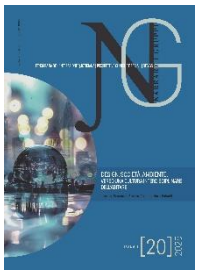
A theoretical approach to *Nature driven Design*, from modernity to contemporary practices

Riccardo Maria Pulselli, Giuliana Randazzo, Alejandro Martínez-Rocamora



Narrare i gruppi

Etnografia dell'interazione quotidiana, prospettive cliniche e sociali, design - vol. 20, n° 1, June 2025

ISSN: 2281-8960

Biannual magazine published online since 2006 - website: www.narrareigruppi.it

Full title of the article

A theoretical approach to Nature driven Design, from modernity to contemporary practices

Autors	Membership organization
Riccardo Maria Pulselli	*Università Mediterranea di Reggio Calabria*
Giuliana Randazzo	*Università Mediterranea di Reggio Calabria*
Alejandro Martínez-Rocamora	*University of Sivilla*

Pages 21-36 | Published online on 30 June 2025

He quotes the article like this

Pulselli, R.M., Randazzo, G., Martinez Rocamora, A. (2025). A theoretical approach to Nature driven Design, from modernity to contemporary practices. In *Narrare i Gruppi*, vol. 20, n° 1, june 2025, pp. 21-36 - website: www.narrareigruppi.it

methodology for research

A theoretical approach to Nature driven Design, from modernity to contemporary practices

Riccardo Maria Pulselli, Giuliana Randazzo, Alejandro Martínez-Rocamora

Abstract

Nature driven Design is a practice frequently mentioned among the possible solutions to affirm a new model of sustainable development, with the aim of progressively replacing the current linear economic system with a circular approach.
This article proposes an interpretation of Nature driven Design starting from the thermodynamic theory of dissipative structures that describes the evolutionary dynamics of living systems in nature through a generalized behavioural model. Various Nature driven Design strategies can be identified and understood in the light of this theory. Among these are highlighted: i) design practices, that support spontaneous natural processes through form, such as natural passive design, biomimicry and biophilia; ii) design management practices, that optimize the energy and material exchanges of manufacturing processes with the external environment, using natural and circular materials and renewable resources; iii) participatory practices of co-design and valorisation of ecosystem services, to encourage social inclusion and human-nature integration.
These strategies are also described through the observation of emblematic solutions, both historical and contemporary, ranging from the scale of the landscape to that of architecture, down to product design. By investigating the correspondence between theory and practice, this study allows us to define a general approach of Nature driven Design and to validate its strategic role in the development of contemporary society.

Keywords: Nature Based Solutions, dissipative structures, ecosystem services, Arts and Crafts

1. *Introduction*

This article briefly introduces a scientific theory, elaborated to describe the general behaviour of natural systems, such as plants, animals and ecosystems. This theory allows the knowledge of processes of sustenance of nature and, at the same time, promotes a better understanding of the sustainability criteria applicable to anthropic systems such as society, the economy and the city, which show similar dynamics.

Nature driven Design, often practiced with the aim of increasing the sustainability of these systems, responds to the same scientific principles. A sustainable development model starts from the assumption that there are physical limits to growth and from understanding the opportunity to adopt strategies inspired by nature.

To understand the possible declinations of this practice, a classification of Nature driven Design strategies is introduced, which concerns design and co-design activities, process management and valorisation of ecosystem services in anthropized contexts.

Furthermore, some examples of Nature driven Design are described as evidence of possible concrete applications, starting from modern experiences up to contemporary ones. In particular, in the second half of the 19th century, the Arts and Crafts movement has consolidated a development model inspired by nature, in opposition to the emerging mechanization and industrialization of manufacturing production, decisively influencing design, applied arts and architecture, up to the present day. In more recent times, the principles of Nature driven Design have found confirmation in new forms of design, from the integration of natural solutions and high-tech technologies in architecture, to the various declinations of strategic design for the creation and management of circular value chains.

The theoretical approach, the classification of operational strategies and some application examples presented in this article aim to help understand the current declinations of Nature driven Design and to identify possible future trajectories.

2. *A thermodynamic theory for* Nature driven Design

The laws of thermodynamics are the scientific reference to determine unavoidable principles of sustainability. Starting from the early 70s of the 20th century, the scientific research began to highlight the irreversibility of the effects of anthropic activities on climate, such as global warming, and proposed a solid scientific theory that demonstrated the need to reverse this trend. In particular, Ilya Prigogine, Nobel Prize winner in Chemistry in 1977, laid the foundations of evolutionary thermodynamics which, starting from the second law of thermodynamics and the concept of entropy, describes the general physical behaviour of living systems in nature (Prigogine, 1977).

With the industrial revolution of the 19th century, classical thermodynamics investigated the theoretical principles underlying the functioning of heat engines, observing, with Rudolf Clausius, how the performance of heat engines could not be completely efficient but always involved a loss. This loss of performance, due to the dispersion of heat towards cold reservoirs, is evidence of a process of deterioration of energy, namely entropy. The machine, consuming energy to perform work, releases entropy into the environment and this process is irreversible.

Entropy tends to increase, more or less quickly, in every isolated system that loses performance over time, until it reaches a condition of thermodynamic equilibrium, corresponding to maximum entropy. However, some systems have the ability to evolve, grow, self-organize, following an opposite direction towards a vital and dynamic state; a proof is the biological evolution and the extraordinary biodiversity of living systems and ecosystems in the biosphere. This evolutionary process can be described as an increase in internal organization and a reduction in entropy that generates ordered structures; the latter are defined by Ilya Prigogine and Isabelle Stengers (1997) as dissipative structures, being open thermodynamic systems that self-organize towards a higher level of order and complexity. This category includes ecosystems, living systems, and all those systems that, not being isolated, exchange energy and matter with the external environment and exploit incoming flows to generate ordered structures and maintain them over time, pouring entropic waste outwards.

Nature has this ability to self-generate, evolving and regenerating through optimized processes that use residual matter and energy within closed cycles and therefore maintaining minimum entropy levels. Similarly, some anthropic systems, such as cities, society and the economy, can be defined as *dissipative structures* that generate organization inside thanks to contributions of energy and matter from the outside. Unlike ecosystems, however, anthropic systems are highly energy-intensive and dissipative and, to maintain their internal order, they release entropy into the external environment in the form of heat, waste, effluents, pollutants, greenhouse gases and other waste (Pulselli, Tiezzi, 2009). Edgar Morin has underlined how the autonomy of an urban system, of a society and an economy, is dependent on the environment; there can be no autonomy without this dependence (Morin, 2022).

From the 19th century to the present, the linear economy has increased this dependence on the external environment from which essential resources are derived and to which energy and residual matter (entropy) are returned. The modern economic model has accelerated entropic production and we have been led to believe that the faster we produce, using nature's resources, the more progress advances in the name of economic growth. In this regard, Enzo Tiezzi points out that this concept of 'technological time' is exactly the opposite of "entropic time"; an organism that consumes more rapidly than the environment produces for its subsistence has no chance of survival (Tiezzi, 1984). Inspired by the thermodynamic principle of dissipative structures, Federico Pulselli and coauthors describe an input-state-output system to represent contemporary society: natural resources are the crucial inputs of the system; society and its organization and structure indicate the state of the system; the output of the system is the real economy. A flow of resources (input), extracted from natural capital, is necessary for the functioning of society and its organizational units (state); society processes, uses and consumes these resources and, the more organized it is, the greater its capacity to obtain economic results by providing output from its production processes (Pulselli *et al.,* 2015). This model demonstrates that every organization is based on a more or less intense input of materials and energy and that the transformation of these resources into useful services and products is more effective and sustainable as the level of organization increases (minimum entropy).

Starting from this principle, the recent rush towards a sustainable and circular economy is an attempt to increase the efficiency of human activities by reducing waste and restoring a low entropy development model, more similar to that of nature. The new evolutionary thermodynamics has therefore introduced a broader vision of the behaviour of natural systems, living systems and human systems, introducing a limit to growth.
Restoring a new alliance between man and nature, as advocated by Ilya Prigonie and Isabelle Stengers (1979), is the challenge to be faced and evolutionary thermodynamics demonstrates its urgency. This article intends to identify a series of strategies that, in accordance with thermodynamic theory, use practical solutions, inspired by nature, to affirm a low entropy sustainable development model, different and alternative to the linear economic model adopted by most of society in the last century.

3. *Nature driven Design strategies*

Nature-driven-Design is a practice that incorporates natural elements and principles in the design and manufacture of spaces and artefacts, for example in urban contexts, landscapes and built environments, from envelopes to interior spaces, or in the production of products through natural processes and materials. The aim is to create functional, sustainable, healthy, beautiful environments connected to nature. This practice includes a series of possible declinations that concern i) design processes, ii) design management and iii) integrated co-design.

i) The design process refers to design practices that adopt solutions inspired by nature or that support natural principles to increase performance and sustainability:

Passive natural Design: the coherent management of natural light and laminar flows of air and water is the most common example of design and construction practices that indulge nature, identifiable with a historical and consolidated know-how. In architecture, this concerns the orientation of a building with respect to solar irradiation, or its positioning based on the prevailing winds or the hydrogeological context, for example taking into account the natural ventilation on the side of a topographic relief or the water basins,

preferring less humid areas and not exposed to environmental risks. In product design, this approach concerns ergonomics, aerodynamics, fluid dynamics and all those physical principles that influence the shape of a product, such as the form of a car or the hull of a boat.
Biomimicry: the imitation of nature for the construction of structures and artifacts is a widespread practice of historical origins. In addition to purely aesthetic solutions, the observation of the tree, the shell of a tortoise, the leaf or the flight of birds, has led to the determination of more advanced technologies such as bridges, membranes, tensile structures, sailboat and airplane wings.
Biophilia: the integration of nature in built space, both outdoor and indoor, is a traditional practice. Recently, the awareness of the psychological value of contact with nature has emphasized the importance of so-called Nature-Based-Solutions in living spaces. Nature integrated into the external envelopes of buildings, in outdoor contexts and in interior spaces has a therapeutic aesthetic function but is also an object of enjoyment and interaction, implying new ways of conceiving and experiencing space both horizontally and vertically. In terms of product design, biophilia is the result of comfort that comes from contact with natural, bio-based and naturally treated materials. The perception of the five senses with respect to a natural material gives a quality to living that has an atavistic origin and represents an added value compared to the spread of synthetic materials or chemically treated surfaces that do not contribute as effectively to the physical and mental well-being of the user.

i) Design management concerns the attention paid to the production chain and to the entire value chain which influences choices to improve sustainability:

Natural materials: typically, this category includes materials of direct natural origin, which include materials extracted from quarries and mines, such as stone materials used in construction or metals, and biological materials, or bio-based materials, obtained from agroforestry activities, such as wood and fibres. These two types of materials are easily distinguished into two groups by referring to the regeneration times of the material; while extracted materials have geological formation times and therefore belong to the family of non-renewable resources, biological materials are potentially renewable,

being able to regenerate periodically. Furthermore, while the former are subject to irreversible entropic degradation, losing quality with each subsequent processing (from the stone block, they are reduced into cuts and subsequently into increasingly smaller parts, until a residue of shredded inert materials), the latter, at the end of a cycle, are reduced to an organic residue that can be reintroduced into the natural cycle, for example in the form of compost for the same agroforestry crop; this is where the intrinsic circularity of bio-based materials lies when they are not contaminated or placed in composite mixtures.

Circular materials: this category identifies those materials that are typically subject to recycling, such as metals, glass, cellulose. This good practice reintroduces into the production system a flow of material that has exhausted its function and transforms the waste of a process into an input for a new process. However, unlike natural cycles, the recycling action of these materials involves a waste of resources typical of an energy-intensive and highly entropic industrial process and is therefore not among the most desirable solutions. Before recycling, it is good practice to first increase the durability of products through maintenance practices or reuse. Some synthetic materials, such as plastic, are typically subject to subsequent recycling processes but the synthetic nature of these materials and the impact on the environment and on health due to their use categorically excludes them from this classification.

Renewable energy: the generation of electrical and thermal energy from renewable sources is a practice that falls within nature-driven solutions. Regarding renewable sources such as the sun, wind, hydrodynamics, wave motion and various types of biomass, the limiting factor is energy storage which finds plausible solutions in the production of biogas, biofuel or hydrogen, and also calls for experimentation of storage systems with common materials. In addition to the constantly evolving technological aspect, the design of energy generation systems from renewable sources raises a question of integration into the landscape and social acceptance that design can help resolve. In this regard, Paolinelli et al. (2022) argue that the syndrome of hiding and removing installations from view should be treated through an opposite approach, that of attributing scenic evidence to the devices through a logic of correct sizing and insertion into the landscape. Furthermore, the need to share renewable sources within collective networks, as in the case of energy communities,

represents a challenge, with strong implications in the modelling and design of production and consumption processes from a short supply chain perspective.

ii) Integrated co-design indicates an interdisciplinary approach aimed at expanding the functions and meanings of design, integrating environmental and social aspects into the design through an inclusive approach:

Collective design: participatory co-design activities are a further category classifiable as nature-driven. Collective actions of definition of shared strategies belong to the co-evolutionary logic of natural ecosystems, in which a symbiosis between plant and animal species is established in a habitat. With the same logic, innovation ecosystems are defined as spaces and processes that promote creativity and innovation by encouraging relationships between subjects, with different skills and social roles, with the aim of identifying strategies of common interest.
Ecosystem Services: the multiple direct and indirect benefits provided by ecosystems to humankind are the object of research especially with regard to the economic value they express and that classical economic indicators neglect (Braat & de Groot, 2012). Ecosystem Services are classified into four main categories: provisioning services, that include all kinds of goods generated by nature such as water, food, materials (see natural materials above), genetic resources and others; regulating services, that include natural processes of climate, water and air regulation, mitigation of extreme weather events and soil erosion, containment of pandemics and pollination; supporting services, that guarantee the maintenance of nutrient cycles, photosynthesis, food chains, habitat and biodiversity; cultural services, being intangible goods contributing to physical and mental health, spiritual and aesthetic value, and including recreational function (see biophilia above). The classification of ecosystem services is useful to guide design in and with nature with the aim of maximising the value of the services provided, their widespread use and accessibility, as well as raising awareness and promoting education of future generations.

4. *Application experiences of* Nature driven Design

Consistently with the categories of practices listed, Nature driven Design has various scales of application, from landscape to built environment to product.

4.1. From nature to design: the influence of the Arts and Crafts movement

The relationship between design and nature highlights tensions and points of contact, still strongly anchored to a conception originating in the context of the Scientific Revolution. Despite the unifying perspective that, in contemporary times, leads to the search for a link between the natural and design spheres, nature continues to be perceived as subordinate in the context of a consolidated hierarchy, in which the human being is at the top.
In this sense, a historical reading of the theories, which, especially in Europe, have shaped current thinking regarding the deep connection between nature and design, is essential to understand the complex path that currently underlies the new theories of Nature driven Design.
If from the 19th century we have inherited *"the environmentalism that flowed from Wordsworth through Ruskin to Morris"* (Woodring, 1997: 200), the theories on organicism of the critic John Ruskin (1819-1900), as well as the artistic and cultural movement Arts and Crafts – which developed in England in the second half of the nineteenth century in reaction to the damaging effects of industrialisation and the generally low *status* of the decorative arts of the time – offer relevant food for thought from the ethical point of view of art and design, as well as from the social one.
Strongly supported by William Morris (1834-1896), the Arts and Crafts movement was based on a critique of mechanisation, of the division of labour, of capitalism and of the consequent loss of traditional craft methods, in favour of the research of quality, beauty and accessibility.
In particular, Morris, a revolutionary designer, as well as a writer, social activist and environmentalist, at the end of the 19th century envisaged an inclusive and egalitarian art that would once again mediate between nature and civilisation, developing an idea of progressive science, in close accordance with nature. (Herbert, 1992).

In a historical context characterised by industrial mass production reaching its apex in the United Kingdom, Morris pioneered a new approach to design and production. Although severely criticised by the progressives of the time, who argued that the movement was anachronistic and could not find a practical application in the new industrialised society, the Arts and Crafts movement had a decisive influence on the connection between nature and design, in the various fields of applied art as well as on architecture.
It can be said that Morris anticipated an environmentally sustainable design, through an approach tending towards the evocation and enhancement of nature, rather than its mere imitation, which maintained a lasting impact throughout the 20th century, right up to its application in contemporary design. In confirmation of this, we are today assisting at the return of a craftsmanship, antagonistic to mass production, but in line with the times and social needs, inevitably connected to the current market demands, necessarily called upon to respond to the challenges imposed by the environmental crisis. A context in which Nature driven Design assumes a strategic role in the development of the contemporary society.

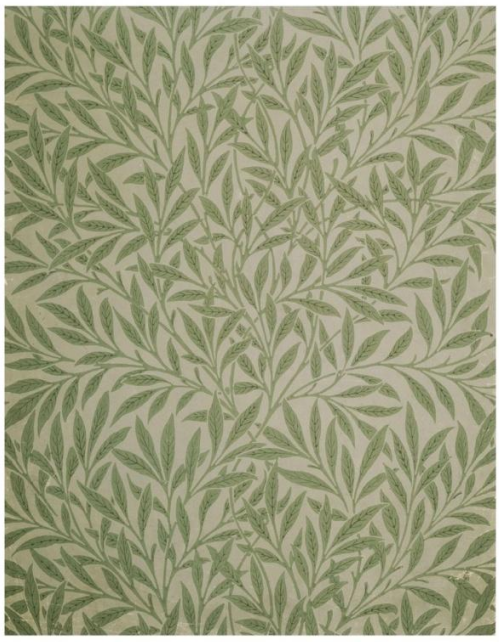


Figure 1. William Morris, 1874, *Willow*, wallpaper pattern, green willow leaves on a grey ground, print on paper, (Vol. 1, Morris & Co. 1862-81), Victoria & Albert Museum, South Kensington, E.493-1919.

4.2. Nature driven Design: architectural design

At the architectural scale of the built environment, Nature driven Design is easily expressed in the integration of vegetation and renewable resources into the building, making the envelope responsive to the light and energy conditions of the surrounding environment. Some innovative explorations aims to bring this concept to the next level.
An emblematic example of Nature driven Design in architecture is the BIQ Building in Hamburg, Germany, also known as the *Algae House* (Armstrong, 2023). This innovative building features a unique facade system consisting of panels filled with water and microalgae that act as bioreactors by taking profit of photosynthesis to create a dynamic and responsive building envelope. By growing the micro-algae, the panels generate biomass while providing natural shading for the building, thus reducing the need for artificial cooling. This biomass can be harvested and converted into biofuel, which can then be used to generate energy, making the building partially self-sufficient and reducing its reliance on non-renewable energy sources. The water in the panels also contributes to the building's thermal regulation by absorbing heat during the day, which can be used to heat the building or be stored for later use. This helps maintain a stable indoor temperature and enhances energy efficiency.
The integration of this solution in the building is both aesthetically pleasing and functional. The panels create a visually striking appearance while serving practical purposes such as energy generation, shading, and thermal regulation. By incorporating renewable resources and natural processes, the BIQ Building exemplifies sustainable architecture. It reduces carbon emissions, lowers energy consumption, and promotes the use of green technologies.

4.3 Nature driven Design: from product design to Strategic design

At the product scale, Nature driven Design is aimed at experimenting with natural bio-based materials. The design product made with these materials have a stronger biophilic effect; moreover, it can be interpreted as a temporary or semi-permanent stock of carbon. Wood, natural fibers, conglomerates and yarns can be made from traditional agroforestry activities and crops such as hemp, bamboo, broom, citrus fruits.

Besides forms and consistency of products, design practices are nowadays focussing on value chains and lifecycle processes. The design and management of integrated supply chains, from cultivation and extraction to manufacturing, up to use and end-of-life treatment, is a current theme of strategic design, rather than product design. With an eye on the life cycle of products, strategic design aims to create highly efficient integrated production chains that, in some cases, can be developed within a closed production-consumption-recovery cycle.

A similar example is represented by hemp. Meffo Kemda *et al.,* (2024) demonstrate that the production chain can be classified as carbon neutral when all the different parts of the plant (flowers, seeds, fibers, leaves and all residues) are used to produce durable goods, such as textiles and construction materials. For example, the use of hemp biomass for insulating panels is equivalent to storing carbon in the long term, considering that the carbon dioxide absorbed during the growth of the plant (2.07 t CO_2 per cultivated hectare), trapped in the form of carbon within the biomass, corresponds to 700 kg CO_2 per ton. Furthermore, hemp cultivation provides a series of additional ecosystem services, including pollination, absorption of heavy metals and biodiversity.

Stremke *et al.,* (2012) investigated how portions of anthropized landscape can be designed to optimize flows and increase the provision of ecosystem services. In the long term, such systems are designed to become completely self-sufficient, through a form of spontaneous self-organization, and autonomously regenerate internal resources, ensuring self-sufficiency in a completely circular ecosystem logic.

The bamboo supply chain, when well-managed, may be an example. In addition to agri-food uses, bamboo has multiple potential uses for the production of wood, fibers, conglomerates and yarns, through processes with minimal greenhouse gas emissions. Moreover, bamboo is recently used in Europe in the carbon credit market by virtue of the plant's growth speed, absorbing over 200 kg CO_2 per hectare on yearly basis, 37 times more than a common forest (Neri et al., 2022). Bamboo can potentially generate market-oriented opportunities for local communities, such as by manufacturing bamboo products generating economic flows, rather than being a cost for maintenance. In an urban neighbourhood, a bamboo forest can be designed to host citizens, such

as in the urban pocket park in Caldas del Reyes in Spain (Figures 2-3), and become an effective climate shelter for its cooling effect in summer. The bamboo value chain is enriched by the ecosystem services it provides in terms of production, support, regulation and cultural services.


Figures 2-3: bamboo forest pocket park in Caldas del Reyes, Pontevedra, Spain (photo: Pulselli R.M. 2022).

5. *Conclusions*

This article introduces a classification of Nature driven Design practices into three categories that concern i) design process, ii) design management and iii) integrated co-design. The definition of these three operational strategies is supported by some examples found in the modern and contemporary history of design, ranging from the simulation of nature's forms to the integration of bio-based materials in high-tech systems, up to strategic design practices for the creation of value chains.

The categories of Nature driven Design presented follow a logic consistent with the thermodynamic model of dissipative structures, being aimed at creating systems that optimize their functional processes, exploiting external resources with greater efficiency, limit the production of entropy as much as possible, reducing the emission of waste towards the external environment, and amplify the creative impulse that produces innovation and well-being, organizing and multiplying their internal and external relationships.

Natural systems and ecosystems already clearly express these properties by maintaining themselves in a state of minimum entropy, which corresponds to a condition of maximum efficiency, with minimum consumption and entropic

waste, and to a greater capacity for adaptation (resilience). Nature driven Design, simulating nature, is aimed at replicating these conditions and properties within anthropic systems, reversing the propensity for excess consumption and entropic dissipation.

The satisfaction of these general principles, through the use of various Nature driven Design strategies, is an indispensable prerequisite for implementing an effective transition towards more sustainable social and economic systems.

This article has outlined a method of interpreting Design practices inspired by nature, integrating a thermodynamic theoretical model with a classification of recurrent Nature driven Design strategies; all supported by the crucial experience of the Arts and Crafts movement, at the end of the nineteenth century, and by contemporary cases showing applications at the scales of landscape, architecture and design.

It is clear that research on Nature driven Design practices has enough room for growth and, in the future, may concern the methods of designing products and services, the identification and optimization of processes upstream and downstream of these, and the integration of multiple functions and meanings in relation to the aspects of environmental sustainability and social inclusion that design expresses.

The interdisciplinary vision that the article proposes identifies an integrated approach for the design of solutions inspired by nature, that can contribute to improve the understanding of current applications and to guide future experiments.

Acknowledgements

The article is the collective result of an interdisciplinary cooperation between the authors. The contributions can be identified as follows: sections 2 and 3 by R.M.P., 4.1 by G.R., 4.2 A.M.R., 4.3 by R.M.P. The text has been entirely shared and edited by all authors.

Bibliography

Braat, L. C., & De Groot, R. (2012). The ecosystem services agenda: bridging the worlds of natural science and economics, conservation and development, and public and private policy. *Ecosystem services*, 1 (1), 4-15.

Herbert, I.K. (1992). Nature and Art: Morris's conception of Progress. *Journal of William Morris Studies*, 10,1.

Meffo Kemda, M., Marchi, M., Neri, E., Marchettini, N. and Niccolucci, V. (2024). Environmental impact assessment of hemp cultivation and its seed-based food products. Front. Environ. Sci. 12:1342330. doi: 10.3389/fenvs.2024.1342330.

Morin, E. (2022). *The challenge of Complexity: essays by Edgar Morin*. Liverpool: University Press.

Neri, E., Esposito, G., Marchi, M., Niccolucci, V., Pulselli, F.M., Marchettini, N., Lajo, M., Rissone, E., Pulselli, R.M. (2022). Analisi del ciclo di vita e CO2 assorbita da un bambuseto gestito in Italia: applicazione ad un caso studio. *XVI Convegno dell'Associazione Rete Italiana LCA*, Palermo, 190-198. ISBN: 9791221004588.

Prigogine I. (1977). Time, structure and fluctuation. Nobel lecture, December 8th 1977.

Prigogine, I., & Stengers, I. (1979). *La Nouvelle Alliance. Métamorphose de la Science*. Paris: Gallimard.

Prigogine, I., & Stengers, I. (1997). *The end of certainty*. Simon and Schuster.

Pulselli, F. M., Coscieme, L., Neri, L., Regoli, A., Sutton, P. C., Lemmi, A., and Bastianoni, S. (2015). The world economy in a cube: A more rational structural representation of sustainability. *Global Environmental Change*, 35, 41-51.

Pulselli R.M., Tiezzi E. (2009). *City Out of Chaos. Urban Self-organization and Sustainability*. WIT Press, Southampton, UK.

Stremke S., Roncken P.A., Pulselli R.M. (2012). Discussing landscape machines in the light of evolutionary thermodynamics. in (Eds.) Czechowski, D.; Hausck, T.; Hausladen, G., *Designing Nature as Infrastructure*. University Munich: Munich 2012; pp. 50-69.

Tiezzi, E. (2003). *The End of Time*. Southampton, UK: WITpress.

Paolinelli, G., Fortuna, L., Marinaro, L., Valentini, A. (2022). On marine wind power expressiveness: not just an issue of visual impact. *Front. Energy Res.* 10:937828. doi: 10.3389/fenrg.2022.937828

Woodring, C. (1977). *Nature and Art in the Nineteenth Century*. Publications of the Modern Language Association of America, 92, 2, 193-202, doi:10.2307/461940.