

Ecological State Evaluation of a Rural Landscape Revealing the Importance of Naturalised and Organic Crop Fields

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Abstract

This study understood the ecological state of an agrarian landscape, by performing the tools and indicators proposed by the "Landscape Bionomics" (LB) discipline. The tested principles and methods offer a systemic approach to study environmental problems at different scales (i.e. crop, field, farm and landscape) and to promote the rehabilitation of compromised areas. The methodology distinguishes specific landscape elements according to their functions, which can be exclusive like human habitats (e.g. productive, residential, subsidiary) and natural habitats (e.g. source, resistant, stabilising, geologic), or in common between these two (e.g. protective, resilient, connective).

Using LB, we assessed the impact of anthropic factors on a rural area (15km² in the South Milan Agricultural Park in Lombardy Region, Italy) in a 62 years timespan (data from 1954, 1999 and 2016). The overall results highlighted that anthropic activity impacts are more strongly on landscape functions:

- A. The productive (Crop Fields)
- B. The resistant (Woods)
- C. The protective (Tree Rows)

Moreover, the temporal reconstruction described an altered ecological state in the entire timespan, with further degradation in the last 17 years. However, at the farm scale, we observed that the resistant, the protective and some productive apparatuses (In particular permanent meadows and organic fields) play an ecological role of potential compensation for landscape fragmentation and urbanisation.

Keywords: Landscape; Ecosystem; Vegetation; Ecological network; Human and Natural habitat

Abbreviations: BTC: Biological Territorial Capacity; EXR: Excretory Apparatus; HH: Human Habitat; LaBiSHH: Landscape Survey of Human Habitats; LB: Landscape Bionomics; LU: Landscape Unit; NH: Natural Habitat; RNT: Resistant Apparatus; PRD: Productive Apparatus; PRT: Protective Apparatus; RSD: Residential Apparatus; RSL: Resilient Apparatus; SBS: Subsidiary Apparatus

Introduction

The good management of agricultural activities has a crucial role in mitigating a strong anthropic impact in rural territories and in promoting cultural ecosystem services [1-4]. On the other hand, uncontrolled human activities linked to climate change are causing the severe degradation of ecosystem and landscapes [5-9].

Several research groups are conducting analysis to compare different methods for assessing the sustainability in agricultural contexts from different points of view [10]. Making available many frameworks, standards and indicators to assess the environmental and social impacts caused by various production sectors, including the agriculture and food sectors [11-13].

Environmental studies in general need a sensitive contextual approach to analyse and evaluate data from both the natural and the anthropic aspects of a landscape [14,15]. Thus, the theoretical principles of Landscape Bionomics (LB) could provide a new systemic and transdisciplinary vision for the study of the environmental state of landscape [16].

The European Landscape Convention defined the concept of landscape combining the visual and the scientific meanings [17]. The LB considers also the landscape as a complex living system, which is always exchanging matter and energy between all its components and with external factors. The landscape as a living system could be resistant, resilient or not tolerant to anthropic or natural stresses, which could damage it with different magnitudes. Each kind of landscape has an irreversible history that we can understand thanks to the measurement of the state of health of its components at different time points, using historical data. According to the theory of emergent properties the LB does not only consider the state of single landscape components, but also the interactions between these, embracing a holistic vision [18].

Envisioning landscape as a living system, LB proposes the figure of an "Ecoiatra" (Doctor of Environmental Systems), which can analyse the symptoms and dysfunction of a landscape. LB is based on the Biological Territorial Capacity (BTC) measured in Mcal/m²/year, which measures the flux of energy in human and natural habitats. The BTC values reveal the state of health of a single ecosystem (e.g. a crop field, a house, a garden, a lake), in order to understand if the landscape (i.e. a living organism composed of a complex tissue of different ecosystems) has a good state of energy or not, compared to standard values provided for European biomes [16]. The ecoiatra, through the evaluation of bionomic parameters (e.g. BTC), can compare the values obtained with the normality ranges (defined by LB), to understand the state of health of a landscape and the cure for the rehabilitation of dysfunctional elements.

The LB could be a suitable tool to study the key issues of current Ecology [19]. This short communication aims to show the results drawn from the practical evaluation of the environmental state of a rural area using methods, approaches and indicators proposed by the LB discipline.

Result and Discussion

Using LB methodology, we analyzed the rural area of Albairate (Milan Municipality, Lombardy Region, Italy), of 15km², taking into account 62 years timespan (data from 1954, 1999 and 2016). The rural area, called Landscape Unit (LU), is located in the South Milan Agricultural Park and represents a significant connection of the green ecological network between Milan and the Ticino River Park in Lombardy Region.

In order to classify the LU elements, we used the "Land Use" maps provided by the Lombardy Region database for three years: 1954, 1999 and 2015. After that, the Q-Gis software was used to make surveys to elaborate an updated version of the 2015 land use map.

We elaborated the "Land Use" maps of the LU, dividing the landscape in apparatuses, according to their ecological functions:

- A. Residential "RSD" (i.e. urbanised surface and farms)
- B. Subsidiary "SBS" (i.e. streets and railway)
- C. Protective "PRT" (i.e. three rows, parks and common gardens)

D. Productive "PRD" (i.e. crop fields organic and conventional, stable meadow, pastures and short rotation forestry areas)

E. Resilient "RSL" (i.e. brushes, riparian vegetation and abandoned green areas)

F. Resistant "RNT" (i.e. woods)

G. Excretory "EXR" (i.e. natural and artificial canals)

The Human Habitat (HH) were considered as the area where human populations live, limiting or strongly influencing the self-regulation capacity of natural systems, while the Natural Areas (NH) includes those characterized by natural components, without direct human influence.

During 2016, surveys covered 220 ha, which were representative of the different landscape apparatuses.

A. LB survey of vegetated tesserae (i.e. crop fields, woods, tree hedgerow) focuses on the

B. Characteristics of the tesserae (i.e. canopy height, tree cover)

C. Characters of the phytomass (i.e. plant biomass volume, litter depth)

D. Biotic, spatial and functional, characters (i.e. species richness, allochthonous species, vertical stratification)

E. Relationships tesserae/landscape unit (i.e. fauna presence, disturbances, connection)

Referring to the study of human habitat, we performed the LaBiSHH: Bionomic Landscape Survey of Human Habitats to estimate the bionomic values of Human Habitat (HH) [16].

In order to score each landscape apparatus according to their ecological functions, we used custom-made tables with bionomic parameters assigning values for vegetation, and atrophic elements [20]. To define bionomic values to landscape apparatuses also in 1954 and 1999 Land Use maps, we integrated the information collected during surveys in 2016, with LB temporal correction factors [16].

Finally, we studied the connection between arboreal and shrub vegetation patches and corridors to evaluate the state of health of the green ecological network of the LU. The LB suggested to use the model of planar graphs, based on the graphical representation of arboreal and shrub vegetation patches (e.g. nodes) and tree-lined corridor as links (e.g. line that connects two nodes) [21].

We elaborate, the connection maps of the LU using the Land Use maps information of 1954, 1999, and 2016 integrating the data collected during surveys.

The overall results suggested that the bionomic status of the rural area is weak and precarious. In details:

A. Woods area (surface less than 5%) is lower than the normal range of agricultural landscapes in Europe (from 10% to 30%).

B. The percentage of alien species is twice (19.82%)

compared to the reference values of agricultural landscapes in Lombardy (11%).

C. The percentage of hedgerows half decreased in the last 60 years, passing from 7.32% to 3.95%.

D. The historical timespan reconstruction of the LU shows a negative trend of the main bionomic parameters passing from a state of alteration to that of dysfunction from 1999 to 2016.

The bionomic values, at the farm scale, highlighted that organic farms ecosystems have double values in comparison with the conventional. Therefore, it could be considered that organic ecosystems are more resilient, and they have a higher ecological quality of vegetation. The impact of human habitat in conventional farms is higher than into the organic. However, in conventional farms, semi-natural permanent meadows (included flooded meadows) have bionomic values, which are similar to those of organic field crops.

Conclusion

We consider interesting to communicate.

A. In a rural landscape when small woods and the few tree-lined corridors do not contribute to realizing a real ecological network, organic fields and semi-natural permanent meadows could have a key role to replace the ecological functions of resistant and protective landscape elements.

B. Naturalized ecosystem and organic crop fields have ecological values, which could enhance landscape fragmentation caused by the presence of human habitat.

C. To improve the ecological network design of landscape the LB discipline recommends to planting new trees-lined corridors or woods patches in connection with the existing.

D. The use of LB to evaluate the state of health of a rural landscape offers tools and indicators that could be useful, but that discipline is less known. It could be interesting to deepen researches in that field.

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