In ecological terms, it can be said that *life* corresponds to a biological *community*, Nature (*Life*) to an *ecosystem*. It is therefore possible to reformulate Wilson's definition, in this way: "biophilia is our innate tendency to focus upon Nature and in some instances to affiliate with some of its components emotionally".

This leads to an important question which can only be mentioned here: is there also a *geophilia* alongside *biophilia*? There is no doubt that the abiotic components (for example: the mountain, the sea, the river, the lake) or the atmospheric events (for example: the clear sky, the clouds, the rain) influence our mood and our psychic state. However, we still do not know whether the cognitive effects of biophilia can also be extended to geophilia (Elena Ferrero, personal communication). The hypothesis should certainly be taken into account, considering that historically there are testimonies - such as those of Hildegard of Bingen (Newmann, 1987), of Francis of Assisi (Stratman, 1982; Barbiero, 2016) and, in

more modern times, of Gary Snyder (Chowka, 1977) - attesting that the clear distinction between 'living' and 'non-living' is artificial. In any case, the abiotic environment is also important for another reason. It seems that the same living creature can arouse different emotions if contemplated while it is in its natural abiotic environment or in an artificial environment and the more the artificial environment approaches that of the natural habitat, the more our emotion becomes powerful (Powell and Bullock, 2014).

A careful analysis of the biophilia ontogeny leads to two important considerations. The first consideration is that if Nature exerts its fascination power over the human being, then Nature is active in this relationship, while the human being is passive. Since Nature is an epiphany of Gaia, then Gaia is an active agent on the human psyche. Gaia's metaphor as Mother Earth thus takes on a significant psychological meaning, considering that the Great Mother is considered a fundamental archetype in analytical psychology (Neumann, 2015). The second consideration is that biophilia is innate but not instinctive. It should therefore be stimulated and educated. From an educational psychology point of view, biophilia represents a psychic potential that can be enhanced so that it contributes to the flowering of different forms of intelligence, inter alia naturalist intelligence (Gardner, 1999, pages 48-52). Correlating the stages of cognitive development (Santrock, 2008, pp. 211-216) with the stages of environmental knowledge (Barbiero and Berto, 2016, p. 67) and the latter with the values associated with Nature (Kellert, 2002; Barbiero and Berto, 2016, p. 79) gains importance.

4. Experimental biophilia

In 2011 it was clear that if the biophilia hypothesis had ever had any chance of becoming a reliable theory, then experimental research could very usefully focus on the two constructs prefigured by Wilson (2002): *focus upon* and *affiliation*. Fortunately, environmental psychology had already identified the two biophilia constructs. The construct "focus upon" is called *fascination* and is defined as the "involuntary attention triggered by Nature" (Berto, 2005). The construct of "affiliation" has been defined as the *connectedness to Nature*, sometimes called *relatedness to Nature* (Nisbet, Zelenski, and Murphy, 2009), understood as the "individual emotional experience with Nature" (Mayer and Frantz, 2004). The important (and decisive) fact for our experimental verification is that both *fascination* and *connectedness to Nature* are constructs measurable with appropriate psychometric scales, the 'Perceived Restoration Scale' (PRS; Hartig et al., 1996) and the 'Connectedness to Nature Scale' (CNS, Mayer, and Frantz, 2004), respectively. From

here on 'fascination' will be used to indicate the involuntary attention triggered by Nature and 'affiliation' to indicate the connectedness to Nature (**Table 1**).

Biophilia	*Environmental Psychology*	*Psychometric scales*
Focus upon	**Fascination**	PRS - Perceived Restorativeness Scale (Hartig et al. 1996)
Affiliation	Connectedness to Nature	CNS - Connectedness to Nature Scale (Mayer and Frantz, 2004)

Table 1. Comparison between the biophilic constructs proposed by E.O. Wilson (2002, p.132) and the corresponding constructs identified in environmental psychology, with the related psychometric scales. The name chosen for each construct in this article is in bold.

4.1 Fascination, and the Attention Restoration Theory

Stephen and Rachel Kaplan devoted their scientific career to studying the mechanisms of restoration of direct and sustained attention after mental fatigue. They identified four constructs that promote the restoration of direct and sustained attention: 1) *being away*; 2) *fascination*; 3) *extent*; 4) *compatibility* (Kaplan, 1995). Particularly interesting for my studies was the second construct: *fascination*. Fascination triggers involuntary attention, an effortless form of attention, and allows direct attention to restore. In a series of experimental tests, Berto and I measured the time spans of restoration of the direct and sustained attention of the children after a mental effort in different environments and situations. We found that children, if they were left free to play in the woods, had shorter attention restoration times than children left free to play in the school yard. Furthermore, we also found that children perceived the restorative qualities of an environment and preferred more restorative environments (Berto, et al., 2015b). This series of experimental observations allowed us to define it as the *Standard of Étroubles*, from the name of the small village in the Valle d'Aosta (Italy) where the outdoor observations were conducted (Barbiero and Berto, 2016, pp. 196-200). The *Standard of Étroubles* establishes a ranking in the restorative power of environments. In general, after mental effort, a restorative process is more effective in a natural environment (woods) than in an artificial environment (classroom). With the same environment (classroom), a restorative process is more effective if the child can use "mindful silence" (Berto and Barbiero, 2014). Subsequent experimental observations then confirmed the *Standard of Étroubles*, noting how Nature

exercises a restorative fascination of cognitive faculties (Kuo, Browning, and Penner, 2018; Chang et al., 2020) and that fascination is closely related to environmental preferences (Wang et al. 2019).

4.2 Affiliation, and the Stress Recovery Theory

The second construct of biophilia is *affiliation* (Wilson, 2002, p. 132). Defining the feeling of affiliation is difficult. The root of the feeling of affiliation seems to originate in "our capacity to experience empathy with other creatures and respond to their concerns as our own" (Goodenough 1998, p. 127). In the first instance, affiliation could correspond to the ability of creating an emotional bond with life. Affiliation could be the equivalent of the construct "connectedness to Nature" (Mayer and Frantz, 2004). In this case, the sense of unity of the word 'affiliation' would reveal all the psychic potential of the relationship between Human and Gaia. The etymological origin of the word 'affiliation' is interesting. It derives from the Latin *ad filius* and indicates a process of adoption. 'Affiliation' literally means "feeling like a son". Therefore, thinking of a parent becomes natural. In this case Mother Earth (Gaia) or more likely a limited epiphany thereof. However, affiliation is not automatic. While fascination is a passive and involuntary phenomenon, affiliation requires a willingness to desire a relationship with another non-human creature. Humans like establishing an emotional relationship with a pet because this type of affiliation reduces stress. In his famous *Why Zebras Don't Get the Ulcers* Robert Sapolsky summarized the crucial psychological variables that modulate the intensity of psychological stressors in primates: (1) outbursts of frustration; (2) social support; (3) predictability; (4) control (Sapolsky, 2004, pp. 234-248). Interestingly, a pet is an excellent modulator of all four psychological stressors. Under certain conditions Nature (*rural* Nature) can offer help reduce stress. It is therefore reasonable to assume that a higher connectedness to Nature tends to favour faster recovery from stress, as Roger Ulrich has empirically pointed out. Initially, Ulrich showed that simple eye contact with Nature had the effect of speeding up recovery from a state of stress (Ulrich, 1984). Ulrich later extended this observation to other sensory functions in his Stress Recovery Theory (Ulrich, 1983; Ulrich et al. 1991).

4.3 Fascination is a 'state', Affiliation is a 'trait'

In the experimental observations that led us to the *Standard of Étroubles*, we repeatedly found that *fascination* - measured as the restorative capacity perceived by children - increased during a day spent in a wooded environment. The feeling of affiliation, however - measured as a connectedness to Nature - remained

unchanged (Berto, Pasini and Barbiero, 2015). This seems reasonable because fascination is a relatively immediate response to a natural environment. Kuo, Browning, and Penner (2018) offer a demonstration which, in a series of experimental observations, managed to trigger a restorative process, evocatively defined as "refuelling students in flight". This suggests that *fascination* is a 'state' that varies in relation to the characteristics of the environment, to its restorative qualities (Purcell et al., 2001; Berto, 2007). *Affiliation* instead seems to be a 'trait' of the temperament: one feels connected to Nature regardless of the environment where we are (Mayer and Frantz, 2004). *Affiliation* can vary, but requires more time, a frequent and direct exposure with Nature (Berto et al., 2018) and a specific educational project aimed at building naturalist intelligence (Meyer, 1997; Nolen, 2003).

5. Building a Naturalist intelligence

Biophilia is a predisposition to learn based on the constructs of fascination and affiliation. Rapid and effective learning offers an evolutionary advantage, and it is therefore probable that fascination and affiliation have consolidated over time as a psychobiological potential of naturalist intelligence.

5.1 The 'environmental concerned' personality

Howard Gardner defined naturalist intelligence as the ability of "recognizing flora and fauna, making other consequent distinctions in the natural world and using this ability productively" (Gardner, 1995). Gardner originally identified seven intelligences in his Multiple Intelligence Theory (1983). Only fifteen years later he recognized, and subsequently integrated, naturalist intelligence into his theory (Gardner, 1999). Naturalist intelligence seems easy to understand intuitively. However, it is a rather complex construct. Although it consists of the ability of processing information and spreading environmental knowledge without including any emotional capacity (Gardner and Moran, 2006), Gardner admits that naturalist intelligence is an expression of "what Wilson has termed «biophilia»". According to Gardner "the naturalist intelligence comfortable in the world of organisms and may well possess the talent of caring for, taming, or interacting subtly with various living creatures" (Gardner 1999, p. 49). The ability to "care for" and to "interact subtly" are manifestations of an affective and emotional connectedness to Nature and correspond to Wilson's affiliation. Basically, naturalist intelligence feeds the affiliation which, in turn, strengthens the desire

to know Nature and prepares for new experiences, in a virtuous experience-reflection-experience circuit (Kahn, 1997; Gill, 2014; Adams and Savahl, 2017; Tillmann et al., 2018). Gardner points out that "biologists' biographies routinely document an early *fascination* with plants and animals" (Gardner, 1999, p. 50, my italics). Although no evidence is available in the literature for a relationship between attention restoration and naturalist intelligence, biologists' biographies show that an "early fascination" (fundamental for restoration) is crucial for the development of naturalist intelligence. Finally, Gardner notes that the biographies of famous naturalists - such as, for example, Rachel Carson (1962) or E.O. Wilson (1994) - show that a mature naturalist intelligence tends to be sensitive to environmental conservation by strengthening the individual's pro-environmental behaviour.

Berto and I proposed a model that correlated affiliation (measured with "connectedness to Nature"), fascination (measured as "perceived restoration"), environmental knowledge and commitment to the environment. The model was designed to highlight how pro-environmental behaviour could be influenced by the cognitive and affective constructs of biophilia (Berto and Barbiero, 2017a). Below we propose a review of that model (**Figure 2**) in which environmental knowledge is replaced by naturalistic intelligence and fascination is also proposed as a motivator for pro-environmental behaviour.

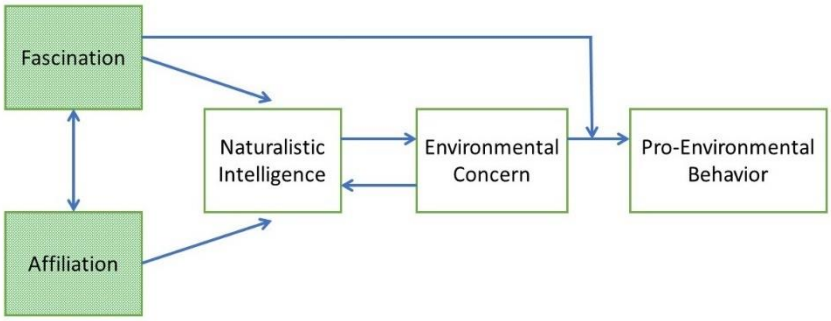

Figure 2. Model that relates the two constructs of biophilia (in green) – fascination and affiliation – and naturalist intelligence, environmental concern, and pro-environmental behaviour (Barbiero and Berto, 2018).

5.2 The biophilic qualities of the environment

Cultivating intelligence always requires an appropriate environment. This is especially true for naturalist intelligence, which needs a natural environment stimulating biophilia. It is therefore important to identify the qualities that stimulate biophilia. The term "biophilic qualities" refers to the set of physical, aesthetic, and functional characteristics of an environment which are perceived as restorative. We know that the restorative power of an environment corresponds to fascination, one of the fundamental constructs of biophilia. To this end, Berto and I have developed an instrument, *Biophilic Quality Index* (BQI, Berto and Barbiero, 2017b), to synthetically measure the characteristics of an environment according to the restorative factors described in Attention Restoration Theory (Kaplan, 1995). When we tried to investigate whether there was a correlation between fascination and affiliation, we discovered that the correlation did exist and it was mediated by the "biophilic quality" of the environment. We compared four different natural parks to which were assigned two levels of "biophilic quality" (high or low) based on two factors: the distance from the subject's residence (*being away*) and the restorative potential (*fascination*) evaluated with the *Recreation Opportunity Spectrum*, a quality assessment system for natural parks (Clark and Stankey, 1979). We evaluated the affiliation with Nature (with the CNS) and the fascination (with the PRS) of each visitor to each park. The study showed that when the environment is characterized by a low biophilic quality (for example, an urban natural park) and the visitor has a low level of affiliation with Nature, then the environment is perceived as highly restorative. On the contrary, when the visitor has a high level of affiliation with Nature, then the environment characterized by a low biophilic quality is perceived as not very restorative. Only when the environment is characterized by a high biophilic quality (for example, a wild natural park), subjects with a high level of affiliation with Nature can fully perceive the restorative potential of the wild environment. The subject with high affiliation seems to have a greater ability to discern restorative environments. Feeling strongly connected with Nature (affiliation) makes you more sensitive to the restorative power (fascination) of an environment and allows you to recognize environments with the best biophilic qualities. A more efficient ability to recognize the most restorative environments could represent an important evolutionary advantage. This experimental observation further reinforces the idea of the evolutionary origin of biophilia.

5.3 Which Nature?

Being in Nature makes you feel good (White et al. 2019). But Nature is not the same everywhere. Some types of Nature seem to stimulate biophilia better than others and are preferred. Other types of Nature seem to stimulate biophobia and are avoided. In general, people seem to be more fascinated by the type of Nature that corresponds to their feeling of affiliation. As a first approximation it can be observed that people with a strong feeling of affiliation are more easily fascinated by wild Nature, while those with a more modest feeling of affiliation tend to prefer rural Nature (Berto et al. 2018). Since rural Nature is usually characterized by a higher population density than wild Nature, it is possible to propose a classification of Nature based on the population density of the areas covered by our studies (**Table 2**).

Type of Nature	**Density (inhabitants/Km²)**	**Examples (inhabitants/Km²)**
Urban	More than 500	Aosta (1,587.7) Pont-Saint-Martin (539.0)
Rural	From 500 to 10	Saint Vincent (222,8) Étroubles (12.5)
Semi-wild	From 10 to 2	Rhêmes-Saint-Georges (4.7) Gressoney-La-Trinité (4.5)
Wilderness	Less than 2	Valsavarenche (1.2) Rhêmes-Notre-Dame (0.9)

Table 2. Classification of Nature based on the population densities of different administrative units. The examples in the last column on the right refer to some settlements in the Valle d'Aosta, Italy.

A first research track could verify if people with high affiliation with Nature really tend to prefer wild Nature, while people with lower affiliation tend to prefer rural Nature. If the observation is confirmed, then we can ask ourselves: why does an affiliation with higher Nature correspond to a desire for a wilder Nature? The answer may once again be evolutionary. Affiliation is a 'trait' of the temperament that has evolved and was successful in the Palaeolithic, when only wild Nature existed. However, the human evolutionary experience with Nature had two breaking moments: the Palaeolithic-Neolithic passage and the Neolithic-Urban passage. An adaptation that has been successful in the relationship with wild Nature may no longer be as effective when the prevailing environment is rural.

The biophilic trait may have entered an adaptation and exaptation cycle (Gould and Vrba, 1982) to develop new forms of adaptation and promote its better use based on the demands of the new Neolithic lifestyle. Indeed, when rural Nature appears, wild Nature becomes an 'enemy', to be removed and rejected. Affiliate feelings are therefore reserved only for pets. An example is our ambiguous relationship with the species *Canis lupus*. Wolf is the wild version of *C. lupus* and it was the only known form in the Palaeolithic. The Palaeolithic Human feared the wolf and admired it, so much so that he made it his own archetype. A Neolithic Human continued to fear the wolf, but rejected it, while protecting the dog, the rural variant of *C. lupus*, because it was useful for his new lifestyle.

Palaeolithic humans lived in small nomadic communities in large areas, population density was low, and encounters were rare. Neolithic humans lived in stable villages in narrower areas, where population density was higher, and encounters were more frequent. The affiliation with wild Nature could be a temperament trait with a pleiotropic effect on the perception of a restorative environment and on the perception of the population density of a certain area. For example, the usual landscape for a Palaeolithic human being was devoid of visible centres of human aggregation. It is therefore presumable that restorative environment was perceived without such centres. For a Neolithic human being, on the other hand, landscape was characterized by visible centres of human aggregation, which in fact served as a landmark and which often constituted the final goal of a transfer. Therefore, the restorative environment was presumably perceived with such centres.

The pleiotropic effect appears more evident in the passage from Neolithic to Urban, from countryside to city. In an urban environment, usual landscape is apparently devoid of Nature. Nature is almost invisible and cannot support restorative processes. Lifestyle changes, naturalist intelligence is no longer necessary, and the feeling of affiliation fades further way, without ever becoming completely extinct. If this hypothesis is correct, three fundamental phylogenetic experiences can be identified (**Table 3**): Palaeolithic, Neolithic and Urban. To which three types of affiliation with Nature, respectively the paleo-type, the neotype, and the urban-type, correspond.

Phylogenetic experience	Type of privileged Nature	Characteristics of the type of affiliation
Palaeolithic	Wild	Connectedness to wild Nature. Circadian rhythm of life. Sober lifestyle and essential nutrition. Preference (and fear) for plants and wild animals.
Neolithic	Rural	Connectedness to rural Nature. Seasonal rhythm of life. Natural lifestyle and organic nutrition. Preference (and no fear) for plants and pets.
Urban	Invisible	Disconnection from Nature. Urban life rhythm. Chemical and circus lifestyle (Galtung, 1984) and feeding with industrially manipulated food. No preference for plants or animals.

Table 3. Phylogenetic experiences of affiliation, type of privileged Nature and fundamental characteristics of affiliation of the corresponding psychological type. See text for details.

The *paleo-type* corresponds to the Palaeolithic human being who knew only wild Nature. He needed to oppose Nature's hostile forces. He was afraid of Nature and in his daily search for resources he prepared himself for fight-or-flight. However, in everyday life these stressful situations happened rather rarely. Still today, hunter-gatherer communities spend no more than 2-3 hours a day researching and preparing food (Sahlins, 2017). Our ancestors therefore had long moments of rest-and-digest, which lead instead to enjoying Nature and the feeling of affiliation (Moreton, Arena, and Tiliopoulos, 2019). Probably rest-and-digest immersed in wild Nature constitutes the phylogenetically oldest nucleus of our biophilia.

The *neo-type* corresponds to the Neolithic human being, who distinguished rural Nature from wild Nature. The wild Nature that obliges fight-or-flight is removed and circumscribed, favouring instead rural Nature, where growing and breeding in a protected environment was possible. Although it takes a lot of time and work, growing plants and rearing pets can be seen as a kind of attempt to prolong the rest-and-digest.

Finally, the *urban-type* is the human being who lives in the cities, where even rural Nature is removed, and where the presence of animals only for affective support is allowed, especially dogs and cats. Nature becomes 'invisible' to the naked eye. Nature is always present as microorganisms, but this Nature can apparently be ignored, unless it becomes particularly aggressive.

All three phylogenetic experiences of affiliation are probably present and settled in each human being. However, since affiliation is a 'trait' of the temperament, it is possible to hypothesize a prevalent experience that gives rise to a specific relationship with Nature. If this hypothesis is correct, then each type of

affiliation corresponds to a prevalent behaviour, which refers to the type of evolutionary experience. Let us take nutrition, for example. In the Palaeolithic, humans had a very sober lifestyle compared to today's standards, with a very frugal type of diet and we can assume that the paleo-type continued to prefer this type of feeding. In the Neolithic, the lifestyle became more lavish. The abundance of food and the continuity of supplies allowed to take greater care of the food. Thus, food traditions were born. Such traditions today are structured in 'natural' feeding patterns (organic, macrobiotic, vegan, etc.), which we can assume are those favoured by the neo-type. In an urban environment, contact with Nature is lost, lifestyle conforms to very intense urban rhythms (Patuano, 2020), which tend to point towards what Johan Galtung calls "chemical and circus lifestyle", where natural stimuli are replaced by chemical stimuli (lights, sounds, alcohol, drugs) or by collective circus moments (social or sporting events) which have an anti-stress function (Galtung, 1984). Diet also suffers from this. So, we can assume that the *urban-type* is more willing to accept manipulated or fast/junk food.

6. Future Perspectives: high quality biophilic environments

The Urban lifestyle has attenuated our contact with Nature. Nature continues to fascinate us (state), but we have loosened the feeling of affiliation (trait) with wild Nature. Sporadicity of encounters no longer stimulates our biophilia which predisposes us to learn from Nature, and biophilia tends to atrophy. It is foreseeable that the phenomenon of disconnection from Nature will tend to accentuate. In 2007, the urban population surpassed the rural population for the first time in human history. Forecasts for 2050 are that 75% of the population will live in the city (Worldbank, 2019). From a certain point of view this is good news. If human presence in rural areas decreases, it is foreseeable that wild Nature will tend to widen its spaces. Larger habitats will increase the chances of survival of wild species that are now threatened with extinction. However, people living in the city will have less and less chance of connecting with Nature. It therefore becomes important to create an environment as stimulating as possible for our biophilia. We have seen that fascination has a restorative effect on attention and on the cognitive system in general and affiliation has a recovery effect on stress and on the limbic-emotional system in general. The research hypothesis for affective ecology is therefore to verify if an adequate environment can offer stimuli to biophilia. Here I propose two research paths, oriented respectively toward the inner psychic environment (*Green Mindfulness*) and the outer natural environment (*Biophilic Design*).

6.1 Inner environment: Green Mindfulness in Ecopsychology

Finding a way to stimulate biophilia, even when we cannot immerse ourselves in Nature as we wish, is necessary to reinforce the emotional bond with Nature. It can be useful to cultivate a mental attitude that allows us to maintain over time an *inner environment* - made up of thoughts and emotions - conducive to the constructs of biophilia, fascination and affiliation: an ecological awareness (Barbiero, 2017, pp. 185-209). A promising research track is *Green Mindfulness*. Mindfulness is an attitude that is cultivated through a meditation practice developed starting from the Buddhist experience, oriented toward bringing the subject's attention to focus on the present moment in a non-judgmental way. The Buddhist tradition has developed practices to cultivate moments of awareness (*mindful*), with the goal of becoming a stable state of awareness (*mindfulness*).

Mindfulness appears to have effects on the anatomical-physiological architecture of the brain (Siegel, 2007), on the areas of the prefrontal cortex and the insula. Sara Lazar has highlighted that people who practice *vipassanā* meditation tend to maintain the thickness of the prefrontal cortex and insula layer almost intact, while in non-practicing people, the corresponding cerebral cortex layer thins with age (Lazar et al., 2005; Hölzel et al., 2011). It is interesting to note that the prefrontal cortex has a regulatory function of the attention and emotional balance, while the insula modulates the activity of the two branches of the autonomic nervous system (**Figure 3**).

Cortical area		Attributed functions
Dorso-lateral prefrontal cortex		Attention, memory, synthesis ability
Ventro-medial prefrontal cortex		Emotional balance, empathy, intuition, fear
Insula		Enterocceptive awareness, sympathetic/parasympathetic balance

Figure 3. Relationship between cortical area and presided function.

Over time, some practices have been standardized as mindfulness-based interventions (MBIs). The standardization of MBIs allows for a more precise comparison between experimental observations conducted under different conditions. Specifically, in 1979 Jon Kabat Zinn developed the eight-week intensive mindfulness meditation training program for stress reduction (Kabat-Zinn et al., 1986; Kabat Zinn, 2011), known as *Mindfulness-Based Stress Reduction* (MBSR). Subsequently, Zindel Segal, Mark Williams and John Teasdale developed a variant of the MBSR for depression prevention (Teasdale et al., 2000; Segal, Williams, and Teasdale, 2002) called *Mindfulness-Based Cognitive Therapy* (MBCT). It is interesting to note that these two standardized systems of MBIs have effects that are at least partially superimposable with those observed in the stimulation of biophilia (**Table 4**).

Biophilia constructs	**Effects of the biophilic construct**	**Mindfulness-based interventions**
Fascination	Attention Restoration (see ART)	Cognitive Therapy (MBCT)
Affiliation	Stress Recovery (see SRT)	Stress Reduction (MBSR)

Table 4. Superimposition of the effects of biophilia constructs with the effects of mindfulness-based interventions. Note how the biophilic construct of fascination acts on a cognitive function (as described by ART, Attention Restoration Theory), exactly like MBCT. While the biophilic construct of affiliation acts on an emotional function (as described by SRT, Stress Recovery Theory), exactly like the MBSR.

MBCT has effects on attention capacity (Batink et al., 2013), while MBSR works reducing stress (Goldin and Gross, 2010; Martín-Asuero and García-Banda, 2010). A research objective could be to verify whether the MBIs practiced immersed in Nature are synergistic in their restorative function. MBIs share the goal of breaking fatiguing mental patterns as described by the Attention Restoration Theory (ART). However, there is a profound difference. The process of attention restoration in Nature is passive and depends on the restorative quality of the environment. Mindfulness is active and, at least initially, requires mental fatigue.

The practice of mindfulness seeks different ways of living places, rather than looking for different places, Mindfulness practiced in natural environments could facilitate our relationship with Nature. As early as 2001 Stephen Kaplan, formulating Hypothesis 6, foreshadowed the possibility that meditation practices could

maintain the benefits of restoration even when high biophilic quality environments were not accessible (Kaplan, 2001; Clarke, Kotera and McEwan, 2021). However, it seems possible that at least some form of synergy between mindfulness and Nature (Nisbet, Zelenski, and Grandpierre , 2019; Choe, Jorgensen, and Sheffield, 2020) can contribute to activating pro-environmental behaviour (Deringer et al., 2020). If mindfulness reinforces the restorative power of Nature, then a space for *Green Mindfulness* opens. Green mindfulness could be a mindfulness practice characterized by immersion in Nature. A space of connectedness to Nature which supports and reinforces ecological awareness even when it is not possible to have direct contact with Nature. According to Marcella Danon, "Green Mindfulness [is an] expansion of one's individual boundaries towards a broader sense of sharing with the world and, in particular, with the natural world to which we belong" (Danon, 2020).

6.2 Outer environment: Biophilic Design in Architecture

An environment stimulating biophilia has restorative and anti-stress effects. Stephen R. Kellert (1943-2016) was the first to realize the importance of biophilia in architectural design. Kellert worked with E.O. Wilson on the biophilia hypothesis (Kellert and Wilson, 1993), then developed different aspects of biophilia (Kellert, 1997) before devoting himself to issues related to *Biophilic Design* (Kellert, 2006; Kellert, Heerwagen & Mador, 2008). According to Kellert "Biophilic Design is the deliberate attempt to translate an understanding of the inherent human affinity to affiliate with natural systems and processes – known as biophilia – into the design of the built environment" (Kellert, 2008, p. 3). The goal of biophilic design is to create artificial environments as similar as possible to natural ones, to ensure the positive effect that Nature has on people's health and wellbeing.

Over the past three decades, several Biophilic Design models have been proposed (Kellert, 2008; Browning, Ryan and Clancy, 2014; Sturgeon, 2017, Kellert, 2018; Browning and Ryan, 2020), which have often been implemented in advanced building certification systems (LBC, 2017; WELL, 2016a, 2016b; LEED, 2018). Guidelines derived from empirical tests and primary scientific literature have been proposed to ensure the quality of biophilic design. There are currently two guidelines for Biophilic Design that are favoured by most experts: *The 14 Patterns of Biophilic Design* by Terrapin Bright Green (Browning, Ryan and Clancy, 2014) and *The Biophilic Environment* by the International Living Future Institute (ILFI), which has created a guide for designers who want to implement biophilic design in the building certification protocol *Living Building Challenge*

(Sturgeon, 2017). Bettina Bolten and I have compared the patterns of the biophilic design described in the most relevant publications (Kellert, 2008; Browning, Ryan and Clancy, 2014; Gillis and Gatersleben, 2015; Sturgeon, 2017; Kellert, 2018) and quantified the recurrence, in order to identify the themes and models that the various authors deem fundamental for Biophilic Design (Bolten and Barbiero, 2020). The analysis was comparative and weighted. We tried to give a different weight to the patterns according to the relative importance that each Author attributed to each model. A ranking of patterns emerged, the first seven of which are listed in **Table 5**.

Kellert, 2008	**Browning *et al.*, 2014**	**Sturgeon, 2017**	**Kellert, 2018**	**Bolten and Barbiero, 2020**
Natural light	Dynamic light	Natural light	Natural light	Light
Prospect and Refuge	Prospect and Refuge	Prospect and Refuge	Prospect and Refuge	Prospect and Protection
Air	Airflow variability	Air	Air	Airflow
Views and vistas	Visual connection	Views and vistas	Views	Views
Plants	Visual connection	Plants	Plants	Greenery
Curiosity and enticement	Mystery	Curiosity and enticement	---	Curiosity
Natural materials	Nature connection with Nature	Natural materials	Materials	Natural materials

Table 5. Comparison of the most important patterns of Biophilic Design by comparing the most relevant specific studies: The last column shows my summary proposal (Bolten and Barbiero, 2020, modified).

The first four patterns – light, prospect[3] and protection, airflow, views – concern the "looking for a place to live" issue (Buss, 2016, p. 83-84) and are the basis of the savannah hypothesis (Orians, 1980; 1986). The next three patterns – greenery, curiosity, materials – are more related to the "acquisition of food" issue

[3] The 'prospect' in architecture indicates the vision of an object on a vertical plane, just like the 'plan' indicates it on a horizontal plane.

(Buss, 2016 p. 70-81). Despite their specific differences, the criteria of Biophilic Design always seem to respond to psychological needs matured during evolution. For example, by graphing the 14 patterns developed by Terrapin Bright Green (Browning, Ryan and Clancy, 2014), three clusters with at least four nodes appear clear (**Figure 4**). The first cluster, whose perimeter is outlined in green, groups five interconnected nodes which, except for the 'presence of water', appear to be linked to the safety of the shelter. The second and third clusters, whose perimeters are shown in red, each group four nodes, which appear to be linked to the search for resources and food issue.

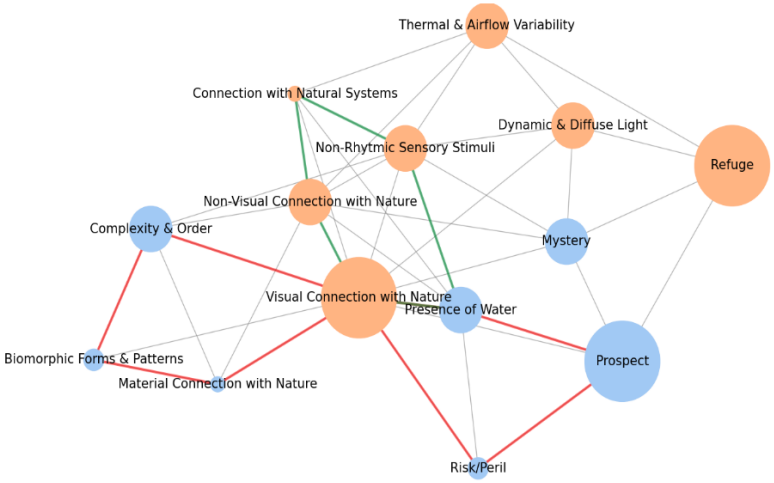

Figure 4. This image offers a visive impact of the 14 patterns of Biophilic Design by Terrapin Bright Green (Browning, Clancy, and Ryan, 2014). The graph has been generated using the Kamada-Kawai force-directed algorithm which models edges as spring forces between all pairs of vertices (Kamada and Kawai, 1989). In this graph dimensions of nodes and their connections represent respectively the robustness of the literature and the connections detected for each pattern by Browning, Clancy, and Ryan (2014). Colors of nodes: orange nodes represent 'search for refuge', blue nodes represent 'search for resources and food'. The perimeter of some of the largest 'cliques' (a subset of nodes such that every pair of nodes in the clique relates to an edge in the graph) is highlighted using a different color: green for 'search for refuge', red for 'search for resources and food' (graph courtesy provided by Pietro Barbiero).

Not surprisingly, the main characteristics of the Biophilic Design follow the evolutionary adaptation principles developed by our species in the search for a habitat rich in resources and with reliable shelters. And it is not surprising that

the top seven places in the ranking are occupied by issues more closely related to our biology, in particular the sensory apparatus, while cultural patterns (e.g., biomimicry) appear lower down, from the eighth place downwards. Instead, it is surprising that the theme of *silence* does not appear explicitly among the biophilic design models taken into consideration. I believe that silence deserves more attention, also in consideration of the experimental observations that show the importance of mindful silence in the processes of cognitive restoration (Berto and Barbiero, 2014).

In any case, one of the biggest problems of biophilic design is its empiricism, as Kellert (2018, p. 111-188) has pointed out. The projects that have been subjected to an experimental verification plan are very few. *Biosphera Project* is one among them. Biosphera Project is a research program managed by the Italian-Swiss company AktivHaus, in which Berto and I participated as Biophilic Design managers. Biosphera Project is a unique research program, because it creates prototypes of housing units that are movable. Being mobile, the housing prototypes so far made – Biosphera 2.0 and Biosphera Equilibrium – have the advantage of being able to be inserted in different urban, rural, or wild environments. Since 2016 we have been collecting numerous experimental indications that have revealed the importance of Biophilic Design, especially in the anti-stress function (Berto, Maculan and Barbiero, 2020), and which have contributed to the realization of the Biophilic Quality Index (BQI, Berto and Barbiero 2017b). The BQI then guided us in a building retrofit project of a rural school in Gressoney-La-Trinité near Monte Rosa in the Western Alps in Italy, where we integrated energy retrofit with a biophilic environment project (Barbiero et al., 2017). The Gressoney-La-Trinité school is the first school registered in Europe for the building certification protocol *Living Building Challenge* and behind which there is a systematic study of the effects that a biophilic environment can have in restoration from mental fatigue and recovery from stress, fundamental issues for primary school (Venturella and Barbiero, 2021).

7. Conclusions

In these last ten years, affective ecology has engaged above all in the experimental verification of the biophilia hypothesis. The first attempts to describe the phenomenon were the prelude to the experimental observations which led to the definition of the two fundamental constructs of biophilia: fascination and affiliation. An increasingly precise definition of the constructs permitted the use of psychometric measurement systems that allowed the psychological effects of biophilia to be estimated with ever greater precision. In this way it has been

possible to demonstrate that the fascination of Nature triggers the restoration of cognitive abilities after mental fatigue, while the feeling of affiliation for Nature has a stress-reducing effect. A biophilic environment is therefore an environment able to stimulate fascination and affiliation for Nature and constitutes the ideal environment for developing naturalistic intelligence. In the future it will be possible to define the characteristics of high biophilic quality environments, which can be both inner environments, as in the case of *Green Mindfulness* in ecopsychology, and outer environments, as in the case of *Biophilic Design* in architecture.

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References

Adams, S., and Savahl, S. (2017). Nature as children's space: A systematic review. *The Journal of Environmental Education*, 48(5), 291-321. https://doi.org/10.1080/00958964.2017.1366160

Arranz-Otaegui, A., Gonzalez Carretero. L., Ramsey, M.N., Fuller, D.Q., and Richter, T. (2018). Archaeobotanical evidence reveals the origins of bread 14,400 years ago in northeastern Jordan. *Proceedings of the National Academy of Sciences, USA* 115 (31), 7925-7930. DOI: http://dx.doi.org/10.1073/pnas.1801071115

Barbiero, G (2009). Revealing children's biophilia. In *Science, society and sustainability: education and empowerment for an uncertain world*. D. Gray, L. Colucci Gray and E. Camino (eds). Routledge, Milton Park, UK, pp. 181-184.

Barbiero, G. (2011). Biophilia and Gaia. Two Hypotheses for an Affective Ecology. *Journal of Biourbanism*, 1, 11-27. Available from: https://es.scribd.com/document/360556916/Journal-of-Biourbanism-1-2011

Barbiero, G. (2014). Affective Ecology for Sustainability. *Visions for Sustainability*, 1, 20-30. http://dx.doi.org/10.13135/2384-8677/1419

Barbiero, G. (2016). Francis of Assisi and the Wolf: Nonviolence as a moral value of biophilia. *Visions for Sustainability*, 5, 28-31. https://doi.org/10.13135/2384-8677/1504

Barbiero, G. (2017). *Ecologia affettiva. Come trarre benessere fisico e mentale dal contatto con la Natura*. Mondadori, Milano, IT

Barbiero, G., and Berto, R. (2016). *Introduzione alla biofilia. La relazione con la Natura tra genetica e psicologia*. Carocci, Roma, IT

Barbiero, G., and Berto, R. (2021). Biophilia as evolutionary adaptation: an onto-and phylogenetic framework for biophilic design. *Frontiers in Psychology*, 12, 700709 https://doi.org/10.3389/fpsyg.2021.700709

Barbiero, G., Berto, R., Freire, D., Ferrando, M., and Camino, E. (2014). Unveiling biophilia in children using active silence training: an experimental approach. *Visions for Sustainability*, 1, 31-38. https://doi.org/10.13135/2384-8677/1420

Barbiero, G., Gasparotti, F., and Baruzzi, E. (2015). *La verde pelle di Gaia. Dialogo tra un biologo e un druido nel bosco*. Libreriauniversitaria.it, Padova, IT

Barbiero, G., and Marconato, C. (2016). Biophilia as Emotion. *Visions for Sustainability*, 6, 45-51. http://dx.doi.org/10.13135/2384-8677/1755

Barbiero G., Venturella A., Maculan N., Miroglio M., Berto R., and Callegari G. (2017). The Restorative Schoolroom of Gressoney-La-Trinité as an example of Biophilic Design integrated in energetic efficiency retrofit. *Proceedings of the 27th Congress of The Italian Society of Ecology*, Napoli, September 12-15, p.147. http://www.ecologia.it/images/pdf/Libro_abstract_SItE_2017.pdf

Bateson, G. (1972) *Steps to an Ecology of Mind*. Chandler Publishing Company, San Francisco, CA.

Batink, T., Peeters, F., Geschwind, N., van Os, J., and Wichers, M. (2013). How Does MBCT for Depression Work? Studying Cognitive and Affective Mediation Pathways. *PLoS ONE*, 8(8): e72778. https://doi.org/10.1371/journal.pone.0072778

Berto, R. (2005). Exposure to restorative environments helps restore attentional capacity. *Journal of Environmental Psychology*, 25, 249-259. http://dx.doi.org/10.1016/j.jenvp.2005.08.004

Berto, R. (2007). Assessing the restorative value of the environment: A study on the elderly in comparison with young adults and adolescents. *International Journal of Psychology*, 42(5), 331 – 341. http://dx.doi.org/10.1080/00207590601000590

Berto, R. (2011). *The Attentional Vantage Offered by Perceiving Fascinating Patterns in the Environment*, in J.A. Daniels (ed.), *Advances in Environmental Research*, vol. 6. 4th quarter. New York: Nova Science Publishers, pp. 503-516.

Berto, R. (2014). The Role of Nature in Coping with Psycho-physiological Stress. A Literature Review of Restorativeness. *Behavioral Science*, 4, 394–409. http://dx.doi.org/10.3390/bs4040394

Berto, R., and Barbiero, G. (2014). Mindful silence produces long lasting attentional performance in children. *Visions for sustainability*, 2, 40-61. https://doi.org/10.13135/2384-8677/1427

Berto, R., and Barbiero, G. (2017a). How the psychological benefits associated with exposure to Nature can affect pro-environmental behavior. *Annals of Cognitive Science*, 1(1), 16-20. https://doi.org/10.36959/447/336

Berto, R., and Barbiero, G. (2017b). The Biophilic Quality Index. A Tool to Improve a Building from "Green" to Restorative. *Visions for Sustainability*, 8, 38-45. http://dx.doi.org/10.13135/2384-8677/2333

Berto, R., Barbiero, G., Barbiero, P., and Senes, G. (2018). Individual's Connection to Nature Can Affect Perceived Restorativeness of Natural Environments. Some Observations about Biophilia. *Behavioral Sciences,* 8(3), 34. https://doi.org/10.3390/bs8030034

Berto, R., Barbiero, G., Pasini, M., and Unema, P. (2015). Biophilic Design Triggers Fascination and Enhances Psychological Restoration in the Urban Environment. *Journal of Biourbanism* 1and2, pp. 27-34. http://dx.doi.org/10.13140/RG.2.1.2177.4961

Berto, R., Baroni, M.R., Zainaghi, A., and Bettella, S. (2010). An Exploratory Study of the Effect of High and Low Fascination Environments on Attentional Fatigue. *Journal of Environmental Psychology*, 30, 494-500. http://dx.doi.org/10.1016/j.jenvp.2009.12.002

Berto, R., Maculan, N., and Barbiero, G. (2020). Does sustainability address perceived restoration? An exploratory study on Biosphera 2.0, a net zero energy house. *Visions for Sustainability*, 13: 17-30. http://dx.doi.org/10.13135/2384-8677/4181

Berto, R., Pasini, M., and Barbiero, G. (2015). How does Psychological Restoration Work in Children? An Exploratory Study. *Journal of Child and Adolescent Behaviour* 3: 200. http://dx.doi.org/10.4172/2375-4494.1000200

Bolten, B., and Barbiero, G. (2020). Biophilic Design: How to enhance physical and psychological health and wellbeing in our built environments. *Visions for Sustainability*, 13, 11-16. http://dx.doi.org/10.13135/2384-8677/3829

Browning, W.D., and Ryan, C.O. (2020). *Nature inside: a Biophilic Design guide*. RIBA Publishing, London, UK.

Browning, W.D., Ryan, C.O., and Clancy, J.O. (2014). *14 Patterns of Biophilic Design*. Terrapin Bright Green, LLC, New York, NY. https://www.terrapinbrightgreen.com/wp-content/uploads/2014/09/14-Patterns-of-Biophilic-Design-Terrapin-2014p.pdf

Buss, D.M. (2016). *Evolutionary psychology: The new science of the mind.* 5th edition. Routledge, New York, NY.

Capra, F. (1996). *The web of life.* Doubleday-Anchor Book, New York, NY.

Carson, R. (1962). *Silent Spring*. Houghton Mifflin, Boston MA, USA

Chang, C., Cheng, G.J.Y., Nghiem, T.P.L., Song, X.P., Oh, R.R.Y., Richards, D.R., and Carrasco, L.R. (2020). Social media, nature, and life satisfaction: global evidence of the biophilia hypothesis. *Scientific Reports* 10, 4125. https://doi.org/10.1038/s41598-020-60902-w

Choe, E. Y., Jorgensen, A., and Sheffield, D. (2020). Does a natural environment enhance the effectiveness of Mindfulness-Based Stress Reduction (MBSR)? Examining the mental health and wellbeing, and nature connectedness benefits. *Landscape and Urban Planning*, 202, 103886. https://doi.org/10.1016/j.landurbplan.2020.103886

Chowka, P.B. (1977). The Original Mind of Gary Snyder. *East West Journal*, 7, 35.

Christie, D.E. (2013). *The Blue Sapphire of the Mind. Notes for a Contemplative Ecology*. Oxford University Press, New York, NY.

Clark, R.N., and Stankey, G.H. (1979). *The recreation opportunity spectrum: A framework for planning, management, and research* (Vol. 98). Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station.

Clarke F.J, Kotera Y., and McEwan K.A. (2021). Qualitative Study Comparing Mindfulness and Shinrin-Yoku (Forest Bathing): Practitioners' Perspectives. *Sustainability*, 13 (12), 6761. https://doi.org/10.3390/su13126761

Clements, R. (2004). An investigation of the status of outdoor play. *Contemporary Issues Early Child*, 5(1), 68–80.

Cloninger, C.R., Svrakic, D.M., and Przybeck, T.R. (1993). A psychobiological model of temperament and character. *Archives of General Psychiatry*, 50 (12), 975-990.

Colucci-Gray, L., Camino, E., Barbiero, G., and Gray, D. (2006). From scientific literacy to sustainability literacy: An ecological framework for education. *Science Education*, 90(2), 227-252. https://doi.org/10.1002/sce.20109

Danon, M. (2020). "From Ego to Eco": The contribution of Ecopsychology to the current environmental crisis management. *Visions for Sustainability*, 12, 8-17. http://dx.doi.org/10.13135/2384-8677/3261

Darwin, C. (1872). *The expression of the emotions in man and animals*. University of Chicago Press. (2015 edition).

Deringer, S. A., Hanley, A. W., Hodges, J. S., and Kent, L. (2020). Improving ecological behavior in outdoor recreation through mindfulness interventions: a mixed methods inquiry. *Journal of Outdoor Recreation, Education, and Leadership*, 12(2). https://doi.org/10.18666/JOREL-2020-V12-I2-9802

Diamond, J. (1997). *Guns, Germs and Steel: A Short History of Everybody for the Last 13,000 Years*. W.W. Norton, New York, NY.

Fellows, A. (2019). *Gaia, Psyche and Deep Ecology. Navigating Climate Change in the Anthropocene*. Routledge, New York, NY.

Fromm, E. (1964). *The Heart of Man*. Harper and Row.

Gardner, H. (1983). *Frames of mind: The theory of multiple intelligences.* New York, NY: Basic Books.

Gardner, H. (1995). Reflections on multiple intelligences: Myths and messages. *Phi Delta Kappan* 77: 200-209. Available from: https://learnweb.harvard.edu/WIDE/courses/files/Reflections.pdf

Gardner, H. (1999). *Intelligence Reframed.* Basic Books, New York, NY.

Gardner, H., and Moran, S. (2006). The Science of Multiple Intelligences Theory: A Response to Lynn Waterhouse. *Educational Psychologist*, 41: 227-232.

Gill, T. (2014). The benefits of children's engagement with nature: A systematic literature review. *Children Youth and Environments,* 24 (2), 10-34. https://doi.org/10.7721/chilyoutenvi.24.2.0010

Gillis, K., and Gatersleben, B. (2015). A review of psychological literature on the health and wellbeing benefits of Biophilic Design. *Buildings*, 5(3), 948-963.

Gimbutas, M. (1989). *The language of the Goddess: unearthing the hidden symbols of Western civilization*. Harper and Row, New York, NY.

Goldin, P.R., and Gross, J.J. (2010). Effects of mindfulness-based stress reduction (MBSR) on emotion regulation in social anxiety disorder. *Emotion*, 10(1), 83–91. https://doi.org/10.1037/a0018441

Goodenough, U. (1998). *The Sacred Depths of Nature*. Oxford University Press, New York, NY.

Hartig, T., Korpela, K., Evans, G.W., and Gärling, T. (1996). Validation of a measure of perceived environmental restorativeness. *Göteborg Psychological Reports*, 1996, 26, No. 7.

Harvard Medical School (2018). Understanding the stress response. Chronic activation of this survival mechanism impairs health: https://www.health.harvard.edu/staying-healthy/understanding-the-stress-response.

Hölzel, B.K., Carmody, J., Vangel, M., Congleton, C., Yerramsetti, S.M., Gard, T., and Lazar, S.W. (2011). Mindfulness practice leads to increases in regional brain gray matter density. *Psychiatry research: neuroimaging*, 191(1), 36-43.

Joye, Y., and van den Berg, A. (2011). Is love for green in our genes? A critical analysis of evolutionary assumptions in restorative environments research. *Urban Forestry and Urban Greening*, 10, 261–268. https://doi.org/10.1016/j.ufug.2011.07.004

Kabat-Zinn, J. (2011). Some reflections on the origins of MBSR, skillful means, and the trouble with maps, *Contemporary Buddhism*, 12(1), 281-306. https://doi.org/10.1080/14639947.2011.564844

Kabat-Zinn, J., Lipworth, L., Burney, R., and Sellers, W. (1986). Four Year Follow-up of a Mindfulness-Based Program for the Self-Regulation of Chronic Pain: Treatment Outcomes and Compliance. *The Clinical Journal of Pain* 2, 159-173.

Kahn, P.H. (1997). Developmental psychology and the biophilia hypothesis: Children's affiliation with nature. *Developmental review*, 17 (1), 1-61. https://doi.org/10.1006/drev.1996.0430

Kamada, T., and Kawai, S. (1989). An algorithm for drawing general undirected graphs. *Information processing letters*, 31(1), 7-15.

Kaplan, R., and Kaplan, S. (1989). *The experience of nature: A psychological perspective*. Cambridge University Press, New York, NY.

Kaplan, S. (1995). The restorative effects of nature: Toward an integrative framework. *Journal of Environmental Psychology*, 15, 169-182.

Kaplan, S. (2001) Meditation, restoration, and the management of mental fatigue. *Environment and Behavior*, 33(4), 480-506.

Kellert, S.R. (1997). *Kinship to Mastery. Biophilia in Human Evolution and Development*. Island Press, Washington, DC.

Kellert, S.R. (2002). Experiencing Nature: Affective, Cognitive, and Evaluative Development in Children. In *Children and Nature*, eds. Kahn and Kellert, Massachusetts Institute of Technology, Cambridge, MA, pp. 117-151.

Kellert, S.R. (2005). *Building for Life. Designing and Understanding the Human-Nature Connection.* Island Press, Washington, DC.

Kellert, S.R. (2008). Dimensions, Elements and Attributes of Biophilic Design. In *Biophilic Design*, Kellert, S., Heerwagen, J., Mador, P. (eds). John Wiley and Sons, Hoboken, NJ, pp. 3-19.

Kellert, S.R. (2018). *Nature by Design*. Yale University Press, New Haven, CT.

Kellert, S.R., Heerwagen, J., and Mador, P. (2008). *Biophilic Design. The Theory, Science, and Practice of Bringing Buildings to Life*. John Wiley and Sons, Hoboken, NJ.

Kellert, S.R., and Wilson, E.O. (1993). *The Biophilia Hypothesis*. Island Press, Washington, DC.

Kump, L.R., Kasting, J.F., and Crane, G.R. (2011). *The Earth System* (3rd edition). Pearson Education Inc., Upper Saddle River, NJ.

Kuo, M., Browning, M.H., and Penner, M.L. (2018). Do lessons in nature boost subsequent classroom engagement? Refueling students in flight. *Frontiers in Psychology*, 8, 2253. https://doi.org/10.3389/fpsyg.2017.02253

Larsen, C.S., Knüsel, C.J., Haddow, S.D., Pilloud, M.A., Milella, M., Sadvari, J.W., Pearson, J., Ruff, C.B., Garofalo, E.M., Bocaege, E., Betz, B.J., Dori, I., and Glencross, B. (2019). Bioarchaeology of Neolithic Çatalhöyük reveals fundamental transitions in health, mobility, and lifestyle in early farmers. *Proceedings of the National Academy of Sciences USA*, 116(26), 12615-12623. https://doi.org/10.1073/pnas.1904345116

Lazar, S.W., Kerr, C.E., Wasserman, R.H., Gray, J.R., Greve, D.N., Treadway, M.T., McGarvey, M., Quinn, B.T., Dusek, J.A., Benson, H., Rauch, S.L., Moore, C.I., and Fischld, B. (2005). Meditation experience is associated with increased cortical

thickness. *Neuroreport*, 16(17), 1893-1897. https://doi.org/10.1097/01.wnr.0000186598.66243.19

LBC, Living Building Challenge TM (2017). *Biophilic Design Exploration Guidebook*, International Living Future Institute https://living-future.org/wp-content/uploads/2016/11/BiophilicDesignExplorationGuidebook.pdf

LEED, Leadership in Energy and Environmental Design v4.1 (2018). *Designing with Nature, Biophilic Design for the Indoor Environment* https://www.usgbc.org/credits/new-construction-core-and-shell-schools-new-construction-retail-new-construction-39?return=/pilotcredits/new-construction/v4.1

Lenton, T.M., Dutreuil, S., and Latour, B. (2020). Life on Earth is hard to spot. *The Anthropocene Review*, 2053019620918939. https://doi.org/10.1177%2F2053019620918939

Liu, T., Geng, L., Ye, L., and Zhou, K. (2019). "Mother Nature" enhances connectedness to nature and pro-environmental behavior. *Journal of Environmental Psychology*, 61, 37-45. https://doi.org/10.1016/j.jenvp.2018.12.003

Longo, C. (2014) Experiences in Drawing From Nature. *Visions for Sustainability*, 2, 5-10

Martín-Asuero, A., and García-Banda, G. (2010) The Mindfulness-Based Stress Reduction Program (MBSR) Reduces Stress-Related Psychological Distress in Healthcare Professionals. *The Spanish Journal of Psychology*, 13 (2), 897-905.

Mayer, F.S., and Frantz, C.M.P. (2004). The connectedness to nature scale: A measure of individuals' feeling in community with nature. *Journal of Environmental Psychology*, 24(4), 503-515.

Meyer, M. (1997). The GREENing of Learning: Using the Eighth Intelligence. *Educational Leadership*, 55(1), 32-34.

Moreton, S., Arena, A., and Tiliopoulos, N. (2019). Connectedness to nature is more strongly related to connection to distant, rather than close, others. *Ecopsychology*, 11(1), 59-65. http://doi.org/10.1089/eco.2018.0063

Neumann, E. (2015). *The great mother: An analysis of the archetype*. Works by Erich Neumann, vol. 15, book 47, revised edition, Princeton University Press.

Newmann, B. (1987) *Sister of Wisdom. St. Hildegard's Theology of the Feminine*. California University Press, Berkeley, CA.

Nisbet, E.K., Zelenski, J.M., and Grandpierre, Z. (2019). Mindfulness in nature enhances connectedness and mood. *Ecopsychology*, 11(2), 81-91. https://doi.org/10.1089/eco.2018.0061

Nisbet, E.K., Zelenski, J M., and Murphy, S. A. (2009). The nature relatedness scale: Linking individuals' connection with nature to environmental concern and behavior. *Environment and behavior*, 41(5), 715-740. https://doi.org/10.1177/0013916508318748

Nolen, J.L. (2003). Multiple intelligences in the classroom. *Education*, 124 (1), 115-119.

Orians, G.H. (1980). Habitat selection: General theory and applications to human behavior. In J.S. Lockard (ed.) *The evolution of human social behavior*. Elsevier, Chicago, IL, pp. 49-66.

Orians, G.H. (1986). An ecological and evolutionary approach to landscape aesthetics. In E.C. Penning-Roswell and D. Lowenthal (Eds) *Landscape meanings and values*. Allen and Unwin, London, UK, pp. 3-25.

Orians, G.H., and Heerwagen, J.H. (1992). Evolved Responses to Landscapes. In *The Adapted Mind: Evolutionary Psychology and the Generation of Culture*; Barkow, J.H., Cosmides, L., Tooby, J., Eds.; Oxford University Press: New York, NY; pp. 555–579.

Patuano, A. (2020). Biophobia and Urban Restorativeness. *Sustainability*, 12, 4312. https://doi.org/10.3390/su12104312

Powell, D.M., and Bullock, E.V.W. (2014). Evaluation of Factors Affecting Emotional Responses in Zoo Visitors and the Impact of Emotion on Conservation Mindedness, *Anthrozoös*, 27:3, 389-405. https://doi.org/10.2752/175303714X13903827488042

Roszak, T.E., Gomes, M.E., and Kanner, A.D. (1995). *Ecopsychology: Restoring the earth, healing the mind*. Sierra Club Books, San Francisco, CA.

Sahlins, M. (2017). *Stone age economics*. Routledge Classics. New York, NY.

Santrock, J.W. (2008). *A Topical Approach To Life-Span Development*. McGraw-Hill, New York, NY.

Sapolsky, R. M. (2004). *Why Zebras Don't Get the Ulcers*. Owl Book, Henry Holt and Co., New York, NY.

Schlesinger, W.H., and Bernhardt E.S. (2013). *Biogeochemistry. An analysis of Global Change* (3rd edition). Academic Press, Waltham, MA.

Schwartzman, D. (1999). *Life, Temperature, and the Earth*. Columbia University Press, New York, NY.

Schwieterman, E.W, Kiang, N.Y., Parenteau, M.N., Harman, C.E., DasSarma, S., Fisher, T.M., Arney, G.N., Hartnett, H.E., Reinhard, C.T., Olson, S.L., Meadows, V.S., Cockell, C.S., Walker, S.I., Grenfell, J.L., Hegde, S., Rugheimer, S, Hu, R., and Lyons, T.W. (2018). Exoplanet Biosignatures: A Review of Remotely Detectable Signs of Life. *Astrobiology*, 663-708. http://doi.org/10.1089/ast.2017.1729

Segal, Z.V., Williams, J.M.G., and Teasdale, J.D. (2002). *Mindfulness-Based Cognitive Therapy for depression. A New Approach to Preventing Relapse*. The Guilford Press, New York, NY.

Shimizu, H., and Okabe, M (2007). Evolutionary origin of autonomic regulation of physiological activities in vertebrate phyla. *Journal Comparative Physiology A*, 193, 1013-1019

Siegel, D.J. (2007). *The mindful brain: Reflection and attunement in the cultivation of well-being*, Norton series on interpersonal neurobiology. WW Norton and Company, New York, NY.

Spinney, L. (2020). How Farmers Conquered Europe. *Scientific American* 323 (1) 60-67. http://doi.org/10.1038/scientificamerican0720-60

Spinney, L. (2021). The first urbanites. *New Scientist*, 249 (3323), 44-47.

Stratman, T. B. (1982). St. Francis of Assisi: Brother to All Creatures. *Spirituality Today*, 34, 222-32.

Sturgeon, A. (2017). *Creating Biophilic Buildings*. Ecotone, Seattle, WA.

Teasdale, J.D., Segal, Z.V., Williams, J.M.G., Ridgeway, V.A., Soulsby, J.M., and Lau, M.A. (2000). Prevention of Relapse/Recurrence in Major Depression by Mindfulness-Based Cognitive Therapy. *Journal of Consulting and Clinical Psychology* 68 (4), 615-623.

Tillmann, S., Tobin, D., Avison, W., and Gilliland, J. (2018). Mental health benefits of interactions with nature in children and teenagers: A systematic review. *J Epidemiol Community Health*, 72 (10), 958-966. http://dx.doi.org/10.1136/jech-2018-210436

Ulrich, R.S. (1983). Aesthetic and affective response to natural environment. In: Altman, I., Wohlwill, J.F. (Eds.), *Human Behavior and Environment*, vol. 6. Plenum Press, New York, pp. 85–125.

Ulrich, R.S. (1984). View through a window may influence recovery. *Science*, 224 (4647), 224-225.

Ulrich, R.S. (1993). Biophilia, Biophobia, and Natural Landscapes. In *The Biophilia Hypothesis*. S.R. Kellert and E.O. Wilson (Eds.). Island Press, Washington, DC: pp. 73-137.

Ulrich, R.S., Simons, R.F., Losito, B.D., Fiorito, E., Miles, M.A., and Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *Journal of Environmental Psychology* 11, 201–230.

Venturella, A., and Barbiero, G. (2021). Bracing Biophilia: l'esperienza educativa della scuola biofila di Gressoney-La-Trinité. *Ecologia della salute* 2, 49–61.

Volk, T. (1997). *Gaia's Body. Towards a Physiology of Earth*. Copernicus, New York, NY.

Wang, R., Zhaob, J., Meitner, M.J., Hua, Y., and Xu, X. (2019). Characteristics of urban green spaces in relation to aesthetic preference and stress recovery, *Urban Forestry and Urban Greening*, 41: 6-13.

Watson, A.J., and Lovelock, J.E. (1983). Biological homeostasis of the global environment: the parable of Daisyworld, *Tellus B: Chemical and Physical Meteorology*, 35:4, 284-289, https://doi.org/10.3402/tellusb.v35i4.14616

WELL Building Standard (2016a). *88. Biophilia I – Qualitative. To nurture the innate human-nature connection within the project.* International WELL Building Institute https://standard.wellcertified.com/mind/biophilia-i-qualitative

WELL Building Standard (2016b). *100. Biophilia II – Quantitative. To support occupant emotional and psychological well-being by including the natural environment in interior and exterior design*. International WELL Building Institute https://standard.wellcertified.com/mind/biophilia-ii-quantitative

White, M.P., Alcock, I., Grellier, J., Wheeler, B W., Hartig, T., Warber, S.L., Bone, A, Depledge, M.H., and Fleming, L.E. (2019). Spending at least 120 minutes a week in nature is associated with good health and wellbeing. *Scientific reports*, 9(1), 1-11. https://doi.org/10.1038/s41598-019-44097-3

Wilson, E.O. (1984). *Biophilia.* Harvard University Press, Cambridge, MA.

Wilson, E.O. (1993). Biophilia and the Conservation Ethic. In *The Biophilia Hypothesis*. S.R. Kellert and E.O. Wilson (Eds.). Island Press, Washington, DC: pp. 31-41.

Wilson, E.O. (1994). *Naturalist*. Island Press, Washington DC.

Wilson, E.O. (2002). *The Future of Life*. Alfred A. Knopf, New York, NY.

Worldbank (2019) https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS

Author

Giuseppe Barbiero

GREEN LEAF - Groupe de Recherche en Education à l'Environnement et à la Nature, Laboratorio di Ecologia Affettiva, University of Valle d'Aosta.

Strada Cappuccini 2/a, 11100 Aosta, Italy.

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Competing Interests

The author has declared that no competing interests exist.