earth

Review

Miyawaki and Urban Tiny Forests in Italy

Bartolomeo Schirone [1], Antonio Pica [2,*], Fabiola Fratini [3,*], Patrizia Menegoni [4] and Kevin Cianfaglione [5]

1 SIRF (Italian Society of Forest Restoration) at DAFNE Department, University of Tuscia, 01100 Viterbo, Italy; segreteria@restauroforestale.it
2 DAFNE Department, University of Tuscia, 01100 Viterbo, Italy
3 DICEA Department, University La Sapienza, 00184 Rome, Italy
4 ENEA, Italian National Agency for New Technologies, Energy and Sustainable Economic Development, 00196 Rome, Italy; patrizia.menegoni@enea.it
5 ICL, Junia, Université Catholique de Lille, LITL, F-59000 Lille, France; kevin.cianfaglione@univ-catholille.fr
* Correspondence: antonio.pica@unitus.it (A.P.); fabiola.fratini@uniroma1.it (F.F.)

Abstract

Rapid urbanization and climate change demand innovative green solutions in city planning. Tiny forests—small artificial wooded areas in urban or peri-urban settings—are gaining attention. This paper explores the use of the Miyawaki method to establish such forests in Italy, highlighting their environmental and educational benefits. The study defines micro-forests (100–200 m^2) and mini-forests (200–2000 m^2) per legislative standards and describes the qualitative features needed for self-sustaining ecosystems. Mimicking natural succession, these forests support biodiversity, reduce urban heat, improve air quality, and act as carbon sinks. Beyond ecological functions, they offer strong pedagogical value, fostering naturalistic intelligence and reconnecting people with natural rhythms and ecosystems. Case studies from Vigevano and Rome show practical applications, demonstrating how tiny forests can enhance sustainability, community well-being, and environmental awareness in cities.

Keywords: tiny forests; standard dimensions; Miyawaki method; pedagogic role

check for updates

Academic Editor: Charles Jones

Received: 30 July 2025
Revised: 15 September 2025
Accepted: 22 September 2025
Published: 26 September 2025

Citation: Schirone, B.; Pica, A.; Fratini, F.; Menegoni, P.; Cianfaglione, K. Miyawaki and Urban Tiny Forests in Italy. *Earth* **2025**, *6*, 116. https://doi.org/10.3390/earth6040116

1. Introduction

Of the approximately 8 billion human beings inhabiting the planet today, 4.4 billion live in cities. This number is steadily increasing and is expected to rise to 7 out of 10 people by 2050 [1]. Urban expansion is further driven by growing conflicts, more than 50% of displaced people live in urban areas, exposing a large percentage of humanity to the resulting impact on spatial resources, biodiversity, energy, water, and air quality. Concurrently, the increasingly evident effects of climate change significantly heighten hydrogeological, environmental, social, and health risks, along with diminished quality of life [2].

One effective tool to mitigate these dramatic effects involves protecting existing vegetation and creating larger and more expansive green spaces within urban areas. These now play a vital and strategic role in urban development policies, becoming an essential component of sustainable city planning. The overarching goal, starting from urban centers, is to establish green and blue corridors—green for vegetation and blue where vegetation coincides with water bodies and their banks—that extend into peri-urban and rural areas, including industrial and agricultural zones [3–6]. These efforts aim to preserve, restore, and construct networks of vegetation and ecological continuity that are beneficial for humans, while enabling other species to move, feed, reproduce, and rest, thus ensuring their life cycles [7]. These measures also enhance the health, diversity, and aesthetics of territories and landscapes, contributing to greater environmental security and an improved quality of life.

The central elements of these new projects are always trees, especially when grouped together. Over time, a specialized discipline has emerged, known as Urban Forestry. According to FAO guidelines, urban forests are defined as "networks or systems comprising all forests, tree groups, and individual trees located in urban and peri-urban areas; they include forests, trees along avenues, trees in parks and gardens, and isolated trees. Urban forests form the backbone of green infrastructure, connecting rural and urban areas and improving the environmental footprint of a city" [8]. Urban Forestry seeks to optimize the ecological, social, and economic benefits offered by trees and urban forests, improving the quality of life in cities. Indeed, the presence of a vast network of plants in cities offers numerous benefits to citizens' health and quality of life while countering the extreme effects of climate change, which come with enormous social costs: reducing urban heat islands, positively influencing physical and mental health, adapting to extreme heat, protecting biodiversity, reducing air pollution, minimizing noise and light impacts, mitigating extreme weather events, and contributing to sustainable social and economic development [9]. The management of urban forests at both national and European levels lacks standardized criteria, whether concerning their location within the urban context or their historical background. In Italy, for instance, many parks that, in terms of size and structure, resemble true forests are actually extensive green areas belonging to renowned noble estates, such as Villa Borghese or Villa Doria Pamphili in Rome, or the Boboli Gardens in Florence. In these cases, historical considerations are prioritized, with efforts made, whenever possible, to preserve the original layout.

By contrast, natural forests integrated into the urban fabric or created ex novo with the explicit aim of providing public spaces for citizens' physical and psychological restoration follow a different rationale. This practice is more common in other European countries than in Italy; notable examples include the Amsterdamse Bos near Amsterdam, the Hamburger Stadtpark in Hamburg, and the Bois de la Cambre in Brussels.

From a technical perspective, all these urban forests are managed using careful maintenance strategies that also ensure public safety. This includes the removal of dead or hazardous trees, the prevention of plant diseases, and, where necessary, the planting of new individuals. Comprehensive guidance on management criteria can be found in the FAO volume Guidelines on Urban and Peri-Urban Forestry [8]. The importance of urban forests in city planning and design is underscored by the fact that Urban Forestry is now regulated by specific laws. In Italy, this is addressed by "Law No. 10 of 14 January 2013" and the "Decree of 9 October 2020," while in Europe, the recent "EU Regulation 2024/1991 (Nature Restoration Law)" explicitly mentions it in Article 8 (Table 1).

In the realm of Urban Forestry, the term "tiny forests" is gaining increasing attention, with numerous articles and books published on the subject [10–13]. This term refers to small artificial forested areas created in urban or peri-urban settings for various purposes. Indeed, a significant increase in urban green cover is closely linked to the ability to plant trees and vegetation even in the smallest available spaces, which are typically the most numerous, especially in historic city centers. Among the various modern afforestation techniques, the Miyawaki method has proven particularly suitable for urban contexts, as it allows the creation of a genuine small forest with remarkable speed and a visually appealing landscape outcome.

For this reason, Miyawaki tiny forests have rapidly spread in several non-European countries, including Japan [14], the United States [15], and India [16–18], as well as in European countries such as Belgium [19,20], France [21,22], Portugal [23], the Netherlands [24], Spain [25], Germany [26], and the United Kingdom [27,28]. Even in Italy, since 2021, tiny forests planted using the Miyawaki method have started to become more widespread. This conceptual note outlines the most important tiny forests in Italy and proposes a nationally applicable standard that could also have broader applications.

Table 1. Legal anchors: overview of relevant national and EU frameworks.

Type	Legislation ID	Name	Reference
European Legislation	Regulation (EU) 2024/1991 of the European Parliament and of the Council of 24 June 2024 on nature restoration and amending Regulation (EU) 2022/869—Nature Restoration Law.	Nature Restoration Law	https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32024R1991&qid=1722240349976 (accessed on 30 June 2025)
Italian Legislation	Law of 14 January 2013, No. 10—Rules for the development of urban green spaces.	Rules for the development of urban green spaces	https://www.normattiva.it/atto/caricaDettaglioAtto?atto.dataPubblicazioneGazzetta=2013-02-01&atto.codiceRedazionale=13G00031&tipoDettaglio=originario&qId= (accessed on 30 June 2025)
Italian Legislation	Decree of the Ministry of the Environment and the Protection of Land and Sea of 9 October 2020 (Official Gazette No. 281 of 11 November 2020)	Procedures for the design of reforestation interventions pursuant to Article 4 of Decree-Law of 14 October 2019, No. 111, converted, with amendments, by Law of 12 December 2019, No. 141	https://www.reteambiente.it/normativa/43092/dm-ambiente-9-ottobre-2020/ (accessed on 30 June 2025)
Italian Legislation	Legislative Decree of 3 April 2018, No. 34—Consolidated Forestry and Forest Supply Chains Act (TUFF)	Consolidated Forestry and Forest Supply Chains Act (TUFF)	https://www.normattiva.it/uri-res/N2Ls?urn:nir:stato:decreto.legislativo:2018;34~art10-com4 (accessed on 30 June 2025)

2. Tiny Forests

But what exactly are tiny forests? For a rational description that ensures clarity, at least in Italy, it is helpful to summarize the main features of these implementations by first examining the quantitative aspects, which are easier to address, and then the qualitative ones.

2.1. Quantitative Features

When discussing tiny forests, the first question to address is their size—how big they are or should be. Currently, there are no precise guidelines in this regard. In Italy, a useful reference criterion is provided by the definition of a forest established in Legislative Decree No. 34 of 3 April 2018, which comprises the Consolidated Forestry and Forest Supply Chains Act (TUFF) (Table 1). When formulating the definition of a forest, including its dimensional limits, the Italian legislator took into account the FAO definition [29] as well as the previous forest definitions in force across the twenty Italian administrative regions. In Italy, agricultural, forestry, and environmental responsibilities fall under the jurisdiction of the Regions, and each had its own definition of a forest in the corresponding regional forestry law. Many of these definitions coincided or were similar, while others differed. At the national level, those definitions that were better articulated, more widespread, and more consistently applied were taken into consideration. According to this law, "a forest is defined as land covered with arboreal forest vegetation, with or without associated shrub vegetation, of natural or artificial origin, at any stage of development, with an area of no less than 2000 m^2, an average width of no less than 20 m, and a coverage of no less than 20%, measured from the external base of the stems." Therefore, forest formations, even of artificial origin, larger than 2000 m^2, are considered forests in every respect. This means that tiny forests must necessarily have a surface area smaller than this threshold.

To remain consistent with the TUFF, using the numerical factor of two as a base for calculation, two threshold values can be proposed to define the dimensional placement and corresponding terminology of tiny forests: areas from 100 m^2 to 200 m^2 can be defined as "micro-forests" (the minimum surface area for a tiny forest according to the literature is 92 m^2 [11,12], and those between 200 m^2 and 2000 m^2 are "mini-forests." These values are not entirely arbitrary but correspond to the minimum and maximum reference surfaces for afforestation executed using the "group and micro-collective" method, commonly adopted in mountain regions [30,31]. The "group and micro-collective" method is a reforestation technique developed by Swiss foresters for high-altitude mountain slopes. Even in extensive plantations, the trees are not planted continuously but form small clusters, or "micro-collectives," which are further organized into larger "groups." Both micro-collectives and groups are spatially separated, with groups positioned farther apart. Over time, micro-collectives may merge, whereas the groups remain distinct, resulting in a forest cover that is never fully continuous, thereby reflecting natural forest patterns. This arrangement is designed to allow snow to flow freely between tree clusters, particularly during the spring thaw, thus minimizing avalanche risk. In this framework, the term "tiny forests" retains a general or generic meaning, while two precise and unequivocal terms become available for scientific analysis and project activities.

To extend this logical approach internationally, the FAO definition of a forest could be adopted, partially replacing the factor of two with five. Indeed, according to the FAO: "Forests are lands of more than 0.5 hectares (5000 m^2), with a tree canopy cover of more than 10 percent, and width of more than 20 m. The trees should be able to reach a minimum height of 5 m in situ" [29]. Finally, it should be noted that there are also extremely small plots of just a few tens of square meters, sometimes referred to as micro-forests. However, these are fragments that could hardly be associated with a true forest in reality. These miniature plantations might humorously be referred to as "nano-forests."

2.2. Qualitative Features and the Miyawaki Method

Once quantitative criterion has been established, it is necessary to focus on the qualitative aspects, i.e., the features that micro- and mini-forests must possess to be considered such. Given the very small areas of these formations, traditional concepts and techniques for afforestation or reforestation would not result in the creation of small forests but rather clusters of trees or shrubs. A forest, however, is an autopoietic system—a dynamic and complex entity dominated by trees but comprising a variety of organisms capable of perpetuating themselves autonomously. As complex systems, forests are characterized by self-organization capabilities and emergent behaviors. Moreover, they are syntropic, meaning they generate order through the photosynthetic activity of plants and naturally evolve toward conditions of maximum complexity [32,33].

Currently, the only approach capable of effectively establishing a miniature forest is the Miyawaki method. This planting technique, developed in the 1970s by the renowned Japanese botanist Akira Miyawaki, reduces the time required for forest development by a factor of 10—for example, enabling a forest to grow in 30 years instead of 300 under natural conditions [34–36] (Figure 1). Introduced to Europe and adapted to the Mediterranean environment in 1996 by B. Schirone, one of the authors of this article, this method stands out from all other reforestation techniques because it respects and mimics the natural processes of vegetation succession, which are themselves founded on the self-organization of complex systems [37]. In other words, it involves creating stands that function as compact ecosystems, perfectly efficient despite spatial limitations. As such, only those created using the Miyawaki method can be accurately defined as tiny forests (micro- and mini-forests).

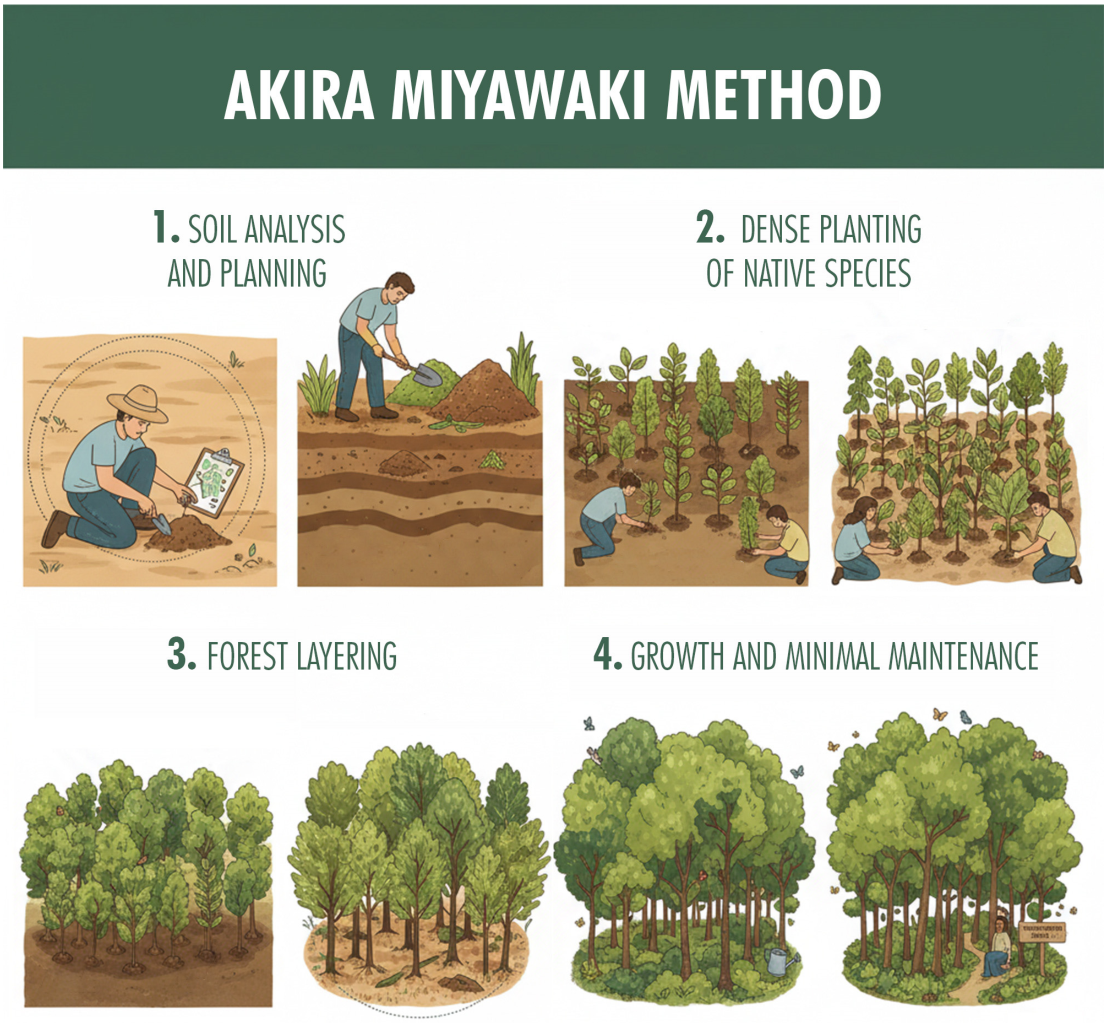

Figure 1. The Miyawaki method: four steps to create a dense, diverse, and self-sustaining forest.

However, this method is not easy to apply, even though many practitioners today—sometimes unprepared—offer it. The Miyawaki method is the direct outcome of the author's empirical observations on the natural dynamics of forests, rather than the application of a pre-existing theoretical model. Conceptual advances followed practice to a large extent, while technical aspects represent the cornerstone of the entire approach. Over time, these techniques were refined by Miyawaki himself and his students, ultimately leading to the development of protocols that are now relatively well defined.

However, when applied in urban contexts, the method often forces designers to deviate—sometimes considerably—from the ideal framework, as unforeseen or insurmountable constraints frequently arise. In Italy, for example, restrictions imposed by the superintendencies for archeological and monumental heritage may apply, particularly in historic city centers. In other cases, public green space regulations or school administrators may prohibit the planting of species considered potentially harmful, either directly or indirectly, to children. Additional challenges may stem from difficulties in sourcing suitable species, or from limited access to the materials and equipment required for site establishment. Economic constraints are also far from uncommon.

Such limitations may lead to partial or temporary failures of interventions, resulting in understandable frustration among designers and disappointment with respect to their expectations. With this necessary caveat, it should be noted that the technical aspects of the Miyawaki method are sometimes not adequately addressed during the planning and design of a micro-forest. Specifically:

(a) Site assessment and reference vegetation.

The design of a micro-forest must first consider the location of the site within the urban context, taking into account both the reference vegetation for the area and the characteristics of the soil, without neglecting the influence of existing built volumes and the shadows they cast. Determining the reference vegetation is often particularly challenging in large urban agglomerations, especially those extending across morphologically heterogeneous territories. Rome, for instance, combines hilly areas with lowland zones even within its central core. In such cases, residual natural vegetation in abandoned areas or large urban parks can provide useful indications, which should be complemented by archival documents to reconstruct the potential natural vegetation of the area.

Soil conditions should reflect the characteristics of the most advanced successional stage of the forest considered compatible with the local environment. Ideally, the soil should be deep, well-drained, rich in organic matter, slightly acidic, and biologically active. Soil amendments and biostimulants may be employed to improve its quality. Where necessary, soil preparation should involve the entire surface rather than being limited to individual planting holes.

At the design stage, particular attention should also be devoted to the built volumes within the intervention area and the shadows they cast on the ground. This includes examining the shading produced by buildings and pre-existing trees on individual plants and on the micro-forest as a whole, as well as the shading of taller trees and shrubs on human-used structures and spaces.

(b) Species pool selection and stratification.

The choice of species to be planted in the creation of a Miyawaki micro-forest is a crucial step. In accordance with the Japanese author, these should correspond to those occurring in the terminal stages of succession. However, experience gained in Mediterranean environments suggests the inclusion of certain mid-successional species, capable of acting as keystone species, as well as shrub elements useful for saturating space and attracting pollinators and birds that can contribute to the maturation of the community.

Moreover, since these species generally display a more heliophilous character compared to terminal-stage species, it may be advisable not to plant them in a completely random pattern, as originally proposed by Miyawaki, but to orient their spatial distribution by reserving the central portions of the plot for the more shade-tolerant taxa.

As the micro-forest progressively evolves towards its final vegetation structure, shaped by local environmental conditions, both composition and architecture will inevitably change over time. Indeed, while one may attempt to guide the composition of a micro-forest, natural dynamics will always prevail. If this were not the case, it could be concluded that the designer has failed to achieve the intended goal.

(c) Planting density and spacing.

Planting density is one of the key aspects of the Miyawaki method, and our experience confirms the recommendations of the Japanese author himself. The number of plants per square meter should range between two and three and never fall below this threshold. Seedlings should be approximately half a meter in height and distributed randomly across the plot, without following any predetermined geometric pattern.

(d) Mulching.

Mulching is a common practice in arboricultural systems, reproducing the natural process whereby fallen leaves form a litter layer covering the bare soil during the unfavorable season. Litter reduces the erosive action of heavy rainfall and allows water to be gradually absorbed by the soil. On flat ground, it also mitigates waterlogging. During dry periods, it decreases soil evaporation—or more precisely, evapotranspiration, since the contribution of the entire soil biota must also be considered. In the cold season, it protects root systems from extreme temperatures and frost, thereby allowing plants to survive even when their aboveground parts die back.

Litter also plays a role in plant competition, acting as a barrier against herbs that might otherwise compete with the seedlings and saplings of the tree species that produce them. An important and often overlooked aspect is its biological function: it shelters the minor biotic components that sustain the soil (microflora, microfauna, fungi, bacteria), buffering sharp thermal, hydric, and light fluctuations. Furthermore, being composed of biodegradable material, it provides an essential nutrient source for fungi, bacteria, and various microorganisms, thereby contributing to soil fertilization. Finally, from a systemic perspective, the role of litter within successional dynamics becomes evident.

The Miyawaki method seeks to replicate all the processes that characterize natural succession from bare soil to a terminal forest, while introducing a set of measures that, in practice, bypass, shorten, or accelerate the various successional stages. With regard to mulching, it is important to respect, as far as possible, natural processes by using organic materials ideally collected on site. As noted above, litter itself should belong to the local environment and the ecosystem of which it is part.

Accordingly, the material employed should preferably be sourced locally, as it will be nearly cost-free, degrade more easily and rapidly, and be processed by decomposers already adapted to the site. In urban environments, however, such conditions are rarely met. In these cases, straw or large leaves (e.g., from plane trees or hybrid poplars) can be used; these should be air-dried and then laid in multiple layers to ensure that the soil remains covered, even if wind displaces part of the mulch. To prevent such losses, the material can be secured with strings or, preferably, with stones, which may also act as small moisture condensers.

In the absence of natural mulch, old jute sacks (such as those used for coffee transport) can be spread over bare soil—either opened or folded—and have already proven highly effective. In extreme cases, nonwoven fabric may also be used, provided it is removed after the first growing season. Moreover, the design of these small Miyawaki forests often fails to consider the future evolution of the planting in subsequent years or over the long term.

3. The Evolution of Tiny Forests

In many articles, tiny forests are described as "islands of biodiversity," but this statement overlooks the fact that, over time, plant biodiversity tends to decrease. This is because, during forest succession, numerous generalist, pioneer, or sun-loving species present in the early stages tend to diminish in favor of more shade-tolerant or late-successional species typical of more advanced stages aligned with the expected potential vegetation. Additionally, the Miyawaki method itself, being focused on late-successional tree species, inherently limits both the quantitative and qualitative richness of flora [38–40].

Another consideration involves competition dynamics, which depend on the spatial availability around the micro- or mini-forest. Over time, trees grow, and through the inexorable ecological process of natural selection—which also underpins much of traditional forestry—their numbers per unit area decrease [41]. Naturally, the rate of selection varies based on species and site conditions, but, as a rule, it falls rapidly. In oaks, for example, from hundreds of seedlings per square meter two years after dissemination, no more than five trees per 100 m^2 would remain after 40 years, potentially reducing to three by 60 years [31]. When applying the Miyawaki method, the mortality rate differs between reforestations carried out in natural environments—where significant plant losses are observed—and those in tiny forests. In the former case, an example is provided in Sardinia, where Schirone et al. [37] reported a mortality rate of 61–84% after 12 years. For urban environments, precise data are not yet available, as there are no very old Miyawaki micro-forests. In any case, plants in cities generally experience better conditions, often being maintained by municipal gardening services. Nevertheless, mortality rates are lower, averaging around 20–25% three to four years after planting, as reported in the UK [42]. Further information can be found in Manuel [43]. Likewise, the shrub undergrowth will be significantly impoverished compared to the initial planting. This means that, of the initial micro-forest, only a patch with three or four large trees will remain, which, while visually impressive, will no longer bear any resemblance to the original forest concept, thus ceasing to be qualified as a tiny forest.

The situation changes if there is available free space around the initial planting. A forest, as a dynamic autopoietic system, continually restructures itself internally and expands outward, constantly striving to increase its surface area. In other words, forests, like rivers, should be considered "living entities" that require room for expansion and fluctuation to retain their identity and functionality. At the same time, the limitations of micro-forests become less pronounced in mini-forests, where greater available space allows for more internal reorganization and the preservation of their image. A stand of approximately 1000 m^2 is already capable of regenerating itself spontaneously and initiating dynamics such as successional processes, as demonstrated in many cases, including a small Mediterranean forest reproduced at the Botanical Garden of the University of Tuscia [44].

The constraint of limited space strongly affects the development of tiny forests, irrespective of the dynamics of forest succession. This situation creates a paradox similar to that of an aquarium: as the fish grow and multiply, either the aquarium must be enlarged or the number of fish reduced. In urban settings, where only very small areas are available for planting, two main strategies can be adopted to preserve the physiognomy of a compact plant community without entirely departing from the principles of the Miyawaki method or the considerations outlined above.

The first strategy involves selecting, among the terminal and sub-terminal species typical of the local vegetation, those with smaller stature or shrub-like growth forms. In Mediterranean contexts, for instance, a micro-forest designed to reproduce the *Quercetum ilicis* community would exclude *Q. ilex*, the climax species, and stop at the sub-terminal stage, corresponding to a secondary Mediterranean shrubland. In this way, the stand would not exceed 5–6 m in height while retaining a relatively compact structure over time.

Alternatively, if terminal tree species are included in the plantation, careful monitoring of growth rates and developmental patterns is required. Once the tallest trees—such as *Q. ilex* in the case of holm oak forests—reach a significant height, they may need to be progressively removed. However, adopting this second strategy implies a much more demanding maintenance regime, both technically and economically

4. The Utility of Tiny Forests

Having defined the quantitative and qualitative aspects necessary to define a tiny forest, the next question arises: What is the specific purpose of these plantings? What exactly are tiny forests intended to accomplish?

The literature presents a long list of benefits provided by tiny forests. For instance, according to the Urban Tiny Forest [15], Miyawaki tiny forests:

- Cool cities by two to six degrees.
- Reduce air pollution, dust, and act as air filters.
- Lower rates of cardiac diseases, stroke, and asthma.
- Increase physical activity.
- Protect biodiversity by providing habitats.
- Act as carbon sinks.
- Support social cohesion.
- Reduce stress and crime.
- Produce oxygen and reduce carbon.
- Assist in active stormwater management.

Valuable insights on each of these aspects can be found in the studies by Ottburg et al. [45] and Akram et al. [46]. In particular, Ottburg et al. [45] measured soil temperatures inside 11 tiny forests and in adjacent urban areas (streets/squares) in the Netherlands (2018–2021). Under extreme conditions, i.e., on very hot days, differences of up to 20 °C lower soil temperatures were recorded compared to asphalt/roads. On average, tiny forests provided an annual cooling effect of ~7 °C compared to streets, and ~10 °C during summer. Moreover, the tiny forests aged between ~1 and 5 years, sequestered on average 127.5 kg of CO_2 per year each, and it is estimated that as they mature, they may achieve a stable sequestration of about 250 kg CO_2/year per tiny forest after ~50 years. However, there was substantial variability among sites: some sequestered very little (~4.3 kg CO_2/year), while others much more (~631.2 kg CO_2/year). These differences were mainly related to the age of the forest (younger stands sequester far less), planting density, species composition, soil conditions, and accidental events. Urban biodiversity also increased thanks to Miyawaki tiny forests, both through directly introduced species and those subsequently attracted to these habitats. In total, ~1167 species of plants, fungi, and animals were recorded, including ~636 animal species (insects, mollusks, arthropods, etc.) and ~298 plant species. The increase in local biodiversity linked to Miyawaki tiny forests is further confirmed by Akram et al. [46], who, although not providing precise numerical data, report that biodiversity may increase 20- to 100-fold compared to the initial baseline.

Regarding psycho-physical and sociological aspects, interesting evidence is provided by Rajadurai [47], who found that 78% of people living near Miyawaki forests reported higher levels of environmental satisfaction, compared to 42% of those living farther away. In addition, 85% of respondents residing close to Miyawaki forests stated that they regularly engage in outdoor activities, compared to 60% among those not living nearby. Furthermore, 72% of residents near a Miyawaki forest reported an improvement in their well-being, while this percentage was only 38% among those living farther away. More detailed information on these topics is offered by Ikei et al. [48], who measured changes in autonomic nervous system activity (e.g., heart rate variability), while Arantes et al. [49] investigated the relationship between green spaces and crime, reporting that crime rates decrease by 1.2% for every 10% increase in tree canopy cover.

Other authors delve deeper into some of these points or focus on additional ones, such as wind mitigation, water absorption, etc. [11]. However, while these claims are valid and the benefits of tiny forests are real, it is difficult to argue that they significantly exceed those offered by other, more traditional forms of urban greenery.

Therefore, our attention has shifted to the educational and pedagogical role of tiny forests, which, in our opinion, is by far the most important function. This role should primarily target children, from the age of one and up, and secondarily teenagers and university students [12]. Tiny forests can support the development of children's cognitive abilities and personalities by fostering:

- The recovery of naturalistic intelligence.
- A reconnection with natural time.
- A "spontaneous" understanding of concepts like adaptation, succession, and evolution.
- A "spontaneous" grasp of competition and cooperation dynamics.
- Recognition of taxa and the distinction between flora and vegetation.
- Study and comprehension of plant/vegetation–climate relationships.
- Study and understanding of soil-flora-fauna interactions.
- Application of modern technologies to studying natural environments (including the use of smartphones).
- And much more.

A comprehensive analysis of all these aspects presents considerable challenges; therefore, in this paper, we focus on three issues that appear to be the least thoroughly examined in the existing literature on Miyawaki micro-forests, reserving the discussion of the remaining aspects for future work.

5. Recovery of Naturalistic Intelligence

If we agree that tiny forests can play a pedagogical role, the central point of all reasoning is knowledge—or, more precisely, enabling knowledge. One might consider this a simple topic, reducible to extensive publications, visitor centers, museum collections, or promoting various botanical and zoological studies. However, knowledge is a complex and winding process, much like the meandering of a river.

While it is impossible to address knowledge from a philosophical or neuropsychological perspective here, applying it to the environment and nature requires at least some consideration of two primary aspects:

1. The method by which the cognitive process is structured and proposed.
2. The object of the cognitive process.

Let us begin with the first. It is useful to consider Howard Gardner's theory of multiple intelligences. In short, this American psychologist, a professor at Harvard, realized—through studying individuals with specific brain damage and conducting targeted tests and experiments on subjects of diverse ethnicities and cultures—that the prevailing focus on linguistic-verbal and logical-mathematical intelligence in psychology was insufficient to explain the cases he observed. By analyzing the various approaches and abilities humans use to interact with themselves and their surroundings, Gardner identified an additional six forms of intelligence. According to Gardner, the different types of intelligence are linguistic-verbal, logical-mathematical, visual-spatial, interpersonal, introspective, body-kinesthetic, musical and naturalistic. In 1983, he published his findings in a book titled *Frames of Mind*, which outlined his theory of multiple intelligences [50].

Although these types of intelligence often operate simultaneously to varying degrees, the one we need to discuss is "naturalistic intelligence"—the ability of humans to recognize and classify different elements in the natural environment, particularly living organisms. Like other intellectual abilities, this one has a genetic basis in human history but does not manifest equally in all individuals, as beautifully illustrated in Gerald Durrell's famous novel *My Family and Other Animals* [51].

Moreover, naturalistic intelligence only sometimes overlaps with or coincides with "biophilia"—the innate human propensity for emotional connection with all living beings, as theorized by the great American ecologist Edward Wilson [52]. Generally, biophilia is an ultimate condition that, as Barbiero argues, can be reached through a specific educational process [53]. Furthermore, in 1990, psychologist Stephen Ceci of Cornell University introduced the "Bioecological Theory of Intelligence", which suggests that the level of mental activity depends on the context in which it develops [54]. Therefore, the challenge lies in awakening or enhancing naturalistic intelligence. How?

This process can be facilitated and accomplished by engaging children from the earliest stages of their development, but, albeit with the limitations imposed by the already formed mental construct of the adult, it can also be attempted to be applied to an already evolved brain. A relevant model could be the internationally renowned Reggio Emilia Children Approach® [55], developed by educator Loris Malaguzzi [56]. This approach is essentially a variation in methods pioneered by Maria Montessori [57], Jean Piaget [58], and Seymour Papert [59]. According to this philosophy, children take an active role in their educational journey and are free to interact with their surroundings. Teachers, along with parents, guide children in their growth, acting as facilitators—true pedagogues in the etymological sense—within an environment rich in stimuli, referred to by Malaguzzi as the Atelier.

Concretely, the Atelier is a space where children can freely explore various objects and materials, such as construction pieces, fabrics, paints, toys, and clay [60]. The Atelier serves as the "third educator," as Malaguzzi asserted that the educational process involves three participants:

- Other children, who are the first educators.
- Parents and teachers, who act as privileged interlocutors.
- The environment, the social and physical context in which the child grows.

We propose extending the concept of the educational space to include the natural environment, transforming it into a third educator. In other words, the natural environment can function as an Atelier where a child exercises naturalistic intelligence, potentially leading to biophilia. It is worth noting that naturalistic intelligence was among the first to develop in humans, as it was vital for survival. Hence, even adults, when placed in environments aligned with their genetic memory, may exhibit significant responses to this type of stimulation.

5.1. The Object of the Cognitive Process

The object of the cognitive process, in this context, coincides with the third educator: the natural environment. What characteristics must it have to activate naturalistic intelligence?

The models related to the types of intelligence and educational processes mentioned earlier find substantial confirmation and new relevance considering recent biological discoveries on the role of epigenetics, both in explanatory and applied terms. Building on hereditary traits from parents, lineage, and species, it is the environment, with all its tools, which shapes the brain's anatomy, physiology, and mental structures [61–64]. This process begins, albeit with some uncertainty about timing, during intrauterine life [65,66].

Statistically speaking, a musically rich environment is likely to foster the development of musical intelligence, particularly among descendants of a family of musicians. Some specialists even differentiate among composers, asserting the greater benefits of listening to Mozart during gestation [67–69]. Similarly, frequent exposure to a natural environment positively influences the development of naturalistic intelligence and related abilities.

What mechanism governs or determines this? Providing a complete answer is challenging. However, if we consider what has been said about musical intelligence—and the importance of language for developing linguistic-verbal intelligence—we can focus on the concept of communication: the exchange of signals among organisms. It has long been known that all living beings, from single cells to the most evolved organisms, receive and transmit information essential for survival [70–72].

In recent decades, it has also been demonstrated that plants exchange signals with their surroundings, leading to hypotheses about plant intelligence [73–75]. Simultaneously, ecosystems are increasingly recognized as superorganisms shaped by symbiotic relationships [76,77]. In forests, for example, the term wood wide web or mycorrhizal network describes the delicate fungal hyphae that connect trees, facilitating water and nutrient absorption and transport within the community [78]. This system also involves all other living organisms, from bacteria to animals, residing in the soil. Since the boundary between soil and surface is uncertain and highly porous, exchanges also occur above ground, involving all living components of the forest. Communication among these organisms involves countless signals—electrical, light, acoustic, chemical, electromagnetic, and mechanical. Sensitivity to these signals appears exceptionally high. Increasingly robust evidence suggests that many of these signals, including those from plants and fungi, reach humans—often subconsciously. Similarly, a significant portion of organisms, including plants, may perceive our presence [79]. These interactions foster the expression of naturalistic intelligence, potentially embedding it in our genome through epigenetic mechanisms. Perhaps it is no coincidence that early advocates for national parks, such as John Muir and Henry David Thoreau, were shaped by similar environments. Similarly, Maria Montessori and Jean Piaget built their pedagogical models on a profound passion for biological and naturalistic studies [80,81].

5.2. What Characteristics Should a Forest Have to Stimulate Naturalistic Intelligence?

What characteristics must the natural environment—specifically, a forest—possess to stimulate and develop naturalistic intelligence, guiding children (and, to some extent, adults) toward biophilia? In our view, the forest must be as intact as possible.

This is not because an untouched forest is inherently more attractive, pleasant, or educational than a logging site—such a comparison is obvious and trivial. If we wish to teach a child to respect and love animals, we do not take them to a slaughterhouse or a butcher shop. Rather, it is because forests are complex systems composed of an incalculable and unknowable number of elements—all interacting according to patterns that are difficult to recognize, decipher, or even imagine.

A child, especially at an early age, should be exposed to all the signals that permeate this environment. Anthropologists like Eduardo Kohn and philosophers like Emanuele Coccia explain why this is important [82,83]. Every organism has its own vital realm and "worldview," which it explores and interacts with using the communication tools most suited to it. In other words, every organism has its own language. To understand and interact with it, one must acquire that language: to converse with a leopard, one must become a leopard; to converse with a plant, one must become a plant.

This is not a difficult concept to grasp if we consider how effortlessly an infant learns the language spoken by those around them—the so-called mother tongue—which relates to linguistic-verbal intelligence. If the environment "speaks" Italian, the child will begin speaking Italian; if it "speaks" Arabic, the child's vocal expression will be shaped by Arabic. If two languages are spoken in the household, the child will grow up bilingual, and so on.

What language should a child learn to interact with the natural environment? The language of the leopard, the oak, or the truffle? We cannot decide this for them. The child must choose the subjects and forms of interaction most congenial to them in their natural Atelier. They must have the freedom to choose! Their capacity for expression and interaction will be greater the richer and more complete the environment offered to them.

Ideally, children would grow up in or near a fairly intact forest. This, however, is often impossible for children living in cities. Here, Miyawaki tiny forests can provide an ideal solution, though they sometimes require adaptations to the original model. What matters is that the design is meticulous—both in selecting plant species and other elements that closely resemble the natural environment, and in considering factors like shape. Even in micro-forests, the design should allow children to “enter” the space, feel surrounded by the forest, and experience residing in or walking through it. For larger mini-forests, this role can persist for many years.

6. The Recovery of Natural Time

This subject may seem marginal or even extraneous to the pedagogical process, but it is essential to naturalistic intelligence and, like this, today it requires to be ‘rediscovered’ through a path of environmental education directly produced by the interaction with nature.

From the time of their emergence on the planet until the differentiation of *Homo neanderthalensis*, humans were perfectly and harmoniously integrated into the ecosystem, following its rhythms and dynamics. Around 125,000 years ago, during the time of Neanderthals—though some authors suggest much earlier—humans began their great secession from the ecosystem they had been an integral part of. This detachment began with the mastery of fire, which became a tool for a unique action: the conscious, premeditated, systematic, and widespread destruction of the environment.

The separation continued and became more radical with subsequent milestones, including the domestication of plants and animals and, more recently, the introduction of plastics—xenobiotic materials not previously present on Earth. Among these transitions, one often overlooked but significant event was the abandonment of local time, marking a definitive break with natural time and signaling humanity’s departure from the integrated cycles that regulate ecosystem life [84].

Since life first appeared on Earth, the evolutionary journey has been a continuous process of adaptation to changing environmental conditions. The primary driver of this process has been light—specifically, the alternation of day and night (light and darkness) and the seasonal variation in the duration of these periods (photoperiod), both in a single location and across different regions. This alternation has provided the first measure of natural time, determined by celestial motions, particularly Earth’s rotation and revolution around the Sun. These cycles have been the primary factors shaping life on Earth, including human activities, which were once dictated by hunting seasons, planting and harvesting, flowering trees, animal mating, leaf fall, seed germination, and fruit ripening.

However—and this is central to the discussion—humans instinctively knew long before Einstein that time does not flow at the same speed everywhere. In plains, plants bloom earlier than in mountainous regions, and in the North, leaves fall sooner. These differences are sometimes evident even in locations close to one another. In short, every phenomenon has its own time and rhythm. Tribes, villages, and cities once lived according to their local rhythms—what we now call local time.

Local time persisted without significant issues until the second half of the 19th century, when the expansion of long-distance railways necessitated synchronized timekeeping to manage train schedules. In 1884, the Washington Meridian Conference established time zones and Greenwich Mean Time as the global standard [85]. This marked the beginning of absolute time.

Since then, efforts to measure time with increasing precision have been relentless, as modern communication systems rely on perfect synchronization worldwide. Today, atomic clocks—using the resonance frequency of caesium atoms—measure time with an accuracy of one nanosecond per day. These clocks determine International Atomic Time (TAI), which is synchronized with astronomical time (based on Earth’s rotation) to establish Coordinated Universal Time (UTC), the time standard for all clocks. However, the motion of celestial bodies is not perfectly regular. This irregularity led to the introduction of leap years during the Augustan era to align the calendar with the solar year. Currently, even the link between atomic and astronomical time has been severed. Due to Earth’s slowing rotation, the annual leap second—introduced in 1972 to synchronize the two scales—has become insufficient to recalibrate global systems and will be abolished in 2035 [86]. At that point, time will become an absolute reference, entirely disconnected from planetary motion and life on Earth. Our clocks will mark a time that does not exist—an abstract concept, a void.

But plants and animals do not know time zones or Universal Time! Since they appeared on the planet, all organisms have co-adapted to the light factor along with all the other organisms present in the same ecosystems [87,88]. This has been particularly true for plants, which are sessile organisms. Over time, a biological clock has evolved, unique to each species, regulating the lives of individual organisms to synchronize their rhythms with those of the surrounding environment. Naturally, human activities are also governed by an internal biological clock that, starting with the sleep–wake cycle, orchestrates various physiological activities throughout the day [87,89,90]. It is important to understand that these biological clocks are highly sensitive to environmental variations and, therefore, require frequent recalibration, ideally daily.

How are biological clocks recalibrated? Quite simply, by passing through or even observing a natural environment. It is important to emphasize the term environment because it is not just the sun and its position that regulate the clock but the entirety of organisms constituting an ecosystem, starting with plants, whose phenological stages are easily observable [90–96].

Humans, after all, must realign not only with the cycles of celestial bodies but also with the other life cycles that collectively shape and harmonize the environment. This process helps to avoid physiological imbalances and maintain good health [97–99].

However, we have failed to notice what is happening while we should pause to reflect on the paradox we have created. By chasing an absolute, false, and impossible time standard, as physicists have demonstrated [84], we have abandoned our natural, biological time—the only one our beings know and recognize. Humans are not made for absolute time, which leads to alienation; plants, by recalibrating our biological clock daily, help maintain our connections with the old world that gave us life. This principle should guide those designing homes and cities. Once again, Miyawaki tiny forests, with their variety of plants, insects, and other small organisms, can provide a solution to this problem.

Children's time should not only be dictated by clocks and school bells marking the start and end of each lesson. Their time should align with the blooming of flowers, the hatching of butterflies, the ripening of small fruits, and the reddening of leaves—the natural time that helps keep them healthy.

7. The Application of Modern Technologies

Miyawaki urban tiny forests can play a crucial pedagogical role in fostering naturalistic intelligence in children but can also serve as educational and formative tools for older students. As noted by [12], these forests provide an ideal training ground for high school and university students. Accompanying the intellectual growth that characterizes the transition from childhood to adolescence and then to youth, tiny forests can help develop individual analytical skills.

This can be achieved, first and foremost, through the study of various organisms, both plant and animal. After careful observation, students can "capture" and internalize their findings through the principal tool of drawing, which can be complemented or followed by photography. In this way, it becomes easier and more immediate to grasp the distinctive features that underpin plant and animal taxonomy. A small forest ecosystem thus becomes a valuable resource for science teachers as they explain complex concepts, such as the definition of species.

As students grow older, they can gain insight into the relationship between plants and their physical environment by observing and recording the flowering dates and other phenological phases of various species in the tiny forest. They might even note differences between individuals of the same species within the ecosystem. Comparing these data can serve as an excellent introduction to statistical analysis.

But the scope goes further. Work in these phenological gardens can lead students to interpret the rhythms governing biological systems. Moreover, starting with the understanding that plants act as “integrated sensors” registering all external variations to which they are exposed, students can delve into identifying specific relationships. Using a simple thermometer, for instance, they could study the relationship between temperature and the onset of different phenophases, potentially calculating the “thermal sums” required for certain events to occur.

At a more advanced educational stage, students will find tiny forests to be ideal laboratories for learning how to use a range of tools for eco-physiological and environmental measurements and even for developing new, customized instruments [100,101]. In Italy, numerous examples already exist of high school and technical institute students working in this direction (e.g., [102,103]). This approach could form the foundation of an educational pathway centered on interaction among students of various grades, returning to Malaguzzi’s concept of the “first educator,” wherein students learn from students.

Finally, it is worth mentioning the potential use of smartphones. These devices, beyond supporting plant recognition apps like PlantNet®, can become genuine scientific instruments. Modern smartphone cameras are increasingly advanced, with lenses capable of significant magnification while maintaining high resolution. This allows for detailed study of plant (or animal) tissue surfaces and structures without requiring access to microscopy labs, which are still absent from many Italian schools. Additionally, by automatically recording the date and time of photos, smartphones facilitate phenological surveys and the construction of phenological calendars. Some models, equipped with laser accessories, can even perform photogrammetric surveys, forming the basis for 3D modeling of objects.

8. The Italian Tiny Forest Project: Some Examples

Based on the principles and objectives summarized in the previous sections, several urban Miyawaki tiny forests have been established, are under development, or are being planned across Italy. These include initiatives near Milan, in Rome, and others underway in the Abruzzo and Puglia regions. Some of the authors of this article have been actively involved in their creation. Among these, two examples stand out.

The first involves a 100 m^2 micro-forest established in March–April 2023, at a school in Vigevano (Pavia, Northern Italy) for children in early elementary grades. This tiny forest, due to its small size, will maintain its characteristics for 7–8 years, but long enough to accompany the children’s first school cycle. It is situated at the center of a large green area owned by the school. As a result, it could be expanded in the future by adding a new outer ring of plants.

The species selected for this project belong to the local flora of the Pavia province and are classified under the physiognomic vegetation category of “oak-hornbeam forests,” corresponding to the EU Directive 92/43/EEC list at “Habitat 9160: Sub-Atlantic and medio-European oak or oak-hornbeam forests of the *Carpinion betuli* phytosociological alliance”. According to CORINE Biotopes [104], this aligns with category 41.24 (“Sub-Atlantic stitchwort oak-hornbeam forests”), and under the EUNIS classification [105,106], it falls under G1.A1 (“Forests of *Quercus* sp.pl., *Fraxinus* sp.pl., and *Carpinus betulus* on eutrophic and mesotrophic soils”). These formations represent the mature stage of vegetation series found in lowland oak forests.

Due to safety constraints imposed by school administration, it was not possible to include large canopy trees that could reach or exceed 30 m in height. The planting and the initial phases of the educational process for children and their accompanying teachers were carried out by members of the Tiny Forest Italia association, who are themselves naturalists and educators (Figure 2).

Figure 2. The two-year-old tiny forest in the municipality of Vigevano (Pavia, Northern Italy), specifically located in the courtyard of the school.

The second noteworthy example is in Rome, where a micro-forest was created in February 2023 in a public park adjacent to a school attended by elementary and middle school students. Here too, the forest can be expanded over time to integrate with the park's preexisting green areas. The climatic conditions are entirely different from the first example, as this site is in a transitional Mediterranean region with a meso-Mediterranean, medium subhumid climate [107].

The selected species belong to the local flora of the Rome province, but it was not possible to base the selection on solid certainties since traces of the area's primeval characteristics and vegetation were lost nearly 2800 years ago. Nonetheless, the vegetation can be classified under the physiognomic category of mixed oak woods. According to CORINE Biotopes, it aligns with 41.75 (Southern *Quercus cerris*-*Q. frainetto* woods) and 41.811. The potential vegetation assessment of this place is complex also due to the presence of possible ecotones that extended on one side towards more depressed and floodable areas of the oak-hornbeam forests type, and on the other side towards less depressed areas of a more foothill type. In any case, this area has been so anthropized, urbanized, and modified over time that they may have generated a biased new condition for a possible foreseeable expected potential vegetation. In a geobotanical point of view, in the past [108] it was proposed to classify the site within a mosaic of the following vegetation series: *Quercus cerris* series (*Teucrio siculi-Quercion cerris*), *Quercus pubescens* series (*Lonicero-Quercus pubescentis*), and *Quercus ilex* and *Quercus suber* series (*Quercion ilicis*).

The creation of this tiny forest was overseen by the MicroForeste Eco-pedagogiche Group, founded by an urban planning professor at the University of Rome, La Sapienza. This initiative has been so well received by city administrators that the Department of Urban Planning has funded the Group to establish 15 mini-forests, one for each city district (Figure 3).

Figure 3. The tiny forest in the S. Lorenzo district (Rome, Central Italy), situated in an abandoned public garden, at the beginning of its third growing season.

Notably, this tiny forest has already become the focus of studies on plant growth in height and diameter, chlorophyll content in leaves, the characteristics used to identify species, soil fauna, and entomofauna. Interviews with students are also being conducted to assess their emotional responses and psychological reactions through the recording of their impressions and experiences during the initiative's various phases. Data analysis is currently underway. As of now, approximately 20 tiny forests have been established in Italy. Of these, 15 were created following shared criteria and are officially registered with the Italian Network of Miyawaki Micro-Forests (Rete Italiana delle Microforeste Miyawaki, RIMM; the network is under the management of the Italian Society of Forest Restoration, SIRF) (Figure 4) [109]. To date, approximately 6–7 tiny forests have been established annually in Italy. However, by the end of 2025 and throughout 2026, a further 7–8 new installations are expected, and the annual number of projects is projected to increase in the near future. The main constraint on implementation thus far has been the novelty of this type of green infrastructure, which remains relatively unfamiliar, combined with the very limited availability of qualified designers.

Figure 4. The tiny forests of the RIMM (Italian Network of Miyawaki Micro-Forests). A total of 15 micro-forests have been created in the following municipalities: Mortara (PV), Vigevano (PV), Vimercate (MB), Rio Saliceto (RE), Viterbo (two sites), Rome (five sites), Pescara, and S. Giovanni Teatino (CH) (three sites). Reference: Google Earth.

9. Conclusions

Across the globe, the demand for urban green spaces—ranging from simple areas with benches and water features to sports facilities and playgrounds—is steadily increasing, thereby making the discipline of Urban Forestry ever more relevant and specialized. Architects, landscape designers, and agronomists have proposed a wide array of innovative solutions for integrating vegetation into cities, including technologically advanced approaches that trace their inspiration back to the legendary Hanging Gardens of Babylon. Notable among these are vertical greening systems such as green walls ("living walls" or "vertical gardens"), first conceived in 1938 by Stanley Hart White, Professor of Landscape Architecture at the University of Illinois [110], and later reintroduced in 1986 by the French botanist Patrick Blanc at the Cité des Sciences et de l'Industrie in Paris, in collaboration with architect Adrien Fainsilber and engineer Peter Rice [111].

In Italy, renowned examples include the Bosco Verticale designed by Architect Stefano Boeri and collaborators [112]. Perhaps even more architecturally striking is "Condominio 25" in Via Chiabrera, Torino, designed by Architect Luciano Pia and collaborators [113]. Yet, all these examples can be regarded as modern reinterpretations of the traditional garden and, as such, they require continuous and often prohibitively expensive maintenance.

To address this limitation, the Miyawaki method has emerged as an effective approach for establishing tiny forests. These forests enable the greening of even very small urban areas, demand comparatively low maintenance, and, most importantly, replicate the successional dynamics of natural forest ecosystems. Consequently, they can play a vital pedagogical and educational role, as highlighted in this study.

This paper represents the first attempt to synthesize the state of the art in Italy. At present, it is not possible to provide detailed outcomes, as Italian tiny forest projects are still in their early stages. Only recently has the systematic collection of field data—essential for documenting the ecological development of these micro-forests—begun. These data are currently being organized and subjected to preliminary analyses. They will be reported in forthcoming publications, since their dissemination at this stage would be premature from the perspective of scientific rigor. Likewise, the social and educational impacts have not yet been assessed and will be presented in future studies.

To this end, an interdisciplinary team of botanists, forestry experts, psychologists, and educators has developed several ad hoc questionnaires designed to capture the perceptions of students and their families, teachers from the schools involved in tiny forest projects, and local residents living nearby. Distribution of these questionnaires will begin in the coming months, marking the first initiative of this kind in Italy.

Overall, the experiences to date have been particularly encouraging. They lay the groundwork for consolidating a specialized field with the ambitious long-term goal of creating at least one tiny forest for every school in Italy.

Author Contributions: Conceptualization, B.S.; writing—original draft preparation, B.S.; writing—review and editing, B.S., A.P., F.F., P.M. and K.C.; supervision, B.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: Data sharing is not applicable.

Acknowledgments: This work is the result of extensive discussions among all authors, each of whom made a substantial and essential contribution to the final manuscript. We extend our heartfelt thanks to the following individuals and organizations for their invaluable contributions: Elisa Manzino, Barbara Beccaria, Fausto Pistoja (Tiny Forest Italia), and Tullia Di Giacomo (MicroForeste Eco-pedagogiche, University of Rome, La Sapienza), for their dedicated efforts in planting and educating children and teachers, making the concept of tiny forests come alive in schools, emerita Kazue Fujiwara, University of Yokohama, and Camilla Wellstein, Free University of Bolzano, for their critical review of the manuscript and their valuable suggestions. Remark: The co-authors of this article, Kevin Cianfaglione, Patrizia Menegoni, and Antonio Pica, are also members of the Italian Society of Forest Restoration.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. World Bank Group. Urban Development Overview. Available online: https://www.worldbank.org/en/topic/urbandevelopment/overview#1 (accessed on 3 April 2025).
2. Abbass, K.; Qasim, M.Z.; Song, H.; Murshed, M.; Mahmood, H.; Younis, I. A review of the global climate change impacts, adaptation, and sustainable mitigation measures. *Environ. Sci. Pollut. Res.* **2022**, *29*, 42539–42559. [CrossRef] [PubMed]
3. Cormier, L.; De Lajartre, A.; Carcaud, N. La Planification des Trames Vertes, du Global au Local: Réalités et Limites. Cybergeo: European Journal of Geography 2010, Aménagement, Urbanisme, Document 504. Available online: http://cybergeo.revues.org/23187 (accessed on 30 June 2025).

4. Konijnendijk, C.; Ricard, R.M.; Kenney, A.; Randrup, T.B. Defining urban forestry: A comparative perspective of North America and Europe. *Urban For. Urban Green.* **2006**, *4*, 93–103. [CrossRef]
5. Konijnendijk, C. The 3-30-300 rule for urban forestry and greener cities. *Biophilic Cities J.* **2021**, *4*, 2.
6. Browning, M.H.E.M.; Locke, D.H.; Konijnendijk, C.; Labib, S.M.; Rigolon, A.; Yeager, R.; Bardhan, M.; Berland, A.; Dadvand, P.; Helbich, M.; et al. Measuring the 3-30-300 rule to help cities meet nature access thresholds. *Sci. Total Environ.* **2024**, *907*, 167739. [CrossRef]
7. Ministry of Ecological Transition, Biodiversity, Forestry, the Sea and Fisheries. Green and Blue Frame. 2023. Available online: https://www.ecologie.gouv.fr/politiques-publiques/trame-verte-bleue (accessed on 30 June 2025).
8. FAO. *Guidelines on Urban and Peri-Urban Forestry*; Salbitano, F., Borelli, S., Conigliaro, M., Chen, Y., Eds.; FAO Forestry Paper No. 178; Food and Agriculture Organization of the United Nations: Rome, Italy, 2016.
9. O'Brien, L.E.; Urbanek, R.E.; Gregory, J.D. Ecological functions and human benefits of urban forests. *Urban For. Urban Green.* **2022**, *75*, 127707. [CrossRef]
10. Cárdenas, M.L.; Pudifoot, B.; Narraway, C.L.; Pilat, C.; Beumer, V.; Hayhow, D.B. Nature-based solutions building urban resilience for people and the environment: Tiny Forest as a case study. *Q. J. For.* **2022**, *116*, 27–37.
11. Lewis, H. *Mini-Forest Revolution: Using the Miyawaki Method to Rapidly Rewild the World*; Chelsea Green Publishing: White River Junction, VT, USA, 2022.
12. Egerer, M.; Suda, M. Designing "Tiny Forests" as a lesson for transdisciplinary urban ecology learning. *Urban Ecosyst.* **2023**, *26*, 1331–1339. [CrossRef] [PubMed]
13. Fratini, F. The eco-pedagogical microforest: A shared oasis of proximity. A cutting-edge project at the intersection of ecology, urbanism and pedagogy. *TeMA J. Land Use Mobil. Environ.* **2023**, *2*, 33–54.
14. Morino Project. Tiny Forests, Japan. Available online: https://morinoproject.com/english/ (accessed on 14 September 2025).
15. Urban Tiny Forest, USA. Available online: https://www.urbantinyforest.com/ (accessed on 14 September 2025).
16. Plant, Earth & Forest, India. Available online: https://www.pef-india.org/ (accessed on 14 September 2025).
17. Nacons, India. Plantation with Afforestation. Available online: https://nacons.org/plantation-with-afforestation/ (accessed on 14 September 2025).
18. SayTrees, India. Urban Forestry. Available online: https://www.saytrees.org/urban-forestry (accessed on 14 September 2025).
19. Sowoods, Belgium. Available online: https://sowoods.be/projet/la-micro-foret-euroclear/ (accessed on 14 September 2025).
20. Urban Forests. Available online: https://www.urbanforest.be/ (accessed on 14 September 2025).
21. ConsciousNet & Mini Big Forest, France. Available online: https://www.consciousnet.org/ (accessed on 14 September 2025).
22. MiniBigForest. Available online: https://www.minibigforest.com/ (accessed on 14 September 2025).
23. Biggest Mini Forest, Portugal. Available online: https://www.biggestminiforest.com/ (accessed on 14 September 2025).
24. IVN, Netherlands. Tiny Forest Program. Available online: https://www.ivn.nl/aanbod/tiny-forest/ (accessed on 14 September 2025).
25. Sugi Project, Spain. Available online: https://www.sugiproject.com/forests/makers/minibig-forest-espana (accessed on 14 September 2025).
26. Miya Forest, Germany. Tiny Forest Initiative. Available online: https://www.miya-forest.de/en/tiny-forest (accessed on 14 September 2025).
27. London Borough of Hammersmith & Fulham/Earthwatch, UK. Tiny Forests. Available online: https://www.lbhf.gov.uk/environment/climate-and-ecological-emergency/tiny-forests (accessed on 14 September 2025).
28. Earthwatch Europe. Tiny Forest. Available online: https://tinyforest.earthwatch.org.uk/ (accessed on 14 September 2025).
29. FAO-FRA. *On Definitions of Forest and Forest Change*; Working Paper 33; FAO Forest Resources Assessment: Rome, Italy, 2000.
30. Bischoff, N. *Selvicoltura di Montagna*; Ufficio federale svizzero dell'Ambiente, delle foreste e del paesaggio: Berna, Switzerland, 1994.
31. Bernetti, G. *Selvicoltura Speciale*; UTET: Torino, Italy, 1995.
32. Heylighen, F. The science of self-organization and adaptivity. In *Knowledge Management, Organizational Intelligence and Learning, and Complexity*; Kiel, L.D., Ed.; EOLSS Publishers Co., Ltd.: Oxford, UK, 2002; Available online: https://www.eolss.net/sample-chapters/c15/E1-29-01-05.pdf (accessed on 14 September 2025).
33. Banzhaf, W. Self-organizing systems. In *Encyclopedia of Complexity and Systems Science*; Meyers, R., Ed.; Springer: New York, NY, USA, 2009; pp. 8040–8050. [CrossRef]
34. Miyawaki, A. Restoration of evergreen broad-leaved forests in the Pacific region. In *Ecosystem Rehabilitation: Ecosystem Analysis and Synthesis*; Wali, M.K., Ed.; SPB Academic Publishing: The Hague, Netherlands, 1992; Volume 2.
35. Butfoy, L. *Miyawaki Method Handbook*; Kent County Council: Kent, UK, 2023. Available online: https://www.kent.gov.uk (accessed on 14 September 2025).
36. Daou, A.; Saliba, M.; Kallab, A. A review of the Miyawaki method. *SSRN* **2024**. [CrossRef]

37. Schirone, B.; Salis, A.; Vessella, F. Effectiveness of the Miyawaki method in Mediterranean forest restoration programs. *Landsc. Ecol. Eng.* **2011**, *7*, 81–92. [CrossRef]
38. Hilmers, T.; Friess, N.; Bässler, C.; Heurich, M.; Brandl, R.; Pretzsch, H.; Seidl, R.; Müller, J. Biodiversity along temperate forest succession. *J. Appl. Ecol.* **2018**, *55*, 2756–2766. [CrossRef]
39. Geng, Q.; Arif, M.; Yuan, Z.; Zheng, J.; He, X.; Ding, D.; Yin, F.; Li, C. Plant species composition and diversity along successional gradients in arid and semi-arid regions of China. *For. Ecol. Manag.* **2022**, *524*, 120542. [CrossRef]
40. Šipek, M.; Ravnjak, T.; Šajna, N. Understorey species distinguish late successional and ancient forests after decades of minimum human intervention: A case study from Slovenia. *For. Ecosyst.* **2023**, *10*, 100096. [CrossRef]
41. Oldeman, R.A.A. *Forests: Elements of Silvology*; Springer: Berlin/Heidelberg, Germany, 2014; ISBN 978-3-642-75213-1.
42. Qi, H.; Dempsey, N.; Cameron, R. Seeing the Forest for the Trees? An Exploration of the Miyawaki Forest Method in the UK. *Arboric. J.* **2024**, *46*, 292–304. [CrossRef]
43. Manuel, C. *The Miyawaki Method—Data & Concepts*; Urban Forests, 2020. Available online: https://www.readkong.com/page/the-miyawaki-method-data-concepts-urban-forests-6923563 (accessed on 15 September 2025).
44. University of Tuscia. The Botanical Garden "Angelo Rambelli". Available online: https://www.ortobotanico.unitus.it/index.php/it/ (accessed on 10 February 2025).
45. Ottburg, F.; Lammertsma, D.; Dimmers, W.; Lerink, B.; Schelhaas, M.-J.; Janssen, J. *Tiny Forests: Groene Mini-Oases in de Stad: Monitoring van Biodiversiteit en Bijdragen aan CO_2-Op-Slag, Wateropvang en Tegengaan Hittestress in Elf Tiny Forests*; Rapport/Wageningen Environmental Research, No. 3189; Wageningen Environmental Research: Wageningen, The Netherlands, 2022. [CrossRef]
46. Akram, M.T.; Khan, M.M.; Taj, N.; Qadri, R.; Al-Maskri, A.; Khan, A.M. Miyawaki Technique for Sustainable Urban Greening and Ecological Restoration: A Review. *CABI Rev.* **2025**, *20*, 0028. [CrossRef]
47. Rajadurai, J. Assessing the Sociological Impact of the Miyawaki Method on Urban Health and Environment. *Int. J. Res. Innov. Soc. Sci.* **2024**, *8*, 3360–3367. [CrossRef]
48. Ikei, H.; Song, C.; Sagasaki, Y.; Nozaki, H.; Miyazaki, Y. Physiological Effects of a Small Green Space Installed on the Side of a Clinic for Outpatients with Depression. *Front. Environ. Health* **2025**, *4*, 1601838. [CrossRef]
49. Arantes, B.L.; Locke, D.H.; Moreira, G.C.; Grove, J.M. The Relationships between Urban Tree Canopy Cover and Crime in São Paulo City, Brazil. *Urban For. Urban Green.* **2024**, *101*, 128497. [CrossRef]
50. Gardner, H. *Frames of Mind: The Theory of Multiple Intelligences*, 2nd ed.; Basic Books: New York, NY, USA, 2011.
51. Durrell, G. *My Family and Other Animals*; Originally published 1956; Open Road Integrated Media: New York, NY, USA, 2016.
52. Wilson, E.O. *Biophilia*; Harvard University Press: Cambridge, MA, USA, 1984.
53. Barbiero, G.; Berto, R. *Introduzione alla Biofilia*; Carocci Editore: Roma, Italy, 2019.
54. Ceci, S.J. *On Intelligence…More or Less: A Bio-Ecological Treatise on Intellectual Development*; Prentice Hall: New York, NY, USA, 1990.
55. Reggio Emilia Approach. 2025. Available online: https://www.reggiochildren.it/en/reggio-emilia-approach/ (accessed on 10 February 2025).
56. Edwards, C.; Gandini, L.; Forman, G. (Eds.) *I Cento Linguaggi dei Bambini. L'approccio di Reggio Emilia All'educazione Dell'infanzia*; Edizioni Junior: Bergamo, Italy, 2014.
57. Montessori, M. *Il Metodo della Pedagogia Scientifica Applicato All'educazione Infantile nelle Case dei Bambini*, 3rd ed.; Maglione & Strini/Loescher: Torino, Italy, 1935.
58. Piaget, J. *The Science of Education and the Psychology of the Child*; Penguin Publishing Group: Harmondsworth, UK, 1976.
59. Papert, S. *The Connected Family: Bridging the Digital Generation Gap*; Longstreet Press: Charlotte, NC, USA, 1996; ISBN 978-1-56352-335-9.
60. Reggio Children. Atelier. 2025. Available online: https://www.reggiochildren.it/rc/atelier/ (accessed on 10 February 2025).
61. Roth, T.L.; Sweatt, J.D. Annual research review: Epigenetic mechanisms and environmental shaping of the brain during sensitive periods of development. *J. Child Psychol. Psychiatry* **2011**, *52*, 398–408. [CrossRef]
62. McEwen, B.S.; Bulloch, K. Epigenetic impact of the social and physical environment on brain and body. *Metabolism* **2019**, *100*, 153941. [CrossRef]
63. Lossi, L.; Castagna, C.; Merighi, A. An overview of the epigenetic modifications in the brain under normal and pathological conditions. *Int. J. Mol. Sci.* **2024**, *25*, 3881. [CrossRef]
64. Weaver, I. Epigenetics in psychology. In *Noba Textbook Series: Psychology*; Biswas-Diener, R., Diener, E., Eds.; DEF publishers: Champaign, IL, USA, 2025; Available online: http://noba.to/37p5cb8v (accessed on 10 April 2025).
65. Bacon, E.R.; Brinton, R.D. Epigenetics of the developing and aging brain: Mechanisms that regulate onset and outcomes of brain reorganization. *Neurosci. Biobehav. Rev.* **2021**, *125*, 503–516. [CrossRef] [PubMed]
66. Dieckmann, L.; Czamara, D. Epigenetics of prenatal stress in humans: The current research landscape. *Clin. Epigenet.* **2024**, *16*, 20. [CrossRef] [PubMed]
67. Reyes Gómez, U.; Hernández Rico, M.P.; Reyes Hernández, D.; Hernández, L.J.; Ortiz Martínez, M. La música de Mozart en el periodo prenatal [Mozart's music in the prenatal period]. *Ginecol. Obstet. Mex.* **2006**, *74*, 424–428.

68. Dastgheib, S.S.; Layegh, P.; Sadeghi, R.; Foroughipur, M.; Shoeibi, A.; Gorji, A. The effects of Mozart's music on interictal activity in epileptic patients: Systematic review and meta-analysis of the literature. *Curr. Neurol. Neurosci. Rep.* **2014**, *14*, 420. [CrossRef]
69. Sujatashamkuwar, A.; Ashokan, V.; Shrivas, Y.; Baghel, P.; Sujata, S. Effect of classical music on fetus: A review. *J. Ayurveda Herb. Med.* **2022**, *8*, 119–124. [CrossRef]
70. Pfeiffer, T.; Bonhoeffer, S. An evolutionary scenario for the transition to undifferentiated multicellularity. *Proc. Natl. Acad. Sci. USA* **2003**, *100*, 1095–1098. [CrossRef]
71. Colizzi, E.S.; Vroomans, R.M.; Merks, R.M. Evolution of multicellularity by collective integration of spatial information. *eLife* **2020**, *9*, e56349. [CrossRef]
72. Combarnous, Y.; Nguyen, T.M.D. Cell communications among microorganisms, plants, and animals: Origin, evolution, and interplays. *Int. J. Mol. Sci.* **2020**, *21*, 8052. [CrossRef]
73. Trewavas, A.J. Aspects of plant intelligence. *Ann. Bot.* **2003**, *91*, 1–20. [CrossRef]
74. Calvo, P.; Gagliano, M.; Souza, G.M.; Trewavas, A. Plants are intelligent, here's how. *Ann. Bot.* **2020**, *125*, 11–28. [CrossRef]
75. Castiello, U. Plant intelligence from a comparative psychology perspective. *Biology* **2023**, *12*, 819. [CrossRef]
76. Lovelock, J.E. *Gaia: A New Look at Life on Earth*; Oxford University Press: Oxford, UK, 1979.
77. Wood, J.D.; Detto, M.; Browne, M.; Kraft, N.J.B.; Konings, A.G.; Fisher, J.B.; Quetin, G.R.; Trugman, A.T.; Magney, T.S.; Medeiros, C.D.; et al. The ecosystem as super-organism, revisited: Scaling hydraulics to forests under climate change. *Integr. Comp. Biol.* **2024**, *64*, 424–440. [CrossRef] [PubMed]
78. Simard, S.W.; Perry, D.A.; Jones, M.D.; Myrold, D.D.; Durall, D.M.; Molina, R. Net transfer of carbon between ectomycorrhizal tree species in the field. *Nature* **1997**, *388*, 579–582. [CrossRef]
79. de la Cal, L.; Gloor, P.A.; Weinbeer, M. Can plants sense humans? Using plants as biosensors to detect the presence of eurythmic gestures. *Sensors* **2023**, *23*, 6971. [CrossRef]
80. Gilsoul, M. *Maria Montessori: Une vie au Service de L'enfant*; Éditions Desclée de Brouwer: Paris, France, 2020.
81. Piaget Org. About Piaget. 2025. Available online: https://piaget.org/about-piaget/ (accessed on 10 February 2025).
82. Kohn, E. *How Forests Think: Toward an Anthropology Beyond the Human*; University of California Press: Berkeley, CA, USA, 2013.
83. Coccia, E. *La vie des Plantes. Une Métaphysique du Mélange*; Editions Payot et Rivages: Paris, France, 2016.
84. Rovelli, C. *L'ordine del Tempo*; Adelphi: Milano, Italy, 2017.
85. Project Gutenberg. *International Conference Held at Washington for the Purpose of Fixing a Prime Meridian and a Universal Day. October, 1884. Protocols of the Proceedings*; Gibson Bros: Banbridge, UK, 1884; Available online: https://www.gutenberg.org (accessed on 12 February 2024).
86. CGPM. *Resolution 4 of the 27th CGPM (2022) on the Use and Future Development of UTC*; BIPM, Pavillon de Breteuil: Sèvres Cedex, France, 2022. [CrossRef]
87. Hut, R.A.; Beersma, D.G. Evolution of time-keeping mechanisms: Early emergence and adaptation to photoperiod. *Phil. Trans. R. Soc. B* **2011**, *366*, 2141–2154. [CrossRef]
88. Morshedian, A.; Fain, G.L. Light adaptation and the evolution of vertebrate photoreceptors. *J. Physiol.* **2017**, *595*, 4947–4960. [CrossRef] [PubMed]
89. Ishida, N.; Kaneko, M.; Allada, R. Biological clocks. *Proc. Natl. Acad. Sci. USA* **1999**, *96*, 8819–8820. [CrossRef]
90. Foster, R.; Kreitzman, L. *Rhythms of Life: The Biological Clocks That Control the Daily Lives of Every Living Thing*; Yale University Press: New Haven, CT, USA, 2005.
91. McClung, C.R. Plant circadian rhythms. *Plant Cell* **2006**, *18*, 792–803. [CrossRef]
92. Harrison, E.M.; Gorman, M.R. Rapid adjustment of circadian clocks to simulated travel to time zones across the globe. *J. Biol. Rhythms* **2015**, *30*, 557–562. [CrossRef]
93. Dunlap, J.C.; Loros, J.J. Making time: Conservation of biological clocks from fungi to animals. *Microbiol. Spectr.* **2017**, *5*, 10–1128. [CrossRef]
94. Thanh Vo, B.; Mas, P.; Johannes, F. Time's up: Epigenetic clocks in plants. *Curr. Opin. Plant Biol.* **2024**, *81*, 102602. [CrossRef]
95. The Nobel Assembly at Karolinska Institutet. The 2017 Nobel Prize in Physiology or Medicine—Press Release. 2017, Announced 2 October 2017. Available online: https://www.nobelprize.org/prizes/medicine/2017/press-release/ (accessed on 30 July 2025).
96. The European Commission. Influenced by Light, Biological Rhythms Say a Lot About Health. *Horizon Magazine, 8 June 2023.* Available online: https://projects.research-and-innovation.ec.europa.eu/en/horizon-magazine/influenced-light-biological-rhythms-say-lot-about-health (accessed on 30 July 2025).
97. Roenneberg, T.; Merrow, M. The circadian clock and human health. *Curr. Biol.* **2016**, *26*, 432–443. [CrossRef] [PubMed]
98. Fishbein, A.B.; Knutson, K.L.; Zee, P.C. Circadian disruption and human health. *J. Clin. Investig.* **2021**, *131*, e148286. [CrossRef]
99. Samanta, S.; Ali, S.A. Impact of circadian clock dysfunction on human health. *Explor. Neurosci.* **2022**, *1*, 4–30. [CrossRef]
100. Ruff, B. *How to Make Weather Instruments*; WikiHow: Palo Alto, CA, USA, 2025; Available online: https://www.wikihow.com/Make-Weather-Instruments (accessed on 10 February 2025).
101. Sciencing. Science Projects. 2025. Available online: https://sciencing.com/science-projects/ (accessed on 10 February 2025).

102. Silvetti, F. BIO Sound Machine. Istituto di Istruzione Superiore "Cattaneo-Dall'Aglio". 2021. Available online: https://www.cattaneodallaglio.edu.it/bio-sound-machine/ (accessed on 14 September 2025).
103. Cesaretti, L. Green Robotic Challenge: Costruire un orto Automatico con il Lego Mindstorms EV3. 2025. Available online: https://www.weturtle.org/dettaglio-progetti/90/green-robotic-challenge-costruire-un-orto-automatico-con-il.html (accessed on 14 September 2025).
104. European Environment Agency (EEA). Corine Biotopes. European Environment Agency. 2017. Available online: https://www.eea.europa.eu/en/datahub/datahubitem-view/d8dd768f-9bc4-4002-9386-0aef2c516f76 (accessed on 30 July 2025).
105. Moss, D. *EUNIS Habitat Classification—A Guide for Users*; European Topic Centre on Biological Diversity: Paris, France, 2008.
106. European Environment Agency (EEA). *EUNIS Habitat Classification*; European Environment Agency: Copenhagen, Denmark, 2025; Available online: https://eunis.eea.europa.eu/index.jsp (accessed on 5 March 2025).
107. Rivas-Martínez, S. *Global Bioclimatics (Clasificación Bioclimática de la Tierra)*; Phytosociological Research Center/Universidad Complutense de Madrid: Madrid, Spain, 2004.
108. Blasi, C. *Fitoclimatologia del Lazio*; Università La Sapienza & Regione Lazio: Roma, Italy, 1994.
109. Società Italiana di Restauro Forestale (SIRF). RIMM—Rete Italiana delle Microforeste Miyawaki. Restauro Forestale, 5 Giugno 2025. Available online: https://www.restauroforestale.it/2025/06/05/rimm-rete-italiana-delle-microforeste-miyawaki/ (accessed on 14 September 2025).
110. Hindle, R.L. A Vertical Garden: Origins of the Vegetation-Bearing Architectonic Structure and System (1938). *Stud. Hist. Gard. Des. Landsc.* **2012**, *32*, 99–110. [CrossRef]
111. Vertical Garden Patrick Blanc. Available online: https://www.verticalgardenpatrickblanc.com/ (accessed on 14 September 2025).
112. Boeri, S. *Bosco Verticale. Morphology of a Vertical Forest*; Mondadori Electa: Milan, Italy, 2024; p. 240, ISBN 978-8891843074/ISBN 8891843075.
113. "25 Verde. L'edificio-Foresta a Torino" Luciano Pia. Architettura Ecosostenibile. Available online: https://www.architetturaecosostenibile.it/architettura/progetti/25-verde-torino-294 (accessed on 14 September 2025).