LENs Italy Program

TECHNICAL REPORT

Evaluation of Biodiversity Indices of

Soil, Water and Air Biodiversity Indices

Assessment Evaluation

of potential and real biodiversity

Client:	**Preferred by Nature FMBA** Registration No. 18044633, VAT No. DK18044633 address Skindergade 23, 3 København K, 1159 Denmark
Delivery date:	**November 30, 2025**
WBA Project s.r.l. Single-member Social Enterprise pursuant to Legislative Decree 155/2006 Viale del Lavoro 52, 37135, Verona (Italy) VAT number and Tax Code 04268860238 Tel.: +39 3474127738 Certified email wbaproject@legalmail.it	

Table of Contents

Framework of the LENs Italia project *1*

Introduction **1**

LENs Northeast Italy **1**

Shared Principles for Regenerative Agriculture in the LENs Northeast Italy program **2**

WBA's activity 2

Assessment of the biological quality of Soil, Water and Air **4**

Specifications of the WBA Soil Biodiversity Index - IBS-bf 5

Specifications of the WBA Lichen Biodiversity Index - IBL-bf 10

Specifications of the WBA Aquatic Biodiversity Index - IBA-bf 14

Survey of potential and real biodiversity **19**

Results *23*

Assessment of the biological quality of Soil, Water and Air 23

Survey of potential and real biodiversity 32

Conclusions *40*

ANNEXES

Annex 1 – Results of the Assessment of the biological quality of Soil, Water and Air
Annex 2 – Shapefile of the Assessment of the biological quality of Soil, Water and Air (survey points)
Annex 3 – Results of the Survey of potential and real biodiversity
Annex 4 – Shapefile of the Survey of potential and real biodiversity (final buffer elements with score, UAA plots of LENs Italia 2022-2024 program companies on PbN database)
Annex 5 – Maps

FRAMEWORK OF THE LENS ITALIA PROJECT

Introduction

As reported in the reference document **LENs North-East Italy Landscape Enterprise Networks - Technical Guide Measures and Call 2025**, the "Landscape Enterprise Networks" (LENs, https://landscapeenterprisenetworks.com/) constitute an organizational system for the purchase and supply of ecosystem services, such as improving water quality, managing hydrogeological risk, resilient supply of agricultural raw materials, reducing emissions and carbon sequestration, as well as protecting and promoting biodiversity.

Those interested in obtaining such services – and therefore willing to co-finance specific activities – are referred to as "demand-side organizations". The expected results derive from the implementation of territorial management interventions called "measures." Generally, these measures are carried out by farmers, identified as the "supply side", who contribute to the achievement of the objectives identified on the demand side.

The LENs methodology was developed by the British B-Corp 3Keel (https://www.3keel.com/) and has been applied in the United Kingdom since 2016 and, since 2022, also in several countries of continental Europe, including Hungary, Poland and Italy. In Italy, the program is managed by Preferred by Nature (hereinafter PbN, https://www.preferredbynature.org/), a non-profit organization active in over one hundred countries and specialized in sustainability in agriculture and forestry.

LENs Northeast Italy

The LENs program was launched in Italy in 2021 with the initial involvement of two funding partners: Nestlé Purina PetCare and the Consorzio Tutela Prosecco DOC, both united by environmental interests related to the same territory. The shared objective is to improve ecosystem services in the Veneto and Friuli-Venezia Giulia regions through the creation of a commercial community capable of connecting economic activities, local communities and the territory.

The LENs Northeast Italy program also includes *supply aggregators*, specifically Cereal Docks and Serena & Manente, suppliers of Nestlé Purina PetCare, which act as intermediaries between arable crop farms and the program operator. The Consorzio Tutela Prosecco DOC, on the other hand, performs a dual function: it is part of the demand side and is an aggregator for the wineries of the Prosecco DOC Denomination.

Shared Principles for Regenerative Agriculture in the LENs Northeast Italy program

The program partners adopt shared principles as a technical reference for the orientation of agricultural practices towards more sustainable and resilient models. These principles are based on a systemic approach aimed at regenerating agricultural ecosystems, promoting soil health, biodiversity and climate resilience, while ensuring the productivity and well-being of farmers.

In summary, the shared principles concern:

- soil fertility and increase in organic matter;
- biodiversity in the field and in the soil;
- sustainable management of water resources;
- strengthening ecosystem complexity.

In line with these principles, the program prioritizes the adoption of regenerative practices such as:

- continuous soil cover, in order to prevent water and wind erosion over the seasons;
- promotion of biodiversity and natural habitats;
- reduction of soil tillage, avoiding the inversion of the layers and the consequent oxidation of the organic substance;
- reducing the use of synthetic chemicals (e.g. limiting insecticides to the sowing of corn and other crops);
- crop rotation, including the introduction of legumes, to foster greater ecosystem complexity.

Since 2022, the LENs North-East Italy program has therefore favored, through the subsidization of specific financing measures to the Italian agricultural world, a start of the agriculture involved towards a systemic transformation that aims at soil regeneration and that allows farms to progress along ***a Regeneration Path***.

WBA's activity

In order to be truly effective and sustainable over time, both in supply and demand and with a view to continuous improvement, a ***Regeneration Path*** should be equipped with internal and management evaluation tools that allow the effectiveness of the actions pursued to be framed according to the objectives identified in the design phase. With this in mind, as part of the LENs Italy project for the years 2022-2024, PbN has commissioned WBA Project srl Unipersonale Impresa Sociale Ex D.Lgs 155/2006 (hereinafter WBA), to carry out two types ***of monitoring actions*** in the territories subject to measures affected by investments in permanent biodiversity. In these areas and for these measures, WBA was also involved as a design technician for the planting of hedges, woods, and groves, as well as a contact person for biodiversity.

The monitoring actions identified concerned, in particular:

- ***an assessment of the biological quality of Soil, Water and Air***;
- ***a survey of potential and real biodiversity***.

Such monitoring therefore acts as a useful *baseline*, similar to an *ante-operam* impact assessment on biodiversity, considering that the communities of animal and plant organisms that insist on an agrosystem cannot change permanently and suddenly, but only as a result of positive or negative actions (pressures) perpetrated over time. In the case of naturalistic woods and hedges, with the use of young seedlings of 3-4 years related to a positive modification in the field of regenerative agriculture, it is estimated that a first significant and permanent effect can only be had when the first climax phase of the plant communities considered (hedges, woods) approaches, therefore in the order of 10-15 years (figure 1). However, it is not certain that already in the first years it is not possible to measure and record a first ***favorable delta***, especially in situations of activity (improvement) in which the initial condition had a relatively low level of potential and real biodiversity. In particular, in the agricultural sector, we refer to those situations of reduced landscape and crop diversity, with simplification of the production environment and with a strong introduction of external *inputs* for the maintenance of production and the containment of pests and diseases, situations characterized by scarcity of soil with permanent cover and where the use of synthetic chemistry and agronomic processes that perturb the system (for example, repeated deep plowing) are still present and implemented continuously and intensively. In such contexts, and in the agricultural sector in particular, the use of smart indicators, codified and implemented on a scientific basis, can be a successful and applicable tool for assessing such impacts on the degree of conservation or development of biodiversity.

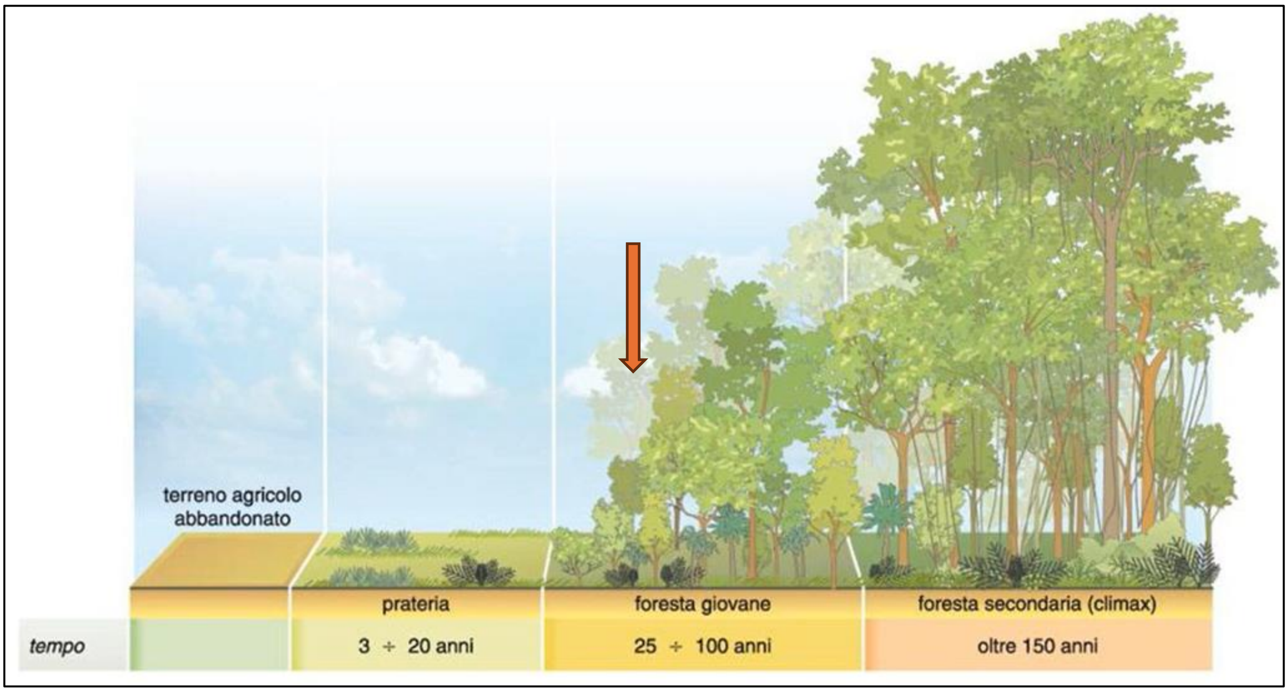

Fig. 1 Ecological succession. The red arrow indicates the first phase of permanent positive influence.

Assessment of the biological quality of Soil, Water and Air

As part of the "***Assessment of the biological quality of Soil, Water and Air"*** monitoring activities envisaged by the LENs Italia project, WBA, a company controlled by the World Biodiversity Association onlus (WBA onlus), has verified the biological quality of soil, water and air at some production sites (agricultural plots). In general, the surveys, carried out in the plots affected by the biodiversity measures (hedge plants, woods and groves) of the LENs Italia project for the years 2022-2024, were carried out by WBA technicians, applying the procedures provided for by the so-called "Biodiversity Indices" (IBS-bf, IBL-bf and IBA-bf indices), developed in 2010 by WBA onlus for the evaluation of biodiversity conservation in agriculture (Caoduro *et al.*, 2025).

The assessment of the environmental quality of the agrosystem is therefore carried out by detecting the presence of particular organisms, defined as biological indicators, as they present:

- high sensitivity to pollutants,
- wide diffusion throughout the territory,
- poor mobility;
- ability to accumulate pollutants in their tissues.

With regard to the soil, the WBA specification provides for the analysis of soil samples in which the presence of soil invertebrates (annelids, springtails, mites, isopods, myriapods, insects, etc.) is detected for the determination of the Soil Biodiversity ***Index (IBS-bf)***, obtained by assigning a score to each morpho-functional group in relation to the role played in the dynamics of the edaphic ecosystem. The assessment of air quality takes place through the Lichen Biodiversity ***Index (IBL-bf)***. Lichens, symbiotic organisms between a fungus and an alga, are very sensitive to atmospheric pollution caused by phytotoxic gases and are considered excellent biological indicators, often used in air biomonitoring, both in urban and rural areas. Lichens, in fact, are sensitive not only to urban pollution, but also to the excessive use of agrochemicals in agricultural areas. The calculation of the Lichen Biodiversity Index is based on a data of presence and frequency of epiphytic lichens, detected on the bark of trees (forophytes) present in the countryside.

Finally, the quality of surface waters is assessed by analyzing the composition of aquatic invertebrate communities. The calculation of the ***Aquatic Biodiversity Index (IBA-bf)*** is based on the presence in surface waters of aquatic macroinvertebrates with different tolerances to pollution; these are in particular plecotteri, tricotteri, ephemeroptera, molluscs, annelids, crustaceans, beetles and others. Each group is evaluated with a specific score based on the sensitivity of the group to pollutants.

Specifications of the WBA Soil Biodiversity Index - IBS-bf

Introduction

Much of the Italian agricultural land is affected by various kinds of alterations, mainly due to erosion, compaction, pollution, and lack of organic matter. Therefore, to pursue sustainability, the agriculture of the future will have to adopt a more rational management of soils. Soil quality can be assessed through physical-chemical and microbiological parameters. Other methods proposed in more recent times are based on the use of endogenous micro-arthropods. In fact, many endogeic animals form a dense network of relationships with each other and continuously interact with the physical environment; any alteration of this environment is "recorded" by the soil community which, therefore, can be used as an indicator of changes in natural conditions.

Soil can therefore be considered an ecosystem formed by a complex set of mineral particles, water, air, organic matter and living organisms; being the main element without which much of agricultural production would not be possible, it can be considered one of the most important natural resources on the planet. Much of Europe's agricultural area is affected by soil alteration due to erosion, compaction, pollution, loss of organic matter and changes in land use (Jones et al., 2012). To be sustainable, agriculture in the future will have to adopt rational soil management.

The use of land to produce food requires a very high level of resource maintenance. Traditionally, soil quality is assessed through physical, chemical and microbiological indicators. Several authors have proposed methods based on the use of endogenous microarthropods in the assessment of soil quality. In fact, many endogeous animals show a high sensitivity to soil management methods and can be easily related to the functions of the soil ecosystem (Black, 1965; Menta, 2008).

The assessment of the state of natural integrity, or alteration, of the edaphic ecosystem can actually be carried out by studying the soil fauna. The edaphic or subterranean animals living in the soil form a dense network of relationships with each other and continuously interact with the physical environment. Any alteration of this environment is "recorded" by the soil community which, therefore, can be used as an indicator of changes in natural conditions (Giachino & Vailati, 2005; 2010).

Given the complexity of the communities that live in the soil, for qualitative investigations, some groups of animals are usually examined whose species possess fundamental requirements to be considered effective biological indicators, including:

- being censurable,
- being easy to identify,
- being sufficiently known from an ecological and biogeographical point of view.

Carabid and Staphylinid beetles, Opilions, Earthworms and Enchytraeids have always been the most used groups in the past for investigations of this type (Brandmayr et al., 2005). However, the application of these procedures has often been limited by the difficulty of classification at the species level, which requires the work of specialist zoologists.

Methods

The WBA protocol method (Caoduro *et al*., 2014, Caoduro *et al.,* 2025) involves the analysis of soil samples in which the presence of the main groups of endogeous animals is detected for the determination of the Soil Biodiversity Index (IBS-bf); the presence of each group is reported with the relative score in a specific survey sheet. Compared to other methods that use only

Arthropods, the IBS-bf also considers Molluscs and Annelids, groups that play a fundamental role in the dynamics of the edaphic ecosystem.

The various taxa of invertebrates, selected through an entomological screening, are identified by the operator and recorded on a special survey sheet. Sampling should be carried out, in an optimal line, in temperate soil conditions, avoiding periods that are too dry or too rainy. At the end of the sampling, the Soil Biodiversity Index is calculated simply by adding the individual scores relating to the taxa detected; the value obtained to correspond to a satisfactory soil quality must be equal to or greater than 100 (figures 2 and 3).

Bibliography

Black, C.A. (ed.), 1965 - Method of Soil Analysis, Part 2, Chemical and Microbiological Properties, American Society of Agronomy, Inc, Publisher, Madison, Wisconsin USA, 1159 pp.

Brandmayr P., Zetto T., Pizzolotto R. (eds), 2005 - I Coleotteri Carabidi per la valutazione ambientale e la conservazione della biodiversità. Manuale operativo. APAT, Manuals and Guidelines, 34: 240 pp.

Caoduro, G., Battiston R., Giachino P.M., Guidolin L. & Lazzarin G., (2014). Biodiversity indices for the assessment of air, water and soil quality of the "Biodiversity Friend" certification in temperate areas. Biodiversity Journal, 2014, 5 (1): 69–86

Caoduro G. *et al.*, 2025. Practical guide to the use of the Biodiversity Indices of the Biodiversity Friend® standard. WBA Handbooks 13, WBA Project
Ed., Verona: 1-160.

Giachino P.M., Vailati D., 2005 - Problems of protection of the hypogeum environment and notes on the impact of research activities in the underground environment. In: The Karst Environment and Man. Atti Conv. Naz., Bossea (September 5-8, 2003): 303- 314.

Giachino P.M., Vailati D., 2010 – The subterranean environment. Hypogean life, concepts and collection techniques. WBA Handbooks 3, 130 pages

Jones A., Stolbovoy V., Tarnocai C., Broll G., Spaargaren O., Montanarella L., Anisimov O., Arnalds O., Arnoldusen A., Bockheim J., Breuning-Madsen H., Brown J., Desyatkin R., Goryachkin S., Jakobsen BH., Konyushkov D., Mazhitova G., Mccallum I., Naumov E., Overduin P., Nilsson, Solbakken E., Ping CL & Ritz KS, 2012 - The State of Soil in Europe. JRC Reference Reports, European Environment Agency. Report EUR 25186 EN. 71 pp.

Fig. 2 Soil Biodiversity Index IBS-bf survey procedure (taken from Caoduro *et al.*, 2025)

SCHEDA DI RILIEVO DELL'INDICE DI BIODIVERSITA DEL SUOLO

wba project

Azienda:
Località: Provincia:
Data rilievo: Rilevatore:
Coordinate UTM: Sito:
Condizioni meteo: sereno poco nuvoloso nuvoloso t = °C
Suolo (tessitura): argilloso argilloso-limoso franco sabbioso
% scheletro =

PHYLUM	CLASSI	ORDINI (o famiglie)	Punteggio	Presenza
Molluschi	**Gasteropodi**	Pulmonati e Prosobranchi	**10**	
Anellidi	**Oligocheti**	Enchitreidi	10	
		Lumbricidi	20	
Artropodi	**Aracnidi**	Pseudoscorpioni	20	
		Scorpioni	5	
		Ragni	5	
		Opilionidi	10	
		Acari	20	
	Crostacei	Isopodi	10	
	Miriapodi	Chilopodi Litobiomorfi, Scutigeromorfi e Scolopendromorfi	10	
		Chilopodi Geofilomorfi	20	
		Pauropodi	20	
		Sinfili	20	
		Diplopodi	15	
	Insetti	Collemboli saltatori (forme epigee)	10	
		Collemboli non saltatori (forme endogee)	20	
		Proturi	20	
		Dipluri	20	
		Tisanuri (Microcoryphia e Zygentoma)	10	
		Blattodei	5	
		Isotteri	5	
		Embiotteri	10	
		Dermatteri	5	
		Ortotteri (Grillotalpidi e Grillidi)	20	
		Psocotteri	5	
		Emitteri	5	
		Tisanotteri	5	
		Coleotteri	10	
		Imenotteri (Formicoidei)	5	
	Forme giovanili	Larve di altri olometaboli e ninfe di Cicadidi	10	
		Larve di Coleotteri	10	
		Larve di Ditteri	5	
		Punteggio finale IBS-bf	**375**	

Fig. 3 Soil Biodiversity Index IBS-bf survey sheet.

Specifications of the WBA Lichen Biodiversity Index - IBL-bf

Introduction

Air pollution in rural areas is an extremely complex environmental aspect that is difficult to read and interpret. Usually, the study of air quality is addressed by simultaneously applying different chemical-physical approaches that each investigate specific aspects of pollution. This often involves the use of sophisticated electronic equipment that analyzes gaseous substances and airborne dust. In this way, the available data is almost always punctiform and concentrated in urban and industrial areas, and almost never available for rural areas of agricultural interest.

The biological approach proposed by WBA is a simple method that allows estimating air quality in relation to the dispersion of phytotoxic gaseous substances. The procedure is based on the Lichen Biodiversity Index (LBI) which is determined through the study of lichen communities that develop on the bark of trees.

Lichens are organisms formed by the symbiosis between a fungus and an alga whose metabolism is strictly dependent on air. For this reason, lichens can give excellent indications on the level of alteration of the atmosphere. They have a high capacity for absorption and accumulation of substances present in it, are very resistant to environmental stress, cannot get rid of polluted parts, are very long-lived, slow to develop, and have a high sensitivity to pollutants.

In the assessment of air quality, lichens can be used both as bioindicators of phytotoxic gases and as bioaccumulators of trace metals.

While morphological and physiological alterations are difficult to quantify and often difficult to interpret, ecological variations allow the lichen responses to be translated into numerical values, referable to the different levels of atmospheric pollution. In general, approaching the polluting sources, there is a progressive deterioration of the health conditions of the lichens and, therefore, a progressive simplification of the communities until their complete disappearance (lichen desert).

Air pollution is usually considered a problem related to urban and industrialized areas. However, in recent decades the impact of agriculture on air quality has been widely recognized. Many authors have shown that atmospheric pollutants produced by agricultural activities have a significant impact on the development of epiphytic lichens (Alstrup, 1991; Loppi, 2003). The sensitivity of lichens is particularly relevant to fungicides, but herbicides and insecticides also have a significant impact on them. In particular, it has been shown that the richness of lichen species is negatively affected by the frequency of pesticide treatments (Bartok, 1999).

The first studies on the sensitivity of lichens to air pollution date back to the nineteenth century, but only in recent decades have they been used as bioindicators on a large scale. The most widely used procedure involves the calculation of the Lichen Biodiversity Index (LBI) which estimates the state of the lichen community under standard conditions after a long exposure to air pollution and/or other types of environmental stress: the lichens considered for the calculation of the index are epiphytes, that is, those living on the bark of trees (Nimis, 1999; ANPA, 2001).

The biodiversity of epiphytic lichens is an excellent indicator of pollution produced by atmospheric pollutants of a gaseous nature. With this approach, certain intensities of environmental disturbance are correlated with variations in the floristic richness of lichen communities.

Methods

For the measurement of air quality, the WBA protocol (Caoduro *et al.*, 2025) is based on the identification of lichen biodiversity detection stations, each consisting of groups of three neighboring trees, at which the variety of species and the frequency of each are estimated, which will be translated into a numerical summary data representing the Lichen Biodiversity Index (IBL-bf) of the station.

Ideally, each station is formed by trees (forophytes) characterized by a straight trunk, with a circumference at breast height greater than 60 cm and insertion of the crown greater than 2 meters in height. The biodiversity survey is carried out using a sampling grid formed by a linear series of five 10x10 cm squares, which must be arranged vertically on the stem of the host tree, with the lower part arranged about one meter from the ground surface.

The grid is positioned at the four cardinal points, avoiding:

- damaged or debarked parts of the trunk,
- parts with the presence of evident knots,
- parts corresponding to the drainage bands with periodic flow of rainwater,
- parts with bryophyte coverage greater than 25%.

During the survey, for each cardinal direction, all lichen species present within the grid and their frequency are recorded, calculated as the number of quadrants in which each species is present (the frequency values of each species therefore vary between 0 and 5).

The lichen biodiversity value relative to the sampled tree (IBL) is obtained by summing the frequencies detected in each cardinal direction.

The lichen biodiversity value of the sampling station (total IBL), on the other hand, is determined statistically as the average of the values measured for each individual host tree.

For Biodiversity values (IBL-bf) equal to or greater than 45, with reference to the scale used at the Italian level, the WBA protocol considers that the air quality, limited to the dispersion of gaseous substances with a phytotoxic effect, is to be considered satisfactory (figures 4 and 5).

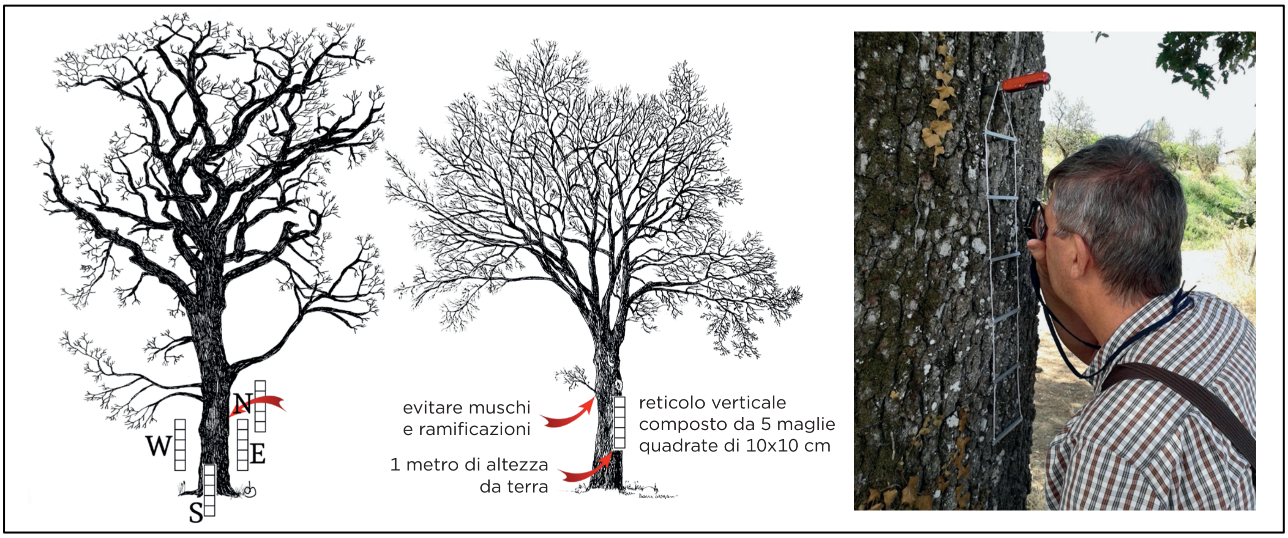

Fig. 4 Lichen Biodiversity Index IBL-bf survey procedure (taken from Caoduro *et al.*, 2025)

SCHEDA DI RILIEVO DELL'INDICE DI BIODIVERSITA LICHENICA

Azienda:

Località: Provincia:

Data: Operatore:

Coordinate del sito: Altitudine m s.l.m.

Indice di Biodiversità Lichenica-bf:

Elenco delle specie	Forofita, esposizione e frequenze											
	1 - specie:				**2** - specie:				**3** - specie:			
	Coord. geogr.				Coord. geogr.				Coord. geogr.			
	N	E	S	W	N	E	S	W	N	E	S	W
TOTALE												

IBL			
IBL TOTALE			

NOTE:

Fig. 5 IBL-bf Lichen Biodiversity Index survey sheet.

Bibliography

Alstrup V., 1991 – Effects of pesticides on lichens. Bryonora, 9: 2–4.

ANPA, 2001 - I.B.L. Lichen Biodiversity Index. ANPA Manual, Rome, 1-85.

Bartok K., 1999 – Pesticide usage and epiphytic lichen diversity in Romanian orchards. Lichenologist, 31 (1): 21–25.

Caoduro G. *et al.*, 2025. Practical guide to the use of the Biodiversity Indices of the Biodiversity Friend® standard. WBA Handbooks 13, WBA Project
Ed., Verona: 1–160.

Loppi S., 2003 - Mapping the effects of air pollution, nitrogen deposition, agriculture, and dust by the diversity of epipytic lichens in central Italy. In: Lichens in a changing pollution environment. English Nature Research Reports Rep., 525: 37-41.

Nimis PL, 1999 - Guidelines for the bioindication of the effects of pollution through the biodiversity of epiphytic lichens. Workshop Proceedings "Biomonitoring of air quality on the national territory" A.N.P.A., Rome, 267-277.

Specifications of the WBA Aquatic Biodiversity Index - IBA-bf

Introduction

There are various methods for carrying out a qualitative environmental analysis of surface waters, each suitable for highlighting different aspects and critical issues. These methodologies can be divided into two main groups: direct, i.e. physical-chemical analyses, and indirect, represented by biotic indices. In general, chemical-physical analyses offer a high level of detail but only elaborate simple and linear problems, highlighting individual critical issues in a punctiform manner. Chemical investigations detect the presence of specific substances and may not record the presence of intermittent or periodic pollutants, or of substances that are not detectable outside the range of analysis.

To analyze complex systems, such as the ecological network of a river or a watercourse, biotic indices offer greater opportunities. The biomonitoring of living organisms in waterways can detect the effects of a contaminant not detected by chemical analyses, as reported in modern literature, since the proposal of Beck's biotic index (Beck, 1955). The strategy of biotic indices is based on the identification of macroinvertebrates, whose sensitivity to water quality is well known; for this reason they are defined as bioindicators. The community of benthic macroinvertebrates of a watercourse is, therefore, particularly suitable for use in bioindication, as:

- it is located in an environment with limited seasonal variations,
- it is easy to sample,
- it is abundant and generally always available.

Monitoring of animals living in waterways can reveal the effects of pollution, not detected by chemical monitoring. For this reason, biotic indices dominated broad-spectrum environmental analyses throughout the middle of the last century until they were standardized and highlighted in national and community regulations (Directive 2000/60/EC and Legislative Decree 152/99 in Italy) in the monitoring and classification of water bodies.

In recent years, however, the standardized model of the Extended Biotic Index (Woodiwiss, 1964, 1978) has been perfected, adding significant conceptual contributions. The EBI works well if conducted in well-known areas, i.e. where the tolerance parameters of the individual species are known and if conducted with great detail of specific determination, therefore by a macroinvertebrate specialist, who is familiar with river ecological dynamics.

To overcome this methodological limitation and at the same time broaden the systemic complexity of the analyses, some authors have suggested reducing the taxonomic detail in the study of bioindicators, compensating for it with a more accurate description of the characteristics of the ecosystem. This would highlight how the abiotic component is suitable for hosting the biotic one, evaluating the entire functionality of the river or lake system (Vannote et al., 1980; Siligardi et al., 2007; or the Italian SEL in the Ministerial Decree 391/2003). In relation to the above, the Aquatic Biodiversity Index (IBA-bf) represents an alternative and a further evolution of the aforementioned methodologies, aiming therefore not so much to assess the presence of pollutants or disturbing elements for particular organisms in the water, but to estimate when an aquatic environment as a whole is favorable to hosting significant biodiversity, a broader spectrum index from which considerations on individual critical issues can naturally also be deduced. The WBA-bf is therefore proposed as an "expert system", in which the sensitivity of the species to variations in water quality and the recognition of the taxa present are only a part of the "integrated assessment" that the protocol proposes. The new sampling and analysis protocol is characterized by its simplicity and is suitable for rapid application since the recognition and calculation procedures are simple, making the index suitable for application even by non-specialists. The WBA Protocol's Aquatic Biodiversity Index aims, in short, to detect the diversification and stability of biotic communities (Klemm et al., 1990; Rosemberg et al., 1997) by relating them to river continuity and the functional components of hydromorphology (Caoduro *et al*., 2025).

Methods

The WBA Protocol's Aquatic Biodiversity Index assesses how much an aquatic environment, as a whole, is conducive to hosting significant biodiversity. In the IBA-bf survey sheet, the analysis of the fauna component is preceded by surveys on the main chemical-physical parameters of the water: temperature, pH, electrical conductivity, and dissolved oxygen. The hydromorphological analysis follows, which considers the amplitude, the river morphology, the water regime, and the riparian and perifluvial vegetation. Finally, the survey sheet considers the taxonomic diversity of the community and the tolerance of each group to phenomena of alteration of water quality. The presence of at least two bioindicators belonging to groups particularly sensitive to pollution offers a significant indication of a good quality of the aquatic environment.

The sampling of aquatic fauna is carried out through a net for aquatic macroinvertebrates, but also from the shore, investigating the lower surfaces of stones and among the debris of the bottom. After completing the sampling, the Aquatic Biodiversity Index of the station is calculated by adding all the scores obtained in each section of the sheet: hydromorphology, taxonomic diversity and tolerance to pollution. To have acceptable biodiversity conditions, the result must reach a value equal to or greater than 30 (figures 6 and 7).

Bibliography

Beck, W.H., Jr., 1955 – Suggested method for reporting biotic data. Sewage and Industrial Waste 27(10): 1193-1197.

Caoduro G. *et al.*, 2025. Practical guide to the use of the Biodiversity Indices of the Biodiversity Friend® standard. WBA Handbooks 13, WBA Project
Ed., Verona: 1-160.

ISO 10870: 2012, 2012 - Water quality. Guidelines for the selection of sampling methods and devices for benthic macroinvertebrates in fresh waters. British Standards Institute, 38 pages

Klemm, D.J., Lewis P., Fulk F., & Lazorchak J., 1990 - Macroinvertebrate field and laboratory methods for evaluating the biological integrity of surface waters. US Environmental Protection Agency, Washington, DC, 256 pp.

Siligardi M., Avolio F., Baldaccini G., Bernabei S., Bucci M.S., Cappelletti C., Chierici E., Ciutti F., Floris B., Franceschini A., Mancini L, Minciardi M.R., Monauni C., Negri P., Pineschi G., Pozzi S., Rossi G.L., Sansoni G., Spaggiari R., Tamburro C. & Zanetti M., 2007 - I.F.F. 2007 Indice di funzionalità fluviale APAT, Ministero dell'Ambiente e della Tutela del Territorio e del Mare, ARPA Trento. [River Function Index] 325 pp.
Vannote R.L., Minshall G.W., Cummins K.W., Sedell J.R. & Cushing C.E., 1980 - The river continuum concept. Canadian Journal of Fisheries and Aquatic Sciences, 37: 130–137.

Fig. 6 Survey procedure of the IBA-bf Aquatic Biodiversity Index (taken from Caoduro *et al.*, 2025)

SCHEDA DI RILIEVO DELL'INDICE DI BIODIVERSITÀ ACQUATICA

Azienda:
Località: Provincia:
Data rilievo: Rilevatore:
Coordinate UTM: Sito:
Lunghezza/perimetro del tratto considerato in m: pH Indice IBA-bf: 0
Parametri chimico-fisici H_2O t °C Cond. Elettr. µS/cm O_2 disciolto mg/l

1) IDROMORFOLOGIA

Categoria	Punteggio: 4		Punteggio: 3		Punteggio: 2		Punteggio: 0		Totale
Larghezza	>2 m		1-2 m		<1 m		artificiale		
Morfologia fluviale	eterogenea		irregolare		semplice		canalizzata		
Regime idrico	naturale		naturale alterato		in parte artificiale		del tutto artificiale		
Vegetazione riparia	erbacea igrofila		arbustiva riparia		arborea riparia		assente o non funzionale		
								TOTALE (1)	

GRUPPI BIOINDICATORI	NUMERO TAXA			TOLLERANZA	
Ninfe di Plecotteri	n.		*<---- indicare il n. di taxa rilevati*	1	
Ninfe di Efemerotteri	n.			3	
Ninfe di Tricotteri	n.			4	
Larve di Megalotteri e Planipenni	n.			4	
Planarie	n.			4	
Coleotteri acquatici (larve ed adulti)	n.			4	
Emitteri acquatici	n.			5	
Idracari	n.			6	
Ninfe di Odonati	n.		*indicare il valore di tolleranza corrispondente ai taxa rilevati, partendo dal valore più basso; E' NECESSARIO INDICARE SOLO I DUE PIU' BASSI (riportare il n.) ---->*	6	
Larve di Ditteri (esclusi Chironomidi rossi)	n.			6	
Anfipodi	n.			5	
Decapodi	n.			5	
Isopodi	n.			7	
Gasteropodi	n.			7	
Bivalvi	n.			7	
Oligocheti	n.			8	
Irudinei acquatici	n.			8	
Larve di Chironomidi rosse	n.			8	
TOTALE TAXA	(*)		MEDIA DEI DUE VALORI PIÙ BASSI DI TOLLERANZA	(**)	

2) DIVERSITÀ TASSONOMICA

Categoria	Punteggio: 25	Punteggio: 15	Punteggio: 5	Punteggio: 0	TOTALE (2)
N° Taxa (*)	distribuzione eterogenea (>10)	dominanza lieve (6-10)	dominanza pesante (3-5)	dominanza - assenza completa (0-2)	

3) TOLLERANZA

Categoria	Punteggio: 25	Punteggio: 15	Punteggio: 5	Punteggio: 0	TOTALE (3)
Media tolleranza (**)	1-2,5	3-4,5	5-7,5	8	

Indice IBA-bf (1+2+3) **Scarso <30** **Sufficiente 30-44** **Buono 45-60** **Ottimo >60**

NOTE:

Fig. 7 Survey sheet of the IBA-bf Aquatic Biodiversity Index.

Survey of potential and real biodiversity

With reference to the ***survey of potential and real biodiversity***, WBA proposed and applied its own method of landscape-territorial analysis developed by WBA naturalists to meet the Client's needs. The latter requested a qualitative-quantitative *baseline* for evaluating the effectiveness of the LENs Italia measures implemented. This method is based on evidence from scientific literature and EU, FAO, and IUCN indications, which all converge on a definition that can be summarized in the following concept: "*the more a landscape is complex and diversified, with the creation of many habitats, micro and meso ecological niches, elements of environmental diversity, refuge and feeding areas, the greater the potential and real biodiversity of that place. This applies to both natural areas and agrosystems, systems in which the disturbance due to anthropic action is greater than in natural or protected areas. Especially in such contexts (including primarily agricultural, peri-urban, and urban), the mapping and evaluation through standardized procedures of the elements that can have functions related to local ecosystem services becomes fundamental. This allows for the initiation of evaluation and improvement processes over time and the application of corrective or protective actions, as well as the evaluation of the effectiveness of the investments made* ". The synthesis of this approach is therefore a naturalistic evaluation of the main elements characterizing an agrosystem.

In line with the above, the method allowed the creation and mapping of linear (table 1), ***punctual*** (table 2), and ***areal*** (table 3) ***elements*** — such as hedges, woods, headlands, isolated trees, meadows, necromass, natural nests, and insect hotels — and to assign them a score based on the potential for biodiversity conservation through an assessment of real and potential biodiversity.

<table>
<tr><th colspan="2">Field</th><th>Description</th><th>Subcategories</th></tr>
<tr><td rowspan="14">Hydrography</td><td rowspan="3">Hydrographic network</td><td rowspan="14">Presence of a hydrographic network, even minor, with evidence of the presence of water, even of an ephemeral nature</td><td>Main hydrography</td></tr>
<tr><td>Off-ground gutters</td></tr>
<tr><td>Drainage</td></tr>
<tr><td rowspan="3">Grid width</td><td><1 m</td></tr>
<tr><td>1 - 3 m</td></tr>
<tr><td>> 3 m</td></tr>
<tr><td rowspan="3">Embankments</td><td>Only artificial</td></tr>
<tr><td>Artificial on one side</td></tr>
<tr><td>Natural</td></tr>
<tr><td rowspan="5">Riparian vegetation

(3 different fields are evaluated for the primary, primary accessory and</td><td>Absent</td></tr>
<tr><td>Herbaceous</td></tr>
<tr><td>Herbaceous Hygrophilous</td></tr>
<tr><td>Shrub</td></tr>
<tr><td>Hygrophilous shrub</td></tr>
</table>

	secondary accessory components)		Arboreal
			Arboreal Hygrophilous
	Internal vegetation		Absent
			Functional
	Lattice character		Ephemeral
			Stable
Hedges	Type	Composition specifications in terms of average height	Shrub (more than 70% with height < 7 m
			Arboreal (more than 70% with height > 7 m)
			Mixed
	Conformation	This refers to the possible identifiable rows. In the case of a single band with a confused structure, there is 1 row which will then be described with its thickness	Single row
			Double
			Beyond
	Hedge thickness	Width of the hedge, including projection of the branch	< 2 m
			< = 2 m - < 5 m
			> = 5 m
	Linear density	Ability to distinguish an adult person beyond the hedge clearly, only partially, not visible. Random survey on the line in the chosen section of at least 10 steps.	Rare
			Average
			Full
	Number of species	Number of species with random survey on the line in the chosen section of at least 10 steps	< = 2
			< 2 - < 5
			> = 5
	Nectariferous/melliferous species	Intended as number of species and degree of coverage	< = 50%
			> 50%
			No
	Allochthonous/invasive species	Presence / absence	Yes
			No
Tree rows	Tree row density	Tree rows are linear formations of trees without evident productive purposes that are kept clear of shrubs. Density means the average distance between the crowns	Interpenetrating
			Contiguous
			Separate
	Number of tree-lined species	Intended as the number of species and degree of coverage	1
			2 - 5
			> 5
	Nectariferous/melliferous species	Intended as number of species and degree of coverage	> = 50%
			< = 50%
			No
	Allochthonous/invasive species	Presence / absence	Yes
			No
Agroforestry	Type of agroforestry	Agroforestry rows are linear formations of trees with productive purposes. Monocyclic formations = without accessory plants	Monocyclic
			Polycyclic
Dry stone walls	Dry stone walls	It is evaluated in a sample section representative of the area	100% dry
			More than 50% dry
			Less than 50% dry
Other	Indicate		

Table 1 Linear elements encoded and detected in the WBA method

Field	Description	Sub-categories
Nests	Refuge areas	Bat-box
		Artificial nest for birds
		Artificial nest for micro and meso mammals
		Artificial nest for reptiles
		Artificial nest for apoids
		Natural nest
Water elements	Multifunction	Spring
		Pond (also artificial)
		Well
		Spring
Entomofauna	Multifunction	Insect hotel
		Natural hive
		Presence of wild pollinators
		Apiary
Birds	Multifunctional	Perch
		Heronry
Reports	Mammals	Signs of the presence of micro and meso mammals
	Birds	Signs of presence, reporting of notable species
	Reptiles	
	Amphibians	
	Other notable fauna	
	This refers to species of particular naturalistic interest (e.g. orchids)	Notable herbaceous vascular flora
		Notable shrubby vascular flora
	Multifunction	Power point
	Multifunction	Tree with naturalistic value
Habitat	Multifunctional	Necromass
		Other microhabitats and refuge areas
		Abandoned ruined buildings
Isolated tree	Multifunctional	Flag in the case of an isolated tree. The species may be entered in the notes
Other	Indicate	

Table 2 Point Elements encoded and detected in the WBA method

<table>
<tr><th>Field</th><th>Description</th><th>Sub-categories</th></tr>
<tr><td rowspan="5">Wooded formation</td><td rowspan="2">type (any formation of at least 25 m 2)</td><td>NON TUFF Forest</td></tr>
<tr><td>TUFF forest</td></tr>
<tr><td rowspan="3">Structure</td><td>Single-layered</td></tr>
<tr><td>Biplane</td></tr>
<tr><td>Multilayer</td></tr>
<tr><td rowspan="3">Water Element</td><td rowspan="3">Type</td><td>Fresh wetlands</td></tr>
<tr><td>Brackish wetlands</td></tr>
<tr><td>Peatlands</td></tr>
<tr><td>Agronomic elements</td><td>Cultivated or uncultivated areas that are not managed assiduously and continuously, which show reduced impacts on the herbaceous component and on the soil in general
(e.g. embankments, slopes, set aside, stable lawn, etc.)</td><td>Surfaces with high ecological value</td></tr>
<tr><td>Other</td><td colspan="2">Indicate</td></tr>
</table>

Table 3 Point Elements encoded and detected in the WBA method

A score was assigned to these element evaluation criteria, in relation to the degree of positive influence on the conservation of the area's biodiversity. An example of these scores (values) can be summarized in the following diagram:

- Monumental isolated tree = **high score**
- Polyspecific hedge connected to ecological network = **medium-high**
- Permanent polyphite lawn = **high**
- Well-functioning insect hotel = **medium**
- Significant necromass (large dead wood): = **high**
- Undisturbed herbaceous headland = **medium**

A score is then assigned to each mapped element that contributes to the construction of a Biodiversity **Index** divided into two components:

- **Real biodiversity**, what is actually present (structures, species, habitats);
- **Potential biodiversity**, the ability of the element to host or promote species and ecological functions over time.

These assessments and the related scores took into account some general criteria and degrees of complexity, including:

- **Structural diversity** (e.g. plant stratification);
- **Naturalness** (e.g. degree of anthropic management);
- **Ecological continuity** (links with neighboring habitats),
- **Ecological rarity** (presence of valuable species or habitats),
- **Conservation status**.

Such information can be very useful, since the sustainable management of agricultural systems requires tools that can support the analysis, planning, and monitoring of natural and semi-natural elements present in the landscape and in agrosystems. However, they must be made intelligible and analyzable. To meet these needs, a *Geographic Information System* (GIS) was used, and in particular the QGIS software, which allows digitizing, classifying, and evaluating these elements. The analysis with QGIS can therefore allow for assessing the impacts on the territory of **real Biodiversity** and **potential Biodiversity**. It also allows for creating buffer areas of influence around the mapped elements.

RESULTS

Assessment of the biological quality of Soil, Water and Air

Monitored farms

The farms monitored through the WBA Biodiversity Indices correspond to the farms subject to subsidy under the LENs Italy 2022-2024 program in which there has been an activity linked to biodiversity measures, in particular permanent biodiversity measures. The survey mainly concerned the plots that were the subject of hedge, wood and grove planting, and in some cases the plots in which measures such as flower strips were applied were also considered. The surveys were carried out in the years 2022, 2023, and 2024 to cover all 25 farms involved and constitute, as a whole, the basic reference point for the *ante operam* value relating to Soil Biodiversity.

The codifications of the farms, surveyed on a structural basis from a GIS dataset provided by PbN to which, for completeness, the MIGLIO ROSSO farm (year 2022) in which the Biodiversity Indices were surveyed, are shown in the following table (table 4, annex 1).

Company_Id	Layer	WBA Indices
667143	EU-EN-2023-009___Francesca_Berton_2025	
667144	EU-EN-2024-001___Alessandro_Fasolo_2025	
667145	EU-EN-2024-002___ARJ_s.s._2025	
667146	EU-IT-2024-003___Az._Agr._Northeast_of_Brotto_s.s._2025	
667147	EU-EN-2024-004___Barduca_2025	
667148	EU-EN-2024-005___Basso_Ruggero_2025	X
667149	EU-EN-2024-006___Bertoldo_Ettore_2025	
667150	EU-EN-2024-007___Bios_is_2025	X
667151	EU-EN-2024-008___Bortolato_Lino_2025	
667152	EU-EN-2024-009___Canal_Dei_Cuori_srl_2025	
667153	EU-EN-2024-010___Carraro_Daniele_2025	
667154	EU-EN-2024-011___Carraro_Massimo_2025	
667155	EU-EN-2024-012___Cerere_SAS_2025	X
667156	EU-EN-2024-013___Cirillo_Vecchiato_2025	X
667158	EU-EN-2024-014___Fertilissima_Soc_Agr_2025	X
667159	EU-EN-2024-015___Gallo_Federico_2025	X
667160	EU-IT-2024-016___Giovanni_di_Brotto_s.s._Soc_Agr_2025	X
667161	EU-EN-2024-017___Migliori_Leonida_2025	
667162	EU-EN-2024-018___Pasqualetti_Massimina_2025	X
667163	EU-EN-2024-019___Petricore_BIO_2025	
667164	EU-EN-2024-020___Zanin_Carlotta_2025	X
672720	EU-IT-2022-001___Ca' Corniani_2025	X
672721	EU-EN-2022-002___Ca'_Felicita_2025	X
672722	EU-EN-2022-004___La_Taviela_2025	
672723	EU-IT-2022-003___Ca'_Solaro_2025	
672724	EU-IT-2022-007___Via_Regia_Soc._Agr._di_Pezzato_M._and_Carraro_E._s.s._2025	
672725	EU-IT-2023-001___Agriamore_Società_Agricola_s.a.s._(ORGANIC)_2025	X
672726	EU-IT-2023-002___Agrifior_Soc.Agr_2025 [Agricultural Company]	
672727	EU-IT-2023-003___soc.agr._Agriverde_di_Corò_Giorgio_e_Figli_S.S. _2025	X
672728	EU-EN-2023-004___Brunello_Stefano_2025	X
672729	EU-IT-2023-005___Cascina_Conca_d 'Oro_SAS_2025	
672730	EU-IT-2023-006___Cola_Eraldo_and_Andrea_soc_agr_semp_2025	X
672731	EU-EN-2023-011___Lissandro_F.lli_Soc_Agr_2025	X
672732	EU-EN-2023-012___Lissandro_Michele_Soc_Agr_Semp_2025	X
672733	EU-IT-2023-013___Az._Agr._Lora_Emilio_2025	
672734	EU-IT-2023-014___Az._Agr._Maritan_Dolores_2025	X
672735	EU-EN-2023-008___Danilo_Messi_2025	
672736	EU-EN-2023-016___Pietrobelli_Pietro_2025	
672737	EU-IT-2023-017___Az._Agr._Orna_by_Ponzio_Pierluigi_2025	X

672738	EU-IT-2023-018___Az._Agr._Pranovi_Fabio_2025	
672739	EU-EN-2023-019___Roda_Soc_Agr_Semp_2025	
672740	EU-EN-2023-022___Tonello_Luigi_2025	
672741	EU-IT-2024-021___Az._Agr._Marchetti_Raffaella_2025 [Marchetti Raffaella Farm]	
672742	EU-IT-2024-022___Agr._Agr._Mogno_Fabio_2025	
672743	EU-IT-2024-023___Agr._Agr._Toaldo_Federico_2025	
672744	EU-EN-2024-024___Camporese_Jerald_2025	X
672745	EU-IT-2024-025___Weldan_Winery_(BIO)_2025	
672746	EU-EN-2024-026___Cappelletto_Gabriele_2025	X
672747	EU-IT-2024-027___Cattolica_Agricola_Sarl_2025	
672748	EU-EN-2024-028___Dalla_Pria_Diego_2025	
672749	EU-EN-2024-029___Gianni_Dartora_2025	
672750	EU-EN-2024-030___Graziano_Benetti_2025	
672752	EU-EN-2024-031___Masiero_Valeriano_Antonio_2025	
672753	EU-IT-2024-032___Soc_Agr_De_Toni_di_Bovo_Mattia_and_C._2025	X
672754	EU-IT-2024-033___soc.agr._Cavi_di_Xodo_Monica_2025	X
672755	EU-IT-2024-034___Agricultural_Agr._Valente_Igino, _Severino, _Luigi_2025	X
672756	EU-EN-2024-035___Top_Grain_2025	
696089	EU-EN-2023-007___Damiano_Piccolo_2025	
696091	EU-EN-2023-021___Santin_Mauro_2025	
696092	EU-EN-2023-020___SAIR_srl_2025	
MR2023	RED MILLET	X

Table 4 Codifications of LENs Italia companies, surveyed on a structural basis from a GIS dataset provided by PbN. "X" indicates the farm subject to measurement of the Soil Biodiversity Index IBS-bf.

Survey of ISB-bf, IBL-bf and IBA-bf indicators

Overall, 25 companies were analyzed, for a total of 117 surveys of the IBS-bf Index (corresponding to 351 total sub-samples), 5 of the IBL-bf Index (equal to 15 analyzed forophytes), and 3 of the IBA-bf Index (equal to 6 IBA-nf sampling and analysis points). The number of surveys per farm was determined based on the extension and homogeneity of the areas investigated, according to the survey protocol of the IBS-bf, IBL-bf and IBA-bf indices of WBA, corresponding to 351 total sub-samples.

The results of the IBS-bf indicator and the values of each farm, assessed individually, are summarized in Table 5 and in extended form for each sample in Annex 1.In general, it can be stated that the average values measured for each company were all equal to or greater than the threshold value of 100 points, corresponding to a sufficient biological quality (potential biodiversity) of the soil. Out of 117 individual IBS-bf samples, only 13 samples (equal to about 11%) were insufficient (value equal to 75 and 80 points) or almost sufficient (values equal to

85, 90, and 95 points). These values are generally attributable to conditions of poor soil coverage at the time of the survey, possibly as a result of seasonality and agricultural rotations.

Company	Sample No.	IBS-bf				
		Single sample value	Average company value	+/- DS	min	max
667146	1	135	135.00			
667148	1	145	130.00	21.21	115.00	145.00
	2	115				
667150	1	150	145.00	7.07	140.00	150.00
	2	140				
667155	1	140	130.00	14.14	120.00	140.00
	2	120				
667156	1	145	126.25	14.93	110.00	145.00
	2	120				
	3	130				
	4	110				
667158	1	120	110.00	18.26	90.00	130.00
	2	100				
	3	130				
	4	90				
667159	1	135	135.00	0.00	135.00	135.00
	2	135				
667162	1	145	128.33	15.28	115.00	145.00
	2	115				
	3	125				
667164	1	170	170.00	0.00	170.00	170.00
	2	170				
672720	1	160	126.76	21.93	90.00	180.00
	2	140				
	3	110				
	4	135				
	5	130				
	6	115				
	7	135				
	8	110				
	9	145				
	10	180				
	11	130				
	12	100				
	13	115				
	14	120				

	15	125				
	16	90				
	17	115				
672721	1	105	103.33	7.64	95.00	110.00
	2	95				
	3	110				
672725	1	110	103.75	15.54	75.00	130.00
	2	85				
	3	130				
	4	90				
	5	75				
	6	105				
	7	120				
	8	100				
	9	105				
	10	105				
	11	120				
	12	100				
672727	1	145	138.33	11.55	125.00	145.00
	2	145				
	3	125				
672728	1	135	118.33	15.28	105.00	135.00
	2	115				
	3	105				
672730	1	150	142.22	14.81	120.00	170.00
	2	140				
	3	130				
	4	130				
	5	140				
	6	150				
	7	170				
	8	120				
	9	150				
672731	1	125	120.00	7.07	115.00	125.00
	2	115				
672732	1	115	115.71	13.36	90.00	130.00
	2	110				
	3	125				
	4	130				
	5	90				
	6	115				
	7	125				

672734	1	150	116.67	32.53	85.00	150.00
	2	85				
	3	115				
672737	1	175	175.00			
672744	1	155	156.67	2.89	155.00	160.00
	2	155				
	3	160				
672746	1	115	120.83	33.38	85.00	170.00
	2	150				
	3	90				
	4	85				
	5	170				
	6	115				
672753	1	130	135.83	12.01	120.00	150.00
	2	120				
	3	150				
	4	135				
	5	150				
	6	130				
672754	1	140	126.67	29.61	90.00	175.00
	2	90				
	3	175				
	4	130				
	5	120				
	6	105				
672755	1	85	101.25	13.77	85.00	115.00
	2	115				
	3	95				
	4	110				
MR2023	1	165	136.50	21.86	105.00	165.00
	2	145				
	3	155				
	4	145				
	5	115				
	6	105				
	7	115				
	8	120				
	9	135				
	10	165				

Table 5 Soil Biodiversity Index (IBS-bf) values detected for each company. In red, the values below the sufficiency threshold set at 100 points.

As regards the survey of the Lichen Biodiversity Index IBL-bf, the areas adjacent to the areas surveyed for the IBS-bf Index were examined for the presence of suitable forophytes, in qualitative and quantitative terms, for the determination of the IBL-bf survey. As part of the monitoring in the context of the LENs project (25 companies), this condition suitable for the indicator survey was achieved in only 5 cases.

Table 6 (Table 6, Annex 1) shows the overall results for the IBL-bf indicator. As can be seen from the table, all five stations considered reported an average IBL-bf value equal to or greater than the threshold value for sufficiency, set at 45 points. In only one case, relating to a tree of the farm "672746", "IBL_07 *Ulmus* sp.", the value of the single IBL-bf survey for that tree was insufficient. This condition is probably not directly attributable exclusively or directly to the agricultural management of the area, but rather to a series of global causes; the average value of the station is still good (67.67 average points).

Farm	**IBL-bf sample (coordinates and tree)**		**IBL-bf value**		
		No. of species detected	**absolute value for single forophyte**	**average value per station**	**+/- DS**
672720	*IBL_01* *Populus* sp.	8	106	105.33	13.01
	IBL_02 *Populus* sp.	8	118		
	IBL_03 *Populus* sp.	9	92		
672746	*IBL_01* *Quercus* sp.	4	55	51.67	5.77
	IBL_02 *Robinia pseudoacacia*	4	55		
	IBL_03 *Robinia pseudoacacia*	4	45		
	IBL_05 *Robinia pseudoacacia*	5	84	67.67	28.29
	IBL_06 *Robinia pseudoacacia*	5	84		
	IBL_07 *Ulmus* sp.	3	35		

667162	*IBL_01* *Ulmus* sp.	4	45	45.00	0.00
	IBL_02 *Ulmus* sp.	3	45		
	IBL_03 *Ulmus* sp.	6	45		
667158	*IBL_01* *Populus* sp.	5	62	54.67	7.51
	IBL_02 *Ulmus* sp.	4	47		
	IBL_03 *Ulmus* sp.	4	55		
672753	*IBL_01* *Acer* sp.	6	50	56.00	7.94
	IBL_02 *Acer* sp.	5	65		
	IBL_03 *Acer* sp.	6	53		

Table 6 Values of the Lichen Biodiversity Index IBL-bf detected for each farm. In red, the values below the sufficiency threshold set at 45 points.

Similar to the survey of the IBL-bf index, the survey of the IBA-bf indicator also provided a direct approach with localized context analysis, with the survey only in ideal situations for the survey of the indicator placed in the vicinity or in conjunction with the sites where the IBS-bf index was also analyzed.

In the present work, 3 suitable situations have been identified, with the presence of:

- non-lentic fresh water
- permanent or semi-permanent flow, i.e. with water present with minimum flow for at least 10 days during the monitoring periods (this is to ensure suitable chances of colonization by aquatic mesoinvertebrates).

As can be seen from Table 7, which shows the specific IBA-bf values for 3 survey stations in three different farms (Table 7, Appendix 1), all the surveys were placed with values above the minimum sufficiency threshold, set for this indicator at 30 points. In the specific case, in two contexts the values are similar to the first sufficiency range, with values of fauna complexity (mesoinvertebrates) found to be significantly poor. On the other hand, in the case of company 672746, the measured value of 54 places the analyzed point in the high range of the good value, high values of both environmental complexity (specific and functional hydromorphology) and biological complexity present.

Type	Specifications	Company		
		672746	672753	672744
1) HYDROMORPHOLOGY (values)	Width	3	3	3
	River morphology	2	0	2
	Water regime	3	2	2
	Riparian vegetation	6	4	6
	TOTAL Score	**14**	**9**	**13**
2) TAXONOMIC DIVERSITY (n. taxa)	Plecotteri nymphs			
	Ephemeroptera nymphs	2	2	1
	Trichopter nymphs		1	
	Megaloptera and Planipenni larvae			
	Planaria			
	Aquatic beetles (larvae and adults)	1		
	Aquatic emitters	2	2	2
	Water beetles			
	Odonata nymphs	3	1	
	Diptera larvae (excluding red Chironomids)	1	1	1
	Amphipods			1
	Decapods			
	Isopods			
	Gastropods	1		
	Bivalves			
	Oligochaeta			
	Aquatic invertebrates			
	Red Chironomid larvae	1		
	TOTAL TAXA NO.	**11**	**7**	**5**
	TOTAL Score	**25**	**15**	**5**
3) TOLERANCE	**TOTAL Score**	**15**	**15**	**15**
	FINAL IBA VALUE	**54**	**39**	**33**

KEY		**Poor <30**
		Sufficient 30-44
		Good 45-60
		Excellent > 60

Table 7 Values of the IBA-bf Aquatic Biodiversity Index detected for each company.

Survey of potential and real biodiversity

From the GIS analysis of the dataset provided by PbN, superimposing some administrative layers (Italian Land Registry) and thematic layers (regional territorial framework maps, natural areas, SCI areas, SPAs, Natura2000 Areas, etc.) on the geospatial data, and using Google Satellite surveys as a base map, it was possible to frame the plots of the LENs Italia farms.

In particular, the total number of plots making up the LENs Italia farms (PbN dataset updated to 2025) is 791, divided into the Veneto Regions (Provinces PD, VE, VI, RO, TV) and Friuli Venezia-Giulia (Provinces PN and UD) (Table 8).

LENs Italia farms	Province							
	PD	VE	VI	RO	TV	PN	UD	Total
672720		70						70
672725	60		6					66
667160			5		50			55
672732	41	4						45
667145		35						35
672727	24	9		2				35
667155		30						30
672730			29	1				30
672746	22	2		1				25
672756	24							24
672731	20	3						23
672747		19			3			22
672723		17			2			19
672753	19							19
667152				17				17
672728			17					17
672745						5	12	17
672729	2		14					16
672737			13					13
672754	1	12						13
667156		9		3				12
672721		12						12
672735	12							12
672739	12							12
672742	12							12
672755			11					11
667153	5	5						10
667159	8	1						9
672724		1			8			9

667161				8				8
667146					6			6
667151		5						5
672722						5		5
672748	5							5
672749		5						5
667147	4							4
667148	4							4
667158		4						4
667162	4							4
672733			4					4
672734		4						4
672738	2	2						4
672752		4						4
696092		4						4
667144	3							3
667150	3							3
667163	1	2						3
672726	2	1						3
696091						3		3
667143		2						2
667149	2							2
672740	2							2
672741			2					2
696089		2						2
667154	1							1
667164			1					1
672736			1					1
672743	1							1
672744	1							1
672750	1							1
Total	**298**	**264**	**103**	**32**	**69**	**13**	**12**	**791**

Table 8 Number of plots of LENs Italia companies divided by Company and Province.

These plots can also be expressed as areas in ha, divided by Municipality and Province (Table 9) and by company and Province (Table 10).

Municipality	**Province**							
	PD	**VE**	**VI**	**RO**	**TV**	**PN**	**UD**	**Total**
Caorle				1507.2497				1507.2497
San Stino di Livenza				386.8379				386.8379
Jesolo				250.5727				250.5727
Loreo		168.2399						168.2399

Venice			7.0724	155.6628				162.7352
Mirano				140.0483				140.0483
San Giorgio in Bosco	113.2073							113.2073
Quarto d'Altino				102.1831				102.1831
Vicenza					98,396			98.396
Grisignano di Zocco					90.7145			90.7145
Salzano				80.4302				80.4302
Roncade			77.8443					77.8443
Vigonza	64.5657			2.1533				66.719
Piazzola sul Brenta	60.3114							60.3114
Loria			55.4203		0.5615			55.9818
Adria		55.7428						55.7428
Camposampiero	53.902							53.902
Borgoricco	48.5047							48.5047
Massanzago	38.9322			9.2835				48.2157
Campodoro	46.6998							46.6998
Villanova di Camposampiero	44.014			1.5665				45.5805
Veggiano	19.0523				19.0523			38.1046
Mestrino	34.1717							34.1717
Santa Maria di Sala				30.6363				30.6363
Pianiga				29.8956				29.8956
Chioggia				26.6407				26.6407
Limena	26.2267							26.2267
Campodarsego	25.8484							25.8484
Mira				23.2575				23.2575
Gazzo	15.957				6.6215			22.5785
Cavarzere				22.1592				22.1592
Porto Tolle		21.8171						21.8171
Montegalda					20.9957			20.9957
San Vito al Tagliamento						18.1306		18.1306
Palazzolo dello Stella							16.8321	16.8321
Pojana Maggiore					16.6378			16.6378
Noale				16.4999				16.4999
Spinea				15.5996				15.5996
Costabissara					15.3042			15.3042
Villafranca Padovana	14.5038							14.5038
Cadoneghe	13.06							13.06
Caldogno					12.6573			12.6573
Sedegliano)							12.4764	12.4764
Camisano Vicentino	0.7764				11.1282			11.9046
Fossò	3.3332			8.1971				11.5303

San Zenone degli Ezzelini			10.3035		1.0016			11.3051
Mogliano Veneto			11.0713					11.0713
Asolo			10.7812					10.7812
Marcon				10.7225				10.7225
Longare					9,867			9.867
Vigodarzere	9.7265							9.7265
Orgiano					9.3297			9.3297
Cordignano			8.5538					8.5538
Castello di Godego			8.2374					8.2374
Codroipo							7.8197	7.8197
Colle Umberto			7.6555					7.6555
Maserà di Padova	7.62							7.62
Meolo				7.5059				7.5059
Grumolo delle Abbadesse					6.8879			6.8879
Santa Giustina in Colle	6.7329							6.7329
Riese Pio X			6.3348					6.3348
Villa del Conte	4.9947							4.9947
Padua	4.8452							4.8452
Mussolente			2.3896		2.3896			4.7792
Campo San Martino	4.7037							4.7037
Sant'Angelo di Piove di Sacco	3.3332							3.3332
Preganziol			2.9069					2.9069
Villaverla					2.6327			2.6327
Sacile						2.3155		2.3155
Loreggia	2.0047							2.0047
Canaro		1.9386						1.9386
Arcugnano					1.9152			1.9152
Quinto Vicentino					1.6858			1.6858
Isola Vicentina					1.5457			1.5457
Vigonovo				1.4068				1.4068
San Giorgio delle Pertiche	1.2071							1.2071
Dueville					1.1526			1.1526
Rossano Veneto			0.5615		0.5615			1.123
Badia Polesine		1.0691						1.0691
Musile di Piave				0.8477				0.8477
Torri di Quartesolo					0.6071			0.6071
Total	**668.2346**	**248.8075**	**209.1325**	**2829.3568**	**331.6454**	**20.4461**	**37.1282**	**4344.7511**

Table 9 Extension in ha of the plots of the LENs Italia companies divided by Municipality and Province.

LENs Italia Companies	Province							
	PD	VE	VI	RO	TV	PN	UD	Total
672720				1894.0876				1894.0876
672747			77.8443	174.0573				251.9016
672725	226.4606				17.7497			244.2103
672721				234.1632				234.1632
667145				191.2642				191.2642
667152		160.8172						160.8172
672729	19.0523				116.9781			136.0304
672730		1.0691			117.1754			118.2445
672727	53.5235	21.8171		27.7654				103.106
667160			90.7536		4.5142			95.2678
672723			14.1448	78.3624				92.5072
672746	59.5494	1.9386		5.7988				67.2868
667155				62.1815				62.1815
667156		7.4227		48.7999				56.2226
667161		55.7428						55.7428
672732	40.3284			5.4694				45.7978
672753	43.3447							43.3447
672745						5.3533	37.1282	42.4815
672735	39.3322							39.3322
672739	36.4706							36.4706
672731	22.0806			7.9679				30.0485
667147	28.5716							28.5716
672737					26.3431			26.3431
672756	24.2955							24.2955
667146			19.484					19.484
672754	1.5665			17.2632				18.8297
672728					16.6378			16.6378
672726	4.2783			10.6976				14.9759
672755					14.109			14.109
667151				13.5088				13.5088
667159	12.1826			0.9746				13.1572
672722						12.7773		12.7773
672749				12.4475				12.4475
672738	6.6664			5.534				12.2004
667153	7.2655			4.6812				11.9467
667143				8.8116				8.8116
672733					8.03			8.03
672724			6.9058	0.8477				7.7535
672743	7.62							7.62
667163	3.252			4.0897				7.3417
672742	6.772							6.772

672741					6.3228			6.3228
672752				5.7593				5.7593
667158				5.603				5.603
672734				4.0699				4.0699
696092				3.962				3.962
667154	3.7728							3.7728
672748	3.6518							3.6518
667162	3.5136							3.5136
667148	3.3596							3.3596
667150	3.0913							3.0913
667164					2.6327			2.6327
696091						2.3155		2.3155
672740	2.1931							2.1931
672750	2.0766							2.0766
667149	1.5231							1.5231
667144	1.4244							1.4244
696089				1.1891				1.1891
672736					1.1526			1.1526
672744	1.0156							1.0156
Total	**668.2346**	**248.8075**	**209.1325**	**2829.3568**	**331.6454**	**20.4461**	**37.1282**	**4344.7511**

Table 10 Extension in ha of the plots of the LENs Italia companies divided by Company and Province.

The data just presented is summarized in Table 11 below.

	Province							
	PD	**VE**	**VI**	**RO**	**TV**	**PN**	**UD**	**Total**
no. of plots	298	264	103	32	69	13	12	791
has total UAA	668.2346	248.8075	209.1325	2829.3568	331.6454	20.4461	37.1282	4344.7511

ha	**Province**						
	PD	**VE**	**VI**	**RO**	**TV**	**PN**	**UD**
average	2.24	1.57	7.78	3.03	3.09	10.72	3.22
min	0.0272	0.1559	0.1712	0.1881	0.1249	0.0751	0.0328
max	20.3136	6.5289	16.8117	40.5641	6.3067	110.3847	34.3843
DS +/-	2.57	1.65	4.61	6.37	2.05	15.88	4.47

Table 11 Summary of data relating to the number of plots and the extension in ha relating to LENs Italia companies divided by Province.

In correspondence with the plots where the permanent biodiversity measures are located (hedges, woods, and groves) and in the neighboring areas of incidence, the GIS survey was carried out using its own proprietary evaluation method of the Linear, Punctual, and Areal

Elements, useful for the evaluation of the Biodiversity Assessment. In particular, Table 12 shows the number of elements identified.

Elements	**Province**					
	PD	**RO**	**TV**	**VE**	**VI**	**Total**
linear	216	2	3	148	65	434
punctual	77			59	11	147
areas	22			10	6	38
Total	**315**	**2**	**3**	**217**	**82**	**619**

Table 12. Number of Linear, Point and Area elements detected.

Applying the GIS analysis according to the scoring and buffer evaluation parameters of the Linear, Point and Area elements, it was possible to generate a greater number of elements and, through interpolation of geospatial analysis, create new buffer layers (Table 13). The new geo-referenced surfaces generated, deriving from the buffer interaction overlap of all the linear, point and area surfaces analyzed, show unique values such as the surface extension and the score deriving from the sum of the individual original starting elements. The choice to operate as a simple summation of the initial scores instead of through multifactorial or exponential interpolations (the values deriving from the ecological relationships between the elements are actually multifactorial) is derived from the application of a rigid methodological precautionary criterion.

number of areas per element		**point**	**areal**	**point areas**	**linear**	**linear point**	**linear areal**	**linear areal point**	**Total**
overlap	NO	542	19	139	234	960	108	411	2413
	YES	**593**	**42**	**137**	**176**	**1095**	**128**	**455**	**2626**
Total		**1135**	**61**	**276**	**410**	**2055**	**236**	**866**	**5039**

Table 13 Number of elements generated by the buffer interpolation analysis. "YES" and "NO" indicate the overlap of the incidence elements with the areas of the LENs companies

Table 13 shows the number of buffer elements generated, divided into areas that coincide with the surfaces of the LENs Italia plots and areas that do not overlap with them. The same values can be expressed as incidence on the surface (ha) (Table 14) and in score (points) (Table 15).

ha		points	areas	area points	linear	linear point	linear areal	linear areal point	Total
sum	NO	3900.9066	968.2212	404.9666	84.2589	125.1652	17.1125	40.0026	**5540.6335**
	YES	577.9308	70.6498	64.0271	17.4373	54.4224	14.6182	22.7879	**821.8736**
	Total	**4478.8374**	**1038.8710**	**468.9936**	**101.6962**	**179.5876**	**31.7308**	**62.7905**	**6362.5072**
average	NO	7.20	50.96	2.91	0.36	0.13	0.16	0.10	
	YES	0.97	1.68	0.47	0.10	0.05	0.11	0.05	
	global	**3.95**	**17.03**	**1.70**	**0.25**	**0.09**	**0.13**	**0.07**	
max	NO	540.24	523.14	72.75	18.12	14.57	6.38	4.42	
	YES	26.76	15.85	6.57	2.11	1.85	1.78	0.94	
	global	**540.24**	**523.14**	**72.75**	**18.12**	**14.57**	**6.38**	**4.42**	
DS +/-	NO	37.06	125.47	9.09	1.46	0.68	0.64	0.29	
	YES	2.98	2.71	0.92	0.24	0.16	0.21	0.10	
	global	**25.88**	**72.51**	**6.58**	**1.12**	**0.48**	**0.46**	**0.21**	

Table 14 incidence in terms of surface area of the elements generated by the buffer interpolation analysis. "YES" and "NO" indicate the overlap of the areas of incidence with the areas of the LENs

points		points	areas	area points	linear	linear point	linear areal	linear areal point	Total
sum	NO	9844	95	2956	4433	30937	2407	15439	**66111**
	YES	9856	353	3024	3050	34739	2664	16968	**70654**
	Total	**19700**	**448**	**5980**	**7483**	**65676**	**5071**	**32407**	**136765**
average	NO	18.16	5.00	21.27	18.94	32.23	22.29	37.56	
	YES	16.62	8.40	22.07	17.33	31.73	20.81	37.29	
	global	**17.36**	**7.34**	**21.67**	**18.25**	**31.96**	**21.49**	**37.42**	
min	NO	1.00	1.00	2.00	2.00	3.00	4.00	6.00	
	YES	1.00	1.00	2.00	2.00	3.00	4.00	6.00	
	global	**1.00**	**1.00**	**2.00**	**2.00**	**3.00**	**4.00**	**6.00**	
max	NO	65.00	18.00	66.00	56.00	92.00	65.00	112.00	
	YES	65.00	18.00	66.00	53.00	92.00	65.00	112.00	
	global	**65.00**	**18.00**	**66.00**	**56.00**	**92.00**	**65.00**	**112.00**	
DS +/-	NO	15.00	4.18	12.44	10.16	18.12	11.62	19.74	
	YES	16.64	5.96	11.97	9.38	18.67	10.54	19.81	
	global	**15.89**	**5.66**	**12.20**	**9.85**	**18.41**	**11.05**	**19.76**	

Table 15 incidence in terms of score of the elements generated by the buffer interpolation analysis. "YES" and "NO" indicate the overlap of the areas of incidence with the areas of the LENs companies

CONCLUSIONS

The work presented in this report summarizes the environmental monitoring data carried out in typical contexts of the agrosystems of the Italian regions of Veneto and Friuli Venezia Giulia. In these areas, agriculture has developed since the 1980s-2000s in an increasingly highly fragmented landscape context, with plots of land that are proportionally much smaller than the typical situation in central Europe or Hungary in particular. This Italian agricultural fragmentation is combined in these places with the (interpenetrating) presence of widespread urban conglomerates, at various levels, in which there is no real single inhabited center, but rather, globally, a widespread diffusion of homes or small nuclei and areas anthropized in various ways (residential areas, industrial areas, commercial areas, transport infrastructures, etc.). In this context, for the purposes of biodiversity conservation, rather than the individual relative dimensions, the frequent presence of natural and/or agricultural elements and the continuity of these, with the possibility of creating permanent and functional ecological corridors, is important overall. Ditches, canals, rivers, drains, wooded areas, hedges, embankments, dirt areas, *set aside* areas, green manure, as well as agricultural areas with low management input, provide areas of resilience at various levels, contributing to the maintenance of the ecosystem functions of a territory.

That said, in relation to the Assessment of the biological quality of Soil, Water and Air carried out through the survey and evaluation of the IBS-bf, IBL-bf and IBA-bf Indices, the work carried out and the related data collected have made it possible to identify how, globally, the territories affected by the investment of the permanent biodiversity measures of the LENs Italia 2022-2024 project present at least sufficient conditions for the conservation of Biodiversity. These values lay the foundations for the possible implementation, over time, of the ecosystem functionality of the territories, through the creation and active maintenance of permanent biodiversity measures, such as those related to the planting of hedges and woods. In relation to this, the choice of investment areas of the LENs Italia measures can be identified as correct. These measures can potentially and over time provide a positive contribution to the maintenance and implementation of the biodiversity of the individual territories investigated.

As regards the Survey of potential and real biodiversity, the buffers deriving from the application of the evaluation method applied to the Linear, Point, and Area elements detected represent the area of ecological influence of each element. They allow for the generation of overlapping layers useful for landscape and context analysis, allowing the creation of context maps useful for defining a true **Assessment of real and potential biodiversity**.

Buffers allow for the identification of areas of High ecological influence (overlapping buffers), Ecological connection between distant habitats, and Critical areas lacking functional elements. Once all the buffers have been generated, a series of thematic layers can be created based on the objectives. These include, for example, a layer of real elements, a layer of potential buffers, a layer of overlapping between buffers, and a layer of aggregate scores.

These layers can allow the construction of a **multifunctional landscape map**, useful for identifying biodiversity hotspots, planning renaturalization interventions, or assessing the overall ecological quality of the agricultural territory. In the case of the LENs Italia project, the final result of the WBA activity is the creation of a map of overlapping layers between buffers and aggregate scores, which identifies the initial degree (*baseline*) of the **real and potential biodiversity assessment**.

In conclusion, it is therefore possible to affirm that the information deriving from the two types of territorial analysis applied, namely the survey of the IBS-bf, IBL-bf, and IBA-bf Biodiversity Indices and the Assessment of real and potential biodiversity, can create a reference database for multiple analyses, measurable with real and potential scales and implementable over time. In fact, if the analyses were repeated over time at suitable intervals (every 3-5 years), this type of survey could allow an inferential assessment of the direct effects on biodiversity conservation. This assessment could be expressed as a *Delta Value* between the initial conditions at time zero, i.e. the data reported in this report, and those directly expressed by a land management system after, for example, 5 years. At the same time, this database could allow a first assessment of the indirect effects, for example through the development of impact models at various levels, placing existing thematic maps as a comparison and implementation layer, such as those relating to land use (CORINE), or the degree of urbanization or protected areas (SIC, ZPS, Natura200 Areas). In the specific case of the LENs Italia project, the data obtained could allow farmers a direct assessment of their agrosystem or part of it, helping them to define strategic management choices for the conservation or implementation of the biodiversity of the territories, and at the same time help investors to define an assessment of the degree of goodness of the investments disbursed, in relation to the potential expected benefits (*ante operam*, forecast assessment) and measured (*post operam* assessment, over time).

In addition, the information deriving from the synergistic analysis of the relevant activities of the IBS-bf, IBL-bf and IBA-bf Biodiversity Indices and the Assessment of real and potential biodiversity can be used at various levels also as sensitive data within the requirements of various certification standards, including for example the Biodiversity Measurement requirements in the Global Gap biodiversity standard, or as an affirmation of concrete evaluation, measurement and commitment activities to achieve corporate objectives in the voluntary certification area and in the dedicated sections in multiple corporate Sustainability Report formats, as well as providing useful information and data in voluntary quantification systems of Biodiversity and impacts.

Precisely in this perspective, to try to offer a first concrete return to all the subjects involved in the LENs Italia 2022-2024 Project, as well as a suggestion for continuous improvement that can concretely contribute to the positive strengthening of the activity financed with the LENS Italia project, it is suggested to evaluate the possibility of returning, to all 25 companies involved in the evaluation process present in this paper, the related data deriving from the analysis.