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When Biophilic Design Meets Restorative Architecture: the Strambinello Project.

Giulia Nota[1], Roxana Georgiana Marian[1], Guido Callegari[1,2], Rita Berto[3], Giuseppe Barbiero[3,4]

[1]Dipartimento di Architettura e Design, Politecnico di Torino, Italy; [2]Be-eco, spinoff from the Politecnico di Torino, Italy; [3]Laboratorio di Ecologia Affettiva, Università della Valle d'Aosta, Italy; [4]IRIS, Interdisciplinary Research Institute of Sustainability, Università di Torino, Italy.

Abstract.
The current crisis in the complex relationship between Man and Nature offers a fertile context for experimentation within the architectural field, where we must rethink the link between Man's structural relationships and his physical-spatial surroundings in terms of material and non-material components. The multidisciplinary vision of the biophilic program examines the design of living spaces with reference to the physiological functions and the psychological, behavioral, emotional and cognitive development of the individual. Biophilic Design thus brings greater awareness of the concept of sustainability in architecture, which can then facilitate the regenerative features of human residential environments. This project presents an experimental case study of biophilic architecture that becomes a design variable for the physical and psychological wellbeing of the inhabitants on the basis of certain characteristics known as regenerative factors within attention restoration theory (ART). The case study, a single-family home that is being built in the municipality of Strambinello (Piedmont, Italy) is an example of a regenerative residential environment that respects the bond between Man and Nature.

Key words. attention restoration theory (ART) · biophilia hypothesis · biophilic design · restorative architecture

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Corresponding Author: Giuseppe Barbiero, Laboratorio di Ecologia Affettiva, Università della Valle'd'Aosta-Université de la Vallée d'Aoste, Strada Cappuccini 2- 11100 Aosta, Italy. **E.mail**: g.barbiero@univda.it

***Perspective**: Experiential and research visions*

***Fields**: Earth Life Support Systems, Social Processes and Structures*

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From sustainable architecture to biophilic design

In an increasingly interconnected world, more than half the world population (54%) lives in urban areas. Within this framework, cities are clearly important factors of development. However, rapid urban expansion, often unplanned and inadequate, brings with it social, environmental and cultural factors that risk marginalizing that innate relationship that has always existed between Man and Nature. Distancing people from life's natural cycles is leading to an increasingly compromised existence in relation to a broad spectrum of physiological, psychological, behavioural, affective and cognitive aspects. It is necessary to think of new models of development capable of facilitating for humanity an intimate and innate connection with Nature. One possible, experimental scenario is biophilic design, a way of designing the places where we live, learn and work. Biophilic design stands at the root of the connection between Man and Nature by setting the goal of creating regenerative environments where human biophilic propensity can find its realization, and thereby contributes to psycho-physical equilibrium and pleasure in living in one's own environment.

According to E. O. Wilson, biophilia is «our innate tendency to focus upon life and life-like forms and, in some instances, to affiliate with them emotionally» (Wilson 2002, p. 134). Humanity, over the course of our evolution, has developed a set of phylogenetically adaptive learning rules that shape our relationships with the natural world (Wilson 1993). If this hypothesis is correct, the human biophilic tendency would find its expression in (1) attention – the capacity to let oneself be fascinated by natural stimuli, and (2) empathy – the capacity to emotively affiliate with the different forms of life. According to Wilson, biophilia is an evolutionarily adaptive character that emerges, often without awareness, in many human activities, in our thoughts as in our artistic expressions (Wilson, 1984). Indeed, the story of the evolution of biophilia follows the traces of human evolution, in its peculiarities of genetic-cultural coevolution (Barbiero, 2017, pp. 137-163). An example is the choice of habitat, crucial to the survival of the species. For two million years the habitat of the *Homo* was the African savannah, when our ancestors sharpened their survival skills. The savannah is characterized by elements such as open grassland, clumps of bushes, scattered trees (so-called "shade trees" because they offer shelter from the sun and predators), elevated view with great visibility, plenty of sunlight, areas of water like lake, river or sea and grazing animals. Savannah is a landscape scheme that we find pleasing and reassuring (Balling & Falk, 1982) and according to Orians and Heervagen (1992) there is a kind of instinct that brings the individual not only to prefer but also to reproduce certain shapes and configurations attributable to savannah. Orians and Heervagen also note that in Great Britain and the United States many parks and gardens are characterized by meadow with low grassy, isolated shade trees, semi-open environments characterized by a good level of stimulation with a coherently complex structure which can be traced back to the spatial characteristics and configuration of the savannah. The long evolutionary path of humanity in natural environments has left its mark in the form of predispositions (not learned but inherited) to pay attention and respond positively to certain characteristics typical of the natural environment (Ulrich, 1991). For this reason, humans prefer environments with attributes similar to *natural environments* where they have evolved, where they have learned to select important information, acquired appropriate response patterns and learned to predict what might happen to them (Berrill, 1955; Kaplan, 1977; Ulrich, 1977). Moreover, the preference of humans for natural rather than built environments is also linked to the fact that they support psycho-physical well-being, as they are perceived as more regenerative. Biophilic design also originates from the innate preference that humans have for the natural environment that is directly related to the perception of the regeneration level of an

environment: high levels of preference are generally associated with high levels of perceived regeneration, and vice versa (Ulrich, 1991; Hernandez, 2001; Purcell, 2001; Berto, 2004; Berto, 2007). Through the case study of Strambinello, we set out to show that an architectural project can be developed as a design feature within a precise theoretical framework and supported by specific scientific evidence: Attention Restoration Theory (ART). According to ART, the regeneration of attention is due to the presence of four characteristics defined as regenerative factors: (1) fascination, (2) being-away, (3) extent and (4) compatibility. The regenerative factors normally differentiate a natural environment. For Strambinello project, we tried to translate these regenerative factors in the project.

The Strambinello case study experimentation began during a cooperative project between the innovative startup Be-eco, the Laboratorio di Ecologia Affettiva (Laboratory of Affective Ecology) at the Università della Valle d'Aosta and the Dipartimento di Architettura e Design at the Politecnico di Torino designed to go beyond the single dimension of energetic efficiency and achieve the objective of physical and psychological wellbeing of the inhabitants. The Strambinello case study is an important opportunity for a multidisciplinary convergence between architecture, ecology and environmental psychology in order to promote a new quality residential environment.

See below - Figure 1. The Strambinello Project.

In recent decades, architecture has often seen the Man-Nature relationship from a utilitarian standpoint, through an excessively technical vision that has shifted the attention from Man to the machine, certifying the energetic performance of the building as the most advanced parameter for evaluating a building in terms of guaranteeing the comfort of the inhabitants. Architecture, in rethinking the vital spaces of Man, and in the face of epochal changes such as the degradation of the environment, the prevalence of anthropogenic environments over natural ones, the exploitation of natural resources and climate change, must identify new ways to look in a systemic manner at sustainability in architecture.

Biophilia can become a very important professional factor in re-establishing a correct relationship between Man and Nature, for planning research in architecture and new working scenarios, not only related to the physical variables of the environment but also to the psycho-physiological variables of individuals. Today we have solid certification protocols for buildings energetic performance, such as the US system of energy efficiency rating and ecological footprint LEED (Leadership in Energy and Environmental Design). But we have no analogous instrument applicable to psycho-physical wellbeing. Strategies for human health and wellbeing play a relatively modest role in the evolution of building standards, and in fact, at the time of this study, it is impossible to estimate the degree of biophilia present in a building (Berto, 2017). Protocols that are currently dealing with biophilic design are the *WELL Building Standard* and *Terrapin Bright Green*. *The WELL Building Standard* is a certification and, as such, is to be applied once the project is completed. It contains qualitative requirements (Characteristic 88_Biophilia I Qualitative) and quantitative requirements (Characteristic 100_Biophilia II Quantitative) that are based on an empirical approach. *Terrapin Bright Green*, on the other hand, provides design guidelines where critical issues emerge regarding the quantity and quality of the support tests, that are based on empirical data that do not make it possible to scientifically evaluate the biophilic design. Also, it does not focus on the individual who will benefit from the architectural work. Our analysis demonstrates that the existing protocols are insufficient because they do not provide a method capable of achieving scientific biophilic design and because they both have an empirical approach.

Individuals' connection to Nature as the project starting point

Since a biophilic perspective has been adopted for the design and construction of the sustainable building in Strambinello, the starting point of this project was the Man-Nature bond, or rather the Customers-Nature bond. This is crucial because the biophilic design starts with the connection that the *individual* has with Nature. For this reason, the level of connection with Nature of future inhabitants was measured by adopting the *Connectedness to Nature Scale* (CNS) (Mayer & McPherson Frantz, 2004).

The CNS evaluates to what extent individuals identify with the natural world and feel they are part of it. It measures the Man-Nature connection by defining a sort of personality trait of the individual. The CNS is a scale with 14 items, aimed at assessing to what extent the individual feels part of the natural world. The scoring (attributed to each item on a scale from 0 to 4, where 0 = never and 4 = always) defines the measure of personal relationship with Nature, and is obtained from the average of the scores attributed to each of the 14 items. After compiling the CNS by the customer, the scores found are similar: 2.6/4.0 for females and 2.9/4.0 for males. Both types of customers have a good connection with Nature meant as a cognitive and intellectual connection, since those who reach a medium average of scores are usually a people sensitive to ecological issues. The first compiling of the CNS was done during the design stage. We will compare this result with a second CNS score after three years of occupancy by the same customers. Although according to much scientific literature the connection to Nature is a stable trait in adults, the second CNS results are expected to increase, if the Strambinello home is to be considered a restorative environment.

The theoretical framework

The challenge is to plan and build a regenerative home, to develop a project based on the biophilia hypotheses designed to promote wellbeing for future occupants. To accomplish this aim we employed the theoretical framework provided by ART in order to explain the positive effects of Nature on human functioning, as contact with Nature promotes regeneration of direct attention, thanks to the presence of the four "regenerative factors" of fascination, being-away, extent and compatibility.

Exposure to the natural environment provides physiological (Ulrich, 1991) and cognitive benefits (Hartig, 1991; Tennessen, 1995; Berto, 2005), and plays an important role in regulating emotions as well as an improvement in perceived wellbeing (Kaplan, 1973; Agyemang, 2007) and a faster recovery from disease (Ulrich, 1984). For this reason, human beings prefer environments with natural attributes, those environments that give us positive emotions and moods. In this regard, according to *environmental preference model* of Kaplan & Kaplan (1989), we can identify the predictors of environmental preference: coherence, complexity, readability and mystery. These are explained as the result of an evolutionary process in terms of adaptation and refer to environmental qualities that derive from the intersection of two important human needs that must be satisfied in order for the subject to decide if s/he likes the environment or not: the need to understand and the need to explore. The coherence and readability of an environment refer to its ability to satisfy our cognitive efforts toward understanding it (Baroni, 2008). Coherence refers to how an environment can be immediately recognized by its organization and repetition of certain elements (e.g. the foliage of the trees, the rocks), the presence of similar textures (e.g. ploughed fields, meadows) and/or defined areas. Readability indicates the presence of information from which we can infer many features of the environment and its potential to be explored once we enter the scene more deeply. A legible environment is well structured, rich in landmarks that facilitate orientation and the formation of a cognitive map (Lynch, 1960). As regards complexity, a low-stimulus environment inhibits the drive toward exploration and is generally evaluated less

positively. However, complexity does not work to the detriment of legibility. Mystery is the promise of further information. Some environments create expectations in that there is something else to explore; windy paths or vegetation that partially obscures the view as when entering a forest are examples of elements that arouse mystery.

Our biophilic design framework is inspired by the model of environmental preference, Nature's characteristics and its positive effects. In this respect, ART distinguishes two forms of attention: direct attention and involuntary attention (or fascination). *Direct attention* is the ability to inhibit competing or distracting stimuli while performing a task. When direct attention is subjected to intense and prolonged use, it becomes exhausted, and mental fatigue appears. This increases distractibility and behaviours become more impulsive and hostile. Involuntary attention or *fascination* is the attention that does not require any effort and is fatigue-resistant. It allows direct attention to rest and regenerate so as to return to normal levels of efficiency. According to ART, stimulation of involuntary attention by contact with the natural environment is an effective way to regenerate direct attention and ensure good cognitive functioning. Fascination is just one of the features that make a natural environment a "restorative environment". From this perspective, direct attention can be restored by the presence of the four restorative factors of *fascination*, *being away, extent* and *compatibility.*

What follows are some examples of how such factors can be translated into an architectural project:

- *fascination*: the building is designed to allow fascinating stimuli such as the presence of water, trees, animals and suggestive elements such as sunsets, light reflections, windy leaves. These features stimulate the use of involuntary attention by regenerating direct attention and ensuring good cognitive functioning
- *being-away*: the building allows individuals to physically and/or mentally move away from their daily routine (e.g. work, everyday worries), that is, from all those situations that require the use of direct attention and which are a cause of mental fatigue as well as environmental stress (noise, crowding, air pollution, traffic);
- *extent*: the building is coherent and legible, characterized by a space-time extension, large enough to be explored and have new experiences where the individual feels "immersed". Immersion is favoured in the environments with coherence, where each part is in harmony with the whole. Natural environments are intrinsically endowed with space-time extension;
- *compatibility*: the environment offers the opportunity to indulge the interests or achieve the purposes of the individual. There is a compatibility or match between the individual's inclinations and the opportunities offered by the environment itself.

Natural environments are more regenerative than built environments, because they feature all four restorative properties (Korpela, 1996; Herzog, 1997; Hernandez, 2001; Purcell, 2001; Peron, 2002; Berman, 2008). Natural environments are different from everyday environments (being away), are rich in ecosystems to observe, paths to follow and explore (extent), are characterized by elements (water, trees, animals) that attract involuntary attention (fascination) and offer a wide range of activities compatible with our personal interests, for example: go out, observe, meditate, walk, etc. (compatibility). Indeed, some researchers have shown a close relationship between preference measures and perception of restorative qualities (for a review see Berto, 2014). Preferred environments recall properties of the ancient environment in which humans evolved (Orians, 1993). In savannah, there is no overload of information and involuntary attention can function while allowing direct attention to rest (Berto, 2011). For this reason, in architecture there should be a special attention to the design of restorative environments to avoid cognitive fatigue and favour the pleasure of living.

In an architectural project, it is possible to work on multiple levels for biophilic design, such as increasing the presence of small ecosystems in buildings through the addition of plants and plant walls, the incorporation of structures with natural shapes or the use of natural materials. Moreover, in the absence of a window or the presence of a natural view from the window, these small ecosystems are a small but effective sources of being-away that allows a temporary escape. This escape is a departure, albeit momentary, from the daily routine with positive effects on the mood of the individual. These are just a few examples showing how the restorative factors can easily be incorporated into everyday settings with significant positive effects both on the wellbeing and the cognitive performance of adults.

Restorative factors in practice

The approach adopted for the Strambinello project is a *scientific approach* because it applies within the architectural field a method and a precise frame of reference, i.e. Attention Restoration Theory. This approach is interdisciplinary and involves frameworks offered by disciplines such as ecology and environmental psychology.

The case study is part of a research and development project launched by the company Be-eco, an innovative start up and spin off from the Politecnico di Torino, which aims to innovate the 'housing system' by realizing ecological architecture. Be-eco has developed the residential system Eco-Home™, through which it promotes greater awareness of the environmental imprint of building projects, guaranteeing the liveability of the residence for the inhabitant.

See below - Figure 2 Solar path

The single-family housing unit is located in the municipality of Strambinello, a small town situated in the geographical area of Canavese (Northern Italy). It is an executive project situated on a former vineyard facing south and has a gross usable surface of 120 m². The house blends into the surrounding environment and there is a rich interaction between Man and Nature due to the presence of natural elements such as green spaces, woods and vineyards. There is the chance to immerse oneself completely in Nature through trails and paths present within and around the project area. This interaction between the inhabitants and their surrounding natural environment allows them to live in a cosy, peaceful and restoring place, away from the noise of the city. What follows is a description of how the four regenerative factors are present within the house.

Fascination

The presence of water, trees, animals and suggestive features such as sunsets, light reflections and rustling leaves guarantees activation of involuntary attention for restoring direct attention. The area of Strambinello project is rich in environmental elements, typically of Pedànea, the geographical area to which the municipality of Strambinello belongs. Pedànea has a clearly recognizable characteristic identity with a widespread presence of vines like Nebbiolo or Neretto; spontaneous and lush arboreal vegetation; a dense forest with plentiful chestnuts and birches; cultivated fields and gardens that signal the presence of nature-friendly horticulture. The view of these elements is conditioned by seasonal factors with varying degrees of colour depending on the time of year. From the site of the house, a hilly landscape of considerable beauty and size can be observed. There is a great variability and intensity of natural light, depending on the time of day time and the season. The site permits being connected to natural seasonal changes. There are also many opportunities for Human-Nature interaction within the internal environment of the building, providing elements which positively influence the individual's psycho-physical well-being. The architect has created internal spaces that have a clear connection with natural systems by evoking the idea of belonging to a larger entity and creating a perceptive change in

what one sees and experiences.

Being away

Being away is the physical and/or mental retreat from all those situations that require the use of direct attention and which are the cause of mental fatigue (work, daily worries, imposed habits), but also environmental stress like noise, crowding, air pollution or traffic.

As far as acoustic perception is concerned, the site is quiet and there are no unpleasant and disturbing noises caused by chainsaws, factories or other buildings. The presence of cars is also very limited as there are no busy streets nearby. The pleasant sound of Nature is constantly present through non-rhythmic stimuli such as birds chirping, the wind blowing between branches, rustling leaves, and the sound of rain. All these features allow for immersion in and connection with the surroundings and consequent distancing from environmental stress.

The house is not too close to the workplace of the inhabitants, thereby permitting them to move away from their daily concerns. This is also visible in the porch, designed to extend the kitchen and living space to outdoors, which allows the people to be in an environment protected from atmospheric agents (through the wooden beam roof) and to indulge activities such as rest, relaxation, reading or meditation. The large glass surfaces in the building allow continuous visual contact with the outside, favouring the view of natural environments and the perception of natural light. The distribution of the rooms follows the path of the sun, from dawn in the east to sunset in the west, so that day and night areas absorb the maximum irradiation. Inhabitants are able to clearly see and contemplate the surroundings, identify people who approach, the presence of animals or changes in the weather. In this way, there is no loss of relationship with the external environment and the notion of time.

The living room and the kitchen are essential, cosy, family gathering places, and the decor does not obstruct doors and windows. They are south-facing, in the part of house that enjoys the best view. The double and single bedrooms are located to the east in order to enjoy the dawn, as the sun's rays are beneficial to the body and create a pleasant feeling of awakening. Passageways and utility rooms such as staircases, workshop, bathroom and wardrobe are north-facing, the coldest side of the building which also presents a view which is more limited since there is a "green" consolidation escarpment. In addition, there is an area designed for horticulture, thus creating a fertile connection between the inhabitants of the building and the surroundings.

Extent

Extent is the space-time extension, the feature of an environment that can be explored and provide new experiences. A person feels "immersed" and this sensation is favoured by the presence of coherence and purpose in the environment, where each part is in harmony with the whole.

The project site is within an extensive natural environment that can be explored so that inhabitants can have new experiences in Nature, such as observing or experimenting, and sense a feeling of being in a wholly-different world. The house plan has been developed following Lynch's approach (Lynch, 1960), which gives meaning to the perception of space and the complexity of environmental information. According to Lynch, the individual creates a mental space map based on the recognition of various elements within the environment, in order to use them for particular purposes. The elements that usually make up mental maps are pathways (along which the observer moves, such as lanes or roads), edges (linear elements that the observer does not perceive as paths and which separate the various parts, such as walls, boundaries buildings, hedges), districts (areas that may have different functions, such as squares, parks), nodes (focal junction points, such as crossroads, squares or places of relationship) and landmarks (reference points, such as noticeable buildings or hills).

Around the area of the Strambinello project

there are pedestrian paths though the greenery. There is only one road where there is no traffic and a feeling of safety in crossing and walking. A small junction point is recognizable close to the road crossing. The landmarks are homes that become a real reference point in particular at night, since there is no street lighting. The perceived borders are fences or walls that identify private properties and are weak borders that do not conceal the view but allow good visibility, providing also a feeling of security. There is also a barrier that can be seen in the woodland located south of the project area which is both enjoyable to look at but does not permit seeing beyond. The "built" area is limited to a few isolated buildings and the conformation of their interior space gives the chance to simultaneously see different places. The open space design of the kitchen, dining area and living room means there are no visible barriers. The interior corridor leading to other places is short, connects the living area to the sleeping area and creates a sense of awareness of space.

Compatibility

Compatibility is the correspondence between people's inclinations and the opportunities offered by the environment to achieve their interests or purposes. Experiences in the natural environment are characterized by a high degree of compatibility that facilitates mental regeneration, whereas lack of compatibility can generate or worsen the state of cognitive fatigue.

In the area of the Strambinello project, inhabitants can admire the surrounding landscapes thanks to good illumination. In the evening or at night, the lack of streetlights means the area is completely dark, but this does not hinder the feeling of safety and familiarity while travelling along the road to get to the site. The natural environment offers various experiences that facilitate mental regeneration and reflection, there are many opportunities for gardening and there is a fenced area dedicated to cultivating fruit and vegetables, with a covered area for storing tools and a water supply. The site offers a wide range of activities for inhabitants with interests such as walking, observing nature and meditating.

The indoor environments are designed to meet all the daily needs of inhabitants while the natural materials used for both structure and interior furnishings improve their wellbeing and health, enabling them to perform a variety of activities in complete harmony with the outside world and themselves.

Future research developments

The Strambinello project has been designed so as to translate each single regenerative factor into an environmental characteristic. The expectation is that the home will be perceived as pleasant and regenerative by the people who live there. In order to verify this hypothesis, the inhabitants will be asked to produce Connectedness to Nature Scales (CNS). Since biophilic design starts with our relationship with Nature, the CNS help us to evaluate people's bond with Nature. This tool was developed during design (CNS at design stage) and the initial outcome reveals a good level connection with Nature. The inhabitants showed a medium-high average of scores, corresponding to sensitive to ecological issues. CNS is a stable trait in adults and should not change from place to place. However, we expect that people who are living in a regenerative environment will strengthen their bond with Nature. This can be evaluated by CNS at post occupancy stage. The next step will be to compare, after two years, the CNSs at design stage with CNS at post occupancy stage. CNS results are expected to increase.

A second study concerns the customers perceived restorativeness and after two years we will administer the *Perceived Restorativeness Scale* to the customers. The scale is based on ART (Kaplan, 1995), consists of 17 items in a Likert-10 scale, and the restorative value of an environment is given by the average of the scores for each item (Purcell, Peron & Berto, 2001).

If the Strambinello project has been successfully developed by following ART, the PRS score will

be high. We expect that inhabitants will acquire a greater awareness of their needs and increase their affiliation with Nature through living in a restorative environment (Berto, Pasini & Barbiero, 2015). The project is intended as a first step towards a biophilic design intended for daily living. Reconciling architecture with Nature by integrating natural elements should increase the perception of restorativeness as well as raise the aesthetic value of the environment (Kellert 2012).

Conclusions

Biophilic design could play an important role in contemporary western society where people are often overwhelmed by a wide variety and large amount of sensory information (Lipowski, 1970), which can cognitively overload their limited processing capacity (Berto, 2014). To prevent this, modern urban environments should be more "cognitively sustainable", and to this end psychological restoration can play a role in coping with mental fatigue (Berto, 2011). Architecture should take into consideration both environmental and cognitive sustainability. Sustainable architecture is currently focusing its attention on the building energy performance to certify the parameters of residential comfort.

Biophilic design encompasses and goes beyond this concept, by involving the inhabitants' cognitive wellbeing. The Strambinello project embodies the necessary energy and restorative factors and is intended as an example of advanced biophilic design that can be subjected to scientific verification.

NOTE: This paper is the result of a research project developed for the degree theses of Roxana Georgiana Marian and Giulia Nota (2017), coordinated by the tutors Professor Guido Callegari and Dr. Giuseppe Barbiero at the Politecnico di Torino, as part of the Master in Architecture for Sustainable Design program. The thesis experimentally applied the scientific protocol of Biophilic Design drawn up by Dr. Giuseppe Barbiero and Dr. Rita Berto, from the Università della Valle d'Aosta, to an architectural case study with low environmental impact designed by the company Be-eco, a spin-off from the Politecnico di Torino, founded by Professor Guido Callegari. In the light of the various contributions to the work, the authors are listed in reverse alphabetical order.

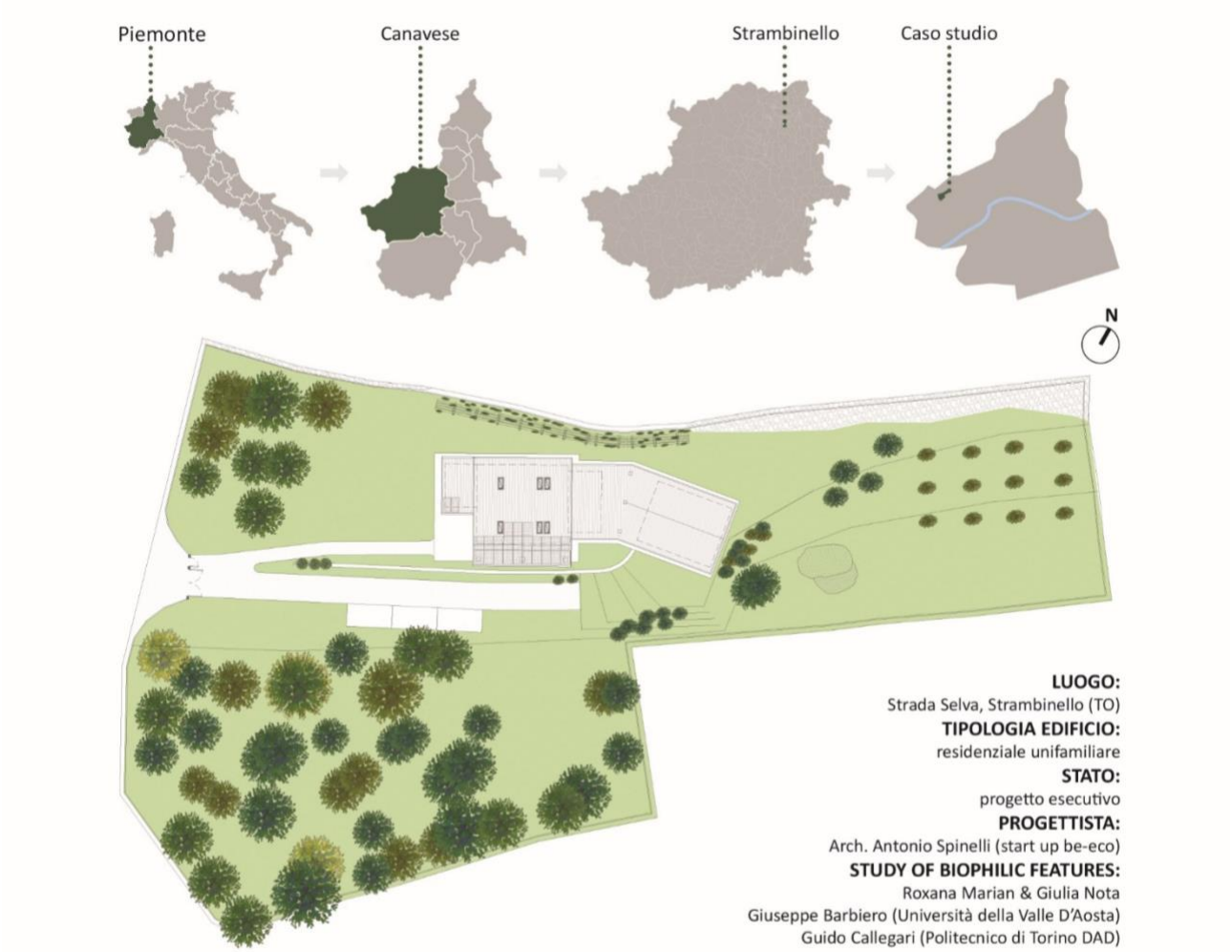

Figure 1: The Strambinello Project.

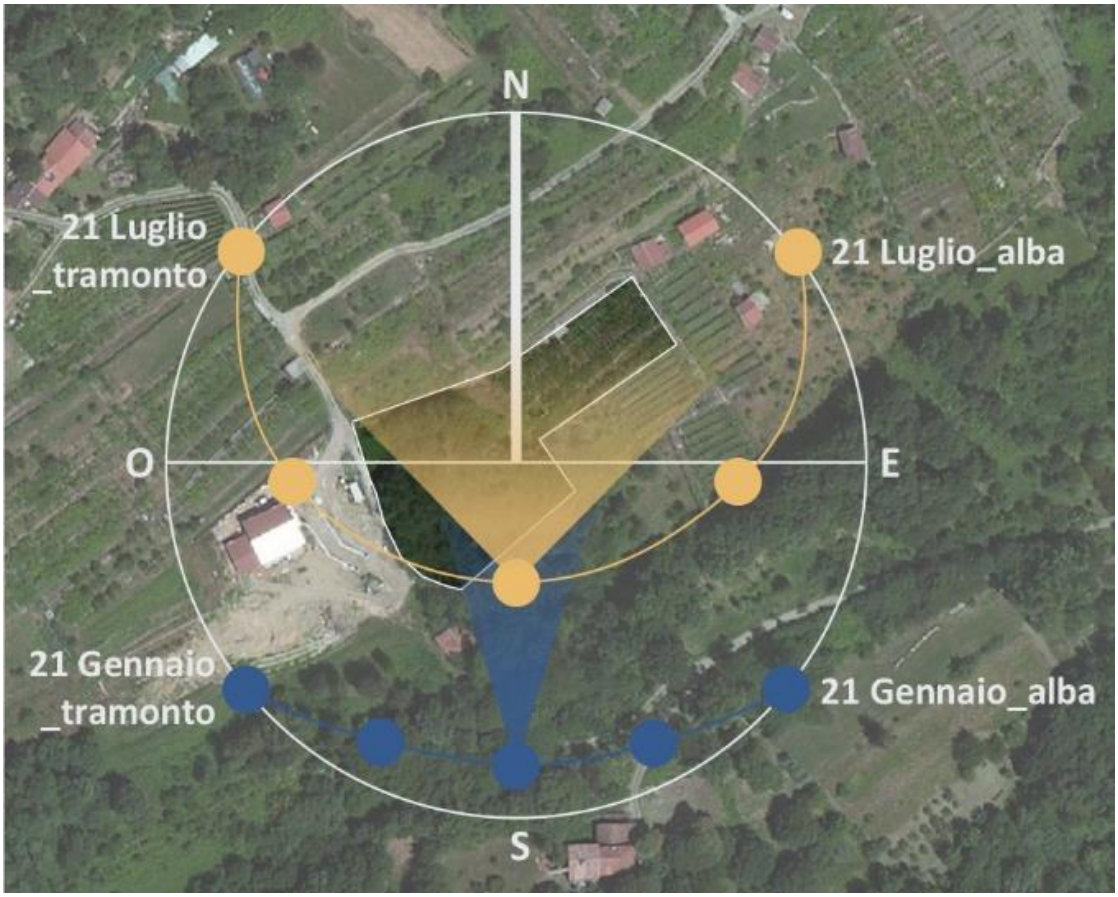

Figure 2. Solar path elaborated by R. G. Marian & G. Nota
(Image source: https://www.bing.com/maps)

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