

1 **Connectivity, landscape structure, and plant diversity across agricultural landscapes: novel**
2 **insight into effective ecological network planning**

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11 **ABSTRACT**

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2 12 Natural habitats in rural and urban areas are increasingly fragmented and altered by human impacts
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5 13 that are limiting the animal and plant dispersal process. Fragmentation and isolation can be reversed
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7 14 by restoring landscape connectivity through effective Ecological Network (EN) planning. However,
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10 15 most of the studies analyzing the influence of connectivity and landscape structure on biodiversity
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12 16 are focused on animals, while the understanding of their interplaying role on plant diversity remains
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14 17 limited.

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17 18 We studied the relationships between α and β diversity pattern and landscape structure and
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19 19 connectivity in the nodes of an EN developed in agricultural landscapes, as a part of regional
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22 20 landscape planning framework in Friuli Venezia Giulia region (North-East of Italy). As an innovation,
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24 21 the study aims at parsing the interacting effect of landscape structure, surrounding habitats and nodes,
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26
27 22 and structural connectivity on EN plant diversity at two specific scales of investigation i.e., the habitat
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29 23 and the node scale. The habitat was the basic ecological unit, while the node was the basic
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31
32 24 cartographical unit for the EN mapping (multi-habitat or mono-habitat nodes).

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34 25 A total of 443 plant species were collected across 219 sample plots, in 14 different habitats and 87
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36 26 nodes of the EN. We found that high node connectivity leads to higher species richness (α -diversity)
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39 27 but also increases plant community similarity (i.e., low β -diversity) at both scales. The effect of
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41 28 landscape structure showed differing trends depending on the habitat. In general, landscape
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44 29 composition of semi-natural land cover (i.e., hedgerows, watercourses) showed a positive effect on
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46 30 species diversity as opposed to that of the configuration of anthropogenic elements on both scales.

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49 31 Our results provided crucial information on the landscape processes useful to improving biodiversity
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51 32 conservation by EN. Our findings suggest that i) improving connectivity within ENs favors α plant
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53 33 diversity ii) different habitats have different sensibility to landscape structure iii) semi-natural land
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56 34 cover around nodes improve plant diversity; iv) planning both mono-habitat and multi-habitats nodes,
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58 35 increases the biodiversity conserved therein; v) nodes with more compact shapes are to be preferred.

36 **Research highlights:** 1) The understanding of the influence of connectivity and landscape structure
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2 37 on plant diversity is limited; 2) Both α and β diversity were considered as response variables; 3) The
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4 38 effects of connectivity and landscape structure on plant diversity were investigated at two scales; 4)
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7 39 Improved connectivity leads to greater species richness but also increases community similarity; 5)
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9 40 Our results provided crucial information useful to improving biodiversity conservation by EN.

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11
12 41 **Keywords:** Landscape composition, Connectivity metrics, Landscape planning; Multi-scale analysis;
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14 42 Multiple regressions; Species richness

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17 43 **Abbreviation:** AREAMN mean area (class natural land use); CCe Closeness centrality; Dg node
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19 44 degree; DsqrtA maximum distance to square root of area ratio; Ec eccentricity; ED edge density (class
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22 45 agricultural land use); EN ecological network; F flux; GLM Generalized Linear Models; GLMM
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24 46 Generalized Linear Mixed Models; GYRATEMN mean radius of gyration (class natural land use);
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26 47 HRA hedgerow area; IF interaction flux; LCBD Local Contributors of Beta Diversity; NOH number
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29 48 of habitats; NOLU number of land uses; TE total edge (class natural land use); WA watercourse area
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49 1. INTRODUCTION

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2 50 Biodiversity loss is one of the major concerns of our time, caused by many factors such as land use
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5 51 change, habitat fragmentation, pollution, natural resource exploitation, climate change, and biological
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7 52 invasion (Landi et al. 2018; IPBES 2019; EEA 2020). Among them, land use change is considered
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10 53 the major cause of natural habitat fragmentation and alteration due to the sprawl of rural and urban
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12 54 areas (Foltête et al. 2014). In these landscapes, natural patches and/or protected areas are often
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14 55 surrounded by an anthropogenic matrix that limits animal and plant dispersal process, increasing their
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17 56 functional isolation (Nowicki et al. 2014; Mossman et al. 2015). Fragmentation and isolation of
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19 57 natural habitats can be reversed by restoring landscape connectivity through an effective Ecological
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22 58 Network (EN) planning by implementing nodes, corridors, and steppingstones (Mossman et al. 2015).
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24 59 Connectivity is a key concept in landscape management as it encompasses all aspects affecting the
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27 60 displacement of an individual among resource or habitat patches within landscapes (Baguette and
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29 61 Van Dyck 2007). In this respect, many analytical tools were developed in recent decades such as
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32 62 indices of landscape pattern, least-cost modeling, circuit theory, and graph-theoretic methods, aiming
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34 63 at design connectivity models (Foltête 2019). Among them, landscape graph modelling is a promising
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37 64 approach applied in different scenarios (Galpern et al. 2011; Foltete et al. 2020; Sahraoui et al. 2021).
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39 65 ENs are increasingly accepted as proactive tools for preserving biodiversity by improving landscape
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42 66 connectivity (Gilbert-Norton et al. 2010; Damschen 2013; Modica et al. 2021). ENs represent also an
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44 67 effective approach integrating environmental management strategies and landscape planning and can
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47 68 be understood by different actors (De Montis et al. 2016; Keeley et al. 2018; Sahraoui et al. 2021).
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49 69 The practical implementation of EN planning depends on opportunities, the interest of landowner and
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52 70 other stakeholders, and costs (Bergsten and Zetterberg 2013; Mossman et al. 2015). Therefore, it is
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55 71 crucially important to provide practitioners with practical, field-tested advice for planning effective
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58 72 ENs to support biodiversity. On the other hand, landscape connectivity and conservation plans often
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61 73 rely solely on environmental and land cover data (Brooks et al. 2004): however, such a broad
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64 74 approach based on these heterogeneity surrogates, hardly can be used to conserve the real biodiversity
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75 content of a large area (Araujo et al. 2001; Schindler et al. 2013), and also raises criticism for the lack
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2 76 of validation and monitoring plans in addition to ignoring the community structure (Gippolitti and
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5 77 Battisti 2017; Luo et al. 2021).
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7 78 EN models are typically based on nodes, such as a single or groups of habitat patches, identified to
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10 79 support the viability of many species, with different movement and dispersal capabilities, and hence
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12 80 expressing different connectivity requirements (Minor and Lookingbill 2010; Brodie et al. 2015).
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15 81 However, many of the studies analyzing the influence of landscape connectivity on biodiversity were
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17 82 studied for animal species, while the understanding of the role of EN connectivity on plants remains
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19 83 limited, especially at the community level (but see Uroy et al. 2019; McLeish et al. 2021). Plant
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22 84 communities are a primary component for habitat identification that has been adopted also in modern
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24 85 European habitat classifications (Devillers et al. 1991; Devillers and Devillers-Terschuren 1996;
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27 86 Davies et al. 2004; European Commission 2013; Maccherini et al. 2020). Plants support the life of
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29 87 most of the other ecosystem organisms, and they also regulate nutrient cycling and soil protection
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32 88 (Lieth 1973) and represent a large portion of biodiversity at landscape level. Landscape connectivity
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34 89 for plants is mainly linked to their ability to disperse between habitat patches via propagules. Their
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36 90 dispersal is only successful if habitat patches are sufficiently connected (Fahrig and Merriam 1985;
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39 91 Bowne and Bowers 2004) or if it is facilitated by suitable landscape features (Taylor et al. 1993).
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41 92 Moreover, the ability of plants to disperse in fragmented landscapes also depends on their dispersal
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44 93 strategy, only specialized species can profit by long-distance dispersal events (Vittoz and Engler
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46 94 2007; Boscutti et al. 2018).
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49 95 Landscape structure and connectivity often interplay generating complex interacting effects on biota
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51 96 (Uroy et al. 2019) that are poorly investigated especially in EN context. The effects of landscape
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54 97 structure (i.e., composition and configuration) on plant communities are still debated (Zambrano et
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56 98 al. 2019; Fahrig 2020; Boscutti et al. 2022) as are those regarding connectivity (Uroy et al. 2019;
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58 99 McLeish et al. 2021), and for this reason our understanding and ability to analyze the interaction
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61 100 between them on plant communities has yet to be improved.
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101 This research integrates the study of both α and β plant diversity as a function of landscape structure
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2102 and connectivity in an EN. As an innovation, it aims at parsing the interacting effect of landscape
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4103 structure, surrounding habitats and nodes, and structural connectivity on EN plant diversity at two
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7104 specific scales of investigation i.e., the habitat and the node scale. The habitat was the basic ecological
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9105 unit for determining the species-specific ecological network, while the node was the basic structural
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11106 unit for the EN mapping (multi-habitat or mono-habitat nodes) obtained from the overlap of all
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14107 species-specific ecological networks (see **Appendix A**).

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17108 We hypothesized that plant diversity (i.e., α and β) is related to landscape structure (i.e., composition
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19109 and configuration) and EN connectivity, and their effect depends on habitat type and node
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21110 complexity. The hypothesis was tested by exploring the plant diversity in the nodes of an EN
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24111 developed as part of regional landscape planning framework in Friuli Venezia Giulia region (North-
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26112 East of Italy). Our aim was to explore how landscape structure and EN connectivity characteristics
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29113 influence the plant diversity of both habitats and EN nodes.

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114 **2. METHODS**

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2 115 *2.1. Study site*

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This study was carried out in a local EN in the lowlands of the Friuli Venezia Giulia region (NE Italy; centroid coordinates: 45°48'13.4"N - 13°08'11.0"E; Fig. 1). The study area has an extent of 298 km² including a large agricultural area embedded in two river systems (Stella and Corno, respectively). The landscape is characterized by a mixed mosaic of intensively and extensively cultivated areas, settlements, semi-natural and natural habitats. It includes eight Natura 2000 Special Area of Conservation (Habitats Directive 92/43/EEC) and nine regional protected sites (biotopes), mainly connecting remnants of wetland habitats and lowland forests. The soils of the area consist mainly of Quaternary sand, silt and silt-clay sediments formed by glacial fluvial transport during the Pleistocene and by alluvial deposition during the Holocene. The area is characterized by an average annual temperature of about 13°C and an average annual precipitation between 1100 and 1400 mm.

2.1.1. Ecological network model

The studied EN was designed using a habitat-species based model (considering flora and fauna) developed at the local scale (Fig.1, see also **Appendix A**) in the context of the regional landscape planning process (Sigura et al. 2017). The model was based on least-cost path analysis, applied to species cost maps derived by expert assessment, and graph theory, which were used to obtain species-specific ENs that were later merged into the final composite multi-species network. The nodes (target habitats), corridors and steppingstones (links between target habitats) were obtained for a set of 19 target species (10 animal species and 9 plant communities, assumed to be crucial for several plant species of conservation concern) to proxy favorable conditions for overall network biodiversity (see **Appendix A**). Specifically, the EN was originally modeled using the regional habitat map based on the habitat classification European Nature Information System (EUNIS, Davies et al. 2004) and crossing costs for species were attributed by expert assessment and literature review data.

140 The entire EN is composed of 108 nodes and 17 different habitats (14 terrestrial, including forests,
1 shrubs, meadows, and fens and 3 aquatic, including water bodies and streams; see **Appendix B** for
241 terrestrial habitats description), corresponding to a total extent of 5900 ha, of which 1700 ha represent
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442 nodes and 4200 ha ecological corridors. Nodes vary greatly in extent, ranging from less than 1 ha up
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7143 to 432 ha, with an average of 22 ± 59 ha, in shape and habitat composition, as they can consist of a
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10144 single habitat (mono-habitat) or many habitats (multi-habitat, Fig. 1).
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14146 The lack of information on the actual distribution of species in the modelling process makes the
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17147 assessment of biodiversity, within the nodes, extremely important for EN model reliability.
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19148 20 21 22149 *2.2. Sampling design and data collection*

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24150 Plant diversity in all EN nodes composed of terrestrial habitats and bigger than 1 ha were sampled
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27151 (i.e., 87 nodes). The sampling design chosen was hierarchical (e.g., Fig.1): each habitat type was
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29152 sampled within each node proportional to the area occupied within the node (see **Appendix B**).
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32153 Sampling density in relation to habitat extent was chosen as follows: a random square plot of 100 m²
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34154 for a habitat area < 5 ha, 2 plots for an area ≥ 5 and ≤ 10 ha, and finally 3 plots for an area > 10 ha. A
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37155 total of 219 plots were randomly selected within the nodes of the EN, corresponding to an overall
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39156 sampling density of 0.13 plot/ha. Presence and abundance (% visual cover estimate) of vascular plants
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41157 rooted in each plot were recorded. Nomenclature and taxonomy of species followed Bartolucci et al.
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44158 (2018) for native species and Galasso et al. (2018) for alien species. Data were collected in spring
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47159 and summer 2019 and 2020.

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49160 The 14 habitats present in the EN were divided into 3 groups based on the similarity of their ecological
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51161 characteristics (e.g., attributable by EUNIS habitat classification level) and differences in species
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54162 richness resulting from Liccari et al. (2022): 1. woods, 2. meadows, and 3. fens (see **Appendix B**).
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56163 57 58164 *2.3. Analysis at the habitat scale*

59 60 61165 *2.3.1. Response variables*

166 We used the 219 plots as singular observations regardless of which node that habitat belonged to (this
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267 information was considered as a random effect in the models), and for each we considered α diversity
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568 (i.e., species richness), and β diversity as response variables. The latter was examined by calculating
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769 Local Contributors of Beta Diversity (LCBD, Legendre and De Caceres 2013) in the R package
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10770 “adespatial” (Dray et al. 2021). LCBDs represent comparative indicators specifying the degree
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1271 by which each sampling unit contributes to β diversity compared to a site with an average species
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1572 composition, thus assessing ecological uniqueness in terms of species composition for each sampling
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1773 unit. LCBDs were obtained as sums of rows derived after centering and squaring each column of the
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2074 composition matrix.

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2275 The relationships between α and β diversity values at the habitat scale were assessed by a Linear
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2476 Model to identify their respective trends.

25 26 2777 28 2978 *2.3.2. Explanatory variables: landscape structure and connectivity metrics*

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3279 Landscape composition and configuration around each plot was assessed using a selection of the most
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3480 used landscape metrics (see **Appendix C**) calculated on a circular buffer centered in the plot and with
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3781 a radius of 250 m (Fig. 2), which has been already proven to be a sensitive scale when analyzing plant
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3982 diversity in similar landscapes (Kumar et al. 2006; Boscutti et al. 2018). All landscape metrics were
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4283 calculated using the R package “landscapemetrics” (Hesselbarth et al. 2019). Connectivity
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4484 within the modeled EN was assessed by 7 connectivity metrics (see **Appendix C**) using Graphab
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4785 software (Foltete et al. 2012a). These metrics were integrated into the final dataset by linking the
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4986 value of the metric for a node to all the plots collected within that node. To reduce multicollinearity
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5187 in the set of landscape and connectivity metrics, correlation analysis was performed in R (R Core
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5488 Team 2021, see **Appendix C**) estimating coefficients using non-parametric Spearman’s ρ . A total of
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5689 29 variables were selected as not highly correlated ($< |\pm 0.7|$) (see **Appendix D**) and used in the full
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5990 models.

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192 2.3.3. *Model selection*

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193 Prior to model simplification, all quantitative variables were standardized (zero mean, unit variance)
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194 to obtain comparable coefficient values. Model selection was performed with a Multi-Model
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195 Inference (MMI) approach (Burnham and Anderson, 2002), using the function “dredge” within the
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196 “MuMIn” R package (Barton 2020), was run for both α and β diversity models. The full models
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197 included all the uncorrelated variables and their interaction with habitat type. We considered the
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198 variables resulting from all models with $\Delta AIC < 2$. Finally, the Minimum Adequate Model
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199 (MAM) was obtained simplifying the resulting models by removing one-by-one the non-significant
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200 interaction terms or variables ($p > 0.1$) using a manual backward selection procedure. The overall
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201 final variables resulting in the two MAMs are reported in Table 1.

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202 The models were designed as follows: the effects of landscape structure and connectivity of the EN
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203 on α and β diversity were examined using two different Generalized Linear Mixed Models (GLMMs;
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204 Bolker et al. 2009) using a Penalized Quasi-likelihood (PQL) method by means of the “MASS” R
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205 package (Venables and Ripley 2002). The random effect in both models was the node to which the
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206 sampling unit belonged to. A quasi-Poisson distribution was used to model the error structure in the
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207 α diversity model, and a Gamma distribution in the β diversity model. The R^2 measure proposed and
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208 described in Nakagawa and Schielzeth (2013), Johnson (2014), and Nakagawa et al. (2017) for
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209 GLMMs was used.

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211 2.4. *Analysis at the node scale*

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212 2.4.1. *Response variables*

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213 The 219 plots used to survey the biodiversity of habitats were pooled by node obtaining 87
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214 observations and then considering α diversity (i.e., species richness of the nodes), and β diversity (i.e.,
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215 LCBD of the nodes) as response variables. Their relationship was then assessed by a Linear Model
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216 to identify the respective trend and compare it to that at the habitat scale.

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218 *2.4.2. Explanatory variables: landscape structure and connectivity metrics*

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219 In contrast to the habitat scale where all areas around the sampled points have the same extent, the
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220 nodes have very different shapes and sizes, so we considered other variables for the landscape
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221 structure: i.e., node shape, number of habitats forming the node and type of land covers (natural and
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222 anthropogenic) surrounding the node. Various shapes indices were calculated with QGIS (QGIS
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1223 Development Team 2021) using the EN nodes as the main spatial unit (see **Appendix C**).
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224 Eighteen landscape metrics were calculated on a buffer area of 250 m around each node (Fig. 2) and
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1225 are reported in **Appendix D**. Connectivity within the EN was assessed using the same 7 metrics
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226 described above. To exclude multicollinear variables, correlation analysis was performed with the
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227 same specification as described above (see **Appendix C**). A total of 18 variables were found to be
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228 uncorrelated (see **Appendix D**) and used in the full models.

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230 *2.4.3. Model selection*

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231 The modeling procedure was the same as explained in the section on the habitat scale. The overall
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232 final variables resulting in the two MAMs are reported in Table 2.
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233 The models were designed as follows: the effects of landscape structure and connectivity of the EN
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234 on total α and β diversity were examined using two different Generalized Linear Models (GLM). In
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235 the α diversity model a quasi-Poisson distribution was used to model the error structure while in the
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236 β diversity model a Gamma distribution was used.

237 3. RESULTS

238 3.1. α and β diversity pattern and relationship in the EN

239 A total of 443 plant species were recorded during the sampling activity, of which 47 were alien and
240 24 were classified as protected, rare, or endemic species according to the European, Italian, or
241 regional Red Lists (see **Appendix E**). The most frequent native species were *Rubus caesius* (present
242 in 57.5% of the plots), *Cornus sanguinea* (54.3%), *Rubus ulmifolius* (53.9%), *Quercus robur* (53.4%),
243 *Hedera helix* (51.1%), and *Salix alba* (45.2%). Among alien species, the most common were *Platanus*
244 *hispanica* (27.9%), *Robinia pseudoacacia* (15.1%) and *Potentilla indica* (14.6%). Finally, the most
245 frequent protected or endemic species were *Ruscus aculeatus* (Habitat Directive 92/43/CEE Annex
246 V, 8.7%), *Centaurea jacea* subsp. *forojulensis* (endemic, 5.0%), and *Gladiolus palustris* (Habitat
247 Directive 92/43/CEE Annex II, 4.6%).

248 The mean number of species per plot was 24.4 ± 7.7 , per habitat was 14.9 ± 5.3 in fens, 23.3 ± 5.8 in
249 woods, and 31.3 ± 8.8 in meadows, and finally per node it was 39.4 ± 29.6 . Concerning β diversity,
250 the mean LCBD value ($\times 10^{-3}$) per plot was 4.6 ± 0.9 , per habitat was 5.6 ± 0.4 in fens, 4.1 ± 0.6 in
251 woods, and 5.8 ± 0.4 in meadows, and finally per node it was 11.5 ± 3.0 .

252 The relationships between α and β diversity values at the habitat and node scales showed significant
253 contrasting relationships ($p < 0.05$; Fig. 3). At the habitat scale, α diversity increased at high values
254 of β diversity, whereas it was negatively related at the node scale

256 3.2. α and β diversity vs connectivity and landscape structure of the EN

257 3.2.1. Habitat scale

258 GLMMs showed that the habitat α and β diversity had consistent responses to both connectivity and
259 landscape structure (Table 3). In particular, the MAM on α diversity ($R^2 = 0.57$, $p = <0.001$, Fig. 4,
260 Table 3) included the following predictive variables: Closeness centrality (CCe), Eccentricity (Ec),
261 Flux (F), and Total Edge (TE) all with a significant interaction term with habitats except for Ec. The
262 α diversity model showed a positive relationship with Ec, F in fens and meadows, CCe in fens, and

263 TE in fens; in contrast it was negatively related to CCE in woods and meadows, and TE in meadows.
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264 No relationship was observed between species richness and F and TE in woods.
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265 On the other side, the MAM developed to explain variation in β diversity ($R^2 = 0.76$, $p = <0.001$, Fig.
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266 5, Table 3) retained the following predictors: Flux (F), Interaction flux (IF), Node degree (Dg), Edge
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267 density of agricultural land use (ED), Mean area of natural land use (AREAMN), Mean radius of
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268 gyration of natural land use (GYRATEMN), and habitat without interaction, as no interaction
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269 between habitat and considered variables emerged. Overall, it was observed a positive relationship
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270 with IF, AREAMN, and a negative relationship with F, Dg, ED, GYRATEMN.

271 3.2.2. Node scale

272 The MAM for α diversity ($R^2 = 0.86$, $p = <0.001$, Fig. 6, Table 4) included the following predictive
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273 variables: Closeness centrality (CCE), Eccentricity (Ec), Interaction flux (IF), Node degree (Dg),
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274 Maximum distance to square root of area ratio (DsqrA), log transformed Hedgerow area (HRA),
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275 Number of habitats (NOH), and Watercourse area (WA). α diversity increased at the increase of Ec,
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276 Dg, HRA, NOH, and WA, but decreased in nodes with high CCE, IF, and DsqrA.

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277 The β diversity MAM at node scale ($R^2 = 0.57$, $p < 0.001$, Fig. 7, Table 4) retained the following
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278 predictive variables: Flux (F), Node degree (Dg), Maximum distance to square root of area ratio
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279 (DsqrA), Hedgerow area (HRA), Number of habitats (NOH), Number of land uses (NOLU), and
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280 Watercourse area (WA). It estimates a positive relationship with HRA and WA and a negative
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281 relationship with F, Dg, DsqrA, NOH and NOLU.

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282 4. DISCUSSION

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283 The present work integrates the study of both α and β plant diversity as a function of landscape
3 structure and connectivity at two different scales of analysis (habitat and node) in an EN.

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285 Landscape structure and connectivity play different roles on plant species depending on whether one

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286 considers species richness or community dissimilarity (Damschen et al.2006; Billeter et al. 2008;

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1287 Concepcion et al. 2012; Thiele et al. 2018; Chisté et al. 2018; Uroy et al. 2019). Our findings showed

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288 contrasting trends when considering different scale of investigation (i.e., habitat or node). Based on

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1289 the models (Tables 3,4), connectivity had a more pronounced effect on α diversity while landscape

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1290 structure on β diversity at both scales. In general, we found that improved connectivity leads to greater

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2291 species richness but also to homogenization of communities. The landscape composition of semi-

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2292 natural land covers (i.e., hedgerows, watercourses) showed a positive effect on species diversity as

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2293 opposed to that of the configuration of anthropogenic elements.

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31 295 *4.1. Plant diversity: α and β contribution and relationships in the EN*

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3296 The number of species (443) found within the EN was about 68.1% of the overall species richness of

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3297 the study area (ca 650 taxa, Poldini 1991). When considering the percentage of the EN nodes extent

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3298 on the overall study area (5.7%), the EN contribution in terms of total biodiversity is remarkable,

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4299 confirming the high conservation potential of the areas that constitute ENs (e.g., Pryke et al. 2015;

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43 300 Xun et al. 2017).

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4301 The relationship between α and β diversity showed contrasting trends (Fig. 3), highlighting a species

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4302 composition homogenization as the species richness increases at the node scale (pools of habitat)

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5303 while promoting β diversity in single habitat patches with high floristic richness. The scale

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5304 dependence of biodiversity patterns is a well-known issue in ecology, where the effects of abiotic and

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5305 biotic processes can only be detected at an appropriate investigation scale and can be masked by using

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5306 large sample units that aggregate environmental heterogeneity (Huston 1999). In our study, the

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6307 differences between communities belonging to different habitats were well detectable at the finest

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308 scale (habitat): habitat showing a high α diversity exhibited also a greater community heterogeneity
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309 (e.g., meadows). At the node scale, habitat pools into nodes resulted in richer communities in multi-
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310 habitat nodes but with low species variation compared to mono-habitat nodes that contributed more,
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311 in term of uniqueness, to the total EN plant diversity. What has been observed in the mono-habitat
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312 nodes could also be related to the presence of rare and/or specialist plant species that contribute to
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1313 the uniqueness of those patches as recently found by Deák et al. (2020) in fragmented dry grassland.
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1315 *4.2. α and β diversity vs connectivity and landscape structure*

1316 *4.2.1. Habitat scale*

1317 Connectivity had different effects depending on the habitat: α diversity in meadows and woods (Fig.
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2418 4) was higher when the belonging nodes were closer to each other (low C_{Ce}), but a higher structural
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319 probability of dispersion (high F) showed no effect on woods, suggesting that landscape connectivity
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2920 might be linked to the species dispersion ability between communities (Fahrig and Merriam 1985;
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321 Bowne and Bowers 2004; Vittoz and Engler 2007; Boscutti et al. 2018).

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3422 Ec also showed a positive effect on α diversity, leading to the conclusion that habitats, belonging to
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3723 the nodes of the EN, that were peripheral, most of the times were also well-connected. We expected
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3924 that the most peripheral nodes were less rich because of the position in the graph, instead we have
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4225 observed that the parameter affecting more species richness was the degree of connection. This
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4526 suggests that the location of the nodes within the network is not as important as the degree of
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4827 connectivity between them and confirm the importance of connections between patches for higher
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328 plant richness (Damschen et al. 2006; Uroy et al. 2019).

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5129 Total β diversity showed opposite trends in response to landscape connectivity (Fig. 5) where habitats
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5430 within nodes with more connections (high F and D_g) had lower community dissimilarity, as already
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5631 pointed out by other studies (see Uroy et al. 2019). In contrast, it has been observed in other research
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5932 (e.g., Mouquet and Loreau 2003; Tschardt et al. 2012), that when connectivity decreases,
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6133 landscapes may become highly heterogeneous, causing strong divergence in the composition of local
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334 communities due to reduced dispersal ability. Thus, rewarding species that have the ability to disperse
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335 over long distances and in anthropogenic landscapes (Boscutti et al. 2018).
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336 Our results showed clear effects of landscape structure on α and β diversity in different habitats
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337 composing the EN nodes, although drivers of diversity are often difficult to identify at the fine scale
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338 and are more readable at a broader scale (Amici et al. 2015).
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1339 The effect of landscape configuration, related to the amount of margin (TE) between habitats and
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340 anthropogenic land use, on α diversity was shaped by habitat type response (Fig. 4). Meadows showed
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1341 to be more sensitive to the agricultural matrix displaying a lower species richness as TE increased,
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342 and this could be due to a reduction in specialist species that are more sensitive to landscape
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2343 composition than generalists, as found for example by Miller et al. (2015) for glades, where specialists
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344 were observed to be generally poor dispersers and more sensitive to anthropogenic disturbance.
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345 Woods appeared to be unaffected by landscape configuration, related to the amount of margin (TE),
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2346 while in fens an increasing in TE resulted in higher species richness (Fig. 4). This may be explained
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347 by ecological conditions of the habitat, characterized by water submersion and low nutrient
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348 availability. As a result, fens plant communities have low species richness in undisturbed landscapes
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349 while at the increase of landscape disturbance species richness tends to increase due to the ingression
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350 of generalist species (Mälson et al. 2008; Øien et al.2018).
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41
351 Concerning β diversity, the effect of landscape structure was consistent in all habitats (not significant
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352 interaction) and showed that the contribution of sampling units to β diversity was the highest when
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353 natural patches were larger (high AREAMN), more compact (low GYRATEMN), and had a smaller
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354 shared boundary with agricultural land use (low ED, Fig. 5). What was observed could be related to
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355 the amount of core area within the patches that is known to play a role in determining diversity: e.g.,
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356 Hill et al. (2003) found that large forest patches contain the greatest local diversity as well as the
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357 greatest number of rare and shade-tolerant tree species, those species that certainly contribute more
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358 to the uniqueness of sampling units' composition.
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360 4.2.2. Node scale

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361 The nodes of the EN represent the hubs of biodiversity and are the basis for effective planning.

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362 Therefore, information on possible drivers that may influence the characteristics of communities

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363 within the nodes is critical. What emerged from the connectivity analysis is consistent with what was

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364 observed at the habitat scale and confirms that α diversity of nodes (Fig. 6) was higher when the nodes

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1365 were closer to each other (low CCE) and with more connections (high Dg) and with β diversity values

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1566 suggesting a homogenization of communities as connectivity increased (Fig. 7). These trends were

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1367 expected based on other studies (e.g., Damschen et al. 2006; Brudvig et al. 2009; Thiele et al. 2018).

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368 Even at the node scale, it can be seen that a decrease in connectivity leads to a decrease in the number

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2269 of species in the nodes: a decrease in connectivity can in fact decrease species richness acting as a

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2470 strong ecological filter and selecting for species that are able to disperse and survive in isolated

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2771 patches (Uroy et al. 2019). Often those species with higher dispersal ability are generalists (Haddad

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2972 and Tewksbury 2006) leading specialist species to be more affected by connectivity loss (Mouquet

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3273 and Loreau 2003; Tschardt et al. 2012; Miller et al. 2015; Boscutti et al. 2018). This decrease in

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3474 response to the loss of structural connectivity was detected to be even stronger in grassland

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3675 communities (Adriaens et al. 2006; Brückmann et al. 2010; Evju et al. 2015).

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3676 The effects of landscape structure on plant diversity at the node scale provide useful insights to EN

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4277 planning, in particular our results (Fig. 6) pointed out that α diversity is positively related to the

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4478 amount of semi-natural land covers (HRA and WA) confirming their positive effects on species

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4679 diversity in agricultural landscapes (Billetter et al. 2008). Moreover, we verified the importance of

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4980 planning multi-habitat nodes (NOH variable) to increase species richness.

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5181 Considering the shape of the node that most contributes to α diversity, we observed that the greater

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5382 and more regular the expansion along the maximum distance between two vertices (lower DsqrtA)

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5583 the greater the α diversity. This is in contrast to other observations that state that more complex shapes

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5884 have more species (e.g., Moser et al. 2002; Heegaard et al. 2007). However, in the first case the

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6185 authors considered all patches in a landscape without distinguishing between natural and rural land

386 uses; while in the latter they considered habitat patches individually, and unlike their study, in our
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387 case nodes often already contained multiple habitats and thus the dispersal ability of species within
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388 nodes probably contributed more to diversity than the contribution resulting from dispersal from the
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389 outer matrix, which, being predominantly agricultural, can be a source of weeds and/or alien species
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390 (Hulme 2005; Boscutti et al. 2018; Pellegrini et al. 2021).

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1391 What we observed in the β diversity models (Fig. 7) is consistent with what was noticed at the habitat
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1392 scale: node contribution to total β diversity was higher when nodes had more compact shape (low
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1393 DsqrtA), were surrounded by few land uses (low NOLU), and numerous semi-natural elements (high
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1394 HRA and WA). The only exception is that mono habitat nodes promoted higher community
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1395 differentiation (low NOH). The resulting signal of DsqrtA and NOLU confirms that different
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2496 anthropogenic land uses shaping the boundary of natural patches promote homogenization of plant
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1397 communities (Chisté et al. 2018).

31 32 399 *4.3. The lesson we learned*

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3400 In summary, the practical implementation of a connectivity plan depends on opportunities, the interest
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3401 of landowners and other stakeholders, and cost (Bergsten and Zetterberg 2013; Mossman et al. 2015).
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3402 Therefore, it is crucially important to provide practitioners with practical, field-tested advice for
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3403 planning effective ENs to improve the viability of target species.

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3404 On the other hand, landscape connectivity and conservation planning often rely solely on
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3405 environmental and land cover data (Brooks et al. 2004): however, such a broad approach based on
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3406 these heterogeneity surrogates, can hardly be used to conserve the real biodiversity content of a large
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3407 area (Araujo et al. 2001; Schindler et al. 2013).

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3408 EN planning should take into account which are the key drivers of biodiversity in the landscape and
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3409 how they interact, rather than being based on untested assumptions, as also emphasized by Mossman
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3410 et al. (2015). Our methodology used simple models to explore the relationships between plant
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411 diversity, landscape structure, and connectivity to provide guidance on how the EN should be
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212 structured and which elements are drivers of plant diversity.
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413 Overall, our results provided important information about the plant diversity pattern within the EN,
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714 allowing us to highlight where action is needed to optimize the expression and conservation of
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415 biodiversity. To the best of our knowledge, our study is the first to test, by extensively sampling all
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1416 nodes in the EN, the effectiveness of an EN model based on a habitat map and expert assessment of
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417 species movement to design the connectivity model. In addition, our work investigated the effects of
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1418 connectivity and landscape structure on a multi-species connectivity model by considering two scales
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419 of investigation: the habitat scale, considering the single habitat patch, and the node scale considering
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420 all habitat patches forming the single node as a whole.
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24121 Our study contributes to an unresolved issue, about the multiplicity of factors that modulate the effects
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422 of landscape connectivity on plant communities (Uroy et al. 2019), adding a new element to an answer
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2923 that likely cannot be unique.
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424 Some weaknesses of the study might be that the animal component that is an integral part of the multi-
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3425 species EN was not able to be included and that multiple buffers of different sizes on sampling units
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426 and nodes to observe the landscape structure effects at different scales was not able to be used. Thus,
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3927 integrating these deficiencies for future studies aimed at EN design and management is suggested.
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428 It is further suggested the use of these indications to support land-use planning decisions, particularly
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4429 in prioritizing, modifying of existing ENs, and designing new ENs.
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430 **5. CONCLUSIONS**

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3 431 In this study, we analyzed the relationships between plant diversity, landscape structure, and
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5 432 connectivity in an EN. From an applied perspective our methodology helped to fill the gaps regarding
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7 433 the knowledge on key-drivers related with landscape context and network pattern that influence plant
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9 434 diversity. Understanding the effects of surrounding landscape patterns and intrinsic properties of ENs
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11 435 on species diversity at different scales, could help promote effective environmental and conservation
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13 436 strategies and management practices of ENs. From our research, it was possible to highlight the role
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15 437 of connectivity and landscape structure in shaping plant diversity. It takes on different meanings
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17 438 depending on whether we consider species richness (α diversity) or dissimilarity among communities
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19 439 (β diversity). The role of connectivity in promoting greater species richness at both scales was evident
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21 440 and was in contrast to that of increasing similarity among communities. Landscape structure has
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23 441 shown different trends in different habitats and that can have a positive or negative effect depending
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25 442 on whether the patches considered are semi-natural or anthropogenic.

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27 443 Our results provided important information about the behavior of plant communities within the EN,
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29 444 allowing us to highlight where action is needed to optimize the expression and conservation of
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31 445 biodiversity. Based on our results, we can conclude that:

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34 446 i) improving connectivity (e.g., planning habitat patches similar to the target), within ENs favors
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36 447 plant α diversity although it increases similarity of plant communities;
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39 448 ii) different habitats have different requirements and imply different management. Forests were
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41 449 less sensitive to land use intensification (e.g., increase in anthropogenic land use edge) than meadows
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43 450 and fens. Specifically, the latter were observed to be very sensitive and the disturbance favored the
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45 451 entry of generalist species;
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48 452 iii) less land use intensity (ED, TE, NOLU) and more semi-natural areas around nodes (HRA and
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50 453 WA) mitigates the effects of landscape structure, as seen at both scales for α and β diversity models;
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53 454 iv) inclusion of nodes in ENs, both mono-habitat (higher β diversity, i.e., more unique
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55 455 community) and multi-habitats (higher α diversity, i.e., richer community), increases the plant

456 diversity conserved therein as attested to by the plant diversity pattern at the node scale (Fig. 3) and
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457 by the effect on α and β diversity of NOH in the models at the node scale (Fig. 6,7);
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458 v) nodes that maximize compactness (low DsqrtA) are to be preferred, as they were observed
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759 increasing both α and β diversity.
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1
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4
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465 **References**

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729 **Tables**

730 Table 1: Explanatory variables resulting from the MAMs at the habitat scale. For more details on formulas and meaning, see Foltete et al. (2012a) for
 731 connectivity metrics and the “landscapemetrics” package vignette (Hesselbarth et al. 2019) for landscape metrics. Connectivity formula terms:
 732 n_k = number of patches in the component k, N_i = all patches close to the patch i, d_{ij} = least-cost distance between the patches i and j, $e^{-\alpha d_{ij}}$ probability
 733 of movement between the patches i and j, α = brake on movement distance, β = exponent to weight more or less capacity. Landscape metric formula
 734 terms: e_{ik} = total edge length in meters, A = area in square meters, G = radius of gyration of each patch.

Connectivity metric	Formula	Meaning	Reference
Closeness centrality (CCe)	$CCe_i = \frac{1}{n_k - 1} \sum_{j=1, j \neq i}^{n_k} d_{ij}$	Mean distance from the patch i to all other patches of its component k.	Freeman 1978
Eccentricity (Ec)	$Ec_i = \max_j d_{ij}$	Maximum distance from the patch i to another patch of its component k.	Urban and Keitt 2001
Flux (F)	$F_i = \sum_{j=1, j \neq i}^n \alpha_j^\beta e^{-\alpha d_{ij}}$	For the focal patch i: sum of capacity of patches other than i and weighted according to their minimum distance to the focal patch through the graph. This sum is an indicator of the potential dispersion from the patch i or, conversely to the patch i.	Urban and Keitt 2001; Saura and Torné 2009; Foltete et al. 2012b
Interaction flux (IF)	$IF_i = \sum_{j=1}^n \alpha_i^\beta \alpha_j^\beta e^{-\alpha d_{ij}}$	Sum of products of the focal patch capacity with all the other patches, weighted by their interaction probability.	Foltete et al. 2014; Sahraoui et al. 2017
Node degree (Dg)	$Dg_i = N_i \vee$	Number of patches connected directly to the patch i.	Freeman 1978
Landscape metric	Formula	Meaning	Reference
Edge density (ED; class agricultural land use)	$ED = \frac{\sum_{k=1}^m e_{ik}}{A} * 10000$	The edge density equals the sum of all edges of class i in relation to the landscape area. The metric describes the configuration of the landscape.	McGarigal et al. 2012
Mean area (AREAMN; class natural land use)	$AREAMN = mean(A[patch_{ij}])$	The metric summarizes each class as the mean of all patch areas belonging to class i. The metric describes the composition of the landscape.	McGarigal et al. 2012
Mean radius of gyration (GYRATEMN; class natural land use)	$GYRATEMN = mean(G[patch_{ij}])$	The metric summarizes each class as the mean of the radius of gyration of all patches belonging to class i. It measures the distance from each cell to the patch centroid and is based on cell center-to-cell center distances. The metrics characterizes both the patch area and compactness.	Keitt et al. 1997; McGarigal et al. 2012

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Total edge (TE; class natural land use)	$TE = \sum_{k=1}^m e_{ik}$	Sum of all edges between class i and all other classes k. It measures the configuration of the landscape because a highly fragmented landscape will have many edges.	McGarigal et al. 2012
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736 Table 2: Explanatory variables resulting from the MAMs at the node scale. For more details on formulas and meaning, see Foltete et al. (2012a) for connectivity
 737 metrics and Forman and Godron (1986) and Lang and Blaschke (2007) for DsqrtA metric. Connectivity formula terms: n_k = number of patches in the
 738 component k, N_i = all patches close to the patch i, d_{ij} = least-cost distance between the patches i and j, $e^{-\alpha d_{ij}}$ probability of movement between the
 739 patches i and j, α = brake on movement distance, β = exponent to weight more or less capacity. Landscape formula terms: D_{max} = maximum distance
 740 between two vertices of a polygon, A = area.

Connectivity metric	Formula	Meaning
Closeness centrality (CCe)	$CCe_i = \frac{1}{n_k - 1} \sum_{\substack{j=1 \\ j \neq i}}^{n_k} d_{ij}$	Mean distance from the patch i to all other patches of its component k.
Eccentricity (Ec)	$Ec_i = \max_j d_{ij}$	Maximum distance from the patch i to another patch of its component k.
Flux (F)	$F_i = \sum_{\substack{j=1 \\ j \neq i}}^n \alpha_j^\beta e^{-\alpha d_{ij}}$	For the focal patch i: sum of capacity of patches other than i and weighted according to their minimum distance to the focal patch through the graph. This sum is an indicator of the potential dispersion from the patch i or, conversely to the patch i.
Interaction flux (IF)	$IF_i = \sum_{j=1}^n \alpha_i^\beta \alpha_j^\beta e^{-\alpha d_{ij}}$	Sum of products of the focal patch capacity with all the other patches, weighted by their interaction probability.
Node degree (Dg)	$Dg_i = N_i \vee$	Number of patches connected directly to the patch i.
Landscape metric	Formula	Meaning
Hedgerow area (HRA)	$HRA = \frac{\sum A[\text{hedgerow}]}{TotalA}$	Percentage of hedgerows area.
Maximum distance to square root of area ratio (DsqrtA)	$DsqrtA = \frac{D_{max}}{\sqrt[2]{A}}$	Maximum distance between two polygon part's vertices divided by the square root of polygon's area. The minimum value of the metric corresponds to a circle, and the value increases as the shape becomes narrower.
Number of habitats (NOH)	$NOH = \sum HAB_i$	Sum of the number of different habitats present inside the node i.
Number of land uses (NOLU)	$NOLU = \sum LUSE_i$	Sum of the number of different land uses present around the node i.
Watercourse area (WA)	$WA = \frac{\sum A[\text{watercourse}]}{TotalA}$	Percentage of watercourse area.

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742 Table 3: Results of the GLMM models testing the effects of landscape metrics and connectivity
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<i>α diversity at the habitat scale</i>				
<i>Coefficients</i>	<i>Estimate</i>	<i>Std. Error</i>	<i>t-value</i>	<i>P-value</i>
Intercept	2.545	0.099	25.707	< 0.001 ***
Eccentricity (Ec)	0.041	0.023	1.779	0.079 .
Flux (F)	0.248	0.090	2.749	0.007 **
Closeness centrality (CCe)	0.286	0.144	1.982	0.051 .
Total edge of natural land use (TE)	0.178	0.076	2.328	0.021 *
Habitat (Meadows)	0.902	0.103	8.772	< 0.001 ***
Habitat (Woods)	0.606	0.099	6.137	< 0.001 ***
CCe:Fens	-0.093	0.152	-0.610	0.543
CCe:Meadows	-0.389	0.151	-2.585	0.011 *
CCe:Woods	-0.322	0.145	-2.224	0.028 *
F:Fens	-0.117	0.096	-1.220	0.225
F:Meadows	-0.169	0.099	-1.698	0.092 .
F:Woods	-0.250	0.091	-2.751	0.007 **
TE:Fens	0.103	0.075	1.370	0.173
TE:Meadows	-0.256	0.080	-3.192	0.002 **
TE:Woods	-0.174	0.079	-2.190	0.030 *
<i>β diversity at the habitat scale</i>				
<i>Coefficients</i>	<i>Estimate</i>	<i>Std. Error</i>	<i>t-value</i>	<i>p-value</i>
Intercept	-5.152	0.029	-174.854	< 0.001 ***
Flux (F)	-0.020	0.010	-2.027	0.045 *
Interaction flux (IF)	0.048	0.029	1.664	0.099 .
Node degree (Dg)	-0.056	0.024	-2.332	0.022 *
Edge density of agricultural land use (ED)	-0.025	0.009	-2.802	0.006 **
Mean area of natural land use (AREAMN)	0.047	0.015	3.007	0.003 **
Mean radius of gyration of natural land use (GYRATEMN)	-0.039	0.014	-2.838	0.005 **
Habitat (Meadows)	-0.008	0.033	-0.236	0.814
Habitat (Woods)	-0.342	0.029	-11.682	< 0.001 ***

745 Table 4: Results of the GLM models testing the effects of landscape metrics and connectivity metrics
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<i>α diversity at the node scale</i>				
<i>Coefficients</i>	<i>Estimate</i>	<i>Std. Error</i>	<i>t-value</i>	<i>p-value</i>
Intercept	3.619	0.031	116.758	< 0.001 ***
Closeness centrality (CCe)	-0.084	0.031	-2.691	0.009 **
Eccentricity (Ec)	0.110	0.031	3.583	< 0.001 ***
Interaction flux (IF)	-0.175	0.034	-5.068	< 0.001 ***
Node degree (Dg)	0.106	0.039	2.716	0.008 **
log (Hedgerow area) (HRA)	0.459	0.109	4.211	< 0.001 ***
Maximum distance to square root of area ratio (DsqrA)	-0.217	0.036	-6.038	< 0.001 ***
Number of habitats (NOH)	0.341	0.039	8.783	< 0.001 ***
Watercourse area (WA)	0.131	0.036	3.616	< 0.001 ***
<i>β diversity at the node scale</i>				
<i>Coefficients</i>	<i>Estimate</i>	<i>Std. Error</i>	<i>t-value</i>	<i>p-value</i>
Intercept	-4.485	0.019	-237.063	< 0.001 ***
Flux (F)	-0.037	0.021	-1.781	0.079 .
Node degree (Dg)	-0.068	0.031	-2.223	0.029 *
Hedgerow area (HRA)	0.142	0.038	3.734	< 0.001 ***
Maximum distance to square root of area ratio (DsqrA)	-0.107	0.026	-4.126	< 0.001 ***
Number of habitats (NOH)	-0.136	0.034	-4.014	< 0.001 ***
Number of land uses (NOLU)	-0.096	0.021	-4.496	< 0.001 ***
Watercourse area (WA)	0.081	0.024	3.319	0.001 **

748 **Figure caption**

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249 **Fig. 1:** Study area location and ecological network representation. An example of the hierarchical
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550 sampling design in which each node was sampled stratified by habitat proportionally to habitat
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751 extension within the node is shown on the top right of the figure.

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1252 **Fig. 2:** Schematization of the study: on the left the representation of the two scales of analysis, at the
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1553 habitat scale (P, red squares) with a 250 m buffer around the plot (red buffer) and at the node scale
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1754 (N, green polygons, different shades of green indicate different habitats) with a 250 m buffer around
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1955 the node (black buffer). Blue arrows (C) indicate connectivity between nodes. In the background,
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2256 land use classes (red for urban land use, yellow for agricultural land use, blue for watercourses, and
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2457 green for hedgerows). On the right, the diagram summarizing the materials and methods: the response
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2658 variables (α and β diversity), the explanatory variables (connectivity metrics and landscape metrics),
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2859 and the statistical analyses (GLMM at the habitat scale and GLM at the node scale).

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1755 the node (black buffer). Blue arrows (C) indicate connectivity between nodes. In the background,
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1956 land use classes (red for urban land use, yellow for agricultural land use, blue for watercourses, and
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2257 green for hedgerows). On the right, the diagram summarizing the materials and methods: the response
23
2458 variables (α and β diversity), the explanatory variables (connectivity metrics and landscape metrics),
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2759 and the statistical analyses (GLMM at the habitat scale and GLM at the node scale).

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2960 **Fig. 3:** observed relationships between α and β diversity values at the habitat scale (a), and at the node
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32761 scale (b).

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3462 **Fig. 4:** Effects on α diversity (i.e., species richness) of eccentricity; flux, closeness centrality and total
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3763 edge with anthropic land uses in different habitats (fens, woods, and meadows) resulting from the
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3964 GLMM at the habitat scale.

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4165 **Fig. 5:** Effects on β diversity (i.e., LCBD) of flux, interaction flux, node degree, edge density of
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4466 agricultural land use, mean radius of gyration of natural land use, and mean area of natural land use
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4667 along with mean values of LCBD per habitat resulting from the GLMM at the habitat scale.

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4968 **Fig. 6:** Effects on α diversity (i.e., species richness) of closeness centrality, eccentricity; interaction
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5269 flux, node degree, hedgerow area, maximum distance to square root of area ratio, number of habitats,
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5470 and watercourse area resulting from the GLM at the node scale.

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5671 **Fig.7:** Effects on β diversity (i.e., LCBD) of flux, node degree, hedgerow area, maximum distance to
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5972 square root of area ratio, number of habitats, number of land uses, and watercourse area resulting
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6173 from the GLM at the node scale.

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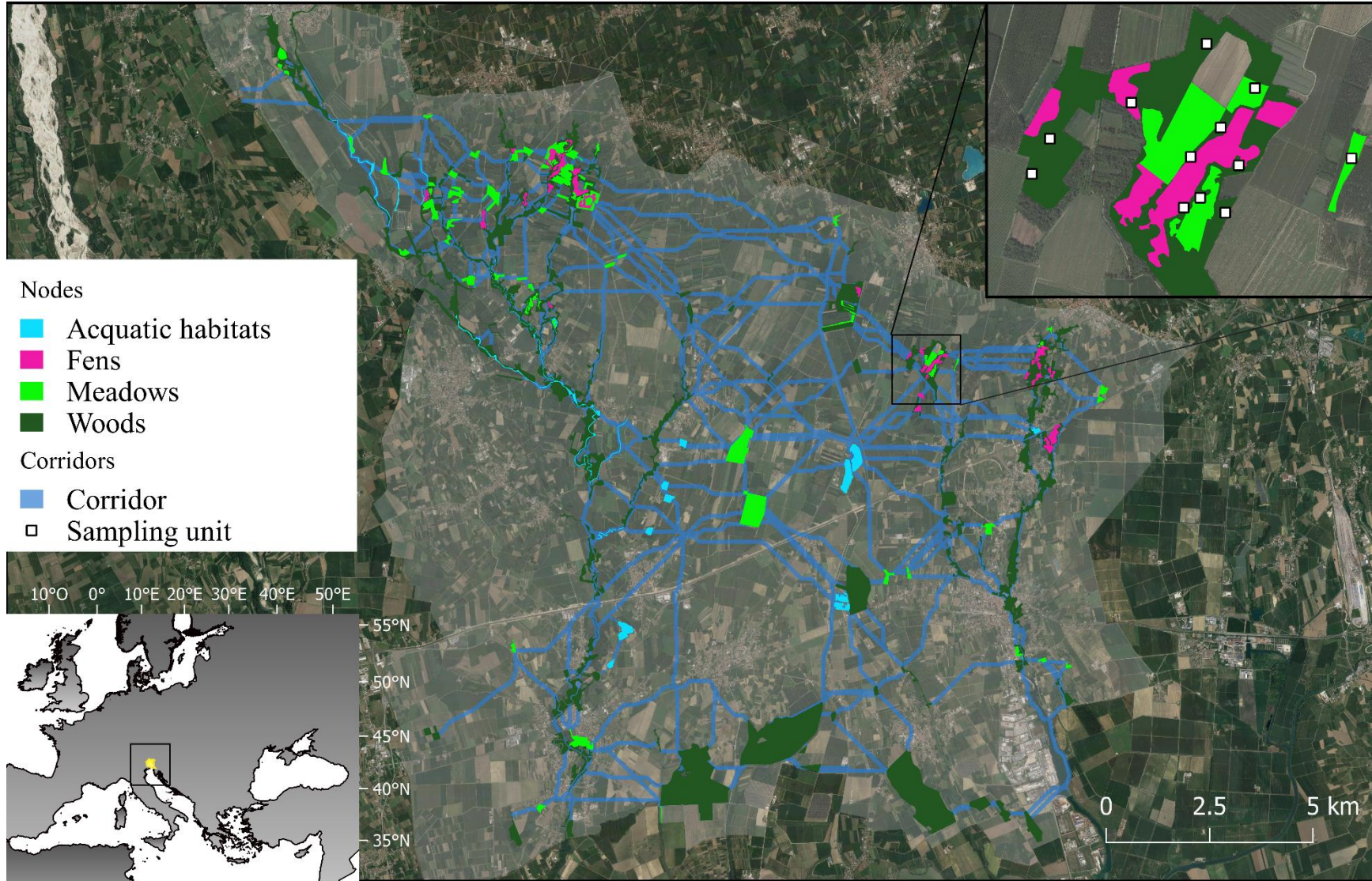
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774 **Figures**

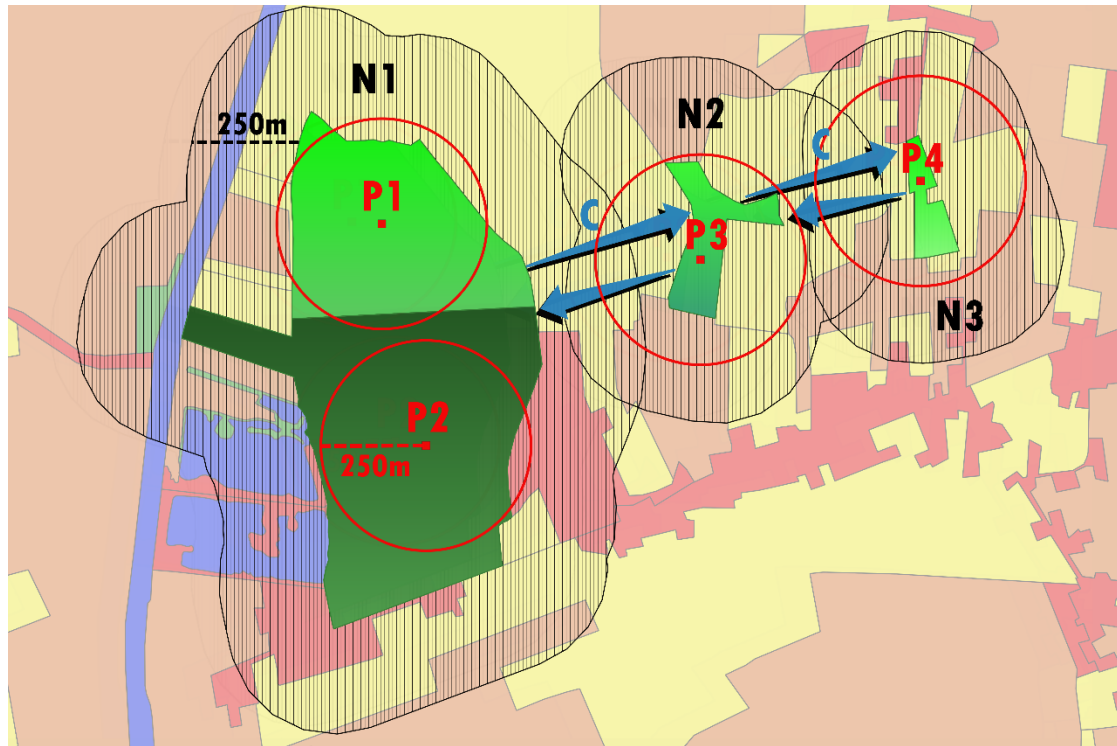
775 Fig. 1



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777 Fig. 2



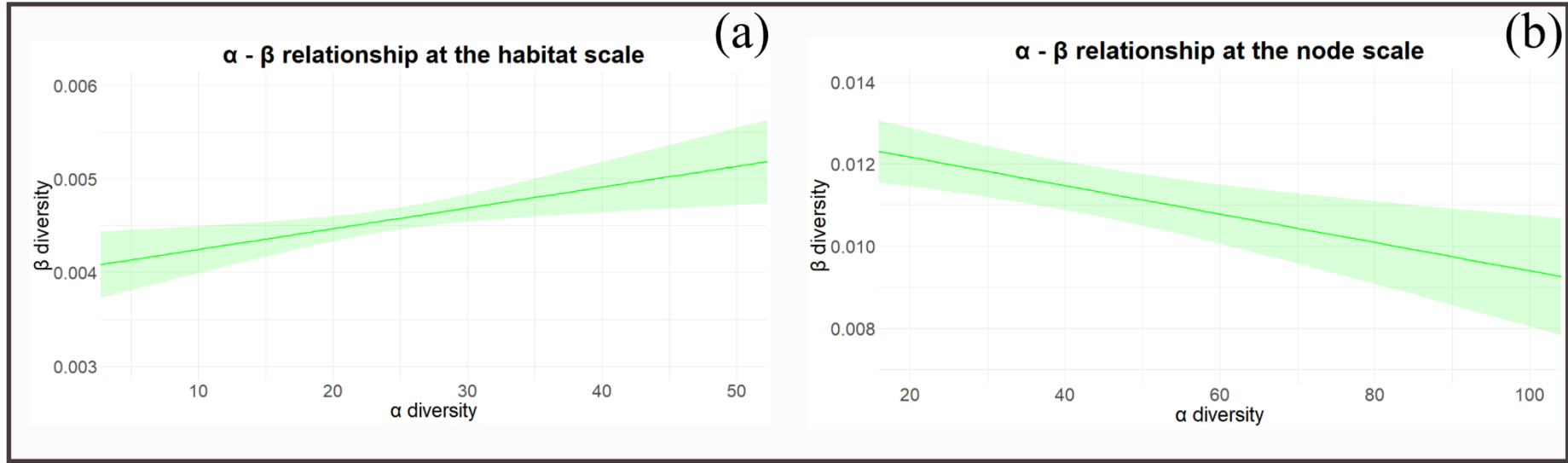
Habitat scale		Node scale	
Response variables		Response variables	
α diversity, i.e., number of species	β diversity, i.e., local contributors of beta diversity (LCBD)	α diversity, i.e., number of species	β diversity, i.e., local contributors of beta diversity (LCBD)
Explanatory variables		Explanatory variables	
Connectivity metrics	Landscape metrics	Connectivity metrics	Landscape metrics
Statistical analysis		Statistical analysis	
GLMM	GLMM	GLM	GLM

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780 Fig. 3

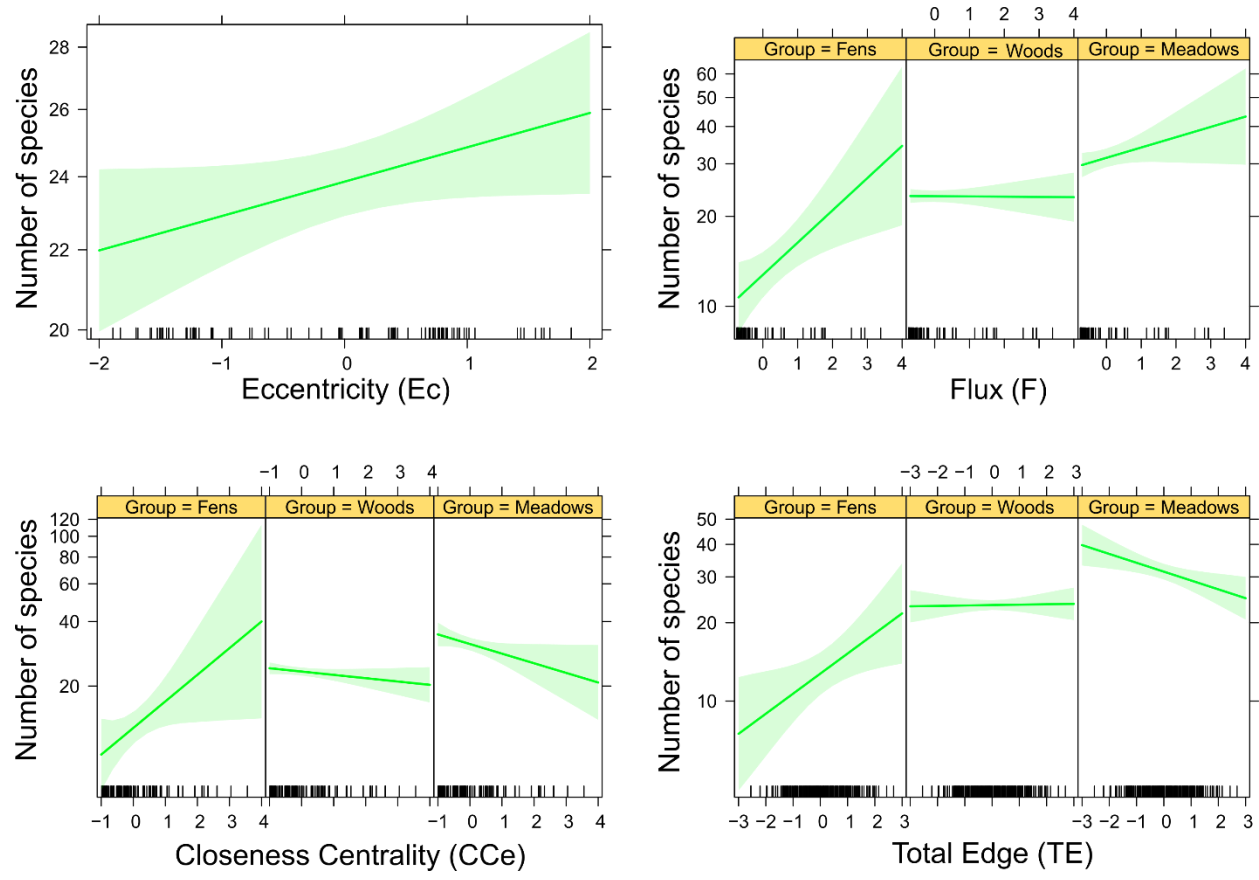


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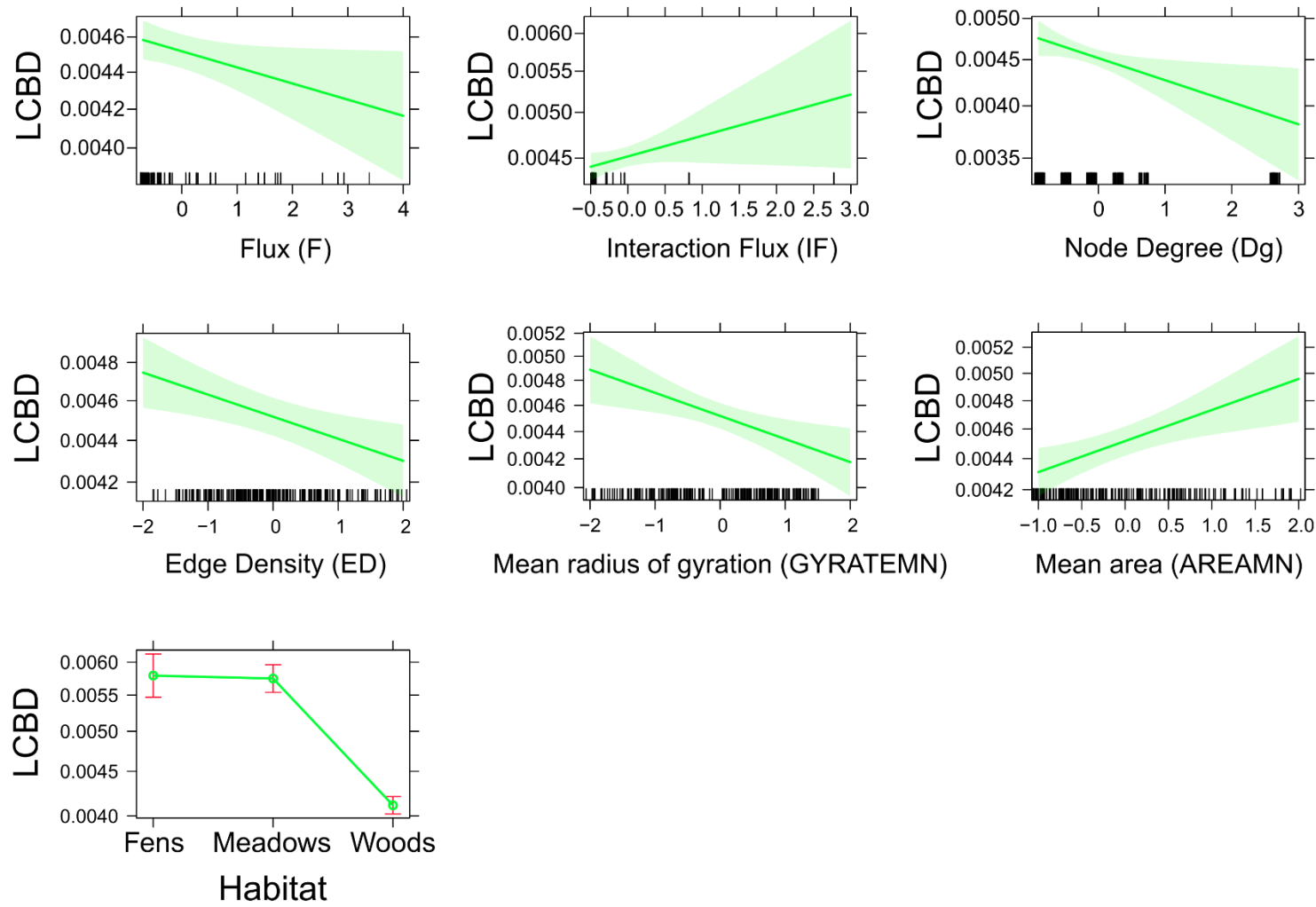
783 Fig. 4



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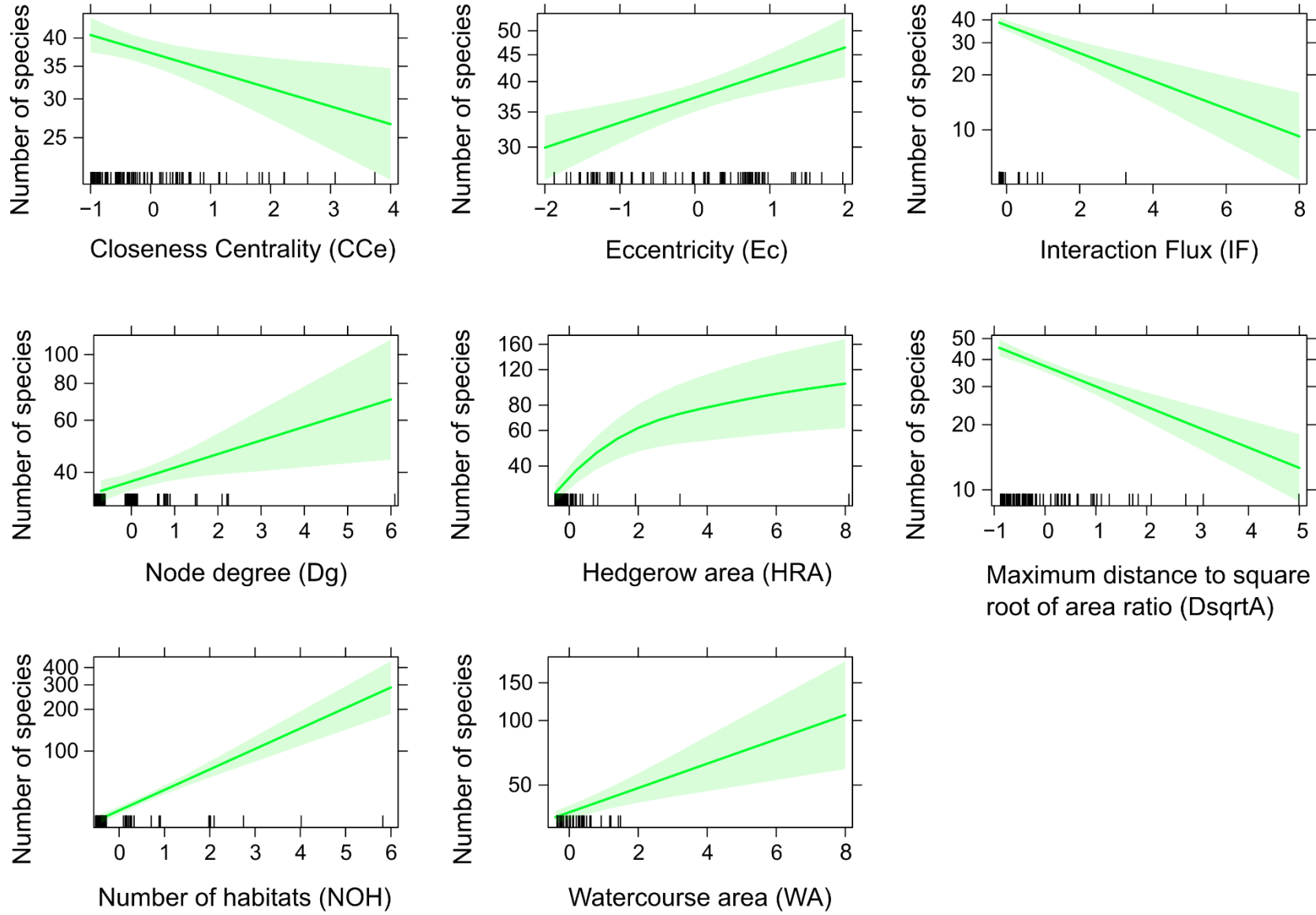
785 Fig. 5



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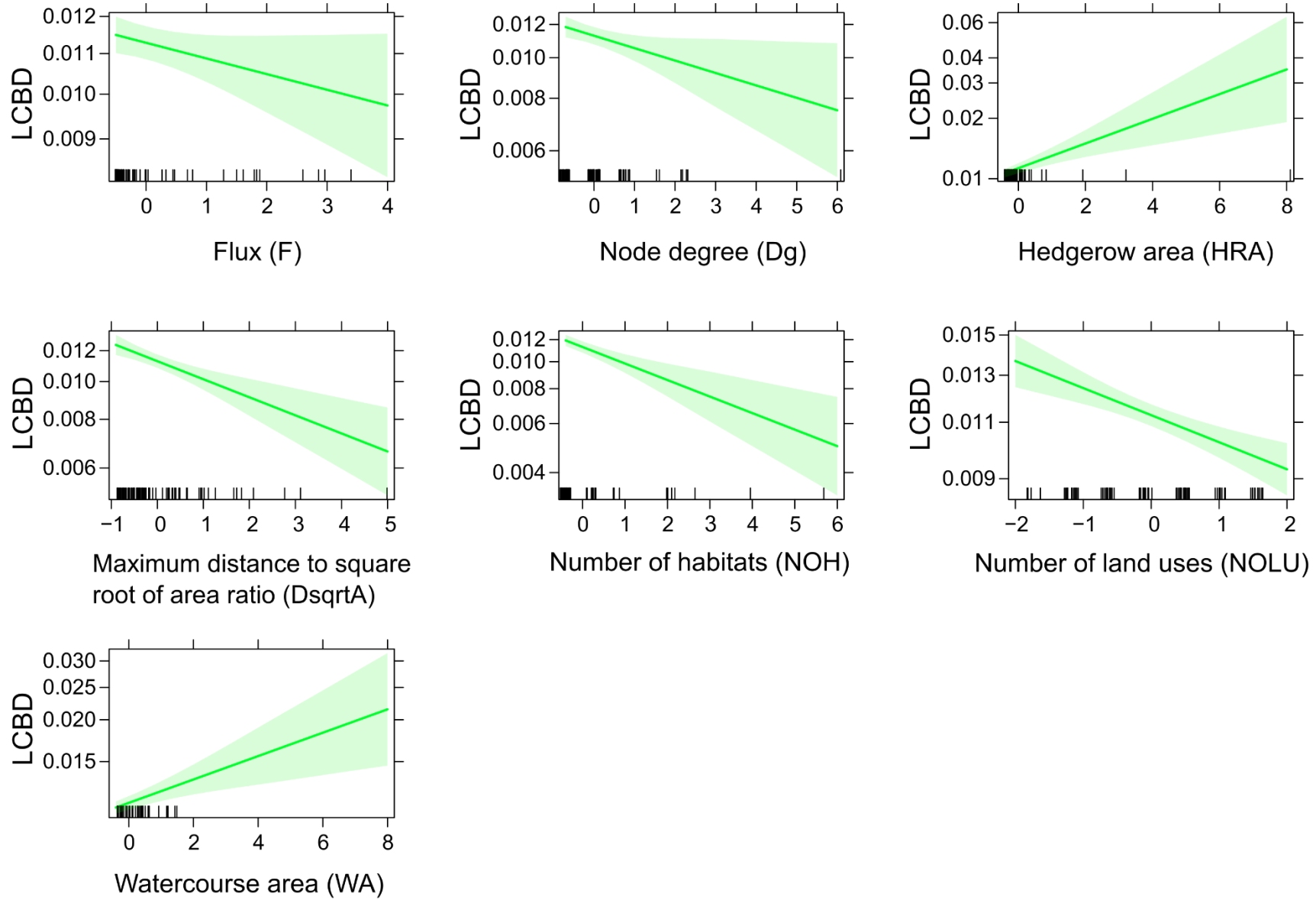
787 Fig. 6



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789 Fig. 7



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Supplementary material

Appendix A

Potential landscape connectivity was assumed as a measure of connectivity that combines the physical attributes of the landscape with limited information about dispersal ability of target species (Bennett et al. 2004; Taylor et al. 2006). We considered any defined and existing area of "preferred habitat" for specific target species, in both protected and unprotected areas, as the EN node. Ecological corridors, on the other hand, were potential connections between nodes, defined according to both context characteristics (landscape structure) and behaviors of the species considered.

The map of the habitats of the study area was combined with a table of dispersal costs that responds to specie-specific behavior (time and effort to travel through an environment) to obtain a map of costs for all 10 animal species and 9 plant communities (habitats, harboring 45 plant species of conservation interest) present in the landscape. Following a scale from 1 (minimum value assigned to preferred habitats) to 100 (maximum value assigned to barriers), the resistance values were adapted to each habitat in the landscape, considering the target species, defined through an expert evaluation process within a focus group, consisting of 3 fauna and 2 flora experts. Among the existing options to parameterize resistance map to species movement, the expert-based approach is widely used due to the lack of adequate biological data and generalizable results from research (Zeller 2012; Breckheimer 2014).

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- Zeller KA, McGarigal K, Whiteley AR (2012) Estimating landscape resistance to movement: a review. *Landscape Ecol* 27:777–797

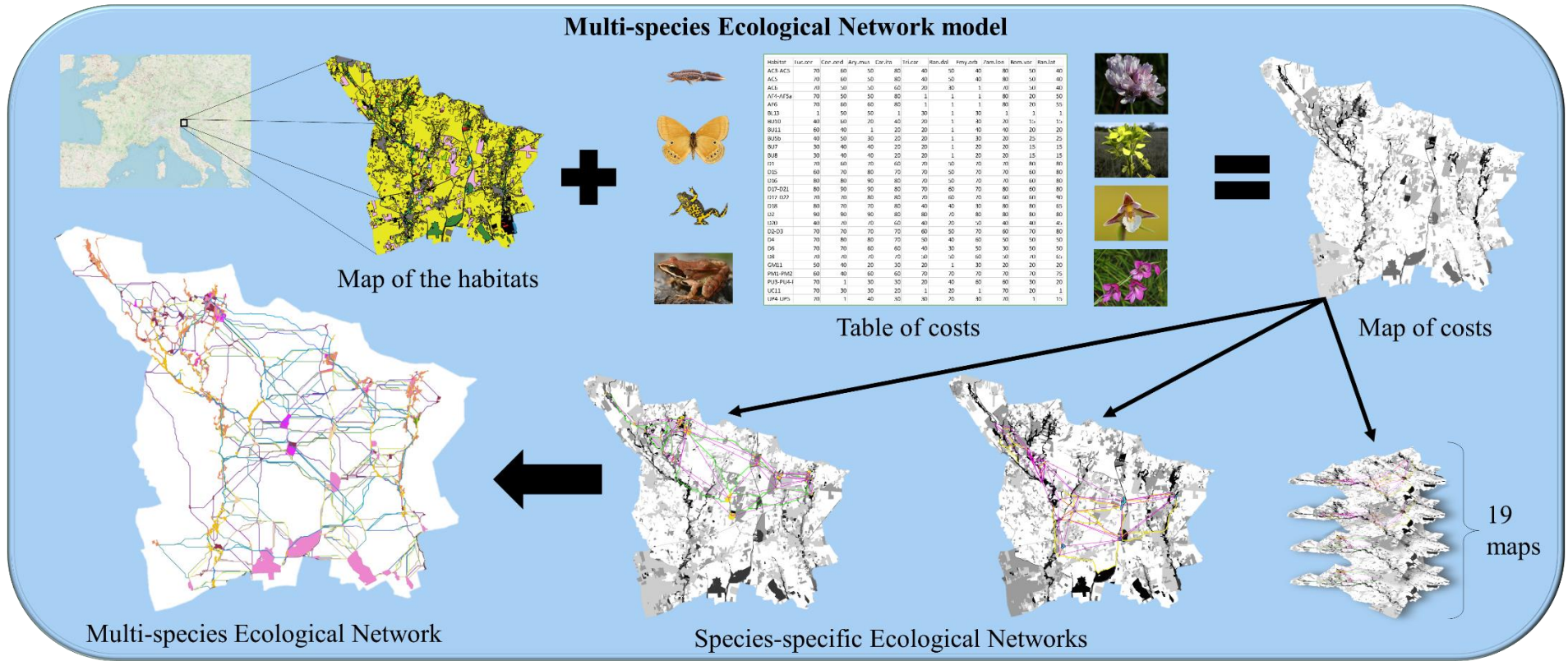


Figure: Flow chart of the main steps applied to model the multi-species Ecological Network: starting from a map of the habitat types of the study area and combining it with a table of costs (time and effort to travel through an environment) it was obtained a map of costs for all 10 animal species and 9 plant communities (habitats, harboring 45 plant species of conservation interest) present in the landscape. From the overlay of all species-specific networks the multi-species ecological network was obtained as the sum of all identified elements.

Appendix B

Habitats of the study area.

Table: Habitat of the area according to EUNIS habitat classification, belonging group in the models along with descriptive statistics of the study area (i.e., total area, mean area \pm standard deviation, number of patches, number of plots and average total, native and alien richness).

EUNIS Habitat	Group	Total area (ha)	Mean area \pm SD (ha)	N. Patches	N. Plots	Average richness (\pm SD)	Average native richness (\pm SD)	Average alien richness (\pm SD)
C3.21 - <i>Phragmites australis</i> beds	2. meadows	3.7	3.7	1	1	21.0	20.0	1.0
D4.11 - <i>Schoenus nigricans</i> fens	3. fens	77.5	2.8 \pm 2.0	28	12	15.1 \pm 5.7	15.0 \pm 5.5	0.1 \pm 0.3
D5.24 - Fen <i>Cladium mariscus</i> beds	3. fens	9.9	5.0 \pm 5.6	2	3	14.3 \pm 4.2	14.3 \pm 4.2	0.0 \pm 0.0
E1.55 - Eastern sub-Mediterranean dry grassland	2. meadows	33.6	11.2 \pm 12.9	3	4	34.8 \pm 7.3	34.8 \pm 7.3	0.0 \pm 0.0
E2.2 - Low and medium altitude hay meadows	2. meadows	149.2	3.7 \pm 3.6	40	30	32.0 \pm 7.7	29.7 \pm 8.1	2.3 \pm 1.5
E3.4 - Moist or wet eutrophic and mesotrophic grassland	2. meadows	8.5	4.3 \pm 0.2	2	3	17.0 \pm 13.2	17.0 \pm 13.2	0.0 \pm 0.0
E3.51 - <i>Molinia caerulea</i> meadows and related communities	2. meadows	50.4	3.7 \pm 5.6	19	8	33.9 \pm 7.4	33.5 \pm 7.0	0.4 \pm 0.5
F3.23 - Tyrrhenian sub-Mediterranean deciduous thickets	1. woods	186.2	3.6 \pm 3.4	46	30	22.4 \pm 5.0	19.9 \pm 5.2	2.5 \pm 1.3

F9.2 - <i>Salix carr</i> and fen scrub	1. woods	46.6	5.2 ± 4.9	9	12	25.0 ± 5.2	23.0 ± 4.9	2.0 ± 1.3
G1.A1A - Illyrian <i>Quercus - Carpinus betulus</i> forests	1. woods	603.4	31.8 ± 56.2	19	36	23.2 ± 5.6	22.9 ± 5.7	0.3 ± 0.7
G1.11 - Riverine <i>Salix</i> woodland	1. woods	199.2	6.0 ± 7.9	34	40	23.4 ± 6.9	20.7 ± 6.3	2.7 ± 1.3
G1.223 - Southeast European <i>Fraxinus - Quercus - Alnus</i> forests	1. woods	112.5	5.6 ± 4.7	20	9	26.1 ± 4.6	23.0 ± 4.9	3.1 ± 2.5
G1.224 - Po <i>Quercus - Fraxinus - Alnus</i> forests	1. woods	1.9	1.9	1	1	18.0	15.0	3.0
G1.41 - <i>Alnus</i> swamp woods not on acid peat	1. woods	416.4	11.0 ± 15.2	38	30	22.6 ± 5.7	20.7 ± 5.7	1.9 ± 1.5

Plant communities' description (modified from Poldini et al. 2006)

1. WOODS

F3.23 - Tyrrhenian sub-Mediterranean deciduous thickets

These are widespread shrublands in southeastern Europe in the lowland to hill belt (< 500 m) on wet soils. They constitute the hedges of the areas with availability of water, but also the mantle of lowland and hilly humid forests; the dominant species (*Frangula alnus*, *Viburnum opulus*, *Alnus glutinosa*) are able to recolonize peat bogs and wet meadows.

Syntaxonomy: *Salici-Viburnion opuli* (Pass. 1985) De Focault 1991.

F9.2 - Salix carr and fen scrub

These are thermophilic marsh shrubs with a European distribution that develop in the basal and hilly (< 500 m) planes on peaty or minerals with prolonged inundation. This is the woody vegetation that grows closest to bodies of water. The dominant species, *Salix cinerea*, forms intricate or mono to paucispecific formations.

Syntaxonomy: *Salicetum cinerae* Zólyomi 1931.

G1.A1A - Illyrian Quercus - Carpinus betulus forests

These forests develop in the basal plain on fine fluvio-glacial sediments, evolved soils and good water availability due to the shallow water table. In addition to the two dominant species (*Quercus robur* and *Carpinus betulus*) *Fraxinus angustifolia* is often present. The understory is characterized by spring geophytes (*Galanthus nivalis*, *Viola* sp.pl.) and *Asparagus tenuifolius*.

Syntaxonomy: *Asparago tenuifolii-Quercetum roboris* (Lausi 1966) Marinček 1994.

G1.11 - Riverine Salix woodland

These are riparian woods with European distribution that develop in the lowland and hill belt (< 500 m) on gravel to sandy alluvial soils. The vegetation assumes a multi-layered or multi-flora woodland structure in the middle and lower river system where the stabilization of sediments and a certain presence of soil favor the presence of tree species such as *Populus nigra* and *Salix alba*. *Salix alba* is almost exclusive to the innermost zone, while the more thermophilic black poplar is concentrated in the lowland belt.

Syntaxonomy: *Salicetum albae* Issl. 1926.

G1.223 - Southeast European Fraxinus - Quercus - Alnus forests

These are marsh forests with an Illyrian distribution that develop in the lowland on peat or mineral substrates with prolonged flooding. The waterlogging favors the hygrophilous *Fraxinus angustifolia* with Mediterranean gravitation. The species-poor understory is characterized by *Leucojum aestivum* and *Carex* sp.pl.

Syntaxonomy: *Leucojo aestivi-Fraxinetum oxycarpae* Glavač 1959.

G1.224 - Po Quercus - Fraxinus - Alnus forests

These are humid forests with an Illyrian distribution range that develop in the lowland areas on mineral substrates of the more evolved river terraces. They are rarely flooded. In fact, they are dominated by already "hardwood" species such as *Quercus robur* and *Fraxinus angustifolia*.

Syntaxonomy: *Populion albae* Br.-Bl. ex Tchou 1948.

G1.41 - Alnus swamp woods not on acid peat

These are marsh forests with a European distribution that develop from the basal to the hill belt (< 500 m) planes on non-acidic peaty or minerals with prolonged inundation. The permanence of water and asphyxiation of soils facilitate the dominance of *Alnus glutinosa*. Other common species are *Carex acutiformis*, *Carex elata*, *Carex pendula*, *Carex remota*, and *Cladium mariscus*.

Syntaxonomy: *Alnion glutinosae* Malcuit 1929.

2. MEADOWS

C3.21 - Phragmites australis beds

These reedbeds are widespread throughout Europe and develop from the coastal line to the mountain belt (< 1600 m) on mineral soils, flooded and moderately rich in nutrients. They form both lacustrine

belts and large areas even in river estuaries. It is clearly dominated by *Phragmites australis* which, in the most developed situations, becomes the only species present.

Syntaxonomy: *Phragmitetum vulgaris* von Soð 1927.

E1.55 - Eastern sub-Mediterranean dry grassland

These are prealpine-illiric communities that develop in the lowland to hill belt (<500 m) on completely stabilized carbonate alluvium (river terraces) in which soil is mature and ferreted. Common species are *Achillea millefolium* aggr., *Brachypodium rupestre*, *Bromopsis erecta*, *Campanula glomerata*, *Chrysopogon gryllus*, *Hypochaeris maculata*, *Molinia caerulea* / *arundinacea*.

Syntaxonomy: *Hypochoeridenion maculatae* (Horvatić1973) Poldini et Feoli ChiapellainFeoli Chiapella et Poldini 1993.

E2.2 - Low and medium altitude hay meadows

These are hay meadows with south-alpine range that develop in the lowland to low-montane belt (< 1100 m) on evolved and moderately rich soils, with good water availability. These are dominated by *Arrhenatherum elatius* or *Lolium multiflorum* and *Poa sylvicola*.

Syntaxonomy: *Arrhenatherion elatioris* W. Koch 1926

E3.4 - Moist or wet eutrophic and mesotrophic grassland

These are tall herbaceous plant communities widespread in Europe that develop in the lowland to hill belt (< 500 m) on humid soils rich in nutrients. They often represent aspects of burying marsh environments. They are dominated by *Filipendula ulmaria* accompanied by *Lysimachia vulgaris*, *Mentha longifolia* and *Calystegia sepium*.

Syntaxonomy: *Filipendulion* Segal 1966

E3.51 - Molinia caerulea meadows and related communities

These are humid meadows widespread in the Friuli-Veneto plain that develop in the lowland to hill belt (< 500 m) on substrates with high water content. These meadows are dominated by *Molinia caerulea* and rich in endemic and rare species (e.g., *Allium suaveolens*, *Anacamptis laxiflora*, *Anacamptis palustris*, *Cirsium canum*, *Euphorbia illirica*, *Limniris sibirica*, *Plantago altissima*, *Platanthera bifolia*, etc.). Abandonment induces intense shrub encroachment by *Frangula alnus*, *Alnus glutinosa*, and *Salix cinerea*.

Syntaxonomy: *Plantagini altissimae-Molinetum caeruleae* (Pignatti 1953) Marchiori et Sburlino 1982.

3. FENS

D4.11 - Schoenus nigricans fens

These are eastern Po Valley fens that develop in the lowland near the resurgences and generally with good water supply. Thin peat deposits are dominated by *Schoenus nigricans* accompanied by three steno-endemic species and glacial relicts (*Armeria helodes*, *Centaurea forojuliensis*, *Erucastrum palustre*, *Senecio fontanicola*). A general reduced water availability favors the shrub encroachment by *Frangula alnus*, *Alnus glutinosa*, and *Salix cinerea*.

Syntaxonomy: *Erucastro-Schoenetum nigricantis* Poldini 1973 em. Sburlino et Ghirelli 1994.

D5.24 - Fen *Cladium mariscus* beds

These are high helophyte formations widespread throughout Europe, mostly occurring in the southern areas, which develop in the lowland and hill belt (< 500 m) on soils constantly flooded by oligo- to meso-eutrophic. It characterizes the first belt of resurgence but also the wettest parts of low alkaline fens. *Cladium mariscus* is dominant and often the exclusive species.

Syntaxonomy: *Mariscetum serrati* Zobrist 1953.

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Appendix C

Metrics and correlation tables

Habitat scale

All class and landscape level metrics of “landscapemetrics” package (Hesselbarth et al. 2019) were used, except for the core area metrics. For more information see the package vignette at: <https://cran.r-project.org/web/packages/landscapemetrics/landscapemetrics.pdf>

The metrics with more than 25% of NA values were discarded.

Correlation analysis was executed using the R function `cor()`, estimating coefficients using non-parametric Spearman’s ρ , and then the metrics were selected using the function `findCorrelation()` of the R package “`caret`” (Kuhn 2008) and setting the cutoff to ± 0.7 .

Correlation values are reported in the attached table: “Cor_table.xlsx”, sheet 1.

Seven connectivity metrics were calculated on Graphab (Foltete et al. 2012): betweenness centrality (BC), closeness centrality (CCe), connectivity correlation (CCor), eccentricity (Ec), flux (F), interaction flux (IF) and node degree (Dg). Correlation analysis was executed using the R function `cor()`, estimating coefficients using non-parametric Spearman’s ρ , and then the metrics were selected using the function `findCorrelation()` of the R package “`caret`” (Kuhn 2008) and setting the cutoff to ± 0.7 . Correlation values are reported in the table below.

	<i>BC</i>	<i>CCe</i>	<i>CCor</i>	<i>Ec</i>	<i>F</i>	<i>IF</i>	<i>Dg</i>
<i>BC</i>	1.00	-0.26	0.50	0.01	0.51	0.48	0.68
<i>CCe</i>	-0.26	1.00	-0.10	0.24	-0.29	-0.19	-0.25
<i>CCor</i>	0.50	-0.10	1.00	-0.07	0.09	0.39	0.82
<i>Ec</i>	0.01	0.24	-0.07	1.00	0.14	0.02	-0.05
<i>F</i>	0.51	-0.29	0.09	0.14	1.00	0.41	0.26
<i>IF</i>	0.48	-0.19	0.39	0.02	0.41	1.00	0.56
<i>Dg</i>	0.68	-0.25	0.82	-0.05	0.26	0.56	1.00

Node scale

All shapes indexes present in Polygon Shape Indices tool were calculated on QGIS (Quantum GIS Development Team 2021) using the EN nodes as the main spatial unit. Namely, perimeter divided by area, perimeter divided by square root of area, maximum distance between to vertices, maximum distance between to vertices divided by area, maximum distance between to vertices divided by

square root of area, and shape index (Perimeter / (2 * Square Root (PI * Area))). All shape indexes are obviously interrelated, so we chose the unitless indexes and then the less correlated to the others.

	<i>Per sqrt A</i>	<i>D sqrt A</i>	<i>Shape index</i>
<i>Per sqrt A</i>	1.00	0.70	1.00
<i>D sqrt A</i>	0.70	1.00	0.70
<i>Shape index</i>	1.00	0.70	1.00

Landscape metrics were calculated for a buffer area of 250 m around each node, taking into accounts the number of land uses, watercourse area, woodland area, hedgerow area, semi-natural woodland area, permanent grassland, agricultural areas with residual natural elements, extensive crops, tree crops, intensive arable land, urban areas and the number of habitats within each node.

Correlation analysis was executed using the R function `cor()`, estimating coefficients using non-parametric Spearman’s ρ , and just woodland area was correlated with number of habitats and hedgerow area (cutoff ± 0.7).

Correlation values are reported in the attached table: “Cor_table.xlsx”, sheet 2.

Seven connectivity metrics were calculated on Graphab (Foltete et al. 2012): betweenness centrality (BC), closeness centrality (CCe), connectivity correlation (CCor), eccentricity (Ec), flux (F), interaction flux (IF) and node degree (Dg). Correlation analysis was executed using the R function `cor()`, estimating coefficients using non-parametric Spearman’s ρ , and then the metrics were selected using the function `findCorrelation()` of the R package “`caret`” (Kuhn 2008) and setting the cutoff to ± 0.7 . Correlation values are reported in the table below.

	<i>BC</i>	<i>CCe</i>	<i>CCor</i>	<i>Ec</i>	<i>F</i>	<i>IF</i>	<i>Dg</i>
<i>BC</i>	1.00	-0.29	0.43	-0.33	0.22	0.29	0.63
<i>CCe</i>	-0.29	1.00	-0.18	0.33	-0.59	-0.35	-0.18
<i>CCor</i>	0.55	-0.18	1.00	-0.10	0.11	0.35	0.89
<i>Ec</i>	-0.33	0.33	-0.13	1.00	-0.18	-0.07	-0.29
<i>F</i>	0.22	-0.59	0.11	-0.18	1.00	0.59	0.03
<i>IF</i>	0.29	-0.35	0.23	-0.07	0.59	1.00	0.26
<i>Dg</i>	0.63	-0.18	0.89	-0.29	0.03	0.26	1.00

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Appendix D

Table: Explanatory variables used to build models at the habitat and node scales and related references.

<i>Connectivity metrics (both scales)</i>	<i>References</i>
Betweenness centrality	Bodin and Saura 2010; Foltete et al. 2012a
Closeness centrality	Freeman 1978
Eccentricity	Urban and Keitt 2001
Flux	Urban and Keitt 2001; Saura and Torné 2009; Foltete et al. 2012b
Interaction flux	Foltete et al. 2014; Sahraoui et al. 2017
Node degree	Freeman 1978
<i>Landscape metrics (habitat scale)</i>	<i>References</i>
Coefficient of variation fractal dimension index	Mandelbrot 1977; McGarigal, et al. 2012
Coefficient of variation of patch area	McGarigal et al. 2012
Coefficient of variation perimeter-area ratio	McGarigal et al. 2012
Coefficient of variation of related circumscribing circle	Baker and Cai 1992; McGarigal et al. 2012
Edge density of agricultural land use	McGarigal et al. 2012
Mean area of natural patches	McGarigal et al. 2012
Mean fractal dimension index	Mandelbrot 1977; McGarigal, et al. 2012
Mean fractal dimension index of agricultural land use	Mandelbrot 1977; McGarigal, et al. 2012
Mean of related circumscribing circle of agricultural land use	Baker and Cai 1992; McGarigal et al. 2012
Mean radius of gyration of agricultural land use	Keitt et al. 1997; McGarigal et al. 2012
Mean radius of gyration of natural patches	Keitt et al. 1997; McGarigal et al. 2012
Mean shape index	Patton 1975; McGarigal et al. 2012
Mean shape index of agricultural land use	Patton 1975; McGarigal et al. 2012
Natural patch density	McGarigal et al. 2012
Normalized landscape shape index of agricultural land use	Patton 1975; McGarigal et al. 2012
Normalized landscape shape index of natural patches	Patton 1975; McGarigal et al. 2012
Patch richness	McGarigal et al. 2012
Patch richness density	McGarigal et al. 2012
Percentage of natural patches	McGarigal et al. 2012
Simpson's diversity index	Simpson 1949; McGarigal et al. 2012
Total edge with anthropogenic land use	McGarigal et al. 2012
<i>Landscape metrics (node scale)</i>	<i>References</i>
Maximum distance to square root of area ratio	Forman and Godron 1986; Lang and Blaschke 2007
Agricultural areas with residual natural elements	/
Extensive crops	/
Hedgerow area	/

Intensive arable land	/
Number of habitats	/
Number of land uses	/
Permanent grassland	/
Semi-natural woodland areas	/
Tree crops	/
Urban areas	/
Watercourse area	/

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Appendix E

Table: List of species.

Type A=alien, N=native, PRE=protected, rare or endemic. % = percentage of occurrence. Protection

HD=habitat directive, RRL=regional red list, NRL=national red list, R=rare, E=endemic

Species	Type	%	Protection	Species	Type	%	Protection
<i>Acalypha virginica</i> L.	A	3.20	-	<i>Lactuca sativa</i> L. subsp. <i>serriola</i> (L.) Galasso, Banfi, Bartolucci & Ardenghi	N	1.83	-
<i>Acer campestre</i> L.	N	30.14	-	<i>Lamium galeobdolon</i> (L.) L.	N	1.83	-
<i>Acer negundo</i> L.	A	5.94	-	<i>Lamium maculatum</i> L.	N	2.28	-
<i>Acer pseudoplatanus</i> L.	N	4.11	-	<i>Lamium orvala</i> L.	N	6.39	-
<i>Achillea millefolium</i> aggr.	N	2.74	-	<i>Lapsana communis</i> L.	N	0.91	-
<i>Aegopodium podagraria</i> L.	N	0.91	-	<i>Lathyrus pratensis</i> L.	N	9.59	-
<i>Agrimonia eupatoria</i> L. subsp. <i>eupatoria</i>	N	1.83	-	<i>Lathyrus venetus</i> (Mill.) Wohlf.	N	1.37	-
<i>Agrostis capillaris</i> L.	N	0.46	-	<i>Lathyrus vernus</i> (L.) Bernh.	N	1.83	-
<i>Agrostis gigantea</i> Roth	N	1.83	-	<i>Laurus nobilis</i> L.	N	5.02	-
<i>Agrostis stolonifera</i> L.	N	3.65	-	<i>Lemna minor</i> L.	N	2.28	-
<i>Ailanthus altissima</i> (Mill.) Swingle	A	0.46	-	<i>Leontodon hispidus</i> L.	N	1.37	-
<i>Ajuga reptans</i> L.	N	10.05	-	<i>Leucanthemum ircutianum</i> DC.	N	5.02	-
<i>Alisma plantago-aquatica</i> L.	N	1.37	-	<i>Leucanthemum platylepis</i> Borbás	PRE	0.46	R
<i>Alliaria petiolata</i> (Bieb.) Cavara & Grande	N	0.46	-	<i>Leucojum aestivum</i> L.	N	1.83	-
<i>Allium carinatum</i> L.	N	1.37	-	<i>Ligustrum lucidum</i> W.T.Aiton	A	5.94	-
<i>Allium polyanthum</i> Schult. & Schult.f.	N	0.46	-	<i>Ligustrum sinense</i> Lour.	A	1.83	-
<i>Allium scorodoprasum</i> L.	A	0.46	-	<i>Ligustrum vulgare</i> L.	N	41.10	-
<i>Allium suaveolens</i> Jacq.	PRE	1.37	NRL	<i>Limniris pseudacorus</i> (L.) Fuss	N	16.44	-
<i>Allium ursinum</i> L.	N	7.31	-	<i>Limniris sibirica</i> (L.) Fuss	PRE	1.37	NRL
<i>Allium vineale</i> L.	N	3.65	-	<i>Linum tenuifolium</i> L.	N	0.46	-
<i>Alnus glutinosa</i> (L.) Gaertn.	N	39.27	-	<i>Lolium arundinaceum</i> (Schreb.) Darbysh. subsp. <i>arundinaceum</i>	N	13.24	-
<i>Alopecurus myosuroides</i> Huds. subsp. <i>myosuroides</i>	N	0.46	-	<i>Lolium multiflorum</i> Lam.	N	2.74	-
<i>Alopecurus pratensis</i> L. subsp. <i>pratensis</i>	N	0.91	-	<i>Lolium perenne</i> L.	N	3.65	-
<i>Amaranthus retroflexus</i> L.	A	0.46	-	<i>Loncomelos pyrenaicus</i> (L.) L.D.Hrouda subsp. <i>pyrenaicus</i>	N	4.11	-
<i>Amorpha fruticosa</i> L.	A	9.59	-	<i>Lonicera caprifolium</i> L.	N	14.16	-

<i>Anacamptis laxiflora</i> (Lam.) R.M.Bateman, Pridgeon & M.W.Chase	PRE	0.46	RRL	<i>Lonicera japonica</i> Thunb.	A	9.13	-
<i>Anacamptis palustris</i> (Jacq.) R.M. Bateman, Pridgeon & M.W. Chase	PRE	0.46	NRL	<i>Lonicera xylosteum</i> L.	N	1.37	-
<i>Anemonoides nemorosa</i> (L.) Holub	N	14.16	-	<i>Lotus corniculatus</i> L. s.s.	N	16.44	-
<i>Angelica sylvestris</i> L.	N	3.20	-	<i>Lotus herbaceus</i> (Vill.) Jauzein	N	5.48	-
<i>Anisantha sterilis</i> (L.) Nevski	N	0.46	-	<i>Lotus maritimus</i> L.	N	0.46	-
<i>Anthericum ramosum</i> L.	N	0.91	-	<i>Luzula multiflora</i> (Ehrh.) Lej.	N	0.46	-
<i>Anthoxanthum</i> <i>odoratum</i> L. subsp. <i>odoratum</i>	N	4.57	-	<i>Lychnis flos-cuculi</i> L. subsp. <i>flos-cuculi</i>	N	2.28	-
<i>Anthriscus sylvestris</i> (L.) Hoffm.	N	0.46	-	<i>Lycopus europaeus</i> L.	N	5.02	-
<i>Aphanes arvensis</i> L.	N	0.46	-	<i>Lysimachia arvensis</i> (L.) U.Manns & Anderb.	N	0.46	-
<i>Arctium minus</i> (Hill) Bernh.	N	0.91	-	<i>Lysimachia nummularia</i> L.	N	5.02	-
<i>Aristolochia clematitis</i> L.	N	0.91	-	<i>Lysimachia vulgaris</i> L.	N	18.72	-
<i>Aristolochia rotunda</i> L. subsp. <i>rotunda</i>	N	1.37	-	<i>Lythrum salicaria</i> L.	N	34.25	-
<i>Armeria helodes</i> F.Martini & Poldini	PRE	1.83	HD	<i>Malus sylvestris</i> (L.) Mill.	N	0.91	-
<i>Arrhenatherum elatius</i> (L.) P.Beauv. ex J.Presl & C.Presl	N	8.22	-	<i>Medicago lupulina</i> L.	N	2.74	-
<i>Artemisia verlotiorum</i> Lamotte	A	0.46	-	<i>Medicago sativa</i> L.	A	2.74	-
<i>Artemisia vulgaris</i> L.	N	0.46	-	<i>Melica nutans</i> L.	N	0.46	-
<i>Arundo donax</i> L.	A	0.91	-	<i>Melittis melissophyllum</i> L.	N	2.28	-
<i>Asarum europaeum</i> L.	N	0.46	-	<i>Mentha aquatica</i> L. subsp. <i>aquatica</i>	N	6.39	-
<i>Asparagus tenuifolius</i> Lam.	N	9.59	-	<i>Mentha longifolia</i> (L.) L.	N	0.46	-
<i>Asperula cynanchica</i> L.	N	0.46	-	<i>Mentha spicata</i> L.	N	0.46	-
<i>Asplenium</i> <i>scolopendrium</i> L. subsp. <i>scolopendrium</i>	N	0.46	-	<i>Mercurialis perennis</i> L.	N	0.46	-
<i>Athyrium filix-foemina</i> (L.) Roth	N	2.28	-	<i>Molinia caerulea</i> (L.) Moench (incl. <i>Molinia</i> <i>arundinacea</i> Schrank)	N	14.61	-
<i>Avena barbata</i> Pott. ex Link. subsp. <i>barbata</i>	N	3.65	-	<i>Morus alba</i> L.	A	1.37	-
<i>Avenula pubescens</i> (Huds.) Dumort. subsp. <i>pubescens</i>	N	0.46	-	<i>Myosotis ramosissima</i> Rochel subsp. <i>ramosissima</i>	N	0.46	-
<i>Bellis perennis</i> L.	N	3.65	-	<i>Myosotis scorpioides</i> L. subsp. <i>scorpioides</i>	N	1.37	-
<i>Bergenia crassifolia</i> (L.) Fritsch	A	0.46	-	<i>Nasturtium officinale</i> R.Br.	N	0.46	-
<i>Berula erecta</i> (Huds.) Coville	N	3.65	-	<i>Neottia ovata</i> (L.) Bluff & Fingerh.	PRE	3.65	NRL

<i>Betonica officinalis</i> L.	N	5.48	-	<i>Nuphar lutea</i> (L.) Sm.	PRE	0.46	RRL
<i>Bidens frondosa</i> L.	A	4.57	-	<i>Oenothera biennis</i> L.	A	1.83	-
<i>Blackstonia perfoliata</i> (L.) Huds.	N	0.91	-	<i>Oenothera glazioviana</i> Micheli	A	0.46	-
<i>Bolboschoenus maritimus</i> (L.) Palla	N	0.46	-	<i>Ononis spinosa</i> L.	N	2.74	-
<i>Brachypodium rupestre</i> (Host) Roem. & Schult. subsp. <i>rupestre</i>	N	11.87	-	<i>Oplismenus undulatifolius</i> (Ard.) P. Beauv.	PRE	0.46	NRL
<i>Brachypodium sylvaticum</i> (Huds.) P.Beauv. subsp. <i>sylvaticum</i>	N	44.75	-	<i>Oreoselinum nigrum</i> Delarbre	N	1.37	-
<i>Briza media</i> L.	N	2.74	-	<i>Orobanche gracilis</i> Sm.	N	0.46	-
<i>Bromopsis erecta</i> (Huds.) Fourr.	N	5.48	-	<i>Oxalis articulata</i> Savigny	A	4.57	-
<i>Bromus hordeaceus</i> L.	N	7.76	-	<i>Oxalis corniculata</i> L.	N	6.39	-
<i>Bryonia dioica</i> Jacq.	N	1.37	-	<i>Oxalis stricta</i> L.	A	2.28	-
<i>Buphthalmum salicifolium</i> L.	N	3.65	-	<i>Parietaria officinalis</i> L.	N	5.02	-
<i>Calamagrostis epigejos</i> (L.) Roth subsp. <i>epigejos</i>	N	0.91	-	<i>Paris quadrifolia</i> L.	N	1.37	-
<i>Callitriche stagnalis</i> Scop.	N	0.46	-	<i>Parthenocissus quinquefolia</i> (L.) Planch.	A	2.28	-
<i>Caltha palustris</i> L.	PRE	2.28	RRL	<i>Paulownia tomentosa</i> (Thunb.) Steud.	A	0.46	-
<i>Calystegia sepium</i> (L.) R. Br.	N	12.33	-	<i>Pentanema hirtum</i> (L.) D. Gut.Larr., Santos-Vicente, Anderb., E. Rico & M.M. Mart.Ort.	N	0.46	-
<i>Campanula glomerata</i> L.	N	1.37	-	<i>Pentanema salicinum</i> (L.) D.Gut.Larr., Santos-Vicente, Anderb., E.Rico & M.M.Mart.Ort.	N	1.83	-
<i>Carex acutiformis</i> Ehrh.	N	5.48	-	<i>Persicaria lapathifolia</i> (L.) Delarbre	N	0.46	-
<i>Carex caryophyllea</i> Latourr.	N	0.46	-	<i>Persicaria maculosa</i> Gray	N	9.13	-
<i>Carex davalliana</i> Sm.	N	0.46	-	<i>Phalaris arundinacea</i> L.	N	0.91	-
<i>Carex distans</i> L.	N	7.31	-	<i>Phleum pratense</i> L.	N	0.46	-
<i>Carex divulsa</i> Stokes	N	6.39	-	<i>Phragmites australis</i> (Cav.) Trin. ex Steud.	N	33.33	-
<i>Carex elata</i> All. subsp. <i>elata</i>	N	2.28	-	<i>Phyllostachys aurea</i> Carrière ex Rivière & C.Rivière	A	0.46	-
<i>Carex flacca</i> Schreb.	N	22.83	-	<i>Picris hieracioides</i> L.	N	1.37	-
<i>Carex flava</i> L.	N	0.46	-	<i>Pilosella officinarum</i> Vaill.	N	0.46	-
<i>Carex hirta</i> L.	N	12.79	-	<i>Pilosella piloselloides</i> (Vill.) Soják	N	0.46	-
<i>Carex hostiana</i> DC.	N	0.46	-	<i>Pimpinella saxifraga</i> L.	N	0.46	-
<i>Carex lepidocarpa</i> Tausch subsp. <i>lepidocarpa</i>	N	0.46	-	<i>Pinus pinaster</i> Aiton	N	0.46	-
<i>Carex montana</i> L.	N	0.46	-	<i>Plantago altissima</i> L.	PRE	0.91	NRL
<i>Carex otrubae</i> Podp.	N	4.57	-	<i>Plantago lanceolata</i> L.	N	15.98	-
<i>Carex pairae</i> F.W.Schultz	N	1.37	-	<i>Plantago major</i> L.	N	0.91	-

<i>Carex pallescens</i> L.	N	0.46	-	<i>Plantago media</i> L.	N	0.46	-
<i>Carex panicea</i> L.	N	1.37	-	<i>Platanthera bifolia</i> (L.) Rchb.	PRE	0.46	NRL
<i>Carex pendula</i> Huds.	N	31.51	-	<i>Platanus hispanica</i> Miller ex Münchh.	A	28.77	-
<i>Carex pseudocyperus</i> L.	N	2.28	-	<i>Poa annua</i> L.	N	4.11	-
<i>Carex remota</i> L.	N	12.79	-	<i>Poa compressa</i> L.	N	0.91	-
<i>Carex riparia</i> Curtis	N	2.28	-	<i>Poa palustris</i> L. subsp. <i>palustris</i>	N	0.46	-
<i>Carex spicata</i> Huds.	N	3.20	-	<i>Poa pratensis</i> L.	N	4.57	-
<i>Carex sylvatica</i> Huds.	N	2.74	-	<i>Poa sylvicola</i> Guss.	N	19.18	-
<i>Carex tomentosa</i> L.	N	0.46	-	<i>Polygala comosa</i> Schkuhr	N	1.37	-
<i>Carex umbrosa</i> Host subsp. <i>umbrosa</i>	N	0.46	-	<i>Polygala vulgaris</i> L.	N	0.46	-
<i>Carex vesicaria</i> L.	N	3.65	-	<i>Polygonatum</i> <i>multiflorum</i> (L.) All.	N	11.87	-
<i>Carex viridula</i> Michx.	N	1.83	-	<i>Polygonatum odoratum</i> (Miller) Druce	N	0.46	-
<i>Carpinus betulus</i> L.	N	16.44	-	<i>Populus alba</i> L.	N	2.74	-
<i>Celtis australis</i> L. subsp. <i>australis</i>	N	0.46	-	<i>Populus nigra</i> L. subsp. <i>nigra</i>	N	18.72	-
<i>Centaurea jacea</i> L. subsp. <i>forojulensis</i> (Poldini) Greuter	PRE	5.02	NRL	<i>Populus tremula</i> L.	N	0.46	-
<i>Centaurea nigrescens</i> Willd.	N	1.37	-	<i>Potamogeton natans</i> L.	N	0.46	-
<i>Centaurea scabiosa</i> L.	N	0.91	-	<i>Potentilla erecta</i> (L.) Räuschel	N	11.42	-
<i>Centaureum erythraea</i> Rafn	N	4.57	-	<i>Potentilla indica</i> (Jacks.) Th.Wolf	A	14.61	-
<i>Centaureum pulchellum</i> (Sw.) Druce subsp. <i>pulchellum</i>	N	0.46	-	<i>Potentilla reptans</i> L.	N	39.73	-
<i>Cerastium</i> <i>brachypetalum</i> Desportes & Pers.	N	1.83	-	<i>Poterium sanguisorba</i> L.	N	0.91	-
<i>Cerastium holosteoides</i> Fr.	N	0.46	-	<i>Primula vulgaris</i> Huds.	N	7.76	-
<i>Cervaria rivini</i> Gaertn.	N	2.28	-	<i>Prunella grandiflora</i> (L.) Scholler	N	0.91	-
<i>Chamaeiris graminea</i> (L.) Medik.	N	0.46	-	<i>Prunella laciniata</i> (L.) L.	N	0.91	-
<i>Chelidonium majus</i> L.	N	0.46	-	<i>Prunella vulgaris</i> L.	N	2.28	-
<i>Chenopodium album</i> L.	N	1.37	-	<i>Prunus avium</i> L.	N	5.48	-
<i>Chrysopogon gryllus</i> (L.) Trin.	N	3.65	-	<i>Prunus cerasifera</i> Ehrh.	A	0.91	-
<i>Cichorium intybus</i> L.	N	2.74	-	<i>Prunus domestica</i> L.	A	3.20	-
<i>Circaea lutetiana</i> L.	N	3.65	-	<i>Prunus mahaleb</i> L.	N	0.46	-
<i>Cirsium arvense</i> (L.) Scop.	N	4.57	-	<i>Prunus padus</i> L. subsp. <i>padus</i>	N	3.65	-
<i>Cirsium canum</i> (L.) All.	PRE	0.46	NRL	<i>Prunus serotina</i> Ehrh.	A	1.37	-
<i>Cirsium oleraceum</i> (L.) Scop.	N	1.83	-	<i>Prunus spinosa</i> L.	N	13.70	-
<i>Cirsium palustre</i> (L.) Scop.	N	3.65	-	<i>Pulicaria dysenterica</i> (L.) Bernh.	N	0.46	-
<i>Cirsium vulgare</i> (Savi) Ten.	N	3.20	-	<i>Pulmonaria officinalis</i> L.	N	5.94	-
<i>Cladium mariscus</i> (L.) Pohl	N	12.33	-	<i>Pyracantha coccinea</i> M. Roem.	N	0.46	-
<i>Clematis recta</i> L.	N	2.74	-	<i>Pyrus communis</i> L.	N	1.83	-

<i>Clematis vitalba</i> L.	N	17.35	-	<i>Quercus robur</i> L.	N	53.42	-
<i>Clematis viticella</i> L.	N	10.96	-	<i>Ranunculus acris</i> L.	N	9.59	-
<i>Clinopodium vulgare</i> L.	N	1.83	-	<i>Ranunculus auricomus</i> L. aggr.	N	4.57	-
<i>Colchicum autumnale</i> L.	N	2.74	-	<i>Ranunculus bulbosus</i> L.	N	1.83	-
<i>Convolvulus arvensis</i> L.	N	5.02	-	<i>Ranunculus</i> <i>polyanthemophyllus</i> W.Koch & H.E.Hess	N	1.37	-
<i>Cornus mas</i> L.	N	3.20	-	<i>Ranunculus repens</i> L.	N	0.91	-
<i>Cornus sanguinea</i> L.	N	54.34	-	<i>Ranunculus sardous</i> Crantz	N	0.91	-
<i>Corylus avellana</i> L.	N	36.99	-	<i>Raphanus raphanistrum</i> L.	N	0.46	-
<i>Crataegus laevigata</i> (Poir.) DC.	N	5.48	-	<i>Rhamnus cathartica</i> L.	N	7.31	-
<i>Crataegus monogyna</i> Jacq.	N	20.55	-	<i>Robinia pseudoacacia</i> L.	A	15.53	-
<i>Crepis capillaris</i> (L.) Wallr.	N	1.37	-	<i>Rosa canina</i> aggr.	N	11.87	-
<i>Crepis foetida</i> subsp. <i>rhoeadifolia</i> (M. Bieb.) Čelak.	A	1.37	-	<i>Rubus caesius</i> L.	N	63.47	-
<i>Crepis taraxacifolia</i> Thuill.	N	2.74	-	<i>Rubus ulmifolius</i> Schott	N	57.08	-
<i>Crocus vernus</i> (L.) Hill	N	0.91	-	<i>Rudbeckia laciniata</i> L.	A	0.46	-
<i>Cruciata glabra</i> (L.) C.Bauhin ex Opiz	N	1.37	-	<i>Rumex acetosa</i> L. subsp. <i>acetosa</i>	N	1.37	-
<i>Cynodon dactylon</i> (L.) Pers.	N	0.46	-	<i>Rumex acetosella</i> L.	N	0.46	-
<i>Cynosurus cristatus</i> L.	N	0.46	-	<i>Rumex conglomeratus</i> Murray	N	2.74	-
<i>Cyperus esculentus</i> L.	A	0.46	-	<i>Rumex crispus</i> L.	N	5.48	-
<i>Cyperus longus</i> L.	N	0.46	-	<i>Rumex obtusifolius</i> L.	N	2.74	-
<i>Dactylis glomerata</i> L.	N	25.11	-	<i>Ruscus aculeatus</i> L.	PRE	8.68	HD
<i>Danthonia decumbens</i> (L.) DC.	N	0.91	-	<i>Salix alba</i> L.	N	45.21	-
<i>Daphne mezereum</i> L.	N	0.46	-	<i>Salix babylonica</i> L.	A	0.46	-
<i>Daucus carota</i> L.	N	11.87	-	<i>Salix cinerea</i> L.	N	36.99	-
<i>Deschampsia cespitosa</i> (L.) P.Beauv.	N	3.65	-	<i>Salix purpurea</i> L.	N	6.39	-
<i>Dianthus hyssopifolius</i> L.	N	0.46	-	<i>Salvia pratensis</i> L. subsp. <i>pratensis</i>	N	1.37	-
<i>Dioscorea communis</i> (L.) Caddick & Wilkin	N	23.29	-	<i>Sambucus ebulus</i> L.	N	0.46	-
<i>Dipsacus fullonum</i> L.	N	0.91	-	<i>Sambucus nigra</i> L.	N	18.72	-
<i>Drosera rotundifolia</i> L.	PRE	0.46	RRL	<i>Samolus valerandi</i> L.	N	0.91	-
<i>Dryopteris filix-mas</i> aggr.	N	3.20	-	<i>Sanguisorba officinalis</i> L.	N	5.02	-
<i>Echinochloa crus-galli</i> (L.) P.Beauv.	N	0.46	-	<i>Scabiosa triandra</i> L.	N	3.65	-
<i>Elymus repens</i> (L.) Gould subsp. <i>repens</i>	N	1.83	-	<i>Schoenoplectus lacustris</i> (L.) Palla	N	0.91	-
<i>Epilobium hirsutum</i> L.	N	2.74	-	<i>Schoenus nigricans</i> L.	N	9.13	-
<i>Epilobium parviflorum</i> Schreb.	N	1.37	-	<i>Scirpoides holoschoenus</i> (L.) Soják	N	10.50	-
<i>Epilobium tetragonum</i> L.	N	0.91	-	<i>Scrophularia canina</i> L.	N	0.46	-
<i>Epipactis palustris</i> (L.) Crantz	PRE	1.37	NRL	<i>Scrophularia nodosa</i> L.	N	0.91	-

<i>Equisetum arvense</i> L.	N	10.96	-	<i>Scrophularia umbrosa</i> Dumort. subsp. <i>umbrosa</i>	N	0.91	-
<i>Equisetum palustre</i> L.	N	9.13	-	<i>Sechium edule</i> (Jacq.) Sw.	A	0.46	-
<i>Equisetum ramosissimum</i> Desf.	N	5.48	-	<i>Senecio fontanicola</i> Grulich & Hodálová	PRE	2.74	NRL
<i>Equisetum telmateia</i> Ehrh.	N	22.37	-	<i>Serratula tinctoria</i> L. subsp. <i>tinctoria</i>	N	3.20	-
<i>Erigeron annuus</i> (L.) Pers.	A	10.50	-	<i>Sesleria uliginosa</i> Opiz	PRE	1.37	NRL
<i>Erigeron canadensis</i> L.	A	0.46	-	<i>Setaria pumila</i> (Poir.) Roem. & Schult.	N	0.91	-
<i>Erucastrum palustre</i> (Pirona) Vis.	PRE	0.91	HD	<i>Silene baccifera</i> (L.) Durande	N	0.46	-
<i>Euonymus europaea</i> L.	N	10.50	-	<i>Silene latifolia</i> Poir.	N	0.46	-
<i>Eupatorium</i> <i>cannabinum</i> L.	N	13.70	-	<i>Silene vulgaris</i> (Moench) Garcke	N	0.91	-
<i>Euphorbia</i> <i>amygdaloides</i> L.	N	1.37	-	<i>Silphiodaucus</i> <i>prutenicus</i> (L.) Spalik, Wojew., Banasiak, Piwczyński & Reduron	N	0.46	-
<i>Euphorbia cyparissias</i> L.	N	0.46	-	<i>Solanum dulcamara</i> L.	N	5.02	-
<i>Euphorbia dulcis</i> L.	N	3.65	-	<i>Solidago canadensis</i> L.	A	0.46	-
<i>Euphorbia illirica</i> Lam.	PRE	0.46	R	<i>Solidago gigantea</i> Aiton	A	4.57	-
<i>Euphorbia nutans</i> Lag.	A	0.91	-	<i>Sonchus oleraceus</i> L.	N	0.46	-
<i>Euphorbia palustris</i> L.	N	0.46	-	<i>Sorbus torminalis</i> (L.) Crantz	N	0.46	-
<i>Euphorbia peplus</i> L.	N	0.46	-	<i>Sorghum halepense</i> (L.) Pers.	A	4.11	-
<i>Euphorbia platyphyllos</i> L.	N	0.91	-	<i>Sparganium neglectum</i> Beeby	N	0.46	-
<i>Euphorbia verrucosa</i> L.	N	3.65	-	<i>Stachys palustris</i> L.	N	0.91	-
<i>Festuca heterophylla</i> Lam.	N	0.46	-	<i>Stachys sylvatica</i> L.	N	0.46	-
<i>Festuca rubra</i> L.	N	10.96	-	<i>Stellaria aquatica</i> (L.) Scop.	N	0.46	-
<i>Ficaria verna</i> Huds.	N	0.91	-	<i>Stellaria holostea</i> L. subsp. <i>holostea</i>	N	0.46	-
<i>Ficus carica</i> L.	N	1.83	-	<i>Succisa pratensis</i> Moench	N	0.46	-
<i>Filipendula ulmaria</i> (L.) Maxim.	N	15.07	-	<i>Symphytum officinale</i> L.	N	9.59	-
<i>Filipendula vulgaris</i> Moench	N	6.85	-	<i>Symphytum tuberosum</i> L. subsp. <i>angustifolium</i> (A.Kern.) Nyman	N	2.74	-
<i>Fragaria vesca</i> L.	N	10.50	-	<i>Taraxacum</i> sect. <i>Taraxacum</i>	N	16.89	-
<i>Frangula alnus</i> Mill. subsp. <i>alnus</i>	N	19.63	-	<i>Thalictrum</i> <i>aquilegiifolium</i> L. subsp. <i>aquilegiifolium</i>	N	3.20	-
<i>Fraxinus angustifolia</i> Vahl subsp. <i>oxycarpa</i> (M.Bieb. ex Willd.) Franco & Rocha Afonso	N	18.72	-	<i>Thalictrum lucidum</i> L.	N	5.02	-
<i>Fraxinus excelsior</i> L. subsp. <i>excelsior</i>	N	9.59	-	<i>Thymus pulegioides</i> L.	N	2.28	-
<i>Fraxinus ornus</i> L. subsp. <i>ornus</i>	N	9.13	-	<i>Tofieldia calyculata</i> (L.) Wahlenb.	N	0.46	-

<i>Galega officinalis</i> L.	A	0.46	-	<i>Torilis arvensis</i> (Huds.) Link	N	2.28	-
<i>Galeopsis pubescens</i> Besser	N	0.46	-	<i>Trachycarpus fortunei</i> (Hooker) Wendl.	A	4.57	-
<i>Galium aparine</i> L.	N	2.74	-	<i>Tragopogon dubius</i> Scop.	N	1.37	-
<i>Galium laevigatum</i> L.	N	1.37	-	<i>Tragopogon orientalis</i> L.	N	6.39	-
<i>Galium mollugo</i> L.	N	12.79	-	<i>Trifolium campestre</i> Schreb.	N	3.20	-
<i>Galium palustre</i> L.	N	3.20	-	<i>Trifolium fragiferum</i> L. subsp. <i>fragiferum</i>	N	0.46	-
<i>Galium verum</i> L.	N	9.59	-	<i>Trifolium montanum</i> L. subsp. <i>montanum</i>	N	1.37	-
<i>Genista tinctoria</i> L.	N	3.20	-	<i>Trifolium pratense</i> L.	N	10.96	-
<i>Geranium dissectum</i> L.	N	4.11	-	<i>Trifolium repens</i> L.	N	5.94	-
<i>Geranium nodosum</i> L.	N	0.46	-	<i>Trifolium rubens</i> L.	N	1.83	-
<i>Geranium pusillum</i> L.	N	1.83	-	<i>Trigonella alba</i> (Medik.) Coulot & Rabaute	N	0.91	-
<i>Geum urbanum</i> L.	N	20.09	-	<i>Trisetaria flavescens</i> (L.) Baumg. subsp. <i>flavescens</i>	N	0.46	-
<i>Gladiolus illyricus</i> W.D.J.Koch	N	0.46	-	<i>Tussilago farfara</i> L.	N	0.46	-
<i>Gladiolus palustris</i> Gaudin	PRE	4.57	HD	<i>Ulmus minor</i> Miller	N	25.11	-
<i>Glechoma hederacea</i> L.	N	12.79	-	<i>Urtica dioica</i> L.	N	17.81	-
<i>Gleditsia triacanthos</i> L.	A	0.46	-	<i>Utricularia vulgaris</i> L.	N	0.46	-
<i>Gratiola officinalis</i> L.	N	0.91	-	<i>Valeriana dioica</i> L.	N	1.37	-
<i>Gymnadenia conopsea</i> (L.) R.Br.	PRE	0.91	NRL	<i>Valeriana officinalis</i> L.	N	29.68	-
<i>Hedera helix</i> L.	N	51.14	-	<i>Verbena officinalis</i> L.	N	9.13	-
<i>Helianthemum nummularium</i> (L.) Mill.	N	0.91	-	<i>Veronica arvensis</i> L.	N	1.37	-
<i>Helminthotheca echioides</i> (L.) Holub	N	1.37	-	<i>Veronica beccabunga</i> L.	N	0.46	-
<i>Heracleum sphondylium</i> L. subsp. <i>sphondylium</i>	N	0.91	-	<i>Veronica chamaedrys</i> L. subsp. <i>chamaedrys</i>	N	0.46	-
<i>Holcus lanatus</i> L.	N	22.83	-	<i>Veronica officinalis</i> L.	N	0.46	-
<i>Houttuynia cordata</i> Thunb.	A	0.46	-	<i>Veronica persica</i> Poir.	A	3.65	-
<i>Humulus lupulus</i> L.	N	26.94	-	<i>Veronica serpyllifolia</i> L.	N	0.46	-
<i>Hypericum perforatum</i> L.	N	10.50	-	<i>Viburnum lantana</i> L.	N	10.50	-
<i>Hypericum tetrapterum</i> Fr.	N	0.91	-	<i>Viburnum opulus</i> L.	N	24.66	-
<i>Hypochaeris maculata</i> L.	N	0.91	-	<i>Vicia cracca</i> L.	N	0.46	-
<i>Hypochaeris radicata</i> L.	N	0.91	-	<i>Vicia sativa</i> L.	N	1.83	-
<i>Impatiens glandulifera</i> Royle	A	0.46	-	<i>Vicia tenuifolia</i> Roth	N	0.46	-
<i>Jacobaea vulgaris</i> Gaertn.	N	0.46	-	<i>Vicia villosa</i> Roth	N	1.37	-
<i>Juglans nigra</i> L.	A	1.83	-	<i>Vinca major</i> L. subsp. <i>major</i>	N	1.37	-
<i>Juglans regia</i> L.	A	12.33	-	<i>Vinca minor</i> L.	N	0.46	-
<i>Juncus articulatus</i> L. subsp. <i>articulatus</i>	N	6.85	-	<i>Vincetoxicum hirundinaria</i> Medik.	N	8.22	-
<i>Juncus compressus</i> Jacq.	N	0.91	-	<i>Viola hirta</i> L.	N	2.74	-

<i>Juncus conglomeratus</i> L.	N	0.91	-	<i>Viola odorata</i> L.	N	4.57	-
<i>Juncus effusus</i> L. subsp. <i>effusus</i>	N	1.83	-	<i>Viola reichenbachiana</i> Jord. ex Boreau	N	9.13	-
<i>Juncus inflexus</i> L. subsp. <i>inflexus</i>	N	0.46	-	<i>Viola riviniana</i> Rchb.	N	0.46	-
<i>Juncus subnodulosus</i> Schrank	N	0.46	-	<i>Vitis vinifera</i> L.	N	2.74	-
<i>Knautia illyrica</i> Beck	N	1.83	-	<i>Xanthoselinum venetum</i> (Spreng.) Soldano & Banfi	N	1.37	-
<i>Knautia ressmannii</i> (Pacher) Briq.	PRE	1.37	E				

CRedit author statement

Francesco Liccari: Methodology, Formal Analysis, Investigation, Data Curation, Writing- Original draft preparation.

Francesco Boscutti: Conceptualization, Methodology, Investigation, Writing - Review & Editing, Supervision.

Giovanni Bacaro: Methodology, Writing - Review & Editing, Supervision.

Maurizia Sigura: Conceptualization, Writing - Review & Editing, Supervision, Project administration.