

Agriculture, Ecosystems and Environment

Land-use intensification reduces multi-taxa diversity patterns of Small Woodlots Outside Forests in a Mediterranean area

--Manuscript Draft--

Manuscript Number:	AGEE32413R1
Article Type:	Research Paper
Keywords:	Land-use influence; Trees Outside Forests; multi-taxa diversity patterns; ground-dwelling invertebrates; Coleoptera; Hymenoptera, Pseudoscorpiones; Araneae; vascular plants
Corresponding Author:	ERIKA BAZZATO, Ph.D. University of Cagliari Department of Life Sciences and Environment: Universita degli Studi di Cagliari Dipartimento di Scienze della Vita e dell'Ambiente Cagliari, Italy ITALY
First Author:	ERIKA BAZZATO, Ph.D.
Order of Authors:	ERIKA BAZZATO, Ph.D. Erik Lallai, Dr. Michele Caria, Dr. Enrico Schifani, Dr. Davide Cillo Cesare Ancona Federico Alamanni, Dr. Paolo Pantini, Dr. Simona Maccherini, Prof. Giovanni Bacaro, Prof. Michela Marignani, Prof.
Manuscript Region of Origin:	ITALY
Abstract:	<p>Land-use intensification exacerbates landscape fragmentation, increasing the negative effects on biodiversity. In this context, the biodiversity value of Trees Outside Forests (TOF; scattered trees, tree lines and small woodlots) is often overlooked by landscape planning and conservation programs, which typically focus on protecting larger and more intact areas. More empirical studies on taxa inhabiting TOF are needed to support and promote their conservation in human-altered lands.</p> <p>However, we are not aware of any study focusing on multiple taxa living in small woodlots outside forests (SWOFs) in the Mediterranean basin. We investigated how diversity patterns of multiple taxa in SWOFs respond to a land-use intensification gradient, from natural areas to more disturbed ones (agricultural and urban areas), in a Mediterranean biodiversity hotspot.</p> <p>We explored the influence of land-use types on species richness and composition of vascular plants and six ground-dwelling invertebrate groups (pseudoscorpions, spiders, darkling beetles, rove beetles, ground beetles, and ants). Species composition was more sensitive than species richness to land-use change, highlighting the need to consider a suitable measure for interpreting ecological processes. We observed a strong influence of land use embedding SWOFs on the mean composition and beta diversity of taxa: land-use intensification led to a general homogenization of diversity patterns, especially among agricultural and urban areas. In our study area, vascular plants responded more sensitively to land-use change than invertebrates. For most invertebrates: the higher the land-use intensity, the lower the species composition dissimilarity due to the dominance of good dispersers or disturbance-tolerant species. More vagile species and disturbance-tolerant species can move across open habitats and colonize new areas, reducing compositional differences and potentially boosting species pools. We demonstrated that SWOFs play a key role in supporting viable</p>

	<p>populations of invertebrates, also in human-altered lands, underlining the need to promote their conservation in this Mediterranean fragmented landscape to avoid homogenization from driving a generalized biodiversity loss.</p>
Suggested Reviewers:	<p>Simone Fattorini, Prof University of L'Aquila Department of Clinical Medicine Life Health and Environmental Sciences: Università degli Studi dell'Aquila Dipartimento di Medicina Clinica Sanita Pubblica Scienze della Vita e dell'Ambiente simone.fattorini@univaq.it Simone Fattorini is an ecologist and evolutionary biologist, expert in the field of insect biogeography, community ecology and conservation biology in island, coastal and urban ecosystems.</p>
	<p>Maria Laura Carranza, Prof University of Molise Department of Bioscience and Environment: Università degli Studi del Molise Dipartimento di Bioscienze e Territorio carranza@unimol.it M.L. Carranza is a ecologist, expert in the field of Plant Ecology, Landscape ecology, community ecology and conservation biology. Her research interest includes quantitative ecology, mainly applied to these disciplines.</p>
	<p>Federico Morelli, Prof Czech University of Life Sciences Prague Faculty of Environmental Sciences: Ceska Zemedelska Univerzita v Praze Fakulta Zivotniho Prostredi morelli@fzp.czu.cz Federico Morelli is a quantitative ecologist. He has been involved in several European projects modelling the impact of land use and climate change on spatial distribution of biodiversity. The main focus of his research interests are macro ecology, species distribution models, landscape metrics and biodiversity patterns and bioindicators useful for conservation planning.</p>
	<p>Pablo Hidalgo Fernández, Prof University of Huelva Faculty of Experimental Sciences: Universidad de Huelva Facultad de Ciencias Experimentales hidalgo@uhu.es P.H. Fernández is a quantitative ecologist, expert in the field of insect Ecology, biodiversity, conservation biology, Forest ecology, Forest conservation, and Ecosystem ecology.</p>
	<p>Xim Cerdá, Prof Spanish National Research Council: Consejo Superior de Investigaciones Cientificas xim@ebd.csic.es Xim Cerdá is a community and evolutionary ecologist working with insects, adopting a multi-focus approach that combines Community and Functional Ecology, behavioural ecology, chemical ecology, morphology, phylogeography and physiology.</p>

Land-use intensification reduces multi-taxa diversity patterns of Small Woodlots Outside Forests in a Mediterranean area

Erika Bazzato^{1*}, Erik Lallai¹, Michele Caria¹, Enrico Schifani², Davide Cillo³, Cesare Ancona⁴, Federico Alamanni¹, Paolo Pantini⁵, Simona Maccherini⁶, Giovanni Bacaro⁷, Michela Marignani¹

¹Department of Life and Environmental Sciences, University of Cagliari, Via Sant' Ignazio da Laconi, 13, 09123 Cagliari, Italy.

²Department of Chemistry, Life Sciences & Environmental Sustainability, University of Parma, Parco Area delle Scienze, 11/a, 43124 Parma, Italy.

³Via Zeffiro 8, 09126 Cagliari, Italy.

⁴Via Mascagni 3, 09020 Ussana, Italy.

⁵Museo Civico di Scienze Naturali "E. Caffi", Piazza Cittadella 10, 24129, Bergamo, Italy.

⁶Department of Life Sciences, University of Siena, Via P.A. Mattioli 4, 53100 Siena, Italy.

⁷Department of Life Sciences, University of Trieste, Via L. Giorgieri 10, 34127 Trieste, Italy.

*Corresponding author: Erika Bazzato, erika.bazzato@hotmail.it

Acknowledgements

We are very grateful to Giulio Gardini and Jan Matějčiček, respectively, for the identification of pseudoscorpions and rove beetles. We also thank Leonardo Rosati for supporting and confirming the identification of plant species. Our gratitude also goes to the director Marco Valle and all the staff of the Museo Civico di Scienze Naturali "E. Caffi" in Bergamo for their hospitality and for placing their equipment at our disposal. We also thank Francesca Ganga, Elisa Serra, and Andrea Ambus, who kindly helped with the fieldwork or laboratory activities.

Author contribution

E.B. designed the study and the methodology, collected and analyzed the data, and wrote the manuscript. E.B., E.L., M.C., C.A., and F.A. helped with the fieldwork and laboratory activities. E.B., E.L., M.C., P.P., E.S., D.C., and F.A. identified specimens.

E.S. contributed to drafting the manuscript. M.M., S.M., and G.B. designed the methodology, supporting statistical analyses and revising the article for important intellectual content. M.M. supervised the research project. All authors revised the manuscript and gave final approval for publication.

Conflict of Interest Statement

The authors declare that they have no conflict of interest. Any research in the paper not carried out by the authors is acknowledged in the manuscript and all forms of approval, whether they be of ethical or other nature, were obtained for this research.

Dear Editor,

Thank you for the very careful review of our paper, and for the comments, corrections and suggestions that ensued. A revision of the paper has been carried out to take all of them into account. In the process, we believe the paper has been significantly improved.

In the present "Revision notes", we first detail the major changes that have been made in the paper to correct the main weaknesses identified by the review. We then sequentially address all the points raised by the referees.

Best regards,

The Authors

REVISION NOTES

Land-use intensification reduces multi-taxa diversity patterns of Small Woodlots Outside Forests in a Mediterranean area

REFeree #1

We thank the first referee for valuable suggestions and critical comments. We adopted all.

GENERAL COMMENT

[...] First, concerning the biodiversity conservation value of SWOFS, I think that a similar system is that of sacred forests that are found all over the world. There are some interesting papers focusing on ants (which is the subject in which I am an expert, sorry to be so ant-centered) about these sacred forests, but also about isolated trees and their ecological role that could help to the authors to enlarge their focus and discussion: Martinez JJI, Amar Z (2014) [...]; Nooten SS, Lee RH, Guénard B (2021) [...]; Reyes-López J, Ruiz N, Fernández-Haeger J (2003) [...]; Majer JD, Delabie JHC (1999) [...]; Gove AD, Majer JD, Rico-Gray V (2005) [...]; Zara L, Tordoni E, et al (2021). [...]

Authors' answer:

We appreciate the suggestion with regard to the incorporation of the above references, which permitted us to include aspects (see lines 402 and 421-426 in text marked) that, despite their relevance, were only marginally taken into account in the original version.

SPECIFIC COMMENTS

We adopted the following changes:

REF#1 LINES 115-116: "using pitfall traps located in the centre of each five-replicated plot". I understand that it is one pitfall trap in the centre of each plot, but please, indicate it. And indicate also (as indicated for vascular plants: LINE 113) that trap contents of the five plots per SWOF were summed for calculations.

Authors' answer:

Done, see lines 116-117

REF#1 LINES 118 and following: (about trap losses). According with the Appendix A:

"The annual activity density of each species (aAD) was calculated by dividing the number of collected individuals during the entire sampling period (tot indiv) with the total (yearly) trapping effort (TE) for each sampled SWOF: Eq. (A.1) $aAD = \text{tot indiv} / TE$; $TE = \sum te$; $te = \text{trap} * (dd/15)$, where trap is the number of active traps and dd is the number of days during which traps were active in each sampling session (Brandmayr et al., 2005)."

But with your formula, since you divided by 15, you are calculating the active number of individuals who fall into a trap during that period of the year within 15 days. However, the original formula of Brandmayr was dividing by 10 (for periods of 10 days). This difference between 10-days or 15-days period is not a big issue, but since it represents a modification with respect to the formula indicated in the reference, it should be indicated. On the other hand, I would propose to include these calculations about aAD in the main text of Data collection.

Authors' answer:

Following the suggestion, we included details on activity density calculation in the main text of the Data collection (see lines 122-130), and we specified the modification concerning the formula indicated in the reference (Brandmayr et al., 2005) (see lines 131-133 in text marked).

REF#1 LINES 193-196: In the Fig. 2 it seems that there are other disjoint curves that could significantly differ: (a2) AGR Pseudoscorpions Simpson's diversity, (D2) NAT Rove beetles Simpson's diversity. If yes, please cite in the text. I think that it could be important to comment also that there are no significant results for invertebrates richness, something like: "For all invertebrate groups, the 95% confidence intervals from different land-use habitats overlap, implying that diversity estimates did not differ significantly".

Authors' answer:

As suggested by the reviewer, we cited the other disjoint curves that could significantly differ for Simpson's diversity profile in Pseudoscorpions and Rove beetles (see lines 209-212 in text marked). We also integrated the suggested phrase in the Results section (see lines 207-209 in text marked).

REF#1 LINES 254 – 257: I agree with the authors about the promising potential use of Pseudoscorpions as bioindicators. However, they must be cautious when interpreting their results about this group, because I am not sure that pitfall traps are the best method to inventory Pseudoscorpions; they just caught 390 individuals, when from the other groups (out of ants) trap catches were between one thousand and seven thousand. Aguiar et al (2006) used both hand-sorting method and Berlese-Tullgren extraction in their study, probably a better-matched reference (where pitfall traps -and other sampling methods- were used to sample pseudoscorpions) could be Battirola et al (2017) Vertical and time distribution of Pseudoscorpiones (Arthropoda: Arachnida) in a floodplain forest in the Brazilian Pantanal. *Rev Biol Trop* 65: 445- 459. DOI 10.15517/rbt.v65i2.24134 (<https://revistas.ucr.ac.cr/index.php/rbt/article/view/24134>)

Authors' answer:

We agree with the referee that the species richness, abundances and activity density of pseudoscorpions were lesser than that observed for other arthropod groups. However, different studies reported a low level of diversity for pseudoscorpions, even adopting different sampling methods (e.g., hand-sorting method, Berlese-Tullgren or traps), reporting richness values ranging from 7 to 14 species (see Aguiar et al., 2006 for a complete list).

In line with these studies, we caught 13 species of pseudoscorpions in the study area, finding a significant variation of beta-diversity patterns among different land-use types, suggesting that "This result may be promising to consider pseudoscorpions as good indicators to monitor land-use changes". However, the

reviewer's concerns have been considered, changing the modal verb to express a greater doubt and an increase in uncertainty of the assertion. We also checked the suggested reference (Battirola et al., 2017) and integrated some others (Liebke et al., 2021; Villarreal et al., 2019) to improve the discussion a little bit (see lines 276-278 in text marked).

REF#1 LINE 375 and following: It is interesting the finding of the social parasite *Plagiolepis xene*. There is a paper proposing to use ant social parasitic species as habitat bio-indicators of low disturbance: Bernal V, Espadaler X (2013) Invasive and socially parasitic ants are good bioindicators of habitat quality in Mediterranean forest remnants in northeast Spain. *Ecol Res* 28: 1011-107. doi:10.1007/s11284-013-1083-4.

Authors' answer:

Thank you for this interesting suggestion. We now briefly discuss a comparison between our results and those obtained by Bernal & Espadaler. In our case, alien species were associated with the most disturbed/anthropogenic habitats as in Bernal & Espadaler, however, we did not notice opposite trends concerning social parasites. The only parasitic species we collected, *P. xene*, was widespread across the disturbance gradient exactly like its host *P. pygmaea*. Probably being dependent on a very generalist and disturbance-tolerant host species, combined with a good dispersal capability, makes *P. xene* not vulnerable to habitat disturbance. There are indeed other examples where specific socially parasitic ant species are not associated with low disturbance, perhaps the most striking case is that of *Tetramorium atratum* which exploited one of its possible hosts, the invasive urban ant *Tetramorium immigrans*, to expand in urban habitats across both Europe and even the US where it represents an alien species.

REF#1 Concerning the Appendix A: it is extremely long (e.g., only Table A17 showing the SIMPER results has an extension of 25 pages). I don't know if it is necessary to include so much information or the authors should try to cut it down a bit. In any case, if the editor agrees, all information is interesting.

Authors' answer:

The appendix is extremely long due to the cut-off level of 90% adopted for low contributions in the SIMPER. Although Table A17 is very long, we decided to include all results in the original version of the appendix because this cut-off highlighted all species that characterized differences among land-use types. We agree with the referee that all these results are interesting, and also useful for the discussion, especially for taxonomic groups where the richness was lower than others. For these taxonomic groups, the adoption of a low cut-off level determines the loss of much information about singletons and doubletons that explain the observed differences among land-use types (mentioned in the discussion). However, we followed the referee's suggestion by cutting results using another threshold (cut-off level of 70%) for spiders and plants, significantly reducing the table length.

REF#1 Fig.2: In the Figure 2 the Y-axis legend (species diversity) is misleading, since the left panel shows species richness, I would propose to put only "diversity" to include the three Hill-numbers.

Authors' answer:

Done, see page 2 in the file called "Figures"

REFEREE #3

We thank the third referee for his/her critical comments. We provided a clarification for the main concern in the following section, and we adopted all referee suggestions.

GENERAL COMMENTS

REF#3: Firstly, there is the case study carried out in the city of Cagliari as an example of the conditions of the Mediterranean basin; I do not believe that this is correct both in terms of climate and in terms of land use, urban planning and agriculture. It would be more honest to say that this is an interesting case study of the Mediterranean area but that one cannot extrapolate the conclusions as an example and for the whole basin.

Authors' answer:

We highly appreciate the reviewer's comment regarding the result generalization of our study. We agree with the referee that the conditions of the Mediterranean basin are different, both in terms of climate and in terms of land use, urban planning and agriculture practices. Our intention was not to extend results, discussion and conclusion to the whole Mediterranean basin. Maybe we were not very explicit in some sentences. To clarify that some phrases were referred to our case study, we included some specifications along the text, such as "In our study area", "in this Mediterranean fragmented landscape", "in the investigated gradient", "observed in this study" (see for example lines 18, 25, 288, 312, 317 in text marked). In addition, we have added in the conclusion section an explicit statement regarding the need for further investigation is required to assess how similar the ecological trends we documented in Sardinia are to those from other Mediterranean areas (see lines 432-435 in text marked).

REF#3: The question that seems fundamental for this kind of studies is to understand what impact different spatial patterns of urbanization and agricultural intensification can have on biodiversity.

It is evident that these phenomena manifest themselves in a very different way when they are analyzed at such a detailed scale as is proposed in the article. The type of area that is proposed in the study can take on very different connotations in different Italian urban areas or even more at the Mediterranean level. I therefore suggest that we consider the results as a very interesting study but with a limited general meaning. It would also be desirable for the assessment in terms of biodiversity to be more accurately related to the spatial and urban model taken into account.

Authors' answer:

We agree that it would be interesting to explore the effect of different urban models or degrees of agricultural intensification on biodiversity in future studies. However, our study was designed to focus specifically on the effect of a land-use intensification gradient on species richness and composition, considering that: (i) we did not recognize either different urbanization models or different degrees of agricultural intensification in our study area; (ii) we only identified the presence of a gradient of land-use intensification that runs roughly in a north-east/south-west direction from natural and semi-natural areas (NAT) at higher altitudes to more disturbed ones at lower altitudes (agricultural areas, AGR; urban and artificial areas, URB).

However, we are aware that it could be interesting to relate our results to the spatial patterns at landscape level and specifically to the spatial habitat heterogeneity. Because of this, we directly linked our findings to the intermediate disturbance hypothesis in the discussion section of the first version of the manuscript, considering that the intermediate disturbance may favour biodiversity by increasing resource heterogeneity (please, see lines 295-308 in text marked). Perhaps in the first version of the manuscript, we did not explain this link clearly enough. Thus, we have taken into account the referee's suggestion of integrating a more details explanation of the compositional and configurational spatial features at landscape level, which describe the spatial habitat heterogeneity model and the increased fragmentation degree observed along the gradient from SWOFs embedded in natural areas to those located in agricultural and urban areas (see lines 296-301 in text marked).

In addition, we introduced some other explanations about the simplification of vegetation structure and the changing of plant composition observed along the gradient (see lines 327-330 in text marked), linking them to

"management practices adopted during the years, responsible for altering not only the vegetation structure but also the biodiversity in managed lands (Rouvinen and Kuuluvainen, 2005) compared to irregular, unmanaged and uneven-aged woodlands (Hansen et al., 1991; McComb et al., 1993)."

1 **Abstract**

2 Land-use intensification exacerbates landscape fragmentation, increasing the negative effects on
3 biodiversity. In this context, the biodiversity value of Trees Outside Forests (TOF; scattered trees,
4 tree lines and small woodlots) is often overlooked by landscape planning and conservation
5 programs, which typically focus on protecting larger and more intact areas. More empirical studies
6 on taxa inhabiting TOF are needed to support and promote their conservation in human-altered
7 lands.

8 However, we are not aware of any study focusing on multiple taxa living in small woodlots outside
9 forests (SWOFs) in the Mediterranean basin. We investigated how diversity patterns of multiple
10 taxa in SWOFs respond to a land-use intensification gradient, from natural areas to more disturbed
11 ones (agricultural and urban areas), in a Mediterranean biodiversity hotspot.

12 We explored the influence of land-use types on species richness and composition of vascular plants
13 and six ground-dwelling invertebrate groups (pseudoscorpions, spiders, darkling beetles, rove
14 beetles, ground beetles, and ants). Species composition was more sensitive than species richness to
15 land-use change, highlighting the need to consider a suitable measure for interpreting ecological
16 processes. We observed a strong influence of land use embedding SWOFs on the mean composition
17 and beta diversity of taxa: land-use intensification led to a general homogenization of diversity
18 patterns, especially among agricultural and urban areas. In our study area, ~~V~~vascular plants
19 responded more sensitively to land-use change than invertebrates. For most invertebrates: the higher
20 the land-use intensity, the lower the species composition dissimilarity due to the dominance of good
21 dispersers or disturbance-tolerant species. More vagile species and disturbance-tolerant species can
22 move across open habitats and colonize new areas, reducing compositional differences and
23 potentially boosting species pools. We demonstrated that SWOFs play a key role in supporting
24 viable populations of invertebrates, also in human-altered lands, underlining the need to promote
25 their conservation in this Mediterranean fragmented landscape to avoid homogenization from
26 driving a generalized biodiversity loss.

27 **Keywords**

28 Land-use influence, Trees Outside Forests, multi-taxa diversity patterns, ground-dwelling
29 invertebrates, Coleoptera, Hymenoptera, Pseudoscorpiones, Araneae, vascular plants

30 1. INTRODUCTION

31 Land-use intensification are among the most important direct drivers of ecosystem service changes
32 from global to local scales. A large percentage of remnant forestland is projected to be converted to
33 other uses by 2050 due to agriculture and urban sprawl (MEA, 2005). In the Mediterranean basin,
34 we observed a constantly increasing rate of land consumption and different sprawling patterns at the
35 local scale (Strollo et al., 2020). The observed trend of land-use intensification (Newbold et al.,
36 2015) and habitat loss exacerbates landscape fragmentation, affecting biodiversity (Fischer and
37 Lindenmayer, 2007).

38 Although large, intact and well-connected patches are vitally important for the maintenance of
39 ecological processes (Lindenmayer, 2019), small isolated fragments and appropriate matrix
40 management are considered valuable complements (Fischer and Lindenmayer, 2002). The high
41 conservation value of small remnant patches in human-modified landscapes is demonstrated
42 (Fischer and Lindenmayer, 2002; Le Roux et al., 2015; Lindenmayer, 2019; Tulloch et al., 2016). In
43 this context, Trees Outside Forests are gaining increasing attention. They are scattered individual
44 trees, linear arboreal elements and small woodlots outside forests (hereafter SWOFs), distributed
45 along watercourses, canals, roads and highways or, in general, over all-natural and human-modified
46 lands (de Foresta et al., 2013). They play a crucial role in climate mitigation, soil and water
47 resources protection, agricultural crop protection and, thanks to their wide distribution, promote
48 biodiversity conservation by representing ecological corridors and offering habitats for animal and
49 plant species (Bellefontaine et al., 2001; Manning et al., 2006).

50 Despite this, small patches are excluded from most connectivity analyses and conservation
51 initiatives (Cadavid-Florez et al., 2020). Considering that policymakers, land planners and
52 conservation organizations generally focus their efforts on large, intact and well-connected areas by
53 underestimating the importance of small fragments (Wintle et al., 2019), more empirical studies on
54 taxa inhabiting these patches are urgently needed to support and promote their conservation
55 (Lindenmayer, 2019). However, only a few studies consider diversity patterns of multiple
56 taxonomic groups across different areas and landscape contexts with scattered trees (Le Roux et al.,
57 2018; Prevedello et al., 2018). Surprisingly enough, we are not aware of any study focusing on
58 multiple taxonomic groups in Mediterranean SWOFs along a land-use intensification gradient.

59 We conducted a study in a Mediterranean fragmented landscape [located in Sardinia \(Southern](#)
60 [Italy](#)): we investigated diversity patterns of vascular plants and six groups of ground-dwelling
61 arthropods (pseudoscorpions, spiders, darkling, rove and ground beetles, ants) living in SWOFs

62 located in different land-use types. We focused on vascular plants and arthropods as potential
63 biological indicator taxa, considering that they constitute more than 80% of all currently described
64 species (Stork, 2018), showing multiple responses to disturbance levels (Noriega et al., 2018). We
65 specifically asked: what is the role of these small patches for biodiversity conservation of multiple
66 taxonomic groups along the gradient of land-use intensification? Does the gradient of land-use
67 intensification affect SWOF multi-taxa diversity?

68 Simultaneously examining the responses of multiple taxonomic groups to the same stressor-
69 environmental gradient could contribute to understanding the effect of land use on SWOFs diversity
70 patterns, with theoretical and applied implications for their management. In a perspective of an
71 increasing need for nature-based solutions, quantitative tests based on multiple taxonomic groups
72 would also provide evidence to explicitly consider SWOFs in future conservation programs
73 (Lindenmayer, 2019; Wintle et al., 2019), particularly in Mediterranean areas, recognized as one of
74 the main hotspots for biodiversity conservation (Médail, 2017).

75 **2. MATERIALS AND METHODS**

76 **2.1. Study area**

77 The study area, covering about 18,300 hectares, is located in the Metropolitan City of Cagliari
78 (Southern Sardinia, Italy), a medium-sized functional urban area characterized by three levels of
79 fragmentation degree (i.e., low, medium, high; Palumbo et al., 2020). The area is ascribable to the
80 Mediterranean pluvioseasonal oceanic bioclimate, with a class of continentality (strong euoceanic),
81 four thermotypic horizons (from lower thermomediterranean to upper mesomediterranean) and five
82 ombrothermic horizons (from lower dry to lower humid), resulting in a combination of 11
83 isobioclimates (Canu et al., 2015) and high climate variability (Bazzato et al., 2021b). Due to the
84 anthropic disturbance, a gradient of land-use intensification runs roughly in a north-east/south-west
85 direction from natural and semi-natural areas (NAT) at higher altitudes to more disturbed ones at
86 lower altitudes (agricultural areas, AGR; urban and artificial areas, URB) (Fig. 1; Table A.1 in
87 Appendix). Considering the vegetation (Bacchetta et al., 2009), the NE sector is characterized by
88 evergreen sclerophylls, dominated by *Quercus ilex* or *Quercus suber*, and different shrub species
89 (*Erica arborea*, *Arbutus unedo*, *Phyllirea latifolia*, *Myrtus communis* and *Juniperus oxycedrus*).
90 The high-shrub and pre-forest successions are distributed in the most thermo-xerophilous SW sector
91 with wild olive and juniper shrublands (*Olea europaea* var. *sylvestris*, *Pistacia lentiscus*, *Juniperus*
92 *turbinata* and *Euphorbia dendroides*). Halophilous and psammophilous communities dominate
93 coastal areas, ponds and lagoons.

94 **2.2. Sampling design**

95 Using photo-interpretation of digital colour orthophotos (RAS, 2016), we identified and mapped all
96 SWOFs ranging from 0.05 to 0.5 hectares. Hence, SWOFs were assigned to the corresponding land-
97 use type (NAT, AGR, URB) according to the first hierarchical level of the land-use map (RAS,
98 2008). We excluded SWOFs smaller than 0.1 hectares (about 42%), as well as those embedded in a
99 mixed land-use type (about 1.50%). A total of 201 SWOFs were retained (67 in URB, 70 in AGR,
100 64 in NAT): from this population, we carried out a proportional stratified random sampling to select
101 a total of 30 SWOFs along the land-use intensification gradient (NAT, AGR, URB). Due to the
102 difficulties to survey in private estates and similar areas located in the URB areas, 8 urban SWOFs
103 were sampled, and the remaining SWOFs (up to 30) were equally assigned to the other two land-use
104 types (11 sites in NAT and AGR; Table A.1 in Appendix).

105 For each SWOF, we used the centroid as the central middle point of a linear transect, which was
106 radiated from the centroid to the farthest sides of SWOF boundaries. For each linear transect, we
107 identified 5 plots equally spaced along the longest axes of the patch (P1-P5; Fig. 1; Table A.2 in
108 Appendix).

109 **2.3. Data collection**

110 We recorded data of vascular plants and six groups of ground-dwelling invertebrates
111 (pseudoscorpions, spiders, darkling beetles, rove beetles, ground beetles, ants).

112 Vascular plant occurrences and abundances were recorded from April to August 2018. We visually
113 estimated vascular plant abundance as percentage cover within five replicate plots of 1 m² in each
114 transect per SWOF. Then, they were summed across the five plots in each transect per SWOF.

115 Ground-dwelling invertebrates were collected from April 2018 to May 2019 to optimize the capture
116 efficiency of seasonally active ground-dwelling groups using five replicate pitfall traps in each
117 transect per SWOF, located in the centre of each ~~five-replicated~~ plot (see Appendix for further
118 details on pitfall trap design and trapping effort). The traps were emptied every 30-40 days; thus,
119 nine trap-emptying made up a year sample for each sampled SWOF. Hence, we pooled abundance
120 data along the year sample to optimize the catch and overcome occasional trap losses (Kotze et al.,
121 2011). Since some traps were found overturned or tampered, we expressed invertebrate abundances
122 as absolute abundance (aA, number of collected individuals) and annual activity density (aAD) to

123 standardize pitfall catches for the trapping effort (i.e., the number of active traps, and the duration of
124 the catching period; see Appendix and Saska et al., 2021).

125 The annual activity density of each species was calculated by dividing the number of collected indi-
126 viduals during the entire sampling period (tot indiv) with the total (yearly) trapping effort (TE) for
127 each sampled SWOF:

128 Eq. (A.1) $aAD = \text{tot indiv} / TE$

129 with $TE = \sum te$ and $te = \text{trap} * (dd/15)$, where trap is the number of active traps and dd is the number
130 of days during which traps were active in each sampling session (Brandmayr et al., 2005).

131 The latest expression, originally proposed by Brandmayr et al. (2005) dividing by 10 (for periods of
132 10 days), was modified to obtain the active number of individuals who fall into the traps during that
133 period of the year within 15 days.

134 ~~Descriptions of the trapping effort per SWOF and aAD calculation were reported in Appendix.~~

135 **2.4. Statistical analyses**

136 **2.4.1. Species richness**

137 To consider the bias due to different sampling efforts, sample-based rarefaction and extrapolation
138 approach (Colwell et al., 2012) was applied based on incidence data, using the *iNEXT* package
139 (Hsieh et al., 2016). This approach extends methods for rarefaction and extrapolation (R/E) of
140 species richness to higher-order Hill numbers: species richness ($q = 0$); Shannon diversity ($q = 1$),
141 the exponential of Shannon entropy interpreted as the effective number of frequent species in the
142 assemblage; Simpson diversity ($q = 2$), the inverse Simpson concentration interpreted as the
143 effective number of highly frequent species in the assemblage (Chao et al., 2020). Rarefaction was
144 used to compare the land-use types by correlating the three orders of taxonomic diversity with a
145 certain number of samples (i.e., the minimum number of samples overall land-use types). We
146 applied asymptotic estimators, via the functions *ChaoRichness* for $q = 0$, *ChaoShannon* for $q = 1$
147 and *ChaoSimpson* for $q = 2$, to compare the potential number of sampled species in a scenario of
148 maximized sampling intensity (Colwell et al., 2012). The 95% confidence intervals obtained by 200
149 replicate bootstrapping runs and associated with the estimates were also calculated. Whenever the
150 95% confidence intervals did not overlap, diversity measures differed significantly at $p < 0.05$
151 (Colwell et al., 2012).

152 We adopted a semi-parametric PERMANCOVA approach (Anderson, 2017) to investigate land use
153 effect (LU, fixed factor with three levels: NAT, AGR and URB) on species richness of each

154 taxonomic group, accounting for altitude (Z) and two-way interaction effects (ZxLU). We omitted
155 the interaction term from the full models when the p-values were not significant. Hence, we
156 calculated the pseudo variance components for each variation source, and post-hoc permutational
157 pairwise comparison tests with PERMANOVA t statistic for the main effect of land use in the final
158 reduced models (ZxLU; Anderson, 2017). All tests were performed using Euclidean distances of
159 untransformed species richness values aggregated at SWOF level, 999 random permutations and the
160 most conservative type III sum of squares for unbalanced designs in PRIMER v.6.1.12 software
161 (Anderson et al., 2008).

162 **2.4.2. Species composition**

163 We evaluated the influence of land-use types on species composition using (1) non-metric
164 multidimensional scaling (NMDS), (2) permutational multivariate analysis of covariance
165 (PERMANCOVA), (3) beta- dispersion analysis, and (4) SIMilarity PERcentages Procedure
166 (SIMPER). Analyses were carried out separately for each taxonomic group using Bray-Curtis
167 distances on square-root transformed abundance data at SWOF level. For invertebrates, all analyses
168 were conducted using both aA and aAD data and considering samples entirely defaunated (i.e., zero
169 animal species) through the use of the zero-adjusted Bray-Curtis coefficients (Clarke et al., 2006).

170 We indirectly visualized differences in species composition among land-use types via NMDS plots,
171 using the `metaMDS` function of the `vegan` package (Oksanen et al., 2019). PERMANCOVA was
172 applied to test the null hypothesis of no differences in the position of centroids (i.e., the average
173 community composition) (Anderson, 2017; Anderson and Walsh, 2013) among land-use types (LU,
174 fixed factor with three levels; NAT, AGR and URB), including altitude (Z) and two-way interaction
175 effects (ZxLU). We omitted the interaction term from the full models when the p-values were not
176 significant (Anderson, 2017). Hence, we calculated the pseudo multivariate variance components
177 and post-hoc permutational pairwise comparison tests with PERMANOVA t statistic for the main
178 effect of land use in the final reduced models (Anderson, 2017).

179 Differences in beta dispersion (hereafter beta diversity) among land-use types were assessed with
180 the `betadispersion2` R function (Bacaro et al., 2013, 2012) using 9999 permutations. This method
181 was used to test the null hypothesis of no differences in multivariate dispersion among groups
182 (Anderson, 2006), avoiding mixing within-group dissimilarities with between-group dissimilarities
183 (Bacaro et al., 2013). We evaluated differences between pairs of group mean dispersion by Tukey
184 HSD (Honestly Significant Difference) tests (Anderson, 2006).

185 Finally, a SIMPER was carried out to identify the most important species of each taxonomic group
186 typifying pairwise differences (Warton et al., 2012) among land-use types, setting a ~~cut~~-cut-off level
187 of 90% for low contributions.

188 3. RESULTS

189 3.1. General results and species richness

190 We collected a total of 330 species of vascular plants and 269 species of ground-dwelling
191 invertebrates grouped into six taxonomic groups: 390 individuals belonging to 13 species of
192 pseudoscorpions; 2,821 spiders assigned to 106 species; 1,084 darkling beetles of 22 species; 7,215
193 rove beetles of 55 species; 2,777 ground beetles assigned to 38 species; 52,125 ants of 35 species.

194 The mean number of pseudoscorpions, spiders and ant species were higher in SWOFs embedded in
195 AGR areas than in those located in URB and NAT areas, but their abundance (aA and aAD)
196 reached the highest values in urban ones (Fig. A.1-A.3 in Appendix). The highest values of the
197 mean species richness and abundance of darkling beetles were in AGR SWOFs, followed by URB
198 and NAT SWOFs (Fig. A.1-A.3 in Appendix). Considering ground beetles, the mean richness and
199 abundance (aA and aAD) were highest in disturbed areas, particularly in URB SWOF. Rove beetles
200 and vascular plants reached the highest values in NAT SWOFs, both for richness and abundance
201 (Fig. A.1-A.3 in Appendix).

202 Sample-based rarefaction and extrapolation curves with 95% confidence intervals for the three Hill
203 numbers of order q based on the 30 samples showed similar patterns for almost all taxonomic
204 groups (Fig. 2; Table A.3 in Appendix). The analysis revealed that the number of samples was
205 sufficient for the representative sampling of the frequent and highly frequent species in the
206 communities (curves of $q = 1$ and $q = 2$ approached an asymptote, Fig. 2). However, infrequent
207 species might be underrepresented ($q = 0$, Fig. 2). For almost all invertebrate groups (except
208 pseudoscorpions, rove beetles and vascular plants), the 95% confidence intervals from different
209 land-use types overlap, implying that diversity estimates did not differ significantly. By contrast, the
210 empirical and estimated asymptotic Simpson's diversity profiles along with 95% confidence
211 intervals ($q = 2$ in Fig. 2) were disjoint for AGR and NAT samples, respectively, in
212 pseudoscorpions and rove beetles, indicating a significant difference from the other land-use types.
213 For vascular plants, the 95% confidence intervals for the URB samples in any
214 rarefaction/extrapolation curve were disjoint, implying a significant difference from both AGR and
215 NAT (Fig. 2).

216 PERMANCOVA showed the highest component of variation to the overall species richness model
217 was the residual for almost all taxonomic groups, except vascular plants, for which effects of land
218 use across altitudes contributed the most (Table A.4-A.5 in Appendix). Statistically significant two-
219 way interaction ($Z \times LU$, $p \leq 0.05$, Table A.4 in Appendix) appeared only for the richness of vascular
220 plants, suggesting that the land-use effects significantly differed across altitudes. Although there
221 was no evidence for a two-way interaction ($Z \times LU$, $p \geq 0.05$) in any other taxa, the main effect of
222 land use was significant only for spider richness (Table A.5 in Appendix). Post-hoc tests further
223 supported general results, underlining that species richness of spiders differed between NAT and
224 disturbed areas, while no significant differences were evident for any other taxonomic groups (Fig.
225 3; Table A.6 in Appendix).

226 3.2. Species composition

227 In NMDS, we observed the shift of group centroids among NAT and disturbed areas for almost all
228 taxa (except rove beetles) and high overlaps of 95% confidence ellipses around centroids. These
229 results suggested that differences in community composition were more related to the changing of
230 the mean composition rather than the increase in within-group variance (Fig. A.4-A.5 in Appendix).
231 This pattern was more evident in beetles than in other groups, using both aA and aAD data (Fig.
232 A.4-A.5 in Appendix). However, the use of aAD for darkling beetles led to the minimization of
233 within-group variance, maximizing the variance among NAT and disturbed areas (Fig. A.5 in
234 Appendix). Results of NMDS were supported by PERMANCOVA and beta diversity analyses.

235 PERMANCOVA analyses showed that the land use had a significant effect on the community
236 composition of almost all taxonomic groups, except rove and darkling beetles, even accounting for
237 altitude and two-way interaction effects (Table A.7-A.10 in Appendix). Statistically significant two-
238 way interaction ($Z \times LU$, $p \leq 0.05$) appeared only for darkling beetles using aAD data (compare
239 Table A.7 vs Table A.9 in Appendix).

240 Results of PERMANOVA t-test revealed that the mean community composition of spiders, ground
241 beetles, ants and vascular plants was significantly different among NAT vs AGR areas (Fig. 3;
242 Table A.11-A12 in Appendix). A significant contrast among NAT vs URB areas was identified for
243 all taxonomic groups, except darkling and rove beetles (Fig. 3; Table A.11-A12 in Appendix). No
244 significant differences in the mean community composition of all ground-dwelling invertebrates
245 were detected among AGR vs URB areas; remarkably, only vascular plants differed across these
246 two land-use types (Fig. 3; Table A.11-A12 in Appendix).

247 On average, beta diversity was slightly higher in NAT areas for spiders and rove beetles, AGR areas
248 for pseudoscorpions and ground beetles, and URB areas for ants and vascular plants (Table A.13-
249 A.14 in Appendix). Beta diversity average dissimilarities, from individual observation samples to
250 their group centroid, proved to be significantly different for pseudoscorpions and spiders, but also
251 darkling beetles using aAD data (Fig. 3; Table A.15-A.16 in Appendix). The Tukey HSD test
252 showed significant differences in beta diversity among NAT vs AGR areas for both of these
253 taxonomic groups, among NAT vs URB areas for spiders and darkling beetles, and among AGR vs
254 URB areas for pseudoscorpions (Fig. 3; Fig. A.6-A.7 in Appendix).

255 According to SIMPER analysis, a limited number of invertebrate species contributed to the
256 dissimilarity between disturbed areas (AGR vs URB; Table A.17 in Appendix).

257 4. DISCUSSION

258 Aside from studies on the role of scattered trees as keystone structures or biodiversity foci of
259 landscapes (Fischer et al., 2010; Manning et al., 2006), we are not aware of any other study
260 focusing on SWOF's diversity pattern using multiple taxonomic groups across different land-use
261 types in a Mediterranean fragmented landscape. Assessing diversity patterns is fundamental to
262 understanding the potential of animal and plant populations to persist in fragmented and disturbed
263 habitats. In this study, we simultaneously examined responses of multiple taxonomic groups to the
264 same stressor-environmental gradient to estimate the land-use intensification effects on SWOF
265 multi-taxa diversity, considering multiple diversity measures. The specific response patterns of taxa
266 to land-use is controversial: the effects of land-use intensity on diversity patterns are described as
267 neutral, positive or negative according to the considered taxa (Gosling et al., 2016), the trophic level
268 (Seibold et al., 2019), the urbanization intensity (McKinney, 2008), as well as the spatial scale
269 (Piano et al., 2020). Most literature focused on the impact of extensive urbanization on species
270 richness, especially for plants (McKinney, 2008). In our study, species richness and composition
271 responded differently to land use surrounding SWOFs, revealing that species composition was more
272 sensitive than species richness to land-use change.

273 To our knowledge, this is the first study comparing different measures of pseudoscorpion diversity
274 among small patches in different land-use types, corroborating the beta diversity sensitivity to land-
275 use change. This result ~~may could~~ be promising to consider pseudoscorpions as good indicators to
276 monitor land-use changes, ~~unlike previously indicated~~ (but see Aguiar et al., 2006), likely thanks to
277 their high habitat dependence and their adaptations to life in environments subject to temporal
278 variations (Battirolo et al., 2017; Liebke et al., 2021; Villarreal et al., 2019).

279 The contrasting pattern of richness and composition observed for the other taxonomic groups are in
280 line with previous studies focused on beetles (scarabs, rove and ground beetles) (Yong et al., 2020)
281 and plants (Aggemyr et al., 2018). The adoption of low-informative measures (e.g., total species
282 richness and abundance) to evaluate the impacts of disturbance intensity may conduct to insufficient
283 or even misleading descriptions of ecological community changes, underling the importance of the
284 use of high-informative measures (e.g., species composition and beta diversity) both in meta-
285 analyses and primary studies (Hekkala and Roberge, 2018).

286 The comparison of richness and compositional differences between land-use types allows the
287 understanding of how the diversity of multiple taxonomic groups can be affected by the increase of
288 human disturbance along the investigated gradient. According to studies demonstrating an
289 increasing species richness with moderate urbanization (McKinney, 2008), we observed that
290 agricultural and urban SWOFs sustained a relatively high richness of all ground-dwelling
291 invertebrates (except rove beetles) compared to natural and semi-natural SWOFs. Conversely, rove
292 beetles and vascular plants showed low levels of species richness in all disturbed areas. These
293 results were also confirmed by the variation in the abundances along the disturbance gradient, and
294 in all ground-dwelling invertebrates, the number of individuals in each land-use type reflected their
295 activity density. The positive effect of disturbance on the richness and abundances of ground-
296 dwelling invertebrates may be related to the compositional and configurational spatial features at
297 landscape level, which describe the increase of fragmentation degree along the gradient: a reduction
298 of mean patch size, patch size standard deviation and mean shape, as well as an increment of the
299 number of patch, Shannon's Diversity and Evenness, but also edge habitat was previously described
300 for the study area from SWOFs embedded in natural areas to those located in agricultural and urban
301 areas increased habitat diversity observed along the gradient (reference omitted for blind review).
302 Similar variations in invertebrate species richness and abundance related to the increase-variation of
303 spatial habitat heterogeneity were documented elsewhere (McKinney, 2008). According to the
304 intermediate disturbance hypothesis (Moi et al., 2020) and specifically to the disturbance
305 heterogeneity model (Porter et al., 2001), the intermediate disturbance may favour biodiversity by
306 increasing resource heterogeneity. It is also known that spatial diversity of habitats enhances the
307 beta diversity of taxonomic groups that can support viable populations in small areas, such as
308 insects (Fattorini et al., 2020; McKinney, 2008).

309 Our results suggest that an increase in land-use intensification homogenizes species composition,
310 reducing the difference in beta diversity (except in pseudoscorpions, spiders and darkling beetles)
311 without reducing species richness, as shown for groups occupying different trophic levels (Gossner

312 et al., 2016). The homogenization driven by land-use intensification observed in this study is
313 consistent with previous studies focusing on species richness (McKinney, 2006), beta diversity
314 patterns (Buhk et al., 2017) and functional traits (Bazzato et al., 2021c).

315 For most of the considered groups, the effects of land use on community composition were more
316 evident when we compared agricultural and urban areas, supporting evidence for biotic
317 homogenization among these land-use types in the study area. The mean composition of all ground-
318 dwelling invertebrates did not differ across disturbed areas considering either their absolute
319 abundance or their annual activity density, while only vascular plants changed their mean
320 composition.

321 Vascular plants responded more sensitively to land-use change than invertebrates, corroborating the
322 findings of other studies (McKinney, 2008). We observed a vertical structure simplification with
323 ~~decreasing-decreased~~ presence of native trees and shrubs (e.g., *Arbutus unedo*, *Erica arborea*, *Erica*
324 *terminalis*, *Salix atrocinerea* subsp. *atrocinerea*); and an ~~increased-increasing~~ presence of cultivated
325 or alien species (e.g., *Pinus halepensis* subs. *halepensis*, *Olea europaea*, *Eucalyptus camaldulensis*
326 subsp. *camaldulensis*) as the land-use intensity increases; due to management practices adopted
327 during the years (reference omitted for blind review), responsible for altering not only the
328 vegetation structure but also the biodiversity in managed lands (Rouvinen and Kuuluvainen, 2005)
329 compared to irregular, unmanaged and uneven-aged woodlands (Hansen et al., 1991; McComb et
330 al., 1993).

331 Plant community composition and its vertical structure contribute to changes in higher trophic-level
332 organisms by altering light penetration, microclimate, resources, and habitat spaces (Schuldt et al.,
333 2019). This could be especially true for pseudoscorpions and spiders, known to be dependent on
334 lower trophic groups and their fluctuations (Cardoso et al., 2011; Jiménez-Hernández et al., 2020).

335 Plant composition can drive beta-diversity patterns of pseudoscorpions, influencing species
336 replacement (Jiménez-Hernández et al., 2020). Here, we observed that community changes along
337 the disturbance gradient were more related to the difference in beta diversity patterns than changes
338 in species richness, likely due to species replacement: two species were found to be almost
339 exclusive of SWOFs in natural areas (*Hysterochelifer tuberculatus*, *Roncus caralitanus*), others
340 showed a variable abundance in agricultural and urban areas (*Chthonius leoi*, *Hysterochelifer* cf.
341 *spinus*, *Pselaphochernes lacertosus*), being absent in natural ones. On the other hand, the beta-
342 dissimilarity among disturbed areas was mainly due to species showing a high abundance (or

343 exclusiveness) in agricultural habitats (*Geogarypus minor*, *Geogarypus italicus*, *Occidenchthonius*
344 *berminii*) or urban ones (*C. leoi*, *P. lacertosus*).

345 Changes in land use can decrease spider species diversity and modify their composition, leading to
346 differentiated spider assemblages (Pinto et al., 2021). Our study confirmed that spider assemblages
347 responded more sensitively to land-use change from natural to disturbed areas than other
348 invertebrates, showing differences in the richness, mean composition, and beta diversity. As plant
349 communities' structure changes resulting from the increase in land-use intensity differed along the
350 disturbance gradient, it may have favoured different spider species according to their habitat
351 requirements. Most of the dissimilarities among natural and disturbed areas resulted from the
352 dominance of species with broad environmental tolerance (e.g., *Lycosoides coarctata*, *Dysdera*
353 *crocata*, *Marinarozelotes barbatus*, *Marinarozelotes lyonneti*, *Urozelotes rusticus*, *Zelotes callidus*,
354 *Zelotes tenuis*, *Loxosceles rufescens*, *Zodarion elegans*, *Zodarion ruffoi*) (Caria et al., 2021; Pantini
355 et al., 2013), in both agricultural and urban habitats.

356 Darkling beetles include species with different responses towards environmental gradients
357 (Fattorini, 2014), and species that occur in the soil do not seem to follow a rural-urban gradient
358 (Fattorini and Galassi, 2016). Our results showed that the beta-diversity of darkling beetles
359 responded to land-use intensification from natural to disturbed areas, due to activity density
360 differences: natural areas were dominated by high activity of habitat-specialist species, strictly
361 range-localized in local forested areas (*Asida androgyna*; Leo, 2012); agricultural and urban areas
362 showed no marked compositional differences, being dominated by species that can support a high
363 activity density even in altered areas (*Stenosis sardoa sardoa*, *Tentyria grossa sardiniensis*; Ruffo
364 and Stoch, 2006) or in a wide variety of environments (*Crypticus gibbulus*, *Pimelia goryi goryi*;
365 Aliquò et al., 2006).

366 Urbanization can reduce favourable conditions for forest specialist species, contributing to their
367 richness decline (Magura et al., 2013). Specialist species may perceive the surrounding matrix as a
368 stronger barrier than generalists or opportunists, which can exploit a wide variety of resources from
369 neighbouring green areas (Niemelä, 2001). As a result, species composition in human-altered areas
370 becomes more and more similar, which may lead to a decrease in functional diversity (Melliger et
371 al., 2018). Accordingly, we observed a reduction of compositional differences of rove beetles due to
372 the dominance of macrohabitat generalists (*Atheta laticollis*, *Atheta oblita*, *Ocypus olens*,
373 *Tachyporus nitidulus*, *Heterothops dissimilis*) (Lupi et al., 2006; Zanetti et al., 2016), both in
374 natural and disturbed areas. Nevertheless, the microhabitats requirements of rove beetles

375 demonstrate that SWOFs can provide suitable substrates (e.g., debris, litter, tree hole, tree base,
376 mosses) (Lupi et al., 2006; Parmain et al., 2015) for the persistence of their populations, also in
377 human-altered areas.

378 Taxa with active or high movement ability may have more chances of (re)colonizing surrounding
379 areas, keeping viable populations and reducing the compositional differences than groups with
380 lower or passive dispersal capacities, such as plants (Silva et al., 2017; Soininen et al., 2007).
381 Ground beetles in fragmented habitats show a higher dispersal power, expressed as the higher
382 frequency of macropterous or dimorphic species compared to more preserved habitats, to allow
383 dispersal to favourable sites when conditions turn difficult (Ribera et al., 2001). In line with these
384 studies, we showed that most of the similarities among agricultural and urban areas in ground beetle
385 communities resulted from the dominance of habitat-generalists and good dispersers (*Amara aenea*,
386 *Calathus cinctus*, *Laemostenus complanatus*, *Orthomus berytensis*) (Brigić et al., 2016; Pizzolotto
387 et al., 2008; Suárez et al., 2018), likely due to their better capacities to maintain populations in
388 altered areas than poor dispersers (Niemelä, 2001). In contrast, more poor dispersal species (e.g.,
389 *Percus strictus ellipticus*, *Laemostenus carinatus*; personally verified) were found in natural
390 habitats than disturbed ones, contributing to explain the compositional differences among these
391 land-use types.

392 As observed in other studies, disturbance has a stronger effect on ant species composition than on
393 species richness (Martinez & Amar, 2014). Disturbance-adapted species can disperse across open
394 habitats and colonize new areas, potentially boosting species pools (Filgueiras et al., 2021). The
395 higher the management intensity, the lower the dissimilarity of ant species composition due to the
396 high presence of disturbance-tolerant species (Escobar-Ramírez et al., 2020; Martins et al., 2022).
397 Coherently, we found a reduction of ant compositional differences as disturbance increases due to
398 the presence of highly-tolerant species absent or rare in natural SWOFs: this is a broad and
399 heterogeneous group of ants, generally linked to open or thermophilous habitats (*Aphaenogaster*
400 *senilis*, *Hypoponera eduardi*, *Linepithema humile*, *Messor*, *Temnothorax sardous*, *Tapinoma*
401 *madeirense*), or highly disturbed areas and cities (*Tetramorium immigrans*, *Tapinoma magnum*)
402 (Reyes-López, et al., 2003; Castracani et al., 2010; 2020; Seifert, 2018; Zara et al., 2021). Most of
403 the ant species characterizing natural SWOFs are associated with moister, cooler conditions or
404 better-developed leaf litter layer (*Aphaenogaster ichnusa*, *Aphaenogaster spinosa*, *Myrmica*
405 *spinosior*, *Stenamma debile*, *Temnothorax tuberum*) (Galkowski et al., 2019; Seifert, 2018;
406 Galkowski et al., 2019; Zara et al., 2021). Others were detected in most SWOFs irrespective of
407 disturbance levels. Among these, the social parasite *Plagiolepis xene*; sometimes In the past, this

408 species was suspected of poor dispersal capability and fragmented populations, ~~whose and its~~
409 presence in Sardinia was recently discovered (Mardulyn et al., 2014; Schifani et al., 2021a). We
410 ~~was~~ collected it across the whole disturbance gradient alongside its host *P. pygmaea*. ~~As~~Since *P.*
411 ~~xene was the only social parasite species we found, we did not detect a higher presence of socially~~
412 ~~parasitic ants in natural SWOFs, yet these were the only ones not to host alien species. This pattern~~
413 ~~partly only partly resembles~~ing what found by Bernal & Espadaler (2013), who suggested social
414 ~~parasite and invasive ant species as indicators of low-disturbance and high-disturbance habitats~~
415 ~~respectively. The success of *P. xene* in disturbed areas apparently depends on the high plasticity of~~
416 ~~its host *P. pygmaea*, and highlights that not all socially parasitic ants are good indicators of low~~
417 ~~disturbance (see *Tetramorium atratulum* (Schenck, 1852) as a futher example, Zhang et al. 2019).~~
418 ~~Unfortunately,~~ dispersal ranges of ant sexuals responsible for colony foundation are currently
419 undocumented in most cases (Seifert, 2018), while they would be crucial to understand how ants
420 can deal with habitat fragmentation by exploiting ecological corridors such as SWOFs. However,
421 SWOFs investigated during this study hosted at least 35 ant species, approximately 45% of the
422 region's diversity (Schifani et al., 2021a, b) and significantly different communities (including both
423 open/dry habitat and forest/moist habitat specialists, see Castracani et al., 2010; Zara et al., 2021).
424 These results highlighted the importance that small wood patches (or sometimes even isolated trees)
425 may have to ant conservation similarly to what is observed in non-Mediterranean regions (Majer &
426 Delabie, 1999; Gove et al., 2005; Nooten et al., 2021).

427 5. CONCLUSIONS

428 Not all species are fully reliant on large patches (Fischer and Lindenmayer, 2002) and small patches
429 cannot provide sufficient habitat for viable populations of any organism type: taxa differ in their
430 responses to habitat fragmentation and land-use intensification (Gosling et al., 2016; McKinney,
431 2008). Our data demonstrated that SWOFs play an important role in supporting viable populations
432 of ground-dwelling invertebrates, particularly in agricultural and urban land-use types of this
433 Mediterranean fragmented landscape. Although further investigation is required to assess how
434 similar the ecological trends we documented in Sardinia are to those from other Mediterranean
435 areas. This this finding re-iterates the high conservation value of green areas surrounded by altered
436 areas as focal habitat for species conservation (Fattorini, 2014), reinforcing the idea that few large
437 patches are not always better than several small (Fattorini, 2020; Le Roux et al., 2015).

438 If on the one hand, small patches can provide suitable habitats for the vast majority of ground-
439 dwelling invertebrate groups, on the other, an increase in disturbance level exacerbates a reduction

440 of compositional changes [in the investigated area](#), potentially leading to cascading effects
441 concerning dispersal, foraging resources and related dynamic interactions (Driscoll et al., 2013).

442 Cascading effects could make the conservation outlook bleak as land use intensifies, underlining the
443 need to preserve these remaining patches to avoid homogenization from driving a generalized
444 biodiversity loss (Buhk et al., 2017; McKinney, 2006), and extinction of entire communities in the
445 long-term (Gámez-Virués et al., 2015).

446 Notwithstanding that the impacts of human disturbance are neither temporary nor entirely avoidable
447 (Araia et al., 2020), solutions to preserve species and communities with the inclusion of wildlife in
448 agricultural (Simons and Weisser, 2017) and urban areas (Apfelbeck et al., 2020, 2019) are possible
449 and needed (Capotorti et al., 2020). In this perspective, an improved understanding of land-use
450 effects on multi-diversity patterns living in small patches will help land-manager to adopt
451 successfully nature-based solutions to biodiversity loss offsets.

452 **Acknowledgements**

453 We are very grateful to Giulio Gardini and Jan Matějček, respectively, for the identification of
454 pseudoscorpions and rove beetles. We also thank Leonardo Rosati for supporting and confirming
455 the identification of plant species. Our gratitude also goes to the director Marco Valle and all the
456 staff of the Museo Civico di Scienze Naturali “E. Caffi” in Bergamo for their hospitality and for
457 placing their equipment at our disposal. We also thank Francesca Ganga, Elisa Serra, and Andrea
458 Ambus, who kindly helped with the fieldwork or laboratory activities.

459 **REFERENCES**

- 460 Aggemyr, E., Auffret, A.G., Jädergård, L., Cousins, S.A.O., 2018. Species richness and
461 composition differ in response to landscape and biogeography. *Landscape Ecol.* 33, 2273–
462 2284. <https://doi.org/10.1007/s10980-018-0742-9>
- 463 Aguiar, N.O., Gualberto, T.L., Franklin, E., 2006. A medium-spatial scale distribution pattern of
464 Pseudoscorpionida (Arachnida) in a gradient of topography (altitude and inclination), soil
465 factors, and litter in a central Amazonia forest reserve, Brazil. *Braz. J. Biol.* 66, 791–802.
466 <https://doi.org/10.1590/S1519-69842006000500004>
- 467 Aliquò, V., Rastelli, M., Rastelli, S., Soldati, F., 2006. Coleotteri Tenebrionidi d’Italia - Darkling
468 Beetles of Italy (DVD), Progetto Biodiversità Piccole Faune, CDROM. ed. Museo Civico di
469 Storia Naturale di Carmagnola (TO), Associazione Naturalistica Piemontese.
- 470 Anderson, M.J., 2017. *Permutational Multivariate Analysis of Variance (PERMANOVA)*. Wiley
471 StatsRef: Statistics Reference Online 1–15.
472 <https://doi.org/10.1002/9781118445112.stat07841>
- 473 Anderson, M.J., 2006. Distance-Based Tests for Homogeneity of Multivariate Dispersions.
474 *Biometrics* 62, 245–253. <https://doi.org/10.1111/j.1541-0420.2005.00440.x>
- 475 Anderson, M.J., Gorley, R.N., Clarke, K.R., 2008. *PERMANOVA+ for PRIMER: Guide to*
476 *Software and Statistical Methods*. PRIMER-E, Plymouth.
- 477 Anderson, M.J., Walsh, D.C.I., 2013. PERMANOVA, ANOSIM, and the Mantel test in the face of
478 heterogeneous dispersions: What null hypothesis are you testing? *Ecol. Monogr.* 83, 557–
479 574. <https://doi.org/10.1890/12-2010.1>
- 480 Apfelbeck, B., Jakoby, C., Hanusch, M., Steffani, E.B., Hauck, T.E., Weisser, W.W., 2019. A
481 Conceptual Framework for Choosing Target Species for Wildlife-Inclusive Urban Design.
482 *Sustainability* 11, 6972. <https://doi.org/10.3390/su11246972>
- 483 Apfelbeck, B., Snep, R.P.H., Hauck, T.E., Ferguson, J., Holy, M., Jakoby, C., Scott MacIvor, J.,
484 Schär, L., Taylor, M., Weisser, W.W., 2020. Designing wildlife-inclusive cities that support
485 human-animal co-existence. *Landscape Urban Plan.* 200, 103817.
486 <https://doi.org/10.1016/j.landurbplan.2020.103817>

- 487 Araia, M.G., Chirwa, P.W., Assédé, E.S.P., 2020. Contrasting the Effect of Forest Landscape
488 Condition to the Resilience of Species Diversity in a Human Modified Landscape:
489 Implications for the Conservation of Tree Species. *Land* 9, 4.
490 <https://doi.org/10.3390/land9010004>
- 491 Bacaro, G., Gioria, M., Ricotta, C., 2013. Beta diversity reconsidered. *Ecol. Res.* 28, 537–540.
492 <https://doi.org/10.1007/s11284-013-1043-z>
- 493 Bacaro, G., Gioria, M., Ricotta, C., 2012. Testing for differences in beta diversity from plot-to-plot
494 dissimilarities. *Ecol. Res.* 27, 285–292. <https://doi.org/10.1007/s11284-011-0899-z>
- 495 Bacchetta, G., Bagella, S., Biondi, E., Farris, E., Filigheddu, R., Mossa, L., 2009. Vegetazione
496 forestale e serie di vegetazione della Sardegna (con rappresentazione cartografica alla scala
497 1:350.000). *Fitosociologia* 46, 3–82.
- 498 [Battirolo, L.D., Rosado-Neto, G.H., Batistella, D.A., Mahnert, V., Brescovit, A.D., Marques, M.I.,
499 2017. Vertical and time distribution of Pseudoscorpiones \(Arthropoda: Arachnida\) in a
500 floodplain forest in the Brazilian Pantanal. *Rev. Biol. Trop.* 65, 445–459.
501 <https://doi.org/10.15517/rbt.v65i2.24134>](https://doi.org/10.15517/rbt.v65i2.24134)
- 502 Bazzato, E., Lallai, E., Serra, E., Melis, M.T., Marignani, M., 2021a. Key role of small woodlots
503 outside forest in a Mediterranean fragmented landscape. *For. Ecol. Manag.* 496, 119389.
504 <https://doi.org/10.1016/j.foreco.2021.119389>
- 505 Bazzato, E., Rosati, L., Canu, S., Fiori, M., Farris, E., Marignani, M., 2021b. High spatial resolution
506 bioclimatic variables to support ecological modelling in a Mediterranean biodiversity
507 hotspot. *Ecol. Modell.* 441, 109354. <https://doi.org/10.1016/j.ecolmodel.2020.109354>
- 508 Bazzato, E., Serra, E., Maccherini, S., Marignani, M., 2021c. Reduction of inter- and intraspecific
509 seed mass variability along a land-use intensification gradient. *Ecol. Indic.* 129, 107884.
510 <https://doi.org/10.1016/j.ecolind.2021.107884>
- 511 Bellefontaine, R., Petit, S., Pain-Orcet, M., Deleporte, P., Bertault, J.-G., 2001. Les arbres hors
512 forêt. Vers une meilleure prise en compte, Cahier FAO Conservation. Food and Agriculture
513 Organization of the United Nations (FAO), Rome.
- 514 [Bernal, V., Espadaler, X. 2013. Invasive and socially parasitic ants are good bioindicators of habitat
515 quality in Mediterranean forest remnants in NE Spain. *Ecol. Res.* 28, 1011–1017.
516 <https://doi.org/10.1007/s11284-013-1083-4>](https://doi.org/10.1007/s11284-013-1083-4)
- 517 Brigić, A., Vujčić-Karlo, S., Slivar, S., Alegro, A., Kepčija, R.M., Peroš, R., Kerovec, M., 2016.
518 Distribution and life-history traits of *Calathus cinctus* Motschulsky, 1850 (Coleoptera:
519 Carabidae) in Croatia, with distribution of closely related species. *Ital. J. Zool.* 83, 549–562.
520 <https://doi.org/10.1080/11250003.2016.1247921>
- 521 Buhk, C., Alt, M., Steinbauer, M.J., Beierkuhnlein, C., Warren, S.D., Jentsch, A., 2017.
522 Homogenizing and diversifying effects of intensive agricultural land-use on plant species
523 beta diversity in Central Europe - A call to adapt our conservation measures. *Sci. Total
524 Environ.* 576, 225–233. <https://doi.org/10.1016/j.scitotenv.2016.10.106>

- 525 Cadavid-Florez, L., Laborde, J., Mclean, D.J., 2020. Isolated trees and small woody patches greatly
526 contribute to connectivity in highly fragmented tropical landscapes. *Landsc. Urban. Plan.*
527 196, 103745. <https://doi.org/10.1016/j.landurbplan.2020.103745>
- 528 Canu, S., Rosati, L., Fiori, M., Motroni, A., Filigheddu, R., Farris, E., 2015. Bioclimate map of
529 Sardinia (Italy). *J. Maps* 11, 711–718. <https://doi.org/10.1080/17445647.2014.988187>
- 530 Capotorti, G., Bonacquisti, S., Abis, L., Aloisi, I., Attorre, F., Bacaro, G., Balletto, G., Banfi, E.,
531 Barni, E., Bartoli, F., Bazzato, E., Beccaccioli, M., Braglia, R., Bretzel, F., Brighetti, M.,
532 Brundu, G., Burnelli, M., Calfapietra, C., Cambria, V., Caneva, G., Canini, A., Caronni, S.,
533 Castello, M., Catalano, C., Celesti-Grapow, L., Cicinelli, E., Cipriani, L., Citterio, S.,
534 Concu, G., Coppi, A., Corona, E., Del Duca, S., Del Vico, E., Di Gristina, E., Domina, G.,
535 Faino, L., Fano, E., Fares, S., Farris, E., Farris, S., Fornaciari, M., Gaglio, M., Galasso, G.,
536 Galletti, M., Gargano, M., Gentili, R., Giannotta, A., Guarino, C., Guarino, R., Iaquina, G.,
537 Iriti, G., Lallai, A., Lallai, E., Lattanzi, E., Manca, S., Manes, F., Marignani, M.,
538 Marinangeli, F., Mariotti, M., Mascia, F., Mazzola, P., Meloni, G., Michelozzi, P., Miraglia,
539 A., Montagnani, C., Mundula, L., Muresan, A., Musanti, F., Nardini, A., Nicosia, E., Oddi,
540 L., Orlandi, F., Pace, R., Palumbo, M., Palumbo, S., Parrotta, L., Pasta, S., Perini, K.,
541 Poldini, L., Postiglione, A., Prigioniero, A., Proietti, C., Raimondo, F., Ranfa, A., Redi, E.,
542 Reverberi, M., Roccotiello, E., Ruga, L., Savo, V., Scarano, P., Schirru, F., Sciarrillo, R.,
543 Scuderi, F., Sebastiani, A., Siniscalco, C., Sordo, A., Suanno, C., Tartaglia, M., Tilia, A.,
544 Toffolo, C., Toselli, E., Travaglini, A., Ventura, F., Venturella, G., Vincenzi, F., Blasi, C.,
545 2020. More Nature in the City. *Plant Biosyst.* 154, 1003–1006.
546 <https://doi.org/10.1080/11263504.2020.1837285>
- 547 Cardoso, P., Pekár, S., Jocqué, R., Coddington, J.A., 2011. Global Patterns of Guild Composition
548 and Functional Diversity of Spiders. *PLoS One* 6, e21710.
549 <https://doi.org/10.1371/journal.pone.0021710>
- 550 Caria, M., Pantini, P., Alamanni, F., Ancona, C., Cillo, D., Bazzato, E., 2021. New records and
551 interesting data for the Sardinian spider fauna (Arachnida, Araneae). *Fragm. Entomol.* 53,
552 321–332. <https://doi.org/10.13133/2284-4880/555>
- 553 [Castracani, C., Grasso, D.A., Fanfani, A., Mori, A. 2010. The ant fauna of Castelporziano](https://doi.org/10.1007/s10841-010-9285-3)
554 [Presidential Reserve \(Rome, Italy\) as a model for the analysis of ant community structure in](https://doi.org/10.1007/s10841-010-9285-3)
555 [relation to environmental variation in Mediterranean ecosystems. *J. Insect Conserv.* 14,](https://doi.org/10.1007/s10841-010-9285-3)
556 [585–594. <https://doi.org/10.1007/s10841-010-9285-3>](https://doi.org/10.1007/s10841-010-9285-3)
- 557 Castracani, C., Spotti, F.A., Schifani, E., Giannetti, D., Ghizzoni, M., Grasso, D.A., Mori, A., 2020.
558 Public Engagement Provides First Insights on Po Plain Ant Communities and Reveals the
559 Ubiquity of the Cryptic Species *Tetramorium immigrans* (Hymenoptera, Formicidae).
560 *Insects* 11, 678. <https://doi.org/10.3390/insects11100678>
- 561 Chao, A., Kubota, Y., Zelený, D., Chiu, C.-H., Li, C.-F., Kusumoto, B., Yasuhara, M., Thorn, S.,
562 Wei, C.-L., Costello, M.J., Colwell, R.K., 2020. Quantifying sample completeness and
563 comparing diversities among assemblages. *Ecol. Res.* 35, 292–314.
564 <https://doi.org/10.1111/1440-1703.12102>
- 565 Clarke, K.R., Somerfield, P.J., Chapman, M.G., 2006. On resemblance measures for ecological
566 studies, including taxonomic dissimilarities and a zero-adjusted Bray–Curtis coefficient for

- 567 denuded assemblages. *J. Exp. Mar. Biol. Ecol.*, A Tribute to Richard M. Warwick 330, 55–
568 80. <https://doi.org/10.1016/j.jembe.2005.12.017>
- 569 Colwell, R.K., Chao, A., Gotelli, N.J., Lin, S.-Y., Mao, C.X., Chazdon, R.L., Longino, J.T., 2012.
570 Models and estimators linking individual-based and sample-based rarefaction, extrapolation
571 and comparison of assemblages. *J. Plant Ecol.* 5, 3–21. <https://doi.org/10.1093/jpe/rtr044>
- 572 de Foresta, H., Somarriba, E., Temu, A., Boulanger, D., Feuily, H., Gauthier, M., 2013. Towards
573 the assessment of trees outside forests: a thematic report prepared in the framework of the
574 Global Forest Resources Assessment. Food and Agriculture Organization of the United
575 Nations (FAO), Rome.
- 576 Driscoll, D.A., Banks, S.C., Barton, P.S., Lindenmayer, D.B., Smith, A.L., 2013. Conceptual
577 domain of the matrix in fragmented landscapes. *Trends Ecol. Evol.* 28, 605–613.
578 <https://doi.org/10.1016/j.tree.2013.06.010>
- 579 Escobar-Ramírez, S., Tschardt, T., Armbrrecht, I., Torres, W., Grass, I., 2020. Decrease in β -
580 diversity, but not in α -diversity, of ants in intensively managed coffee plantations. *Insect*
581 *Conserv. Divers.* 13, 445–455. <https://doi.org/10.1111/icad.12417>
- 582 Fattorini, S., 2020. Conservation Biogeography of Tenebrionid Beetles: Insights from Italian
583 Reserves. *Diversity* 12, 348. <https://doi.org/10.3390/d12090348>
- 584 Fattorini, S., 2014. Urban biodiversity hotspots are not related to the structure of green spaces: a
585 case study of tenebrionid beetles from Rome, Italy. *Urban Ecosyst.* 17, 1033–1045.
586 <https://doi.org/10.1007/s11252-014-0375-y>
- 587 Fattorini, S., Galassi, D.M.P., 2016. Role of urban green spaces for saproxylic beetle conservation:
588 a case study of tenebrionids in Rome, Italy. *J. Insect Conserv.* 20, 737–745.
589 <https://doi.org/10.1007/s10841-016-9900-z>
- 590 Fattorini, S., Mantoni, C., Bergamaschi, D., Fortini, L., Sánchez, F.J., Biase, L.D., Giulio, A.D.,
591 2020. Activity density of carabid beetles along an urbanisation gradient. *Acta zool. Acad.*
592 *Sci. Hung.* 66, 21–36. <https://doi.org/10.17109/AZH.66.Suppl.21.2020>
- 593 Filgueiras, B.K.C., Peres, C.A., Melo, F.P.L., Leal, I.R., Tabarelli, M., 2021. Winner–Loser Species
594 Replacements in Human-Modified Landscapes. *Trends Ecol. Evol.* 36, 545–555.
595 <https://doi.org/10.1016/j.tree.2021.02.006>
- 596 Fischer, J., Lindenmayer, D.B., 2007. Landscape Modification and Habitat Fragmentation: A
597 Synthesis. *Glob. Ecol. Biogeogr.* 16, 265–280.
- 598 Fischer, J., Lindenmayer, D.B., 2002. Small patches can be valuable for biodiversity conservation:
599 two case studies on birds in southeastern Australia. *Biol. Conserv.* 106, 129–136.
600 [https://doi.org/10.1016/S0006-3207\(01\)00241-5](https://doi.org/10.1016/S0006-3207(01)00241-5)
- 601 Fischer, J., Stott, J., Law, B.S., 2010. The disproportionate value of scattered trees. *Biol. Conserv.*
602 143, 1564–1567. <https://doi.org/10.1016/j.biocon.2010.03.030>

- 603 Galkowski, C., Aubert, C., Blatrix, R., 2019. *Aphaenogaster ichnusa* Santschi, 1925, bona species,
604 and Redescription of *Aphaenogaster subterranea* (Latreille, 1798) (Hymenoptera,
605 Formicidae). *Sociobiology* 66, 420–425. <https://doi.org/10.13102/sociobiology.v66i3.3660>
- 606 Gámez-Virués, S., Perović, D.J., Gossner, M.M., Börschig, C., Blüthgen, N., de Jong, H., Simons,
607 N.K., Klein, A.-M., Krauss, J., Maier, G., Scherber, C., Steckel, J., Rothenwöhrer, C.,
608 Steffan-Dewenter, I., Weiner, C.N., Weisser, W., Werner, M., Tschardtke, T., Westphal, C.,
609 2015. Landscape simplification filters species traits and drives biotic homogenization. *Nat.*
610 *Commun.* 6, 8568. <https://doi.org/10.1038/ncomms9568>
- 611 Gosling, L., Sparks, T.H., Araya, Y., Harvey, M., Ansine, J., 2016. Differences between urban and
612 rural hedges in England revealed by a citizen science project. *BMC Ecol.* 16, 15.
613 <https://doi.org/10.1186/s12898-016-0064-1>
- 614 Gossner, M.M., Lewinsohn, T.M., Kahl, T., Grassein, F., Boch, S., Prati, D., Birkhofer, K., Renner,
615 S.C., Sikorski, J., Wubet, T., Arndt, H., Baumgartner, V., Blaser, S., Blüthgen, N., Börschig,
616 C., Buscot, F., Diekötter, T., Jorge, L.R., Jung, K., Keyel, A.C., Klein, A.-M., Klemmer, S.,
617 Krauss, J., Lange, M., Müller, J., Overmann, J., Pašalić, E., Penone, C., Perović, D.J.,
618 Purschke, O., Schall, P., Socher, S.A., Sonnemann, I., Tschapka, M., Tschardtke, T., Türke,
619 M., Venter, P.C., Weiner, C.N., Werner, M., Wolters, V., Wurst, S., Westphal, C., Fischer,
620 M., Weisser, W.W., Allan, E., 2016. Land-use intensification causes multitrophic
621 homogenization of grassland communities. *Nature* 540, 266–269.
622 <https://doi.org/10.1038/nature20575>
- 623 Gove, A.D., Majer, J.D., Rico-Gray, V. 2005. Methods for conservation outside of formal reserve
624 systems: The case of ants in the seasonally dry tropics of Veracruz, Mexico. *Biol. Conserv.*
625 126, 328–338. <https://doi.org/10.1016/j.biocon.2005.06.008>
- 626 Hansen, A.J., Spies, T.A., Swanson, F.J., Ohmann, J.L., 1991. Conserving Biodiversity in Managed
627 Forests: Lessons from natural forests. *BioScience* 41, 382–392.
628 <https://doi.org/10.2307/1311745>
- 629 Hekkala, A.-M., Roberge, J.-M., 2018. The use of response measures in meta-analyses of land-use
630 impacts on ecological communities: a review and the way forward. *Biodivers. Conserv.* 27,
631 2989–3005. <https://doi.org/10.1007/s10531-018-1583-1>
- 632 Hsieh, T.C., Ma, K.H., Chao, A., 2016. iNEXT: an R package for rarefaction and extrapolation of
633 species diversity (Hill numbers). *Methods Ecol. Evol.* 7, 1451–1456.
634 <https://doi.org/10.1111/2041-210X.12613>
- 635 Jiménez-Hernández, V.S., Villegas-Guzmán, G.A., Casasola-González, J.A., Vargas-Mendoza,
636 C.F., 2020. Altitudinal distribution of alpha, beta, and gamma diversity of pseudoscorpions
637 (Arachnida) in Oaxaca, Mexico. *Acta Oecol.* 103, 103525.
638 <https://doi.org/10.1016/j.actao.2020.103525>
- 639 Kotze, D.J., Brandmayr, P., Casale, A., Dauffy-Richard, E., Dekoninck, W., Koivula, M., Lovei, G.,
640 Mossakowski, D., Noordijk, J., Paarmann, W., Pizzoloto, R., Saska, P., Schwerk, A.,
641 Serrano, J., Szyszko, J., Palomares, A.T., Turin, H., Venn, S., Vermeulen, R., Brandmayr,
642 T.Z., 2011. Forty years of carabid beetle research in Europe – from taxonomy, biology,
643 ecology and population studies to bioindication, habitat assessment and conservation.
644 *ZooKeys* 100, 55–148. <https://doi.org/10.3897/zookeys.100.1523>

Formatted: English (United Kingdom)

- 645 Le Roux, D.S., Ikin, K., Lindenmayer, D.B., Manning, A.D., Gibbons, P., 2018. The value of
646 scattered trees for wildlife: Contrasting effects of landscape context and tree size. *Divers.*
647 *Distrib.* 24, 69–81. <https://doi.org/10.1111/ddi.12658>
- 648 Le Roux, D.S., Ikin, K., Lindenmayer, D.B., Manning, A.D., Gibbons, P., 2015. Single large or
649 several small? Applying biogeographic principles to tree-level conservation and biodiversity
650 offsets. *Biol. Conserv.* 191, 558–566. <https://doi.org/10.1016/j.biocon.2015.08.011>
- 651 Leo, P., 2012. Tre nuove specie di Asida della Sardegna (Coleoptera, Tenebrionidae). *Annali del*
652 *Museo civico di storia naturale Giacomo Doria* 104.
- 653 [Liebke, D.F., Harms, D., Widyastuti, R., Scheu, S., Potapov, A.M., 2021. Impact of rainforest](#)
654 [conversion into monoculture plantation systems on pseudoscorpion density, diversity and](#)
655 [trophic niches. *Soil Org.* 93, 83–96. <https://doi.org/10.25674/so93iss2id147>](#)
- 656 Lindenmayer, D., 2019. Small patches make critical contributions to biodiversity conservation.
657 *Proc. Natl. Acad. Sci. USA* 116, 717–719. <https://doi.org/10.1073/pnas.1820169116>
- 658 Lupi, D., Colombo, M., Zanetti, A., 2006. The rove beetles (Coleoptera Staphylinidae) of three
659 horticultural farms in Lombardy (Northern Italy). *Boll. Zool. agr. Bachic.*, II 38, 143–165.
- 660 Magura, T., Nagy, D., Tóthmérész, B., 2013. Rove beetles respond heterogeneously to urbanization.
661 *J. Insect Conserv.* 17, 715–724. <https://doi.org/10.1007/s10841-013-9555-y>
- 662 [Majer, J. D., Delabie, J.H.C. 1999. Impact of tree isolation on arboreal and ground ant communities](#)
663 [in cleared pasture in the Atlantic rain forest region of Bahia, Brazil. *Insectes Soc.* 46, 281–](#)
664 [290. <https://doi.org/10.1007/s000400050147>](#)
- 665 Manning, A.D., Fischer, J., Lindenmayer, D.B., 2006. Scattered trees are keystone structures –
666 Implications for conservation. *Biol. Conserv.* 132, 311–321.
667 <https://doi.org/10.1016/j.biocon.2006.04.023>
- 668 Mardulyn, P., Thurin, N., Piou, V., Grumiau, L., Aron, S., 2014. Dispersal in the inquiline social
669 parasite ant *Plagiolepis xene*. *Insect. Soc.* 61, 197–202. [https://doi.org/10.1007/s00040-014-](https://doi.org/10.1007/s00040-014-0345-7)
670 [0345-7](https://doi.org/10.1007/s00040-014-0345-7)
- 671 Martins, I.S., Ortega, J.C.G., Guerra, V., da Costa, M.M.S., Martello, F., Schmidt, F.A., 2022. Ant
672 taxonomic and functional beta-diversity respond differently to changes in forest cover and
673 spatial distance. *Basic Appl. Ecol.* <https://doi.org/10.1016/j.baae.2022.02.008>
- 674 [McComb, W.C., Spies, T.A., Emmingham, W.H., 1993. Douglas-Fir Forests: Managing for Timber](#)
675 [and Mature-Forest Habitat. *J. For.* 91, 31–42. <https://doi.org/10.1093/jof/91.12.31>](#)
- 676 McKinney, M.L., 2008. Effects of urbanization on species richness: A review of plants and animals.
677 *Urban Ecosyst.* 11, 161–176. <https://doi.org/10.1007/s11252-007-0045-4>
- 678 McKinney, M.L., 2006. Urbanization as a major cause of biotic homogenization. *Biol. Conserv.*,
679 *Urbanization* 127, 247–260. <https://doi.org/10.1016/j.biocon.2005.09.005>

Formatted: English (United Kingdom)

- 680 MEA, 2005. Ecosystems human well-being: Biodiversity Synthesis, A Report of the Millennium
681 Ecosystem Assessment (MEA). World Resources Institute, Washington, DC.
- 682 Médail, F., 2017. The specific vulnerability of plant biodiversity and vegetation on Mediterranean
683 islands in the face of global change. *Reg. Environ. Change* 17, 1775–1790.
684 <https://doi.org/10.1007/s10113-017-1123-7>
- 685 Melliger, R.L., Braschler, B., Rusterholz, H.-P., Baur, B., 2018. Diverse effects of degree of
686 urbanisation and forest size on species richness and functional diversity of plants, and
687 ground surface-active ants and spiders. *PLoS One* 13, e0199245.
688 <https://doi.org/10.1371/journal.pone.0199245>
- 689 [Martinez, J.J.I., Amar, Z. 2014. The preservation value of a tiny sacred forest of the oak *Quercus*
690 *calliprinos* and the impact of livestock presence. *J. Insect Conserv.* 18, 657–665.
691 \[https://doi.org/10.1016/S1146-609X\\(03\\)00086-9\]\(https://doi.org/10.1016/S1146-609X\(03\)00086-9\)](#)
- 692 Moi, D.A., García-Ríos, R., Hong, Z., Daquila, B.V., Mormul, R.P., 2020. Intermediate Disturbance
693 Hypothesis in Ecology: A Literature Review. *Ann. Zool. Fenn.* 57, 67–78.
694 <https://doi.org/10.5735/086.057.0108>
- 695 Newbold, T., Hudson, L.N., Hill, S.L.L., Contu, S., Lysenko, I., Senior, R.A., Börger, L., Bennett,
696 D.J., Choimes, A., Collen, B., Day, J., De Palma, A., Díaz, S., Echeverria-Londoño, S.,
697 Edgar, M.J., Feldman, A., Garon, M., Harrison, M.L.K., Alhousseini, T., Ingram, D.J., Itescu,
698 Y., Kattge, J., Kemp, V., Kirkpatrick, L., Kleyer, M., Correia, D.L.P., Martin, C.D., Meiri,
699 S., Novosolov, M., Pan, Y., Phillips, H.R.P., Purves, D.W., Robinson, A., Simpson, J.,
700 Tuck, S.L., Weiher, E., White, H.J., Ewers, R.M., Mace, G.M., Scharlemann, J.P.W., Purvis,
701 A., 2015. Global effects of land use on local terrestrial biodiversity. *Nature* 520, 45–50.
702 <https://doi.org/10.1038/nature14324>
- 703 Niemelä, J., 2001. Carabid beetles (Coleoptera: Carabidae) and habitat fragmentation: a review.
704 *Eur. J. Entomol.* 98, 127–132. <https://doi.org/10.14411/eje.2001.023>
- 705 [Nooten, S.S., Lee, R.H., Guénard, B. \(2021\). Evaluating the conservation value of sacred forests for
706 ant taxonomic, functional and phylogenetic diversity in highly degraded landscapes. *Biol.*
707 *Conserv.*, 261, 109286. <https://doi.org/10.1016/j.biocon.2021.109286>](#)
- 708 Noriega, J.A., Hortal, J., Azcárate, F.M., Berg, M.P., Bonada, N., Briones, M.J.I., Del Toro, I.,
709 Goulson, D., Ibanez, S., Landis, D.A., Moretti, M., Potts, S.G., Slade, E.M., Stout, J.C.,
710 Ulyshen, M.D., Wackers, F.L., Woodcock, B.A., Santos, A.M.C., 2018. Research trends in
711 ecosystem services provided by insects. *Basic Appl. Ecol., Insect Effects on Ecosystem*
712 *services* 26, 8–23. <https://doi.org/10.1016/j.baee.2017.09.006>
- 713 Oksanen, J., Blanchet, F.G., Friendly, M., Kindt, R., Legendre, P., McGlenn, D., Minchin, P.R.,
714 O'Hara, R.B., Simpson, G.L., Solymos, P., Stevens, M.H.H., Szoecs, E., Wagner, H., 2019.
715 *vegan: Community Ecology Package.*
- 716 Palumbo, M.E., Mundula, L., Balletto, G., Bazzato, E., Marignani, M., 2020. Environmental
717 Dimension into Strategic Planning. The Case of Metropolitan City of Cagliari, in: Gervasi,
718 O., Murgante, B., Misra, S., Garau, C., Blečić, I., Taniar, D., Apduhan, B.O., Rocha,
719 A.M.A.C., Tarantino, E., Torre, C.M., Karaca, Y. (Eds.), *Computational Science and Its*

- 720 Applications – ICCSA 2020, Lecture Notes in Computer Science. Springer International
721 Publishing, Cham, pp. 456–471. https://doi.org/10.1007/978-3-030-58820-5_34
- 722 Pantini, P., Sassu, A., Serra, G., 2013. Catalogue of the spiders (Arachnida Araneae) of Sardinia.
723 Biodiversity Journal 4, 3–104.
- 724 Parmain, G., Bouget, C., Müller, J., Horak, J., Gossner, M.M., Lachat, T., Isacsson, G., 2015. Can
725 rove beetles (Staphylinidae) be excluded in studies focusing on saproxylic beetles in central
726 European beech forests? Bull. Entomol. Res. 105, 101–109.
727 <https://doi.org/10.1017/S0007485314000741>
- 728 Piano, E., Souffreau, C., Merckx, T., Baardsen, L.F., Backeljau, T., Bonte, D., Brans, K.I., Cours,
729 M., Dahirel, M., Debortoli, N., Decaestecker, E., Wolf, K.D., Engelen, J.M.T., Fontaneto,
730 D., Gianuca, A.T., Govaert, L., Hanashiro, F.T.T., Higuti, J., Lens, L., Martens, K.,
731 Matheve, H., Matthysen, E., Pinseel, E., Sablon, R., Schön, I., Stoks, R., Doninck, K.V.,
732 Dyck, H.V., Vanormelingen, P., Wichelen, J.V., Vyverman, W., Meester, L.D., Hendrickx,
733 F., 2020. Urbanization drives cross-taxon declines in abundance and diversity at multiple
734 spatial scales. Glob. Chang. Biol. 26, 1196–1211. <https://doi.org/10.1111/gcb.14934>
- 735 Pinto, C.M., Pairo, P.E., Bellocq, M.I., Filloy, J., 2021. Different land-use types equally impoverish
736 but differentially preserve grassland species and functional traits of spider assemblages. Sci
737 Rep 11, 10316. <https://doi.org/10.1038/s41598-021-89658-7>
- 738 Pizzolotto, R., Mazzei, A., Belfiore, T., Bonacci, T., 2008. Biodiversità dei Coleotteri Carabidi
739 (Coleoptera: Carabidae) nell'agroecosistema oliveto in Calabria. Entomologica 41, 5–11.
740 <https://doi.org/10.15162/0425-1016/793>
- 741 Porter, E.E., Forschner, B.R., Blair, R.B., 2001. Woody vegetation and canopy fragmentation along
742 a forest-to-urban gradient. Urban Ecosyst. 5, 131–151.
743 <https://doi.org/10.1023/A:1022391721622>
- 744 Prevedello, J.A., Almeida-Gomes, M., Lindenmayer, D.B., 2018. The importance of scattered trees
745 for biodiversity conservation: A global meta-analysis. J. Appl. Ecol. 55, 205–214.
746 <https://doi.org/10.1111/1365-2664.12943>
- 747 RAS, 2016. Orthophoto 2016 AGEA [WWW Document]. Sardegna Geoportale. URL
748 <http://www.sardegnaegeoportale.it/index.php?xsl=2425&s=338354&v=2&c=14469&t=1&tb=14401> (accessed 12.22.20).
- 750 RAS, 2008. Land use map [WWW Document]. Sardegna Geoportale. URL
751 http://webgis2.regione.sardegna.it/catalogodati/card.jsp?uuid=R_SARDEG:WBMEW
752 (accessed 12.29.20).
- 753 [Reyes-López, J., Ruiz, N., Fernández-Haeger, J. 2003. Community structure of ground-ants: the](#)
754 [role of single trees in a Mediterranean pastureland. Acta Oecol., 24, 195–202.](#)
755 [https://doi.org/10.1016/S1146-609X\(03\)00086-9](https://doi.org/10.1016/S1146-609X(03)00086-9)
- 756 Ribera, I., Dolédec, S., Downie, I.S., Foster, G.N., 2001. Effect of Land Disturbance and Stress on
757 Species Traits of Ground Beetle Assemblages. Ecology 82, 1112–1129.
758 [https://doi.org/10.1890/0012-9658\(2001\)082\[1112:EOLDAS\]2.0.CO;2](https://doi.org/10.1890/0012-9658(2001)082[1112:EOLDAS]2.0.CO;2)

Formatted: Italian (Italy)

Formatted: English (United Kingdom)

- 759 [Rouvinen, S., Kuuluvainen, T., 2005. Tree diameter distributions in natural and managed old *Pinus*](#)
760 [sylvestris](#)-dominated forests. *For. Ecol. Manag.* 208, 45–61.
- 761 <https://doi.org/10.1016/j.foreco.2004.11.021>
- 762 Ruffo, S., Stoch, F. (Eds.), 2006. Checklist and distribution of the Italian fauna: 10,000 terrestrial
763 and inland water species, Memorie del Museo civico di storia naturale di Verona. Comune
764 di Verona, Verona.
- 765 [Saska, P., Makowski, D., Bohan, D.A., van der Werf, W., 2021. The effects of trapping effort and](#)
766 [sources of variability on the estimation of activity-density and diversity of carabids in](#)
767 [annual field crops by pitfall trapping: a meta-analysis. *Entomol. Gen.* 41, 553–566.](#)
768 <https://doi.org/10.1127/entomologia/2021/1211>
- 769 Schifani, E., Nalini, E., Gentile, G., Alamanni, F., Ancona, C., Caria, M., Cillo, D., Bazzato, E.,
770 2021a. Ants of Sardinia: an updated checklist based on new faunistic, morphological and
771 biogeographical notes. *Redia* 104, 21–35. <https://doi.org/10.19263/REDIA-104.21.03>
- 772 [Schifani, E., Scupola, A., Menchetti, M., Bazzato, E., Espadaler, X. 2021b. Morphology and](#)
773 [Phenology of Sexualls and New Distribution Data on the Blind Mediterranean Ant](#)
774 [Hypoponera abeillei \(Hymenoptera, Formicidae\). *Sociobiology* 68, e7261.](#)
775 <https://doi.org/10.13102/sociobiology.v68i4.7261>
- 776 Schuldt, A., Ebeling, A., Kunz, M., Staab, M., Guimarães-Steinicke, C., Bachmann, D., Buchmann,
777 N., Durka, W., Fichtner, A., Fornoff, F., Härdtle, W., Hertzog, L.R., Klein, A.-M., Roscher,
778 C., Schaller, J., von Oheimb, G., Weigelt, A., Weisser, W., Wirth, C., Zhang, J., Bruehlheide,
779 H., Eisenhauer, N., 2019. Multiple plant diversity components drive consumer communities
780 across ecosystems. *Nat. Commun.* 10, 1460. <https://doi.org/10.1038/s41467-019-09448-8>
- 781 Seibold, S., Gossner, M.M., Simons, N.K., Blüthgen, N., Müller, J., Ambarlı, D., Ammer, C.,
782 Bauhus, J., Fischer, M., Habel, J.C., Linsenmair, K.E., Nauss, T., Penone, C., Prati, D.,
783 Schall, P., Schulze, E.-D., Vogt, J., Wöllauer, S., Weisser, W.W., 2019. Arthropod decline
784 in grasslands and forests is associated with landscape-level drivers. *Nature* 574, 671–674.
785 <https://doi.org/10.1038/s41586-019-1684-3>
- 786 Seifert, B., 2018. The Ants of Central and North Europe. Lutra Verlags- und Vertriebsgesellschaft,
787 Tauer, Germany.
- 788 Silva, V.X. da, Sacramento, M., Hasui, É., Cunha, R.G.T. da, Ramos, F.N., Silva, V.X. da,
789 Sacramento, M., Hasui, É., Cunha, R.G.T. da, Ramos, F.N., 2017. Taxonomic groups with
790 lower movement capacity may present higher beta diversity. *Iheringia Ser. Zool.* 107.
791 <https://doi.org/10.1590/1678-4766e2017005>
- 792 Simons, N.K., Weisser, W.W., 2017. Agricultural intensification without biodiversity loss is
793 possible in grassland landscapes. *Nat. Ecol. Evol.* 1, 1136–1145.
794 <https://doi.org/10.1038/s41559-017-0227-2>
- 795 Soininen, J., Lennon, J.J., Hillebrand, H., 2007. A Multivariate Analysis of Beta Diversity across
796 Organisms and Environments. *Ecology* 88, 2830–2838.

Formatted: English (United Kingdom)

- 797 Stork, N.E., 2018. How Many Species of Insects and Other Terrestrial Arthropods Are There on
798 Earth? *Annu. Rev. Entomol.* 63, 31–45. [https://doi.org/10.1146/annurev-ento-020117-](https://doi.org/10.1146/annurev-ento-020117-043348)
799 043348
- 800 Strollo, A., Smiraglia, D., Bruno, R., Assennato, F., Congedo, L., Fioravante, P.D., Giuliani, C.,
801 Marinosci, I., Riitano, N., Munafò, M., 2020. Land consumption in Italy. *J. Maps* 16, 113–
802 123. <https://doi.org/10.1080/17445647.2020.1758808>
- 803 Suárez, D., Hernández-Teixidor, D., Oromí, P., 2018. First report of wing dimorphism in the genus
804 *Orthomus* (Coleoptera: Carabidae). *Ann. Soc. Entomol. Fr.* 54, 67–72.
805 <https://doi.org/10.1080/00379271.2017.1414632>
- 806 Tulloch, A.I.T., Barnes, M.D., Ringma, J., Fuller, R.A., Watson, J.E.M., 2016. Understanding the
807 importance of small patches of habitat for conservation. *J. Appl. Ecol.* 53, 418–429.
808 <https://doi.org/10.1111/1365-2664.12547>
- 809 [Villarreal, E., Martínez, N., Ortiz, C.R., 2019. Diversity of Pseudoscorpiones \(Arthropoda:](#)
810 [Arachnida\) in two fragments of dry tropical forest in the colombian Caribbean region.](#)
811 [Caldasia 41, 139–151. https://doi.org/10.15446/caldasia.v41n1.72189](#)
- 812 Warton, D.I., Wright, S.T., Wang, Y., 2012. Distance-based multivariate analyses confound
813 location and dispersion effects. *Methods Ecol. Evol.* 3, 89–101.
814 <https://doi.org/10.1111/j.2041-210X.2011.00127.x>
- 815 Wintle, B.A., Kujala, H., Whitehead, A., Cameron, A., Veloz, S., Kukkala, A., Moilanen, A.,
816 Gordon, A., Lentini, P.E., Cadenhead, N.C.R., Bekessy, S.A., 2019. Global synthesis of
817 conservation studies reveals the importance of small habitat patches for biodiversity. *Proc.*
818 *Natl. Acad. Sci. USA* 116, 909–914. <https://doi.org/10.1073/pnas.1813051115>
- 819 Yong, D.L., Barton, P.S., Okada, S., Crane, M., Cunningham, S.A., Lindenmayer, D.B., 2020.
820 Conserving focal insect groups in woodland remnants: The role of landscape context and
821 habitat structure on cross-taxonomic congruence. *Ecol. Indic.* 115, 106391.
822 <https://doi.org/10.1016/j.ecolind.2020.106391>
- 823 Zanetti, A., Sette, A., Poggi, R., Tagliapietra, A., 2016. Biodiversity of Staphylinidae (Coleoptera)
824 in the Province of Verona (Veneto, Northern Italy). *Mem. Soc. Entomol. Ital.* 93, 3–237.
825 <https://doi.org/10.4081/MemorieSEI.2016.3>
- 826 [Zhang, Y.M., Vitone, T.R., Storer, C.G., Payton, A.C., Dunn, R.R., Hulcr, J., McDaniel, S.F.,](#)
827 [Lucky, A., 2019. From Pavement to Population Genomics: Characterizing a Long-](#)
828 [Established Non-native Ant in North America Through Citizen Science and ddRADseq.](#)
829 [Front. Ecol. Evol. 7. https://doi.org/10.3389/fevo.2019.00453](#)
- 830 [Zara, L., Tordoni, E., Castro-Delgado, S., Colla, A., Maccherini, S., Marignani, M., Panepinto, F.,](#)
831 [Trittoni, M., Bacaro, G. 2021. Cross-taxon relationships in Mediterranean urban ecosystem:](#)
832 [A case study from the city of Trieste. Ecol. Indic., 125, 107538.](#)
833 <https://doi.org/10.1016/j.ecolind.2021.107538>
- 834

Highlights

- Land-use intensity exacerbates landscape fragmentation, affecting biodiversity.
- Species composition was more sensitive than species richness to land-use change.
- Plants and invertebrates responded differently to land-use surrounding patches.
- The higher the land-use intensity was, the lower composition dissimilarities were.
- Small patches can be valuable for biodiversity conservation in human-altered areas.

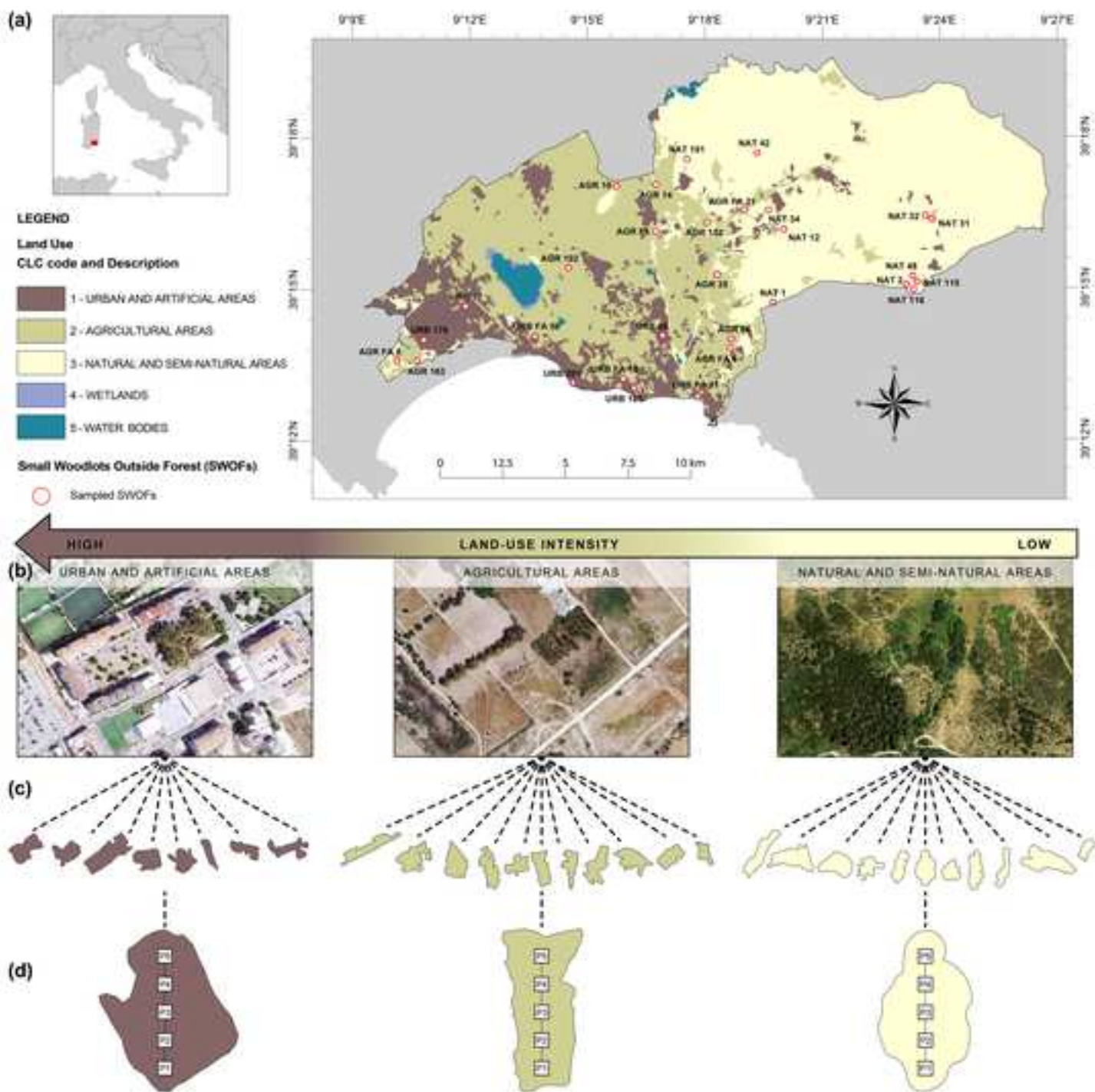




FIGURE LEGENDS

Fig. 1. Study area located in the Metropolitan City of Cagliari (Sardinia, Southern Italy) (a), and sampling scheme adopted for the study (b-d). At the first level (b), we find the land-use types along the gradient of land-use intensification from hilly natural areas to urbanised coastline zones (natural and semi-natural, agricultural, urban and artificial areas). At the second level (c), we categorized SWOFs according to the embedding land use. At the third level (d), the sample units (plots and traps) were arranged along a linear transect within each SWOF.

Fig. 2. Sample-based rarefaction (solid line) and its extrapolation (dashed line) to 22 samples (twice the maximum sample size) including 95% confidence intervals (shaded regions) obtained by bootstrapping based on 200 replications. For each taxonomic group, panels show diversity quantified in terms of Hill-numbers of order q (0: Species richness, 1: Shannon diversity and 2: Simpson diversity). A total of 30 SWOFs were considered in three land-use types: 11 SWOFs in natural and semi-natural areas (NAT), and agricultural areas (AGR), 8 SWOFs in urban and artificial areas (URB).

Fig. 3. Summary of differences among land-use types calculated for each taxonomic group by PERMANOVA pairwise tests based on Euclidean distances of untransformed species richness values, PERMANOVA pairwise tests and BETA Tukey's post hoc tests based on Bray-Curtis distances on square-root transformed abundance data (cover percentage for vascular plants; absolute abundance and annual activity density data (aAD) for invertebrates) at SWOF level (Table A.4-A.16 and Fig. A.6-A.7 in Appendix S1). NA for taxa where the land use (LU) resulted not significant in the final models (see Table A.5, A.8 and A.10 in Appendix S1).

FIGURES

Fig. 1. Study area located in the Metropolitan City of Cagliari (Sardinia, Southern Italy) (a), and sampling scheme adopted for the study (b-d). At the first level (b), we find the land-use types along the gradient of land-use intensification from hilly natural areas to urbanised coastline zones (natural and semi-natural, agricultural, urban and artificial areas). At the second level (c), we categorized SWOFs according to the embedding land use. At the third level (d), the sample units (plots and traps) were arranged along a linear transect within each SWOF.

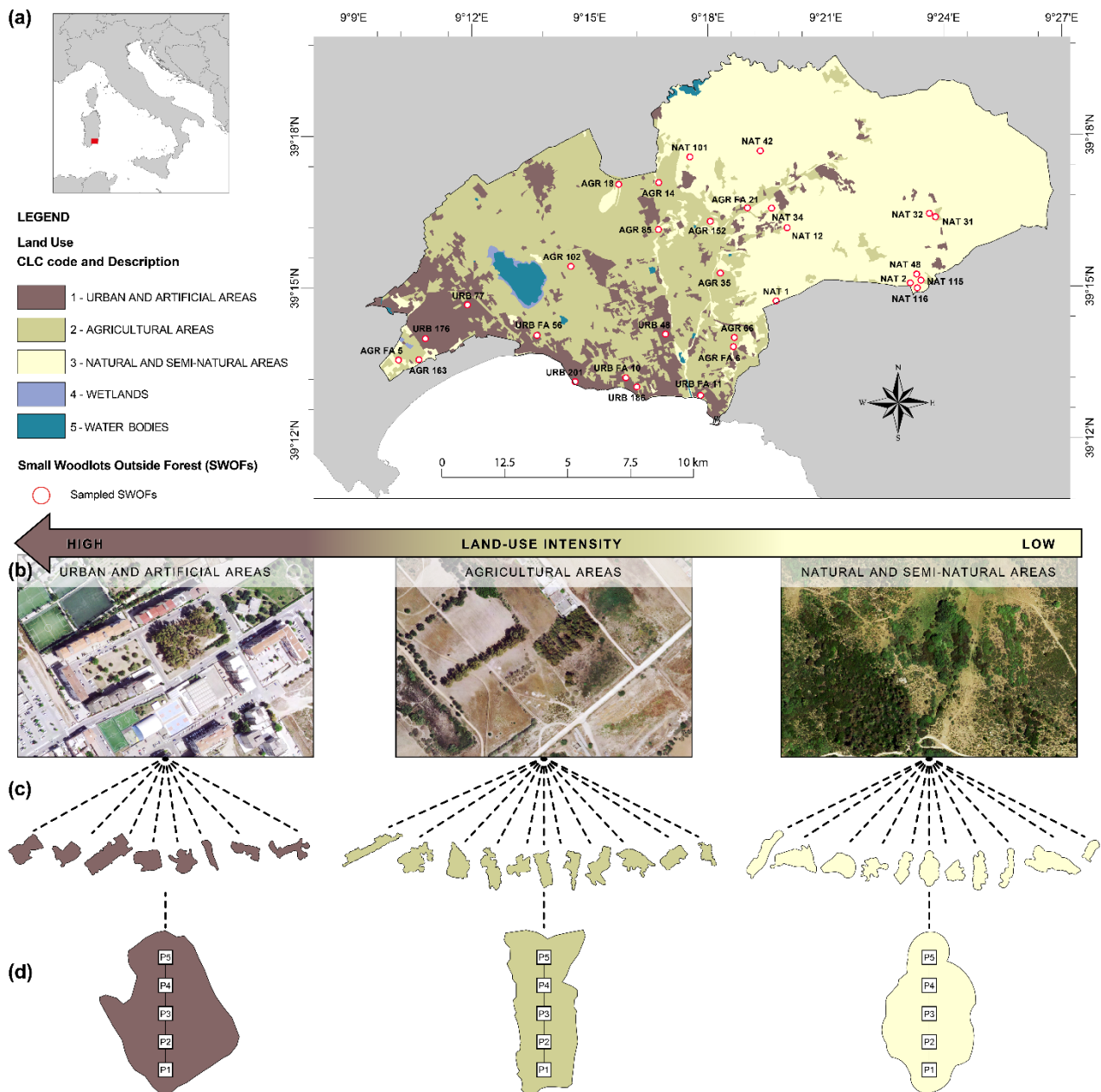


Fig. 2. Sample-based rarefaction (solid line) and its extrapolation (dashed line) to 22 samples (twice the maximum sample size) including 95% confidence intervals (shaded regions) obtained by bootstrapping based on 200 replications. For each taxonomic group, panels show diversity quantified in terms of Hill-numbers of order q (0: Species richness, 1: Shannon diversity and 2: Simpson diversity). A total of 30 SWOFs were considered in three land-use types: 11 SWOFs in natural and semi-natural areas (NAT), and agricultural areas (AGR), 8 SWOFs in urban and artificial areas (URB).

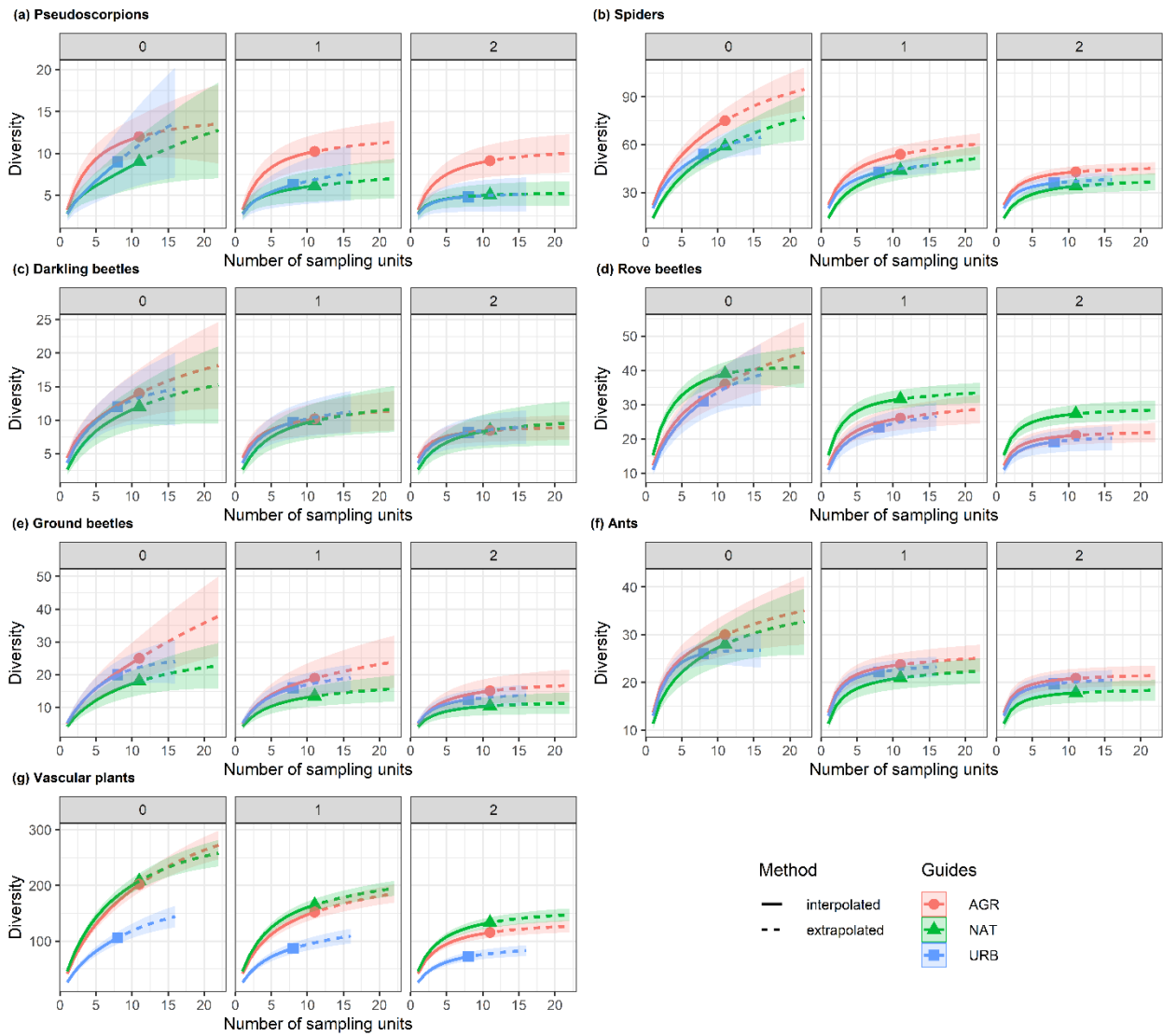
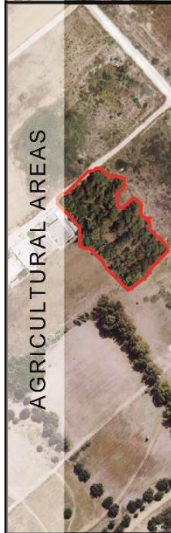
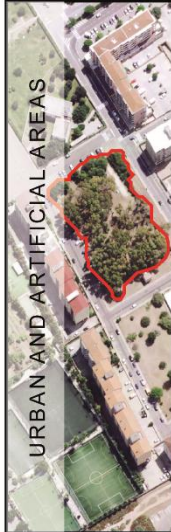
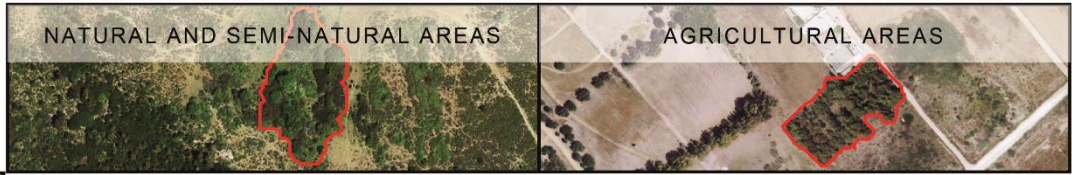


Fig. 3. Summary of differences among land-use types calculated for each taxonomic group by PERMANOVA pairwise tests based on Euclidean distances of untransformed species richness values, PERMANOVA pairwise tests and BETA Tukey's post hoc tests based on Bray-Curtis distances on square-root transformed abundance data (cover percentage for vascular plants; absolute abundance and annual activity density data (aAD) for invertebrates) at SWOF level (Table A.4-A.16 and Fig. A.6-A.7 in Appendix). NA for taxa where the land use (LU) resulted not significant in the final models (see Table A.5, A.8 and A.10 in Appendix).

Vs.



GROUP - SPECIES RICHNESS - MEAN COMPOSITION - BETA DISPERSION

	NA	≠	=
	≠	≠	≠
	NA	NA [⊗]	≠*
	NA	NA	=
	NA	≠	=
	NA	≠	=
	⊖	≠	=

GROUP - SPECIES RICHNESS - MEAN COMPOSITION - BETA DISPERSION

	NA	=	≠
	=	=	=
	NA	NA [⊗]	=
	NA	NA	=
	NA	=	=
	NA	=	=
	⊖	≠	=

GROUP - SPECIES RICHNESS - MEAN COMPOSITION - BETA DISPERSION

	NA	=	≠
	≠	≠	≠
	NA	NA [⊗]	≠*
	NA	NA	=
	NA	≠	=
	NA	≠	=
	⊖	≠	=

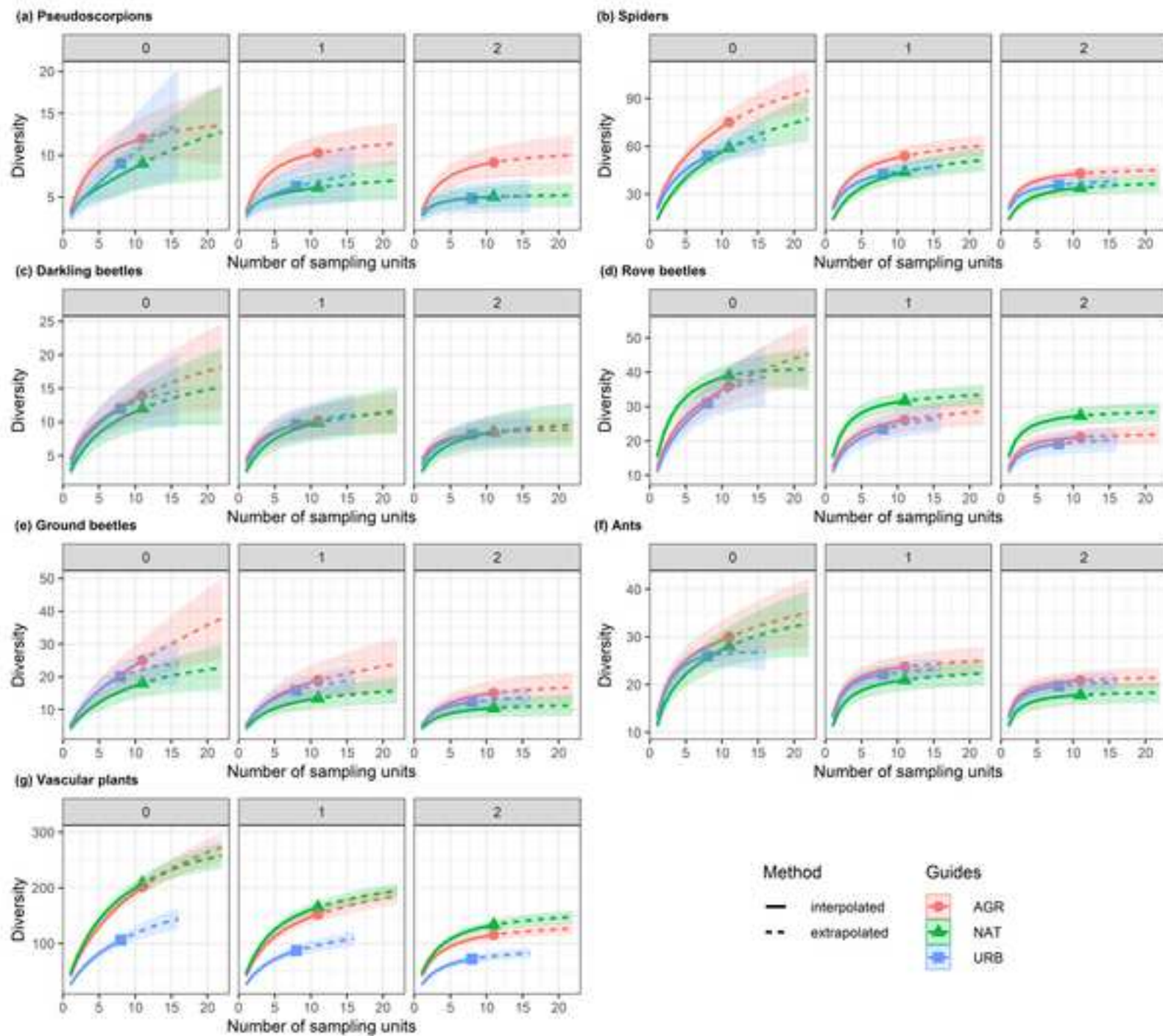
TAXONOMIC GROUP

- Pseudoscorpions (Pseudoscorpiones)
- Spiders (Araneae)
- Darkling beetles (Tenebrionidae)
- Rove beetles (Staphylinidae)
- Ground beetles (Carabidae)
- Ants (Formicidae)
- Vascular plants

⊖ Significant interaction (ZxLU, p ≤ 0.05)

⊗ Significant interaction only using aAD data

* Only using annual activity density (aAD) data



Appendix A

Land-use intensification reduces multi-taxa diversity patterns of Small Woodlots Outside Forests in a Mediterranean area

Erika Bazzato^{1*}, Erik Lallai¹, Michele Caria¹, Enrico Schifani², Davide Cillo³, Cesare Ancona⁴, Federico Alamanni¹, Paolo Pantini⁵, Simona Maccherini⁶, Giovanni Bacaro⁷, Michela Marignani¹

Table of Contents

1. MATERIALS AND METHODS	2
1.1. Site locations and features	2
1.2. Pitfall trap design, trapping effort, and aAD calculation	4
2. RESULTS	6
3.1. General results and species richness.....	6
3.2. Species composition.....	14
References listed in the Appendix	45

1. MATERIALS AND METHODS

1.1. Site locations and features

A proportional stratified random sampling was carried out to select a total of 30 Small Woodlots Outside Forests (hereafter SWOFs; Italian National Forest Inventory; <http://www.infc.it>) distributed along a land-use intensification gradient (NAT, AGR, URB) in Sardinia, Southern Italy (Table A.1). SWOFs embedded in NAT areas were characterized by the presence of dead and decaying trees, a significant cover of leaf litter, shrubs and herbs and a high variation of tree stem diameter (DBH) (Bazzato et al., 2021). SWOFs in AGR areas showed a structure similar to NAT ones, while urban small woodlots were marked by the absence of the shrub layer and the presence of high human trampling disturbance (Bazzato et al., 2021).

Table A.1 List of the 30 Small Woodlots Outside Forests sampled along the gradient of land-use intensification in Sardinia (Southern Italy). Geographic coordinates (Latitude, and Longitude), Municipality, locality, altitude (m a.s.l.), the nearest distance (m) among patches, and the dominant plant species are shown.

Site code	Latitude	Longitude	Municipality	Locality	Altitude (m a.s.l.)	Nearest Distance (m)	Dominant plant species
AGR_14	39.2844	9.2791	Maracalagonis	Corongiu, Sirigragiu	81	1423.83	<i>Eucalyptus tereticornis</i> Sm.
AGR_18	39.2838	9.2622	Maracalagonis	Corongiu, Carroghedda	85	1423.83	<i>Eucalyptus camaldulensis</i> Dehnh. subsp. <i>camaldulensis</i>
AGR_35	39.2545	9.3051	Quartucciu	Piscina Nuxedda	52	1839.69	<i>Olea europaea</i> L.
AGR_66	39.2332	9.3110	Quartu S.E.	Cani Nieddu, Frapponti	84	261.90	<i>Olea europaea</i> L.
AGR_85	39.2688	9.2789	Maracalagonis	Corongiu	60	1647.67	<i>Eucalyptus camaldulensis</i> Dehnh. subsp. <i>camaldulensis</i>
AGR_102	39.2568	9.2418	Quartu S.E.	Simbirizzi, Sa Guardia Lada	35	2658.75	<i>Eucalyptus camaldulensis</i> Dehnh. subsp. <i>camaldulensis</i>
AGR_152	39.2715	9.3009	Maracalagonis	Gruxi Lillius, Bacca Aruis	99	1373.01	<i>Eucalyptus camaldulensis</i> Dehnh. subsp. <i>camaldulensis</i>
AGR_163	39.2261	9.1774	Quartu S.E.	Stagno di Quartu, C. D'Aquila	3	687.10	<i>Olea europaea</i> L.
AGR_FA_5	39.2260	9.1687	Quartu S.E.	Stagno Quartu, Bingia Spada	5	687.10	<i>Eucalyptus camaldulensis</i> Dehnh. subsp. <i>camaldulensis</i>
AGR_FA_6	39.2301	9.3105	Quartu S.E.	Str. Comunale Cani Nieddu	68	261.90	<i>Olea europaea</i> L.

AGR_FA_21	39.2759	9.3167	Maracalagonis	Riu Piscina Nuxedda	80	833.64	<i>Eucalyptus camaldulensis</i> Dehnh. subsp. <i>camaldulensis</i>
NAT_1	39.2452	9.3287	Quartucciu	Corti de Perda	120	1915.42	<i>Eucalyptus camaldulensis</i> Dehnh. subsp. <i>camaldulensis</i>
NAT_2	39.2491	9.3889	Maracalagonis	Sette Fratelli, Codoleddu	700	243.42	<i>Salix atrocinerea</i> Brot. subsp. <i>atrocinerea</i>
NAT_12	39.2693	9.3335	Maracalagonis	Riu Monte Nieddu	140	816.85	<i>Eucalyptus camaldulensis</i> Dehnh. subsp. <i>camaldulensis</i>
NAT_31	39.2727	9.3963	Sinnai	Sette Fratelli, Monte Cresia	663	182.11	<i>Arbutus unedo</i> L.
NAT_32	39.2739	9.3938	Sinnai	Sette Fratelli, Monte Cresia	677	182.11	<i>Arbutus unedo</i> L.
NAT_34	39.2758	9.3270	Maracalagonis	Villaggio dei Gigli	120	816.85	<i>Eucalyptus camaldulensis</i> Dehnh. subsp. <i>camaldulensis</i>
NAT_42	39.2947	9.3223	Sinnai	Burranca	150	2060.91	<i>Eucalyptus camaldulensis</i> Dehnh. subsp. <i>camaldulensis</i>
NAT_48	39.2520	9.3917	Maracalagonis	Sette Fratelli, Codoleddu	714	203.57	<i>Salix atrocinerea</i> Brot. subsp. <i>atrocinerea</i>
NAT_101	39.2927	9.2923	Maracalagonis	Corongiu, Sedda Brandanu	140	1438.60	<i>Populus canescens</i> (Aiton) Sm.
NAT_115	39.2499	9.3934	Maracalagonis	Sette Fratelli, Codoleddu	706	203.57	<i>Salix atrocinerea</i> Brot. subsp. <i>atrocinerea</i>
NAT_116	39.2474	9.3918	Maracalagonis	Sette Fratelli, Codoleddu	700	243.42	<i>Arbutus unedo</i> L.; <i>Quercus suber</i> L.
URB_48	39.2344	9.2818	Quartu S.E.	Via delle Bouganvillee	22	2097.94	<i>Tamarix canariensis</i> Willd.
URB_77	39.2442	9.1979	Quartu S.E.	Sant'Antonio, Via Belgio	9	1896.98	<i>Eucalyptus camaldulensis</i> Dehnh. subsp. <i>camaldulensis</i>
URB_176	39.2330	9.1801	Quartu S.E.	Is Arenas, Via Pizzetti	6	733.65	<i>Pinus halepensis</i> Mill. subsp. <i>halepensis</i> ; <i>Robinia pseudoacacia</i> L.; <i>Melia azedarach</i> L.; <i>Ailanthus altissima</i> (Mill.) Swingle; <i>Ceratonia siliqua</i> L.
URB_186	39.2171	9.2696	Quartu S.E.	Sant'Andrea, Via Rimini	4	462.58	<i>Pinus halepensis</i> Mill. subsp. <i>halepensis</i>
URB_201	39.2188	9.2434	Quartu S.E.	Foxi, Via Ischia	1	1790.29	<i>Olea europaea</i> L.
URB_FA_10	39.2200	9.2649	Quartu S.E.	Porticciolo, Via Riccione	11	462.58	<i>Pinus pinea</i> L.
URB_FA_11	39.2142	9.2965	Quartu S.E.	Via Lago di Varese	2	2087.45	<i>Eucalyptus camaldulensis</i> Dehnh. subsp. <i>camaldulensis</i>
URB_FA_56	39.2341	9.2274	Quartu S.E.	Margine Rosso, Via Valenzia	37	2125.91	<i>Pinus halepensis</i> Mill. subsp. <i>halepensis</i>

1.2. Pitfall trap design and trapping effort

We recorded data of vascular plants and six groups of ground-dwelling invertebrates: pseudoscorpions (Arachnida, Pseudoscorpiones), spiders (Arachnida, Araneae), darkling beetles (Insecta, Coleoptera, Tenebrionidae), rove beetles (Insecta, Coleoptera, Staphylinidae), ground beetles (Insecta, Coleoptera, Carabidae), and ants (Insecta, Hymenoptera, Formicidae). Ground-dwelling invertebrates were collected using pitfall traps, located in the centre of each five-replicated plot. Pitfall traps are considered a standard, cost-effective and reliable method for sampling mobile, surface-dwelling arthropods (Skvarla et al., 2014; Yi et al., 2012). Following Brandmayr et al. (2005), traps were made by transparent plastic cups, 9 cm in diameter and 11 cm deep, with a small hole near the top to allow the rainwater drainage. Each trap was filled with white wine vinegar saturated with sodium chloride as a preservation method.

Since some traps were found overturned or tampered (101 out of 1350 placed traps: 5 traps for each of the 30 sampled SWOFs, for nine sampling sessions), before analyses, invertebrate abundances were expressed both as absolute abundance (aA, number of collected individuals) and as annual activity density (aAD; Brandmayr et al., 2005).

Detailed descriptions of pitfall trap design and trapping effort for each of the 30 Small Woodlots Outside Forests sampled along the gradient of land-use intensification were reported in Table A.2. Table A.2 Detailed descriptions of pitfall trap design and trapping effort for each of the 30 Small Woodlots Outside Forests sampled along the gradient of land-use intensification in Sardinia (Southern Italy).

Site code	Transect length (m)	Inter-trap spacing (m)	Average sampling Interval (Days)	Average number of active traps per sampling session	Total number of active traps in a year sample	Total trapping effort (TE)
AGR_14	40	8	36.89	4.78	43	105.33
AGR_18	100	20	39.22	5.00	45	117.67
AGR_35	80	16	35.89	4.89	44	105.00
AGR_66	80	16	39.22	4.44	40	99.40
AGR_85	92	18	39.33	5.00	45	118.00
AGR_102	155	31	38.89	5.00	45	116.67
AGR_152	96	19	38.89	4.78	43	108.00

AGR_163	57	11	36.44	4.89	44	107.00
AGR_FA_5	67	13	36.44	4.78	43	104.13
AGR_FA_6	80	16	36.33	5.00	45	109.00
AGR_FA_21	76	15	37.88	4.13	33	81.13
NAT_1	150	30	35.56	4.78	43	102.00
NAT_2	67	13	34.33	4.56	41	93.93
NAT_12	151	30	38.56	4.56	41	98.33
NAT_31	85	17	35.00	4.89	44	103.07
NAT_32	56	11	35.56	4.11	37	87.00
NAT_34	75	15	37.56	3.56	32	78.53
NAT_42	90	18	35.56	4.67	42	99.80
NAT_48	60	12	34.67	4.78	43	99.47
NAT_101	40	8	36.89	4.67	42	102.13
NAT_115	83	17	33.17	4.67	28	62.53
NAT_116	48	11	34.33	5.00	45	103.00
URB_48	45	9	39.11	4.78	43	110.60
URB_77	94	19	39.56	4.11	37	95.87
URB_176	95	19	39.56	4.44	40	102.87
URB_186	70	14	36.67	4.78	43	104.00
URB_201	67	13	36.22	5.00	45	108.67
URB_FA_10	57	11	36.33	5.00	45	109.00
URB_FA_11	92	18	36.67	4.89	44	107.00
URB_FA_56	111	22	37.22	4.89	44	108.53

2. RESULTS

3.1. General results and species richness

Fig. A.1 Bar plots show patterns of variation in species richness across the three land-use types. For each taxonomic group, data at SWOF level were used to show the mean value and standard error bar for each land-use type.

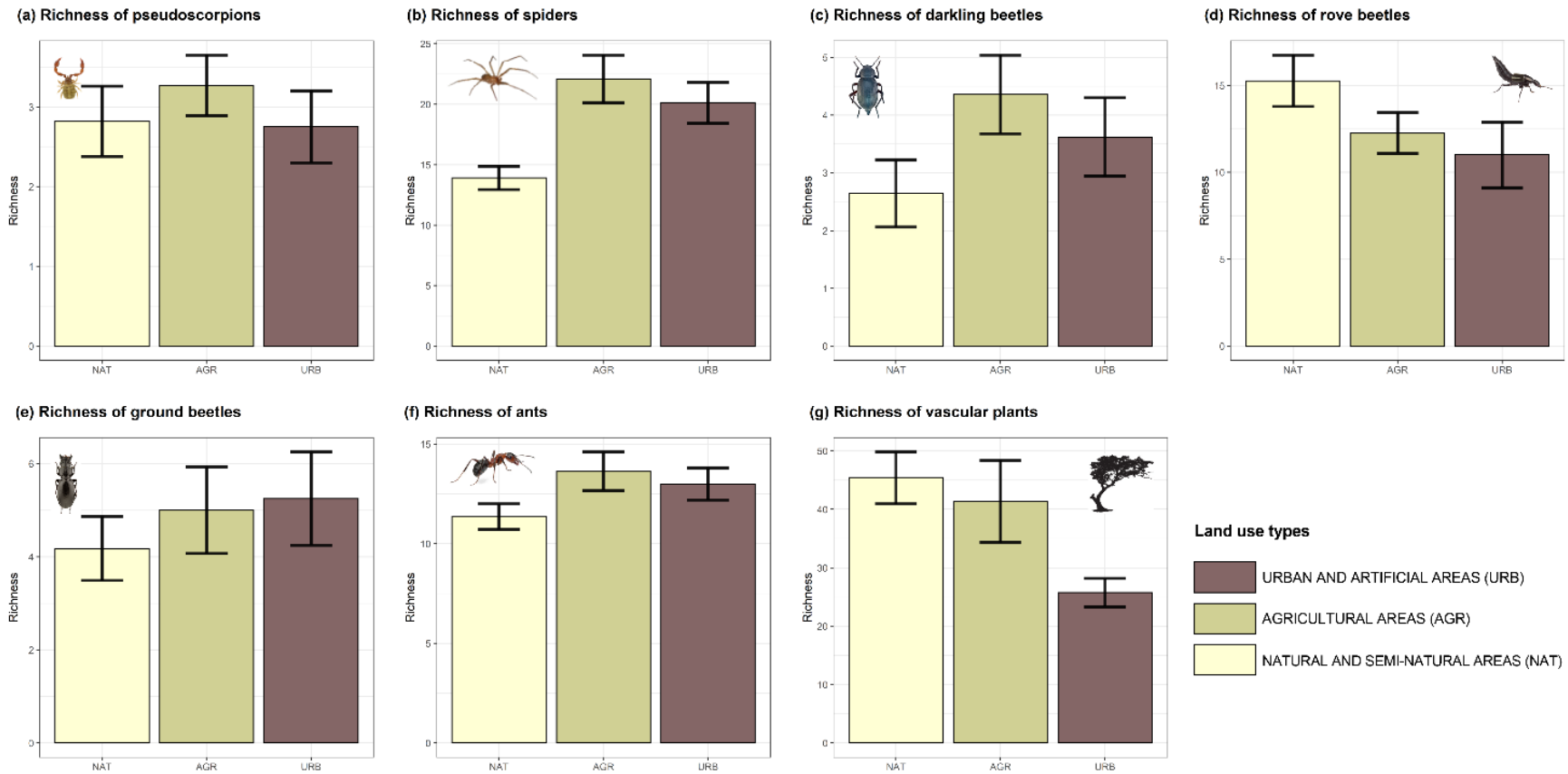


Fig. A.2 Bar plots show patterns of variation in species abundance across the three land-use types. For each taxonomic group, abundances (aA for invertebrates, and cover percentage for vascular plants) at SWOF level were used to show the mean value and standard error bar for each land-use type.

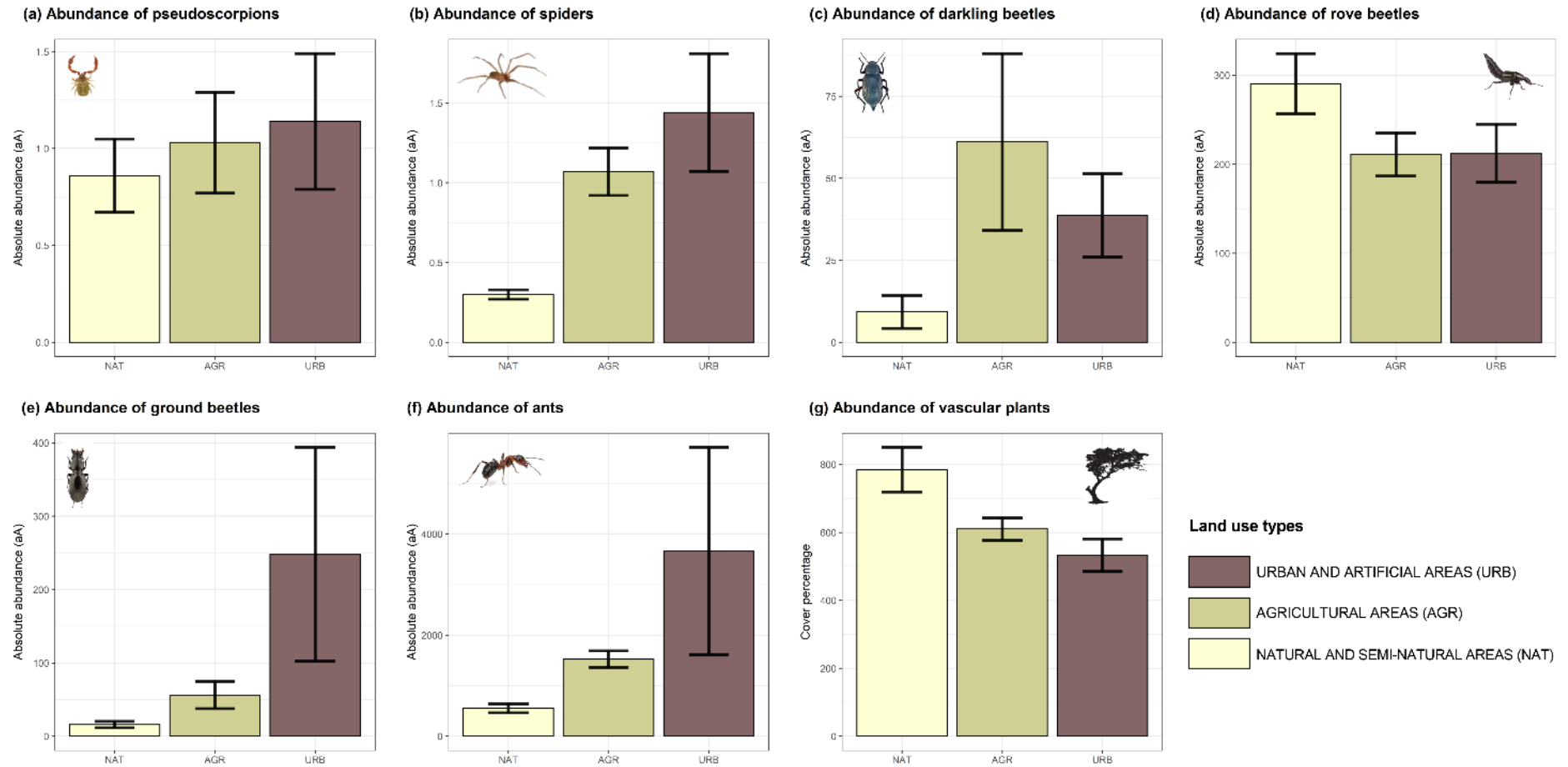
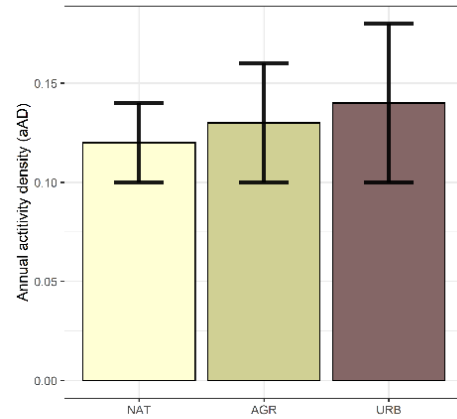
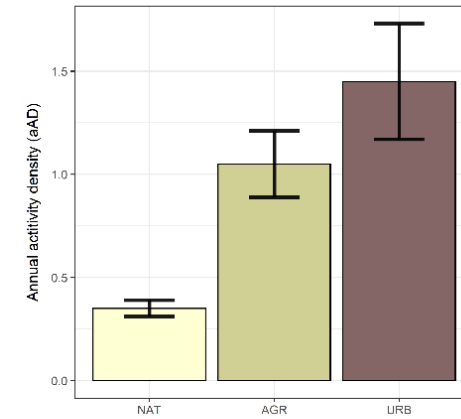


Fig. A.3 Patterns of variation in the annual activity density (aAD) of ground-dwelling invertebrates (pseudoscorpions, spiders, darkling beetles, rove beetles, ground beetles, and ants) across the three land-use types in Sardinia (Southern Italy). The aAD at SWOF level were used to show the mean value and standard error bar for each land-use type: natural and semi-natural areas (NAT), agricultural areas (AGR), urban and artificial areas (URB).

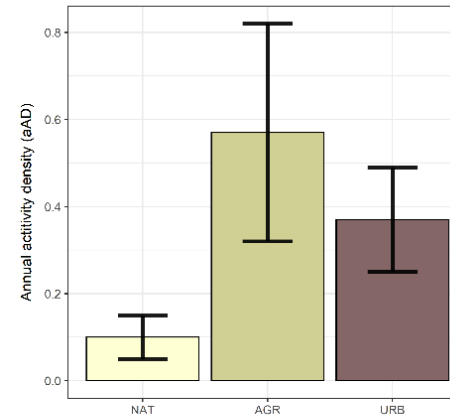
(a) Pseudoscorpions



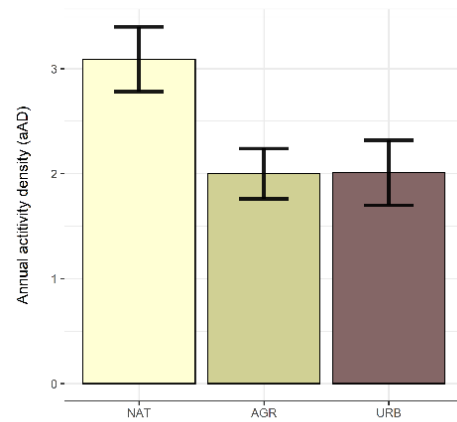
(b) Spiders



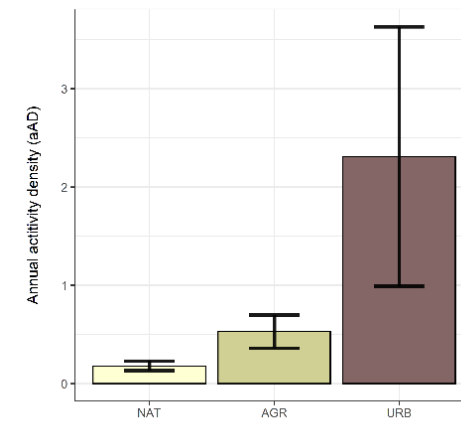
(c) Darkling beetles



(d) Rove beetles



(e) Ground beetles



(f) Ants

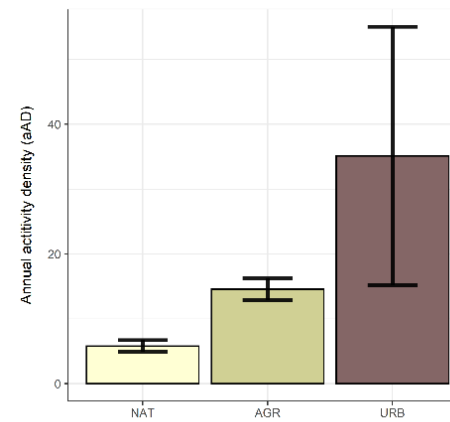


Table A.3 Comparison of empirical diversities and asymptotic estimated diversities (with estimated bootstrap standard error, SE) for Hill numbers of order q (0: Species richness, 1: Shannon diversity and 2: Simpson diversity) calculated using the sample-based rarefaction and extrapolation approach based on the sample size considered in the three land-use types. The estimated asymptotes are calculated via the functions ChaoSpecies() for q = 0, ChaoEntropy() for q = 1, and EstSimpson() for q = 2 (Chao et al., 2014).

Taxonomic group	Land-use type	Diversity measure	Empirical diversity	Estimated diversity	S.E.
Pseudoscorpions	NAT	Species richness	9.000	18.091	9.254
Pseudoscorpions)	NAT	Shannon diversity	6.141	7.937	1.682
Pseudoscorpions	NAT	Simpson diversity	5.031	5.375	0.823
Pseudoscorpions	AGR	Species richness	12.000	14.045	3.117
Pseudoscorpions	AGR	Shannon diversity	10.242	12.164	1.398
Pseudoscorpions	AGR	Simpson diversity	9.127	10.897	1.463
Pseudoscorpions	URB	Species richness	9.000	22.125	11.869
Pseudoscorpions	URB	Shannon diversity	6.255	9.670	2.595
Pseudoscorpions	URB	Simpson diversity	4.840	5.308	1.192
Spiders	NAT	Species richness	59.000	92.136	17.482
Spiders	NAT	Shannon diversity	43.927	58.613	5.233
Spiders	NAT	Simpson diversity	33.975	39.535	3.098
Spiders	AGR	Species richness	75.000	108.601	16.314
Spiders	AGR	Shannon diversity	53.882	66.069	3.821

Spiders	AGR	Simpson diversity	42.945	47.317	2.861
Spiders	URB	Species richness	54.000	69.794	9.657
Spiders	URB	Shannon diversity	42.619	51.115	3.374
Spiders	URB	Simpson diversity	35.951	40.375	2.233
Darkling beetles	NAT	Species richness	12.000	17.682	6.903
Darkling beetles	NAT	Shannon diversity	9.887	13.273	2.496
Darkling beetles	NAT	Simpson diversity	8.495	10.636	1.969
Darkling beetles	AGR	Species richness	14.000	22.182	9.289
Darkling beetles	AGR	Shannon diversity	10.205	12.536	1.942
Darkling beetles	AGR	Simpson diversity	8.471	9.247	1.092
Darkling beetles	URB	Species richness	12.000	15.646	4.326
Darkling beetles	URB	Shannon diversity	9.687	12.408	2.306
Darkling beetles	URB	Simpson diversity	8.165	9.726	1.533
Rove beetles	NAT	Species richness	39.000	41.045	2.315
Rove beetles	NAT	Shannon diversity	31.644	34.511	1.520
Rove beetles	NAT	Simpson diversity	27.296	29.543	1.344
Rove beetles	AGR	Species richness	36.000	55.205	14.996
Rove beetles	AGR	Shannon diversity	26.089	31.031	2.617
Rove beetles	AGR	Simpson diversity	21.069	22.619	1.603
Rove beetles	URB	Species richness	31.000	43.323	9.185

Rove beetles	URB	Shannon diversity	23.459	29.108	2.894
Rove beetles	URB	Simpson diversity	19.168	21.324	1.855
Ground beetles	NAT	Species richness	18.000	25.273	6.851
Ground beetles	NAT	Shannon diversity	13.469	17.605	2.196
Ground beetles	NAT	Simpson diversity	10.475	12.154	1.710
Ground beetles	AGR	Species richness	25.000	76.136	45.342
Ground beetles	AGR	Shannon diversity	18.927	32.796	8.986
Ground beetles	AGR	Simpson diversity	15.050	18.584	3.299
Ground beetles	URB	Species richness	20.000	25.062	4.485
Ground beetles	URB	Shannon diversity	15.927	21.197	2.638
Ground beetles	URB	Simpson diversity	12.423	15.192	1.890
Ants	NAT	Species richness	28.000	35.273	6.851
Ants	NAT	Shannon diversity	20.971	23.417	1.510
Ants	NAT	Simpson diversity	17.816	18.829	0.992
Ants	AGR	Species richness	30.000	41.136	12.001
Ants	AGR	Shannon diversity	23.748	26.201	1.547
Ants	AGR	Simpson diversity	20.872	21.986	1.107
Ants	URB	Species richness	26.000	26.788	1.318
Ants	URB	Shannon diversity	22.191	23.918	1.085
Ants	URB	Simpson diversity	19.737	21.235	1.159

Vascular plants	NAT	Species richness	208.000	282.792	21.298
Vascular plants	NAT	Shannon diversity	165.176	218.103	8.018
Vascular plants	NAT	Simpson diversity	133.227	164.989	6.315
Vascular plants	AGR	Species richness	202.000	333.878	35.385
Vascular plants	AGR	Shannon diversity	152.174	218.642	11.721
Vascular plants	AGR	Simpson diversity	115.463	140.443	6.795
Vascular plants	URB	Species richness	106.000	176.083	25.352
Vascular plants	URB	Shannon diversity	87.054	132.097	10.179
Vascular plants	URB	Simpson diversity	72.170	96.856	6.539

Table A.4 Full model results of permutational univariate analysis of covariance, including the land use (LU), altitude (Z) and two-way interaction effects (ZxLU). Estimates of components of variation were calculated after removing terms with a negative estimate, for which contributions were set to zero (Anderson, 2017). Analyses were based on the Euclidean distance of species richness data at SWOF level of each taxonomic group: pseudoscorpions (Pseudoscorpiones), spiders (Araneae), darkling beetles (Tenebrionidae), rove beetles (Staphylinidae), ground beetles (Carabidae), ants (Formicidae), and vascular plants. Significance codes: (**) $p \leq 0.01$, (*) $p \leq 0.05$.

Taxonomic group	Source of variation	Df	SS	MS	Pseudo-F and p-value	Variance components (%)
Pseudoscorpions	Z	1	1.43	1.43	0.81	0.00
	LU	2	1.24	0.62	0.35	0.00
	ZxLU	2	1.00	0.50	0.29	0.00
	Residuals	24	42.18	1.76	-	100.00
	Total	29	50.97	-	-	100.00
Spiders	Z	1	20.66	20.66	0.82	0.00
	LU	2	235.00	117.50	4.66*	29.15
	ZxLU	2	73.86	36.93	1.47	44.01

	Residuals	24	604.98	25.21	-	26.83
	Total	29	1085.40	-	-	100.00
	Z	1	0.09	0.09	0.02	0.00
	LU	2	2.66	1.33	0.32	0.00
Darkling beetles	ZxLU	2	0.29	0.15	0.04	0.00
	Residuals	24	98.88	4.12	-	100.00
	Total	29	129.47	-	-	100.00
	Z	1	0.12	0.12	0.01	0.00
	LU	2	10.31	5.15	0.22	0.00
Rove beetles	ZxLU	2	1.97	0.99	0.04	0.00
	Residuals	24	573.65	23.90	-	100.00
	Total	29	684.97	-	-	100.00
	Z	1	0.54	0.54	0.07	0.00
	LU	2	14.41	7.20	0.90	0.00
Ground beetles	ZxLU	2	1.29	0.65	0.08	0.00
	Residuals	24	193.14	8.05	-	100.00
	Total	29	209.37	-	-	100.00
	Z	1	0.00	0.00	0.00	0.00
	LU	2	13.16	6.58	0.97	0.00
Ants	ZxLU	2	17.30	8.65	1.28	56.01
	Residuals	24	162.13	6.76	-	43.99
	Total	29	210.97	-	-	100.00
	Z	1	178.01	178.01	0.82	0.00
	LU	2	2907.40	1453.70	6.69**	18.69
Vascular plants	ZxLU	2	2231.80	1115.90	5.14*	67.51
	Residuals	24	5213.50	217.23	-	13.80
	Total	29	9816.70	-	-	100.00

Table A.5 Final model results of permutational multivariate analysis of covariance (PERMANCOVA), including the effects of land use (LU) and altitude (Z) after the omission of the interaction term (ZxLU) due to a lack of statistical significance in the full models (see Table A.4). Estimates of components of variation were calculated after removing terms with a negative estimate, for which contributions were set to zero (Anderson, 2017). Analyses were based on the Euclidean distance of species richness data at SWOF level of each taxonomic group: pseudoscorpions (Pseudoscorpiones), spiders (Araneae), darkling beetles (Tenebrionidae), rove beetles (Staphylinidae), ground beetles (Carabidae), and ants (Formicidae). Significance codes: (***) $p \leq 0.001$, (**) $p \leq 0.01$, (*) $p \leq 0.05$.

Taxonomic group	Source of variation	Df	SS	MS	Pseudo-F and p-value	Variance components (%)
Pseudoscorpions	Z	1	6.14	6.14	3.70	28.65
	LU	2	3.73	1.86	1.12	8.33
	Residuals	26	43.18	1.66		63.02
	Total	29	50.97			100.00
Spiders	Z	1	11.85	11.85	0.45	0.00
	LU	2	263.88	131.94	5.05*	43.26
	Residuals	26	678.84	26.11		56.74
	Total	29	1085.40			100.00
Darkling beetles	Z	1	13.79	13.79	3.62	30.92
	LU	2	3.97	1.99	0.52	0.00
	Residuals	26	99.18	3.81		69.08
	Total	29	129.47			100.00
Rove beetles	Z	1	14.74	14.74	0.67	0.00
	LU	2	14.99	7.49	0.34	0.00
	Residuals	26	575.63	22.14		100.00
	Total	29	684.97			100.00
Ground beetles	Z	1	8.70	8.70	1.16	10.07
	LU	2	14.93	7.46	1.00	0.00
	Residuals	26	194.43	7.48		89.93
	Total	29	209.37			100.00
Ants	Z	1	1.67	1.67	0.24	0.00

LU	2	22.50	11.25	1.63	23.11
Residuals	26	179.42	6.90		76.89
Total	29	210.97			100.00

Table A.6 PERMANOVA t statistic and significance values of pairwise tests for the main effect of land use (LU in Table A.5), examined after the omission of the two-way interaction term (ZxLU) from the full models in Table A.4 (Anderson, 2017). Analyses were based on the Euclidean distance of species richness data at SWOF level of each taxonomic group: pseudoscorpions (Pseudoscorpiones), spiders (Araneae), darkling beetles (Tenebrionidae), rove beetles (Staphylinidae), ground beetles (Carabidae), and ants (Formicidae). Land-use types: natural and semi-natural areas (NAT), agricultural areas (AGR), urban and artificial areas (URB). Significance code: (**) $p \leq 0.01$. NA for taxa where LU resulted not significant in the final models (see Table A.5)

Taxonomic group	Pairs of levels of "land use" factor		
	NAT versus AGR	NAT versus URB	AGR versus URB
Pseudoscorpions	NA	NA	NA
Spiders	3.07**	3.17**	0.89
Darkling beetles	NA	NA	NA
Rove beetles	NA	NA	NA
Ground beetles	NA	NA	NA
Ants	NA	NA	NA

3.2. Species composition

Fig. A.4 Non-metric multidimensional scaling (NMDS) of community composition of each taxonomic group analysed separately based on Bray-Curtis dissimilarity on square-root transformed abundance data (aA for invertebrates and cover percentage for vascular plants) at SWOF level. In the plots, points are sampled SWOFs with lines connecting to land use centroids; coloured ellipses represent standard deviation-based confidence intervals (e.g., 95% confidence interval) from the centroid of each land-use type: natural and semi-natural areas (NAT), agricultural areas (AGR), urban and artificial surfaces (URB).

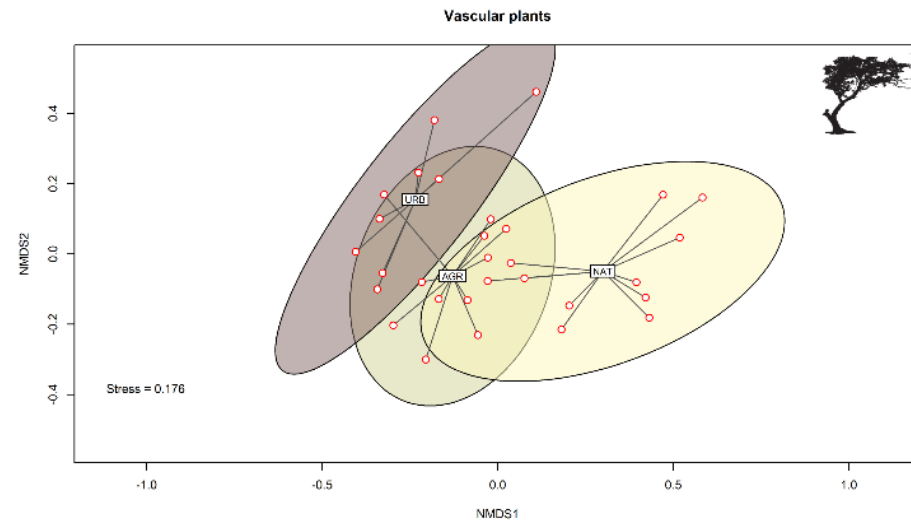
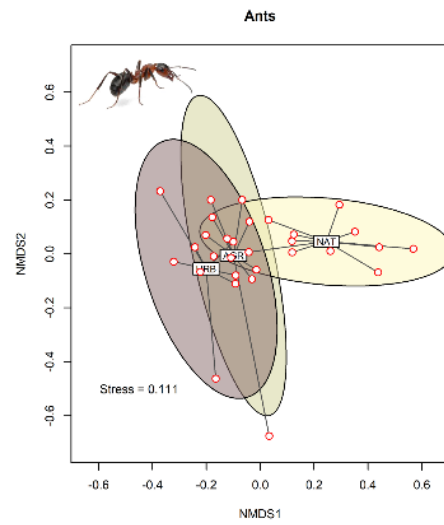
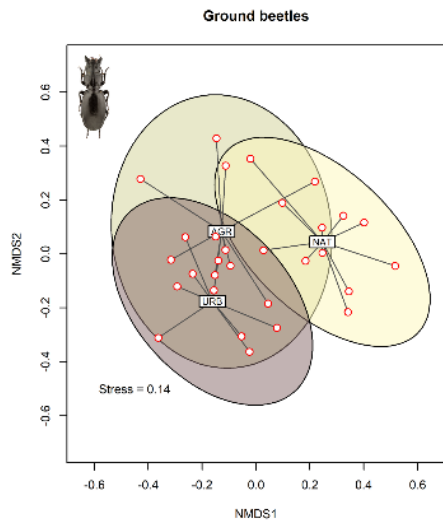
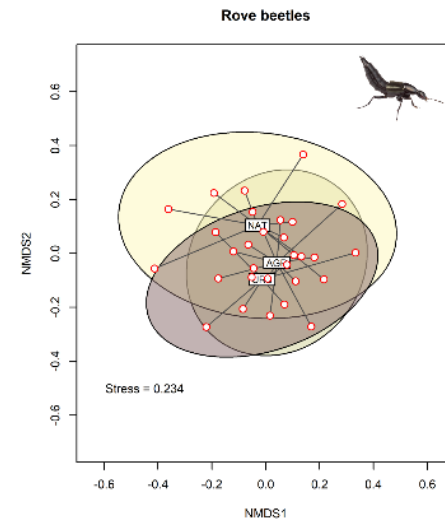
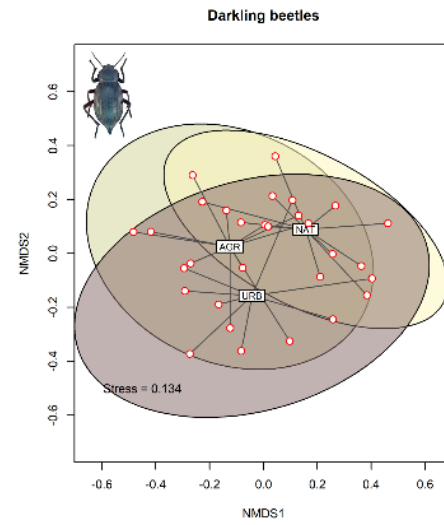
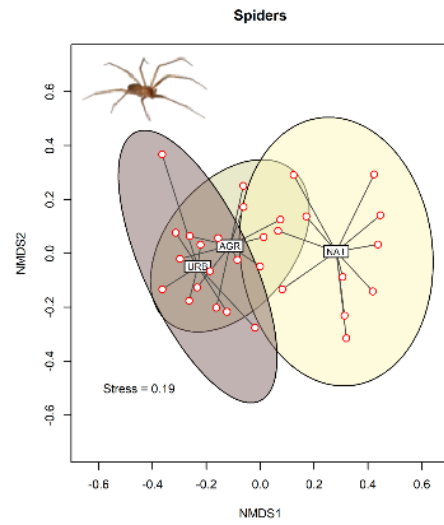
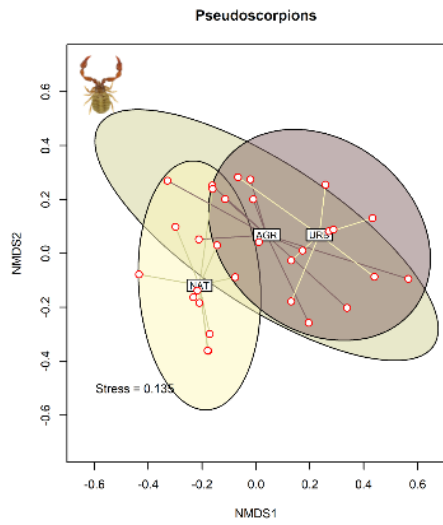


Fig. A.5 Non-metric multidimensional scaling (NMDS) of community composition of each ground-dwelling invertebrate analyzed separately based on Bray-Curtis dissimilarity on square-root transformed annual activity density data (aAD) at SWOF level. In the plots, points are sampled SWOFs with lines connecting to land use centroids; coloured ellipses represent standard deviation-based confidence intervals (e.g., 95% confidence interval) from the centroid of each land-use type: natural and semi-natural areas (NAT), agricultural areas (AGR), urban and artificial surfaces (URB). Each panel shows a different taxonomic group sampled from 30 SWOFs at the three land-use types in Sardinia (Southern Italy): pseudoscorpions (Pseudoscorpiones), spiders (Araneae), darkling beetles (Tenebrionidae), rove beetles (Staphylinidae), ground beetles (Carabidae), ants (Formicidae), and vascular plants.

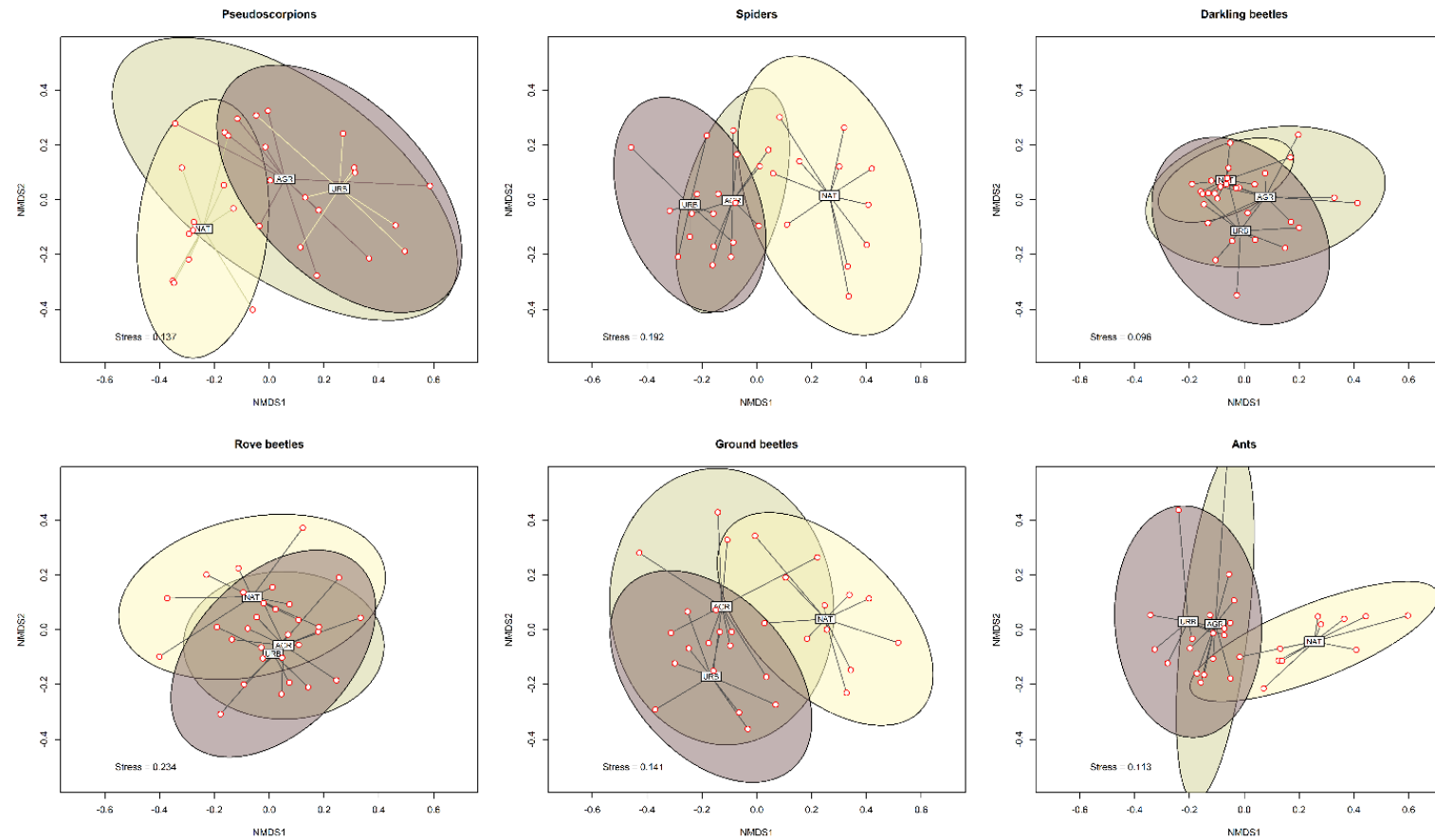


Table A.7 Full model results of permutational multivariate analysis of covariance (PERMANCOVA), including the land use (LU), altitude (Z) and two-way interaction effects (ZxLU). Estimates of components of variation were calculated after removing terms with a negative estimate, for which contributions were set to zero (Anderson, 2017). Analyses were based on the Bray-Curtis distances on square-root transformed abundance data (aA for invertebrates and cover percentage for vascular plants) of each taxonomic group: pseudoscorpions (Pseudoscorpiones), spiders (Araneae), darkling beetles (Tenebrionidae), rove beetles (Staphylinidae), ground beetles (Carabidae), ants (Formicidae), and vascular plants. Significance codes: (***) $p \leq 0.001$, (**) $p \leq 0.01$, (*) $p \leq 0.05$.

Taxonomic group	Source of variation	Df	SS	MS	Pseudo-F and p-value	Variance components (%)
Pseudoscorpions	Z	1	2074.60	2074.60	0.93	0.00
	LU	2	10774.00	5387.00	2.41**	19.12
	ZxLU	2	7121.90	3561.00	1.59	52.50
	Residuals	24	53699.00	2237.50	-	28.38
	Total	29	94212.00	-	-	100.00
Spiders	Z	1	2055.70	2055.70	1.07	19.07
	LU	2	8277.00	4138.50	2.15***	15.87
	ZxLU	2	5337.70	2668.80	1.39	39.03
	Residuals	24	46119.00	1921.60	-	26.02
	Total	29	73132.00	-	-	100.00
Darkling beetles	Z	1	3593.00	3593.00	1.81	42.86
	LU	2	8767.40	4383.70	2.21*	10.71
	ZxLU	2	5967.00	2983.50	1.50	29.26
	Residuals	24	47673.00	1986.40	-	17.17
	Total	29	69611.00	-	-	100.00
Rove beetles	Z	1	474.05	474.05	0.44	0.00
	LU	2	2147.50	1073.70	0.99	0.00
	ZxLU	2	1259.40	629.68	0.58	0.00
	Residuals	24	26140.00	1089.20	-	100.00
	Total	29	32624.00	-	-	100.00
Ground beetles	Z	1	2953.80	2953.80	0.99	0.00

	LU	2	11407.00	5703.40	1.92*	35.28
	ZxLU	2	5315.80	2657.90	0.90	0.00
	Residuals	24	71248.00	2968.70	-	64.72
	Total	29	109650.00	-	-	100.00
	Z	1	1521.50	1521.50	0.93	0.00
Ants	LU	2	6874.60	3437.30	2.10*	37.32
	ZxLU	2	3079.70	1539.90	0.94	0.00
	Residuals	24	39287.00	1637.00	-	62.68
	Total	29	66827.00	-	-	100.00
	Z	1	3632.80	3632.80	1.25	35.01
Vascular plants	LU	2	11351.00	5675.30	1.95***	13.97
	ZxLU	2	6864.40	3432.20	1.18	25.84
	Residuals	24	69687.00	2903.60	-	25.18
	Total	29	107620.00	-	-	100.00

Table A.8 Final model results of permutational multivariate analysis of covariance (PERMANCOVA), including the effects of land use (LU) and altitude (Z) after the omission of the interaction term (ZxLU) due to a lack of statistical significance in the full models (see Table A.7). Analyses were based on the Bray-Curtis distances on square-root transformed abundance data (aA for invertebrates and cover percentage for vascular plants) of each taxonomic group: pseudoscorpions (Pseudoscorpiones), spiders (Araneae), darkling beetles (Tenebrionidae), rove beetles (Staphylinidae), ground beetles (Carabidae), ants (Formicidae), and vascular plants. Significance codes: (***) $p \leq 0.001$, (**) $p \leq 0.01$, (*) $p \leq 0.05$.

Taxonomic group	Source of variation	Df	SS	MS	Pseudo-F and p-value	Variance components (%)
Pseudoscorpions	Z	1	8007.30	8007.30	3.42*	23.19
	LU	2	10626.00	5313.00	2.27*	22.98
	Residuals	26	60821.00	2339.30	-	53.83
	Total	29	94212.00	-	-	100.00
Spiders	Z	1	4787.50	4787.50	2.42**	18.63
	LU	2	9299.00	4649.50	2.35***	24.85

	Residuals	26	51457.00	1979.10	-	56.51
	Total	29	73132.00	-	-	100.00
	Z	1	5377.00	5377.00	2.61*	21.96
Darkling beetles	LU	2	5879.40	2939.70	1.42	15.45
	Residuals	26	53640.00	2063.10	-	62.59
	Total	29	69611.00	-	-	100.00
	Z	1	1897.20	1897.20	1.8*	17.85
Rove beetles	LU	2	2393.90	1197.00	1.14	10.06
	Residuals	26	27399.00	1053.80	-	72.09
	Total	29	32624.00	-	-	100.00
	Z	1	6802.60	6802.60	2.31**	17.63
Ground beetles	LU	2	15376.00	7688.20	2.61**	26.74
	Residuals	26	76564.00	2944.80	-	55.64
	Total	29	109650.00	-	-	100.00
	Z	1	7396.80	7396.80	4.54***	26.34
Ants	LU	2	7987.20	3993.60	2.45**	23.07
	Residuals	26	42367.00	1629.50	-	50.59
	Total	29	66827.00	-	-	100.00
	Z	1	9050.10	9050.10	3.07***	21.95
Vascular plants	LU	2	13057.00	6528.50	2.22***	23.00
	Residuals	26	76552.00	2944.30	-	55.05
	Total	29	107620.00	-	-	100.00

Table A.9 Full model results of permutational multivariate analysis of covariance (PERMANCOVA), including the land use (LU), altitude (Z) and two-way interaction effects (ZxLU). Estimates of components of variation were calculated after removing terms with a negative estimate, for which contributions were set to zero (Anderson, 2017). Analyses were based on the Bray-Curtis distances on square-root transformed annual activity density data (aAD) of the six ground-dwelling invertebrates: pseudoscorpions (Pseudoscorpiones), spiders (Araneae), darkling beetles (Tenebrionidae), rove beetles (Staphylinidae), ground beetles (Carabidae), and ants (Formicidae). Significance codes: (**) $p \leq 0.01$, (*) $p \leq 0.05$.

Taxonomic group	Source of variation	Df	SS	MS	Pseudo-F and p-value	Variance components (%)
Pseudoscorpions	Z	1	2062.80	2062.80	0.91	0.00
	LU	2	10821.00	5410.40	2.39*	19.11
	ZxLU	2	7157.40	3578.70	1.58	52.34
	Residuals	24	54323.00	2263.50	-	28.55
	Total	29	94442.00	-	-	100.00
Spiders	Z	1	2096.60	2096.60	1.10	21.25
	LU	2	8294.10	4147.00	2.17**	15.16
	ZxLU	2	5462.40	2731.20	1.43	38.87
	Residuals	24	45908.00	1912.80	-	24.71
	Total	29	72696.00	-	-	100.00
Darkling beetles	Z	1	805.34	805.34	1.78	33.86
	LU	2	3213.40	1606.70	3.55**	12.53
	ZxLU	2	2201.80	1100.90	2.43*	39.79
	Residuals	24	10866.00	452.73	-	13.82
	Total	29	17242.00	-	-	100.00
Rove beetles	Z	1	464.97	464.97	0.43	0.00
	LU	2	2261.10	1130.60	1.05	10.82
	ZxLU	2	1268.80	634.38	0.59	0.00
	Residuals	24	25949.00	1081.20	-	89.18
	Total	29	33032.00	-	-	100.00
Ground beetles	Z	1	2947.90	2947.90	0.99	0.00
	LU	2	11394.00	5697.00	1.91**	35.11
	ZxLU	2	5317.10	2658.60	0.89	0.00
	Residuals	24	71652.00	2985.50	-	64.89
	Total	29	109880.00	-	-	100.00
Ants	Z	1	1536.90	1536.90	0.94	0.00

LU	2	6902.50	3451.30	2.11**	37.47
ZxLU	2	3107.70	1553.80	0.95	0.00
Residuals	24	39196.00	1633.20	-	62.53
Total	29	66409.00	-	-	100.00

Table A.10 Final model results of permutational multivariate analysis of covariance (PERMANCOVA), including the effects of land use (LU) and altitude (Z) after the omission of the interaction term (ZxLU) due to a lack of statistical significance in the full models (see Table A.9). Analyses were based on the Bray-Curtis distances on square-root transformed annual activity density data (aAD) of ground-dwelling invertebrates: pseudoscorpions (Pseudoscorpiones), spiders (Araneae), rove beetles (Staphylinidae), ground beetles (Carabidae), and ants (Formicidae). Significance codes: (***) $p \leq 0.001$, (**) $p \leq 0.01$, (*) $p \leq 0.05$.

Taxonomic group	Source of variation	Df	SS	MS	Pseudo-F and p-value	Variance components (%)
Pseudoscorpions	Z	1	7880.10	7880.10	3.33**	22.91
	LU	2	10625.00	5312.70	2.25*	22.91
	Residuals	26	61480.00	2364.60	-	54.18
	Total	29	94442.00	-	-	100.00
Spiders	Z	1	4825.70	4825.70	2.44***	18.82
	LU	2	9140.10	4570.00	2.31***	24.56
	Residuals	26	51370.00	1975.80	-	56.61
	Total	29	72696.00	-	-	100.00
Rove beetles	Z	1	1969.70	1969.70	1.88*	18.12
	LU	2	2537.90	1268.90	1.21	12.16
	Residuals	26	27218.00	1046.80	-	69.72
	Total	29	33032.00	-	-	100.00
Ground beetles	Z	1	6785.10	6785.10	2.29**	17.57
	LU	2	15306.00	7653.10	2.59***	26.61
	Residuals	26	76969.00	2960.40	-	55.82
	Total	29	109880.00	-	-	100.00

	Z	1	7294.10	7294.10	4.48***	26.23
Ants	LU	2	7917.40	3958.70	2.43***	23.01
	Residuals	26	42304.00	1627.10	-	50.76
	Total	29	66409.00	-	-	100.00

Table A.11 PERMANOVA t statistic and significance values of pairwise tests for the main effect of land use (LU in Table A.8), examined after the omission of the two-way interaction term (ZxLU) from the full models in Table A.7 (Anderson, 2017). Analyses were based on the Bray-Curtis distances on square-root transformed abundance data (aA for invertebrates and cover percentage for vascular plants) of each taxonomic group: pseudoscorpions (Pseudoscorpiones), spiders (Araneae), darkling beetles (Tenebrionidae), rove beetles (Staphylinidae), ground beetles (Carabidae), ants (Formicidae), and vascular plants. Land-use types: natural and semi-natural areas (NAT), agricultural areas (AGR), urban and artificial areas (URB). Significance codes: (***) $p \leq 0.001$, (**) $p \leq 0.01$, (*) $p \leq 0.05$. NA for taxa where LU resulted not significant in the final models (see Table A.8).

Taxonomic group	Pairs of levels of "land use" factor		
	NAT versus AGR	NAT versus URB	AGR versus URB
Pseudoscorpions	1.03	2.31***	0.80
Spiders	1.44*	1.91***	1.08
Darkling beetles	NA	NA	NA
Rove beetles	NA	NA	NA
Ground beetles	1.59**	2.00***	1.08
Ants	1.81***	2.01***	0.78
Vascular plants	1.28*	1.64***	1.36**

Table A.12 PERMANOVA t statistic and significance values of pairwise tests for the main effect of land use (LU in Table A.10), examined after the omission of the two-way interaction term (ZxLU) from the full models in Table A.9 (Anderson, 2017). Analyses were based on the Bray-Curtis distances on square-root transformed annual activity density data (aAD) of ground-dwelling invertebrates: pseudoscorpions (Pseudoscorpiones), spiders (Araneae), rove beetles (Staphylinidae), ground beetles (Carabidae), and ants (Formicidae). Land-use types: natural and semi-natural areas (NAT), agricultural areas (AGR), urban and artificial areas (URB). Significance codes: (***) $p \leq 0.001$, (**) $p \leq 0.01$, (*) $p \leq 0.05$. NA for taxa where LU resulted not significant in the final models (see Table A.10).

Taxonomic group	Pairs of levels of "land use" factor		
	NAT versus AGR	NAT versus URB	AGR versus URB
Pseudoscorpions	1.02	2.29**	0.80
Spiders	1.44**	1.89***	1.09
Rove beetles	NA	NA	NA
Ground beetles	1.58*	1.99***	1.07
Ants	1.81***	2.00***	0.79

Table A.13 Mean beta diversity calculated separately for each taxonomic group using `betadispersion2` R function (Bacaro et al., 2013, 2012) based on Bray-Curtis distances on square-root transformed abundance data (aA for invertebrates and cover percentage for vascular plants) at SWOF level. Taxonomic groups sampled from 30 SWOFs at the three land-use types (LU) in Sardinia (Southern Italy): pseudoscorpions (Pseudoscorpiones), spiders (Araneae), darkling beetles (Tenebrionidae), rove beetles (Staphylinidae), ground beetles (Carabidae), ants (Formicidae), and vascular plants.

Taxonomic group	NAT	AGR	URB
Pseudoscorpions	0.58	0.78	0.65
Spiders	0.69	0.59	0.62
Darkling beetles	0.62	0.62	0.68
Rove beetles	0.48	0.44	0.45
Ground beetles	0.73	0.80	0.74
Ants	0.56	0.58	0.63
Vascular plants	0.79	0.76	0.82

Table A.14 Mean beta diversity calculated separately for each taxonomic group using `betadispersion2` R function (Bacaro et al., 2013, 2012) based on Bray-Curtis distances on square-root transformed annual activity density data (aAD) at SWOF level. Taxonomic groups sampled from 30 SWOFs at the three land-use types (LU) in Sardinia (Southern Italy): pseudoscorpions (Pseudoscorpiones), spiders (Araneae), darkling beetles (Tenebrionidae), rove beetles (Staphylinidae), ground beetles (Carabidae), and ants (Formicidae).

Taxonomic group	NAT	AGR	URB
Pseudoscorpions	0.59	0.79	0.65
Spiders	0.69	0.59	0.61
Darkling beetles	0.22	0.34	0.34
Rove beetles	0.47	0.44	0.45
Ground beetles	0.73	0.81	0.74
Ants	0.55	0.58	0.63

Table A.15 Differences in beta diversity among land-use types obtained using `betadispersion2` R function (Bacaro et al., 2013, 2012) based on Bray-Curtis dissimilarity on square-root transformed abundance data (aA for invertebrates and cover percentage for vascular plants) at SWOF level. Analyses were conducted separately for each taxonomic group sampled from 30 SWOFs at the three land-use types in Sardinia (Southern Italy): pseudoscorpions (Pseudoscorpiones), spiders (Araneae), darkling beetles (Tenebrionidae), rove beetles (Staphylinidae), ground beetles (Carabidae), ants (Formicidae), and vascular plants. Significance code: (***) $p \leq 0.001$.

Taxonomic group	Source of variation	Df	SS	MS	F Model and p-value
Pseudoscorpions	Land use	2	1.13	0.57	11.99***
	Residuals	135	6.39	0.05	-
Spiders	Land use	2	0.27	0.13	12.17***
	Residuals	135	1.49	0.01	-
Darkling beetles	Land use	2	0.09	0.04	1.43
	Residuals	135	4.15	0.03	-
Rove beetles	Land use	2	0.03	0.02	1.98
	Residuals	135	1.07	0.01	-
Ground beetles	Land use	2	0.17	0.08	2.11
	Residuals	135	5.31	0.04	-

Ants	Land use	2	0.09	0.05	1.68
	Residuals	135	3.76	0.03	-
Vascular plants	Land use	2	0.09	0.05	2.96
	Residuals	135	2.08	0.02	-

Table A.16 Differences in beta diversity among land-use types obtained using `betadisper2` R function (Bacaro et al., 2013, 2012) based on Bray-Curtis dissimilarity on square-root transformed annual activity density data (aAD) at SWOF level, analysed separately for each invertebrate group sampled from 30 SWOFs at the three land-use types in Sardinia (Southern Italy): pseudoscorpions (Pseudoscorpiones), spiders (Araneae), darkling beetles (Tenebrionidae), rove beetles (Staphylinidae), ground beetles (Carabidae), and ants (Formicidae). Significance code: (***) $p \leq 0.001$.

Taxonomic group	Source of variation	Df	SS	MS	F Model and p-value
Pseudoscorpions	Land use	2	1.07	0.53	11.81***
	Residuals	135	6.10	0.05	-
Spiders	Land use	2	0.29	0.15	13.12***
	Residuals	135	1.51	0.01	-
Darkling beetles	Land use	2	0.47	0.23	17.35***
	Residuals	135	1.81	0.01	-
Rove beetles	Land use	2	0.02	0.01	1.25
	Residuals	135	1.07	0.01	-
Ground beetles	Land use	2	0.17	0.09	2.22
	Residuals	135	5.24	0.04	-
Ants	Land use	2	0.11	0.05	1.97

Fig. A.6 Results of the Tukey HSD test on beta dispersion analyses (beta diversity analyses) among land-use types calculated for each taxonomic group, separately, based on Bray-Curtis distances on square-root transformed abundance data (aA for invertebrates and cover percentage for vascular plants) at SWOF level. Land-use types: natural and semi-natural areas (NAT), agricultural areas (AGR), urban and artificial surfaces (URB).

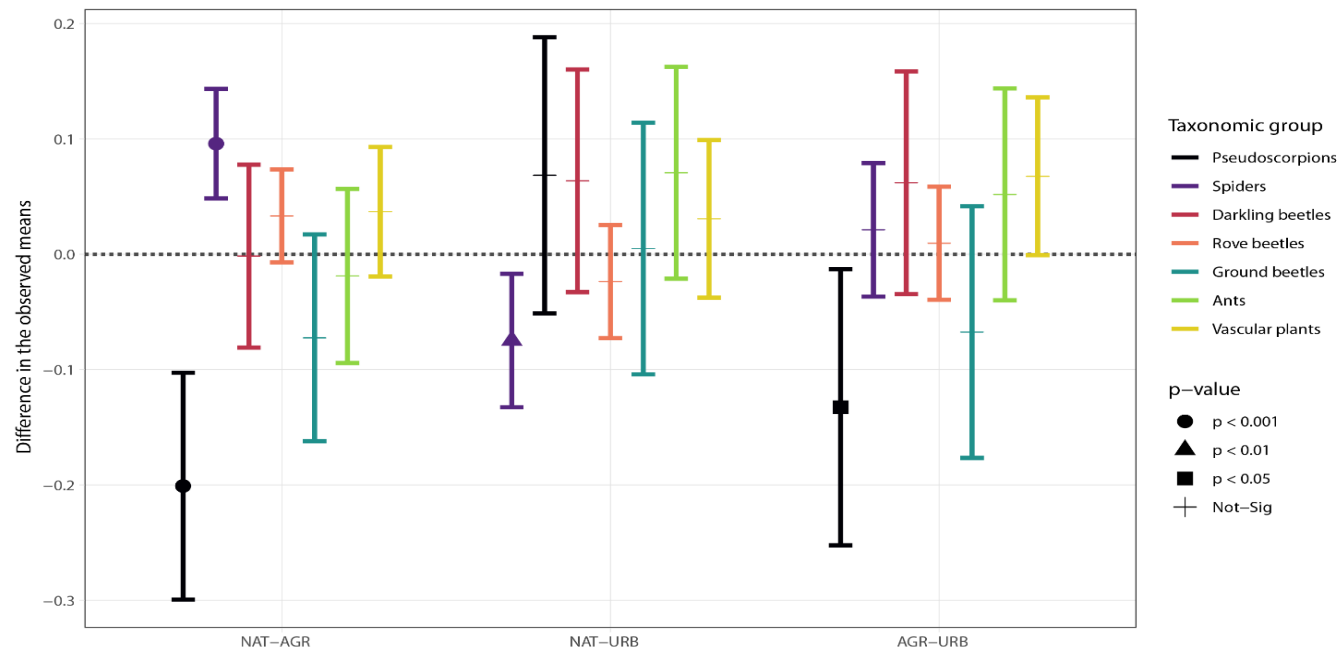


Fig. A.7 Results of the Tukey HSD test on beta dispersion analyses (beta diversity analyses) among land-use types calculated for each taxonomic group, separately, based on Bray-Curtis distances on square-root transformed abundance data (aAD for invertebrates and cover percentage for vascular plants) at SWOF level. Land-use types: natural and semi-natural areas (NAT), agricultural areas

(AGR), urban and artificial surfaces (URB). Taxonomic groups sampled from 30 SWOFs at the three land-use types (LU) in Sardinia (Southern Italy): pseudoscorpions (Pseudoscorpiones), spiders (Araneae), darkling beetles (Tenebrionidae), rove beetles (Staphylinidae), ground beetles (Carabidae), ants (Formicidae), and vascular plants.

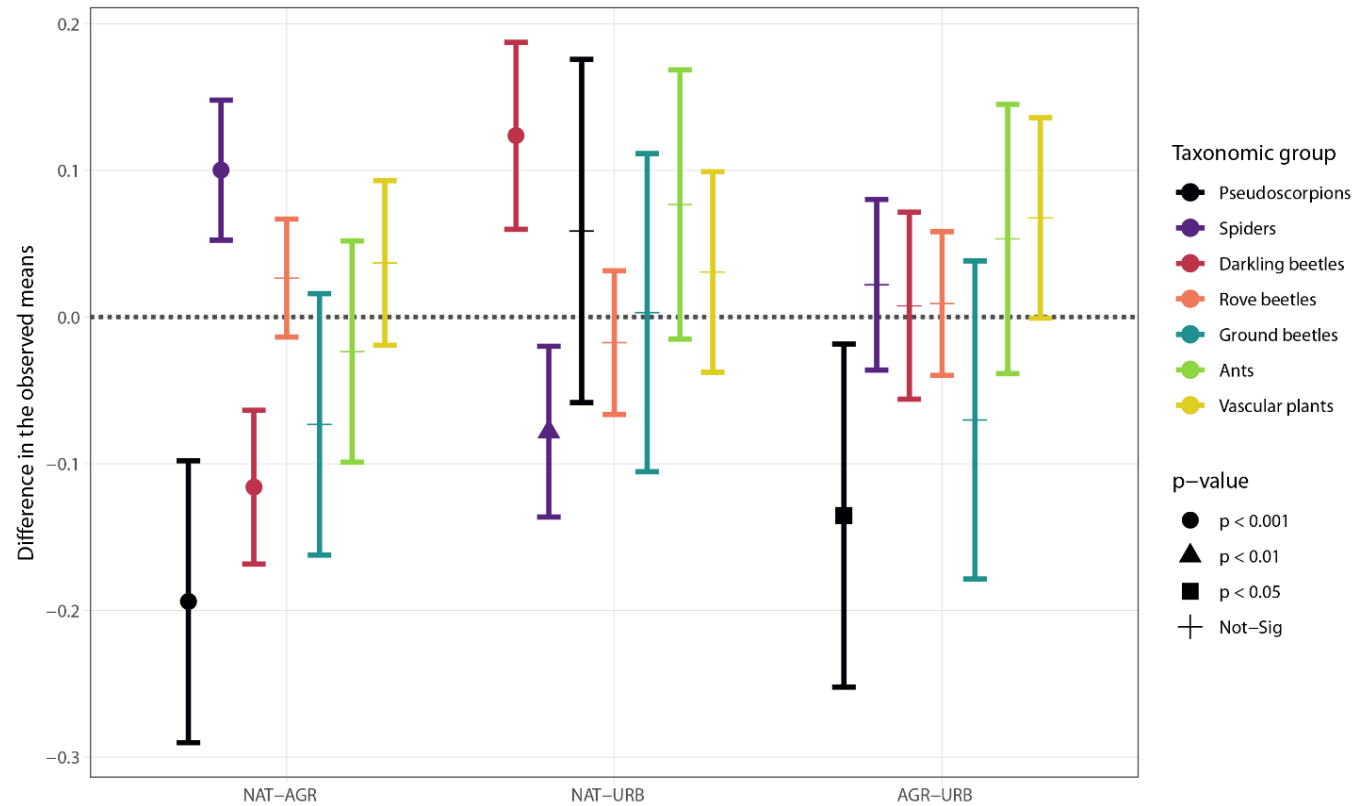


Table A.17 Results of the SIMilarity PERcentages (SIMPER) analysis based on Bray-Curtis distances on square-root transformed abundance data (cover percentage for vascular plants, and absolute abundance - aA, number of collected individuals - for invertebrates) at SWOF level for each of the seven taxonomic groups sampled from 30 Small Woodlots Outside Forest in Sardinia (Southern Italy): pseudoscorpions (Pseudoscorpiones), spiders (Araneae), darkling beetles (Tenebrionidae), rove beetles (Staphylinidae), ground beetles (Carabidae), ants (Formicidae), and vascular plants.

Abbreviations: Av. Abund. = average abundance; Av. Diss. = average dissimilarity (%); Diss/SD = dissimilarity/standard deviation; Contrib. = contribution to overall dissimilarity (%); Cum. = cumulative dissimilarity (%). Results of a cut-off level of 90% were showed only for pseudoscorpions, darkling beetles, rove beetles, ground beetles and ants. For spiders and vascular plants, only the cumulative dissimilarity of up to 70% was showed.

NAT vs. AGR		NAT	AGR				
Taxonomic group	Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib. (%)	Cum. (%)
Pseudoscorpions	<i>Hysterochelifer tuberculatus</i> (Lucas. 1849)	1.87	0.09	18.55	1.17	22.64	22.64
Pseudoscorpions	<i>Occidenchthonius berninii</i> (Callaini. 1983)	1.17	1.29	13.82	1.09	16.88	39.52
Pseudoscorpions	<i>Ephippiochthonius siculus</i> (Beier. 1961)	0.56	0.93	9.72	1.01	11.86	51.38
Pseudoscorpions	<i>Roncus caralitanus</i> Gardini. 1981	0.95	0.44	8.71	1.24	10.63	62.02
Pseudoscorpions	<i>Pselaphochernes lacertosus</i> (L. Koch. 1873)	0.00	0.96	8.61	0.70	10.51	72.53
Pseudoscorpions	<i>Geogarypus italicus</i> Gardini. Galli & Zinni. 2017	0.09	0.42	4.48	0.62	5.47	77.99
Pseudoscorpions	<i>Geogarypus minor</i> (L. Koch. 1873)	0.09	0.40	3.91	0.73	4.78	82.77
Pseudoscorpions	<i>Neobisium incertum</i> Chamberlin. 1930	0.09	0.33	3.52	0.54	4.29	87.06
Pseudoscorpions	<i>Chthonius leoi</i> (Callaini. 1988)	0.00	0.44	2.95	0.45	3.60	90.66

AGR vs. URB		AGR	URB				
Taxonomic group	Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib. (%)	Cum. (%)
Pseudoscorpions	<i>Pselaphochernes lacertosus</i> (L. Koch. 1873)	0.96	2.11	17.49	1.42	22.95	22.95
Pseudoscorpions	<i>Occidenchthonius berninii</i> (Callaini. 1983)	1.29	0.18	12.28	0.93	16.11	39.05
Pseudoscorpions	<i>Ephippiochthonius siculus</i> (Beier. 1961)	0.93	0.90	9.15	1.13	12.00	51.05
Pseudoscorpions	<i>Chthonius leoi</i> (Callaini. 1988)	0.44	0.83	7.97	0.82	10.45	61.50
Pseudoscorpions	<i>Hysterochelifer cf. spinosus</i> (Beier. 1930)	0.31	0.41	5.02	0.65	6.58	68.08
Pseudoscorpions	<i>Roncus caralitanus</i> Gardini. 1981	0.44	0.31	4.92	0.65	6.45	74.53
Pseudoscorpions	<i>Calocheiridius olivieri</i> (Simon. 1879)	0.18	0.43	4.62	0.48	6.06	80.59
Pseudoscorpions	<i>Geogarypus minor</i> (L. Koch. 1873)	0.40	0.00	3.67	0.68	4.81	85.40
Pseudoscorpions	<i>Geogarypus italicus</i> Gardini. Galli & Zinni. 2017	0.42	0.00	3.63	0.54	4.76	90.17

NAT vs. URB		NAT	URB				
Taxonomic group	Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib. (%)	Cum. (%)
Pseudoscorpions	<i>Pselaphochernes lacertosus</i> (L. Koch. 1873)	0.00	2.11	20.17	1.44	22.68	22.68
Pseudoscorpions	<i>Hysterochelifer tuberculatus</i> (Lucas. 1849)	1.87	0.31	18.91	1.14	21.27	43.95
Pseudoscorpions	<i>Occidenchthonius berninii</i> (Callaini. 1983)	1.17	0.18	10.88	1.00	12.24	56.19
Pseudoscorpions	<i>Ephippiochthonius siculus</i> (Beier. 1961)	0.56	0.90	10.14	1.42	11.41	67.60

Pseudoscorpions	<i>Roncus caralitanus</i> Gardini. 1981	0.95	0.31	9.96	1.34	11.20	78.80
Pseudoscorpions	<i>Chthonius leoi</i> (Callaini. 1988)	0.00	0.83	6.78	0.69	7.63	86.43
Pseudoscorpions	<i>Calocheiridius olivieri</i> (Simon. 1879)	0.13	0.43	4.25	0.47	4.78	91.21

Taxonomic group	NAT vs. AGR Species	Group NAT	Group AGR	Av. Diss.	Diss/SD	Contrib. (%)	Cum. (%)
		Av. Abund.	Av. Abund.				
Spiders	<i>Zodarion elegans</i> (Simon. 1873)	1.40	4.43	5.41	1.35	7.38	7.38
Spiders	<i>Zelotes fuscorufus</i> (Simon. 1878)	0.86	2.51	3.35	1.49	4.57	11.94
Spiders	<i>Zelotes tenuis</i> (L. Koch. 1866)	0.42	2.01	3.13	1.19	4.27	16.22
Spiders	<i>Scytodes velutina</i> Heineken & Lowe. 1832	0.57	1.93	3.09	1.25	4.21	20.43
Spiders	<i>Dysdera crocata</i> C. L. Koch. 1838	0.49	1.71	2.61	1.25	3.56	23.99
Spiders	<i>Ozyptila confluens</i> (C. L. Koch. 1845)	1.23	2.25	2.58	1.58	3.52	27.51
Spiders	<i>Zelotes callidus</i> (Simon. 1878)	0.13	1.47	2.22	1.65	3.03	30.54
Spiders	<i>Marinarozelotes barbatus</i> (L. Koch. 1866)	0.09	1.45	2.03	1.01	2.77	33.31
Spiders	<i>Lycosoides coarctata</i> (Dufour. 1831)	0.00	1.19	1.98	1.27	2.70	36.01
Spiders	<i>Harpactea</i> sp. <i>corticalis</i> group	1.66	1.00	1.86	1.38	2.54	38.54
Spiders	<i>Zelotes sardus</i> (Canestrini. 1873)	0.78	1.29	1.84	1.40	2.51	41.05
Spiders	<i>Marinarozelotes lyonneti</i> (Audouin. 1826)	0.00	1.19	1.81	0.95	2.46	43.52
Spiders	<i>Zodarion pusio</i> Simon. 1914	0.00	1.08	1.74	0.56	2.38	45.89
Spiders	<i>Liophrurillus flavitarsis</i> (Lucas. 1846)	0.74	0.79	1.51	1.09	2.06	47.95
Spiders	<i>Palliduphantes angustiformis</i> (Simon. 1884)	1.31	1.72	1.47	1.25	2.01	49.96
Spiders	<i>Zodarion pseudonigriceps</i> Bosmans & Pantini. 2019	0.71	0.16	1.36	0.65	1.85	51.81
Spiders	<i>Centromerus isaiai</i> Bosmans. 2015	0.78	0.09	1.35	0.95	1.84	53.65
Spiders	<i>Zodarion ruffoi</i> Caporiacco. 1951	0.22	0.73	1.26	0.79	1.72	55.37
Spiders	<i>Evarcha jucunda</i> (Lucas. 1846)	0.36	0.59	1.22	0.87	1.66	57.03
Spiders	<i>Euophrys</i> sp.	0.40	0.66	1.21	1.08	1.65	58.68
Spiders	<i>Loxosceles rufescens</i> (Dufour. 1820)	0.09	0.75	1.17	1.15	1.59	60.27
Spiders	<i>Silhouettella loricatula</i> (Roewer. 1942)	0.09	0.75	1.14	1.20	1.56	61.82
Spiders	<i>Urozelotes rusticus</i> (L. Koch. 1872)	0.00	0.68	1.06	0.58	1.45	63.27
Spiders	<i>Spermophorides elevata</i> (Simon. 1873)	0.48	0.43	1.01	0.95	1.38	64.65
Spiders	<i>Euryopsis episinoides</i> (Walckenaer. 1847)	0.36	0.56	0.99	1.01	1.35	66.01
Spiders	<i>Cyrba algerina</i> (Lucas. 1846)	0.00	0.57	0.88	0.67	1.20	67.20
Spiders	<i>Cybaeodes marinae</i> Di Franco. 1989	0.40	0.27	0.86	0.87	1.17	68.38
Spiders	<i>Euophrys rufibarbis</i> (Simon. 1868)	0.09	0.44	0.86	0.75	1.17	69.55

AGR vs. URB		Group AGR	Group URB				
Taxonomic group	Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib. (%)	Cum. (%)
Spiders	<i>Zodarion elegans</i> (Simon. 1873)	4.43	4.41	6.65	1.26	10.49	10.49
Spiders	<i>Marinarozelotes barbatus</i> (L. Koch. 1866)	1.45	2.37	2.62	1.31	4.14	14.63
Spiders	<i>Zelotes fuscorufus</i> (Simon. 1878)	2.51	0.83	2.61	1.53	4.12	18.75
Spiders	<i>Dysdera crocata</i> C. L. Koch. 1838	1.71	2.55	2.38	1.17	3.75	22.50
Spiders	<i>Zelotes tenuis</i> (L. Koch. 1866)	2.01	2.46	2.30	1.34	3.62	26.12
Spiders	<i>Scytodes velutina</i> Heineken & Lowe. 1832	1.93	0.89	2.24	1.29	3.53	29.65
Spiders	<i>Lycosoides coarctata</i> (Dufour. 1831)	1.19	2.63	2.17	1.03	3.42	33.08
Spiders	<i>Zelotes callidus</i> (Simon. 1878)	1.47	1.77	1.92	1.51	3.04	36.11
Spiders	<i>Ozyptila confluens</i> (C. L. Koch. 1845)	2.25	2.24	1.89	1.27	2.99	39.10
Spiders	<i>Heser nilicola</i> (O. Pickard-Cambridge. 1874)	0.49	1.79	1.88	1.70	2.97	42.07
Spiders	<i>Zodarion ruffoi</i> Caporiacco. 1951	0.73	1.55	1.67	1.34	2.63	44.70
Spiders	<i>Zodarion pusio</i> Simon. 1914	1.08	0.61	1.55	0.74	2.45	47.15
Spiders	<i>Harpactea</i> sp. <i>corticalis</i> group	1.00	0.87	1.53	1.05	2.42	49.56
Spiders	<i>Urozelotes rusticus</i> (L. Koch. 1872)	0.68	1.17	1.51	1.13	2.38	51.95
Spiders	<i>Nurscia albomaculata</i> (Lucas. 1846)	0.00	1.15	1.46	1.25	2.30	54.25
Spiders	<i>Zelotes sardus</i> (Canestrini. 1873)	1.29	0.76	1.39	1.33	2.19	56.43
Spiders	<i>Marinarozelotes lyonneti</i> (Audouin. 1826)	1.19	0.59	1.35	1.11	2.13	58.57
Spiders	<i>Gnaphosa alacris</i> Simon. 1878	0.09	0.99	1.28	0.65	2.02	60.58
Spiders	<i>Euophrys</i> sp.	0.66	1.06	1.10	1.21	1.74	62.32
Spiders	<i>Palliduphantes angustiformis</i> (Simon. 1884)	1.72	1.91	1.09	1.14	1.73	64.05
Spiders	<i>Loxosceles rufescens</i> (Dufour. 1820)	0.75	0.96	1.07	1.16	1.69	65.74
Spiders	<i>Cyrba algerina</i> (Lucas. 1846)	0.57	0.45	1.03	0.72	1.63	67.36
Spiders	<i>Alopecosa albofasciata</i> (Brullé. 1832)	0.22	0.83	1.02	0.88	1.61	68.97
NAT vs. URB		Group NAT	Group URB				
Taxonomic group	Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib. (%)	Cum. (%)
Spiders	<i>Zodarion elegans</i> (Simon. 1873)	1.40	4.41	7.67	0.88	9.44	9.44
Spiders	<i>Lycosoides coarctata</i> (Dufour. 1831)	0.00	2.63	4.27	1.55	5.26	14.70
Spiders	<i>Dysdera crocata</i> C. L. Koch. 1838	0.49	2.55	3.54	1.30	4.35	19.05
Spiders	<i>Marinarozelotes barbatus</i> (L. Koch. 1866)	0.09	2.37	3.51	1.22	4.32	23.37
Spiders	<i>Zelotes tenuis</i> (L. Koch. 1866)	0.42	2.46	3.45	1.76	4.24	27.62
Spiders	<i>Ozyptila confluens</i> (C. L. Koch. 1845)	1.23	2.24	2.73	1.56	3.36	30.98
Spiders	<i>Heser nilicola</i> (O. Pickard-Cambridge. 1874)	0.00	1.79	2.72	2.05	3.34	34.32
Spiders	<i>Harpactea</i> sp. <i>corticalis</i> group	1.66	0.87	2.66	1.60	3.27	37.59

Spiders	<i>Zelotes callidus</i> (Simon. 1878)	0.13	1.77	2.58	1.15	3.18	40.77
Spiders	<i>Zodarion ruffoi</i> Caporiacco. 1951	0.22	1.55	2.23	1.43	2.75	43.51
Spiders	<i>Nurscia albomaculata</i> (Lucas. 1846)	0.00	1.15	1.97	1.22	2.42	45.93
Spiders	<i>Scytodes velutina</i> Heineken & Lowe. 1832	0.57	0.89	1.87	0.95	2.30	48.24
Spiders	<i>Zelotes fuscorufus</i> (Simon. 1878)	0.86	0.83	1.87	0.99	2.30	50.54
Spiders	<i>Urozelotes rusticus</i> (L. Koch. 1872)	0.00	1.17	1.78	1.08	2.19	52.73
Spiders	<i>Palliduphantes angustiformis</i> (Simon. 1884)	1.31	1.91	1.67	1.08	2.06	54.80
Spiders	<i>Gnaphosa alacris</i> Simon. 1878	0.00	0.99	1.67	0.64	2.06	56.85
Spiders	<i>Euophrys</i> sp.	0.40	1.06	1.64	1.20	2.02	58.87
Spiders	<i>Loxosceles rufescens</i> (Dufour. 1820)	0.09	0.96	1.57	1.08	1.93	60.80
Spiders	<i>Liophrurillus flavitarsis</i> (Lucas. 1846)	0.74	0.43	1.39	0.89	1.71	62.51
Spiders	<i>Centromerus isaiai</i> Bosmans. 2015	0.78	0.00	1.32	0.92	1.63	64.14
Spiders	<i>Zelotes sardus</i> (Canestrini. 1873)	0.78	0.76	1.32	1.23	1.63	65.76
Spiders	<i>Alopecosa albofasciata</i> (Brullé. 1832)	0.09	0.83	1.31	0.86	1.61	67.38
Spiders	<i>Zodarion pseudonigriceps</i> Bosmans & Pantini. 2019	0.71	0.00	1.17	0.57	1.44	68.81
Spiders	<i>Marinarozelotes lyonneti</i> (Audouin. 1826)	0.00	0.59	0.94	0.93	1.15	69.97
	NAT vs. AGR	NAT	AGR				
Taxonomic group	Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib. (%)	Cum. (%)
Darkling beetles	<i>Tentyria grossa sardiniensis</i> Ardoin. 1973	0.74	3.95	19.79	1.09	24.50	24.50
Darkling beetles	<i>Pimelia (Pimelia) goryi goryi</i> Solier. 1836	1.38	1.68	13.94	1.16	17.25	41.75
Darkling beetles	<i>Stenosis sardoa sardoa</i> (Küster. 1848)	0.09	1.29	11.65	0.71	14.41	56.16
Darkling beetles	<i>Crypticus (Crypticus) gibbulus</i> (Quensel. 1806)	0.31	1.02	9.09	0.88	11.25	67.42
Darkling beetles	<i>Akis trilineata barbara</i> Solier. 1837	0.18	1.27	6.87	0.79	8.50	75.91
Darkling beetles	<i>Scaurus atratus</i> Fabricius. 1775	0.43	0.84	4.93	1.07	6.10	82.02
Darkling beetles	<i>Asida (Asida) androgyna</i> Leo. 2012	0.31	0.00	2.89	0.51	3.58	85.59
Darkling beetles	<i>Dichillus (Dichillus) corsicus</i> (Solier. 1838)	0.00	0.09	1.51	0.29	1.87	87.46
Darkling beetles	<i>Probaticus ebeninus ebeninus</i> (Villa. 1838)	0.13	0.00	1.39	0.27	1.72	89.18
Darkling beetles	<i>Lagria (Lagria) hirta</i> (Linnaeus. 1758)	0.09	0.00	1.25	0.26	1.55	90.73
	AGR vs. URB	AGR	URB				
Taxonomic group	Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib. (%)	Cum. (%)
Darkling beetles	<i>Tentyria grossa sardiniensis</i> Ardoin. 1973	3.95	2.24	18.38	1.19	24.44	24.44
Darkling beetles	<i>Stenosis sardoa sardoa</i> (Küster. 1848)	1.29	2.96	14.43	1.13	19.18	43.62
Darkling beetles	<i>Pimelia (Pimelia) goryi goryi</i> Solier. 1836	1.68	0.43	9.71	1.02	12.90	56.52
Darkling beetles	<i>Crypticus (Crypticus) gibbulus</i> (Quensel. 1806)	1.02	0.87	5.82	0.80	7.74	64.26

Darkling beetles	<i>Akis trilineata barbara</i> Solier. 1837	1.27	0.18	5.23	0.72	6.96	71.22
Darkling beetles	<i>Scaurus atratus</i> Fabricius. 1775	0.84	0.60	4.88	0.76	6.49	77.71
Darkling beetles	<i>Opatroides punctulatus</i> Brullé. 1832	0.18	0.80	4.10	0.66	5.45	83.16
Darkling beetles	<i>Gonocephalum (Gonocephalum) rusticum</i> (A. G. Olivier. 1811)	0.09	0.80	3.94	0.60	5.24	88.39
Darkling beetles	<i>Probaticus ebeninus cassolai</i> (Ardoin. 1973)	0.00	0.30	2.68	0.45	3.56	91.96

NAT vs. URB		NAT	URB				
Taxonomic group	Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib. (%)	Cum. (%)
Darkling beetles	<i>Stenosis sardoa sardoa</i> (Küster. 1848)	0.09	2.96	19.28	1.32	21.66	21.66
Darkling beetles	<i>Tentyria grossa sardiniensis</i> Ardoin. 1973	0.74	2.24	14.86	1.04	16.70	38.36
Darkling beetles	<i>Pimelia (Pimelia) goryi goryi</i> Solier. 1836	1.38	0.43	12.19	0.80	13.69	52.05
Darkling beetles	<i>Crypticus (Crypticus) gibbulus</i> (Quensel. 1806)	0.31	0.87	6.87	0.84	7.72	59.77
Darkling beetles	<i>Probaticus ebeninus cassolai</i> (Ardoin. 1973)	0.00	0.30	5.67	0.38	6.37	66.14
Darkling beetles	<i>Scaurus atratus</i> Fabricius. 1775	0.43	0.60	5.48	0.67	6.15	72.29
Darkling beetles	<i>Opatroides punctulatus</i> Brullé. 1832	0.00	0.80	4.95	0.60	5.56	77.85
Darkling beetles	<i>Gonocephalum (Gonocephalum) rusticum</i> (A. G. Olivier. 1811)	0.00	0.80	4.80	0.56	5.39	83.24
Darkling beetles	<i>Lagria (Lagria) hirta</i> (Linnaeus. 1758)	0.09	0.13	3.77	0.38	4.24	87.48
Darkling beetles	<i>Asida (Asida) androgyna</i> Leo. 2012	0.31	0.00	3.30	0.48	3.70	91.18

NAT vs. AGR		NAT	AGR				
Taxonomic group	Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib. (%)	Cum. (%)
Rove beetles	<i>Atheta (gruppo I) laticollis</i> (Stephens. 1832)	11.00	9.14	3.79	1.42	7.94	7.94
Rove beetles	<i>Atheta (Atheta) castanoptera</i> (Mannerheim. 1831)	6.65	6.44	2.96	1.31	6.19	14.14
Rove beetles	<i>Atheta (gruppo I) oblita</i> (Erichson. 1839)	3.29	2.88	2.95	1.25	6.17	20.31
Rove beetles	<i>Ocypus olens</i> (O.F. Müller. 1764)	1.93	2.03	2.29	1.15	4.79	25.10
Rove beetles	<i>Othius punctulatus</i> (Goeze. 1777)	2.02	0.34	2.07	1.01	4.34	29.44
Rove beetles	<i>Lordithon exoletus</i> (Erichson. 1839)	1.88	0.81	1.79	1.31	3.75	33.19
Rove beetles	<i>Atheta (Dimetrota) atramentaria</i> (Gyllenhal. 1810)	0.29	1.55	1.79	0.77	3.74	36.93
Rove beetles	<i>Ischnosoma splendidum</i> (Gravenhorst. 1806)	1.41	1.49	1.76	1.34	3.69	40.62
Rove beetles	<i>Heterothops dissimilis</i> (Gravenhorst. 1802)	2.07	1.65	1.67	1.45	3.51	44.13
Rove beetles	<i>Quedius brevicornis</i> Thomson. 1860	1.55	0.09	1.65	1.00	3.46	47.59
Rove beetles	<i>Quedius (Raphirus) humeralis</i> Stephens. 1832	1.48	1.04	1.62	1.18	3.40	50.99
Rove beetles	<i>Aleochara erythroptera</i> Gravenhorst. 1806	1.00	1.09	1.60	1.11	3.35	54.33
Rove beetles	<i>Sepedophilus nigripennis</i> (Stephens. 1832)	0.62	1.23	1.52	0.79	3.18	57.52
Rove beetles	<i>Quedius (Raphirus) semiaeneus</i> (Stephens. 1833)	1.19	0.94	1.51	1.17	3.16	60.68

Rove beetles	<i>Tachyporus nitidulus</i> (Fabricius. 1781)	3.42	3.26	1.45	1.34	3.03	63.71
Rove beetles	<i>Proteinus atomarius</i> Erichson. 1840	1.26	0.31	1.40	0.76	2.93	66.64
Rove beetles	<i>Habrocerus capillaricornis</i> (Gravenhorst. 1806)	0.50	0.81	1.12	0.81	2.35	68.99
Rove beetles	<i>Omalium rugatum</i> Rey. 1880	1.04	0.00	1.12	0.81	2.35	71.34
Rove beetles	<i>Proteinus brachypterus</i> (Fabricius. 1792)	0.97	0.00	1.06	0.68	2.22	73.56
Rove beetles	<i>Philonthus carbonarius</i> (Gravenhorst. 1802)	0.53	0.77	1.03	0.80	2.15	75.71
Rove beetles	<i>Philonthus cognatus</i> (Stephens. 1832)	0.93	0.09	1.02	0.95	2.13	77.84
Rove beetles	<i>Quedius (Quedius) pallipes</i> (Lucas. 1849)	0.56	0.67	0.98	0.81	2.06	79.90
Rove beetles	<i>Ocypus ophthalmicus</i> (Scopoli. 1763)	0.31	0.71	0.94	0.72	1.97	81.87
Rove beetles	<i>Ocypus morsitans cerdo</i> Erichson. 1840	0.92	0.00	0.88	0.56	1.85	83.72
Rove beetles	<i>Quedius (Raphirus) semiobscurus</i> (Marsham. 1802)	0.41	0.56	0.85	0.83	1.79	85.51
Rove beetles	<i>Aleochara bilineata</i> Gyllenhal. 1810	0.79	0.00	0.83	0.74	1.74	87.25
Rove beetles	<i>Amarochara cribripennis</i> Mulsant & Rey. 1874	0.43	0.25	0.64	0.75	1.35	88.60
Rove beetles	<i>Atheta</i> (gruppo II) <i>trinotata</i> (Kraatz. 1856)	0.00	0.58	0.58	0.46	1.22	89.81
Rove beetles	<i>Astrapaeus ulmi</i> (Rossi. 1790)	0.44	0.13	0.58	0.46	1.21	91.02

Taxonomic group	AGR vs. URB	AGR	URB	Av. Diss.	Diss/SD	Contrib. (%)	Cum. (%)
	Species	Av. Abund.	Av. Abund.				
Rove beetles	<i>Atheta</i> (gruppo I) <i>laticollis</i> (Stephens. 1832)	9.14	9.84	4.23	1.07	9.49	9.49
Rove beetles	<i>Atheta</i> (gruppo I) <i>oblita</i> (Erichson. 1839)	2.88	3.81	3.54	1.20	7.94	17.43
Rove beetles	<i>Atheta (Atheta) castanoptera</i> (Mannerheim. 1831)	6.44	5.59	3.24	1.02	7.27	24.70
Rove beetles	<i>Ocypus olens</i> (O.F. Müller. 1764)	2.03	1.73	2.34	1.13	5.25	29.94
Rove beetles	<i>Tachyporus nitidulus</i> (Fabricius. 1781)	3.26	2.73	2.27	1.39	5.08	35.02
Rove beetles	<i>Atheta (Dimetrota) atramentaria</i> (Gyllenhal. 1810)	1.55	0.43	2.16	0.84	4.85	39.87
Rove beetles	<i>Sepedophilus nigripennis</i> (Stephens. 1832)	1.23	0.91	2.01	0.85	4.51	44.38
Rove beetles	<i>Heterothops dissimilis</i> (Gravenhorst. 1802)	1.65	2.13	1.90	1.38	4.26	48.64
Rove beetles	<i>Philonthus carbonarius</i> (Gravenhorst. 1802)	0.77	1.39	1.85	1.24	4.15	52.80
Rove beetles	<i>Quedius (Raphirus) humeralis</i> Stephens. 1832	1.04	0.83	1.64	1.03	3.67	56.46
Rove beetles	<i>Quedius (Raphirus) semiaeneus</i> (Stephens. 1833)	0.94	1.04	1.61	1.08	3.62	60.08
Rove beetles	<i>Ischnosoma splendidum</i> (Gravenhorst. 1806)	1.49	0.68	1.59	1.28	3.56	63.64
Rove beetles	<i>Aleochara erythroptera</i> Gravenhorst. 1806	1.09	0.00	1.40	0.72	3.15	66.79
Rove beetles	<i>Habrocerus capillaricornis</i> (Gravenhorst. 1806)	0.81	0.22	1.18	0.76	2.64	69.43
Rove beetles	<i>Lordithon exoletus</i> (Erichson. 1839)	0.81	0.25	1.08	0.77	2.43	71.86
Rove beetles	<i>Quedius (Quedius) pallipes</i> (Lucas. 1849)	0.67	0.43	1.07	0.79	2.39	74.25
Rove beetles	<i>Quedius brevicornis</i> Thomson. 1860	0.09	0.71	0.92	0.62	2.07	76.32

Rove beetles	<i>Philonthus cognatus</i> (Stephens. 1832)	0.09	0.80	0.91	0.82	2.04	78.37
Rove beetles	<i>Ocyopus ophthalmicus</i> (Scopoli. 1763)	0.71	0.00	0.86	0.53	1.94	80.31
Rove beetles	<i>Quedius (Raphirus) semiobscurus</i> (Marsham. 1802)	0.56	0.22	0.79	0.80	1.76	82.07
Rove beetles	<i>Othius punctulatus</i> (Goeze. 1777)	0.34	0.38	0.78	0.65	1.76	83.83
Rove beetles	<i>Meotica filaria</i> (Fauvel. 1898)	0.22	0.41	0.69	0.56	1.56	85.38
Rove beetles	<i>Atheta</i> (gruppo II) <i>trinotata</i> (Kraatz. 1856)	0.58	0.00	0.67	0.46	1.50	86.88
Rove beetles	<i>Proteinus atomarius</i> Erichson. 1840	0.31	0.00	0.48	0.31	1.07	87.95
Rove beetles	<i>Quedius (Raphirus) nemoralis</i> Stephens. 1832	0.20	0.22	0.47	0.45	1.06	89.00
Rove beetles	<i>Cordalia obscura</i> (Gravenhorst. 1802)	0.00	0.41	0.47	0.37	1.05	90.05

NAT vs. URB		NAT	URB				
Taxonomic group	Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib. (%)	Cum. (%)
Rove beetles	<i>Atheta</i> (gruppo I) <i>laticollis</i> (Stephens. 1832)	11.00	9.84	4.31	1.28	8.91	8.91
Rove beetles	<i>Atheta (Atheta) castanoptera</i> (Mannerheim. 1831)	6.65	5.59	4.04	1.25	8.35	17.26
Rove beetles	<i>Atheta</i> (gruppo I) <i>oblita</i> (Erichson. 1839)	3.29	3.81	3.02	1.13	6.25	23.51
Rove beetles	<i>Othius punctulatus</i> (Goeze. 1777)	2.02	0.38	2.20	0.95	4.54	28.05
Rove beetles	<i>Tachyporus nitidulus</i> (Fabricius. 1781)	3.42	2.73	2.18	1.47	4.51	32.56
Rove beetles	<i>Ocyopus olens</i> (O.F. Müller. 1764)	1.93	1.73	2.00	1.22	4.13	36.69
Rove beetles	<i>Heterothops dissimilis</i> (Gravenhorst. 1802)	2.07	2.13	1.97	1.30	4.07	40.77
Rove beetles	<i>Lordithon exoletus</i> (Erichson. 1839)	1.88	0.25	1.93	1.36	3.99	44.76
Rove beetles	<i>Quedius brevicornis</i> Thomson. 1860	1.55	0.71	1.82	1.06	3.76	48.52
Rove beetles	<i>Quedius (Raphirus) humeralis</i> Stephens. 1832	1.48	0.83	1.67	1.12	3.45	51.97
Rove beetles	<i>Quedius (Raphirus) semiaeneus</i> (Stephens. 1833)	1.19	1.04	1.65	1.10	3.41	55.38
Rove beetles	<i>Philonthus carbonarius</i> (Gravenhorst. 1802)	0.53	1.39	1.57	1.14	3.24	58.63
Rove beetles	<i>Ischnosoma splendidum</i> (Gravenhorst. 1806)	1.41	0.68	1.56	1.12	3.22	61.85
Rove beetles	<i>Proteinus atomarius</i> Erichson. 1840	1.26	0.00	1.30	0.72	2.68	64.52
Rove beetles	<i>Philonthus cognatus</i> (Stephens. 1832)	0.93	0.80	1.28	1.18	2.64	67.17
Rove beetles	<i>Sepedophilus nigripennis</i> (Stephens. 1832)	0.62	0.91	1.23	0.83	2.55	69.71
Rove beetles	<i>Omalium rugatum</i> Rey. 1880	1.04	0.00	1.17	0.81	2.43	72.14
Rove beetles	<i>Ocyopus morsitans cerdo</i> Erichson. 1840	0.92	0.40	1.12	0.72	2.32	74.46
Rove beetles	<i>Aleochara erythroptera</i> Gravenhorst. 1806	1.00	0.00	1.12	0.81	2.31	76.77
Rove beetles	<i>Proteinus brachypterus</i> (Fabricius. 1792)	0.97	0.00	1.11	0.68	2.30	79.07
Rove beetles	<i>Aleochara bilineata</i> Gyllenhal. 1810	0.79	0.00	0.87	0.73	1.80	80.87
Rove beetles	<i>Quedius (Quedius) pallipes</i> (Lucas. 1849)	0.56	0.43	0.84	0.83	1.73	82.60
Rove beetles	<i>Habrocerus capillaricornis</i> (Gravenhorst. 1806)	0.50	0.22	0.69	0.60	1.42	84.02

Rove beetles	<i>Atheta (Dimetrota) atramentaria</i> (Gyllenhal. 1810)	0.29	0.43	0.65	0.68	1.35	85.37
Rove beetles	<i>Astrapaeus ulmi</i> (Rossi. 1790)	0.44	0.18	0.63	0.48	1.31	86.67
Rove beetles	<i>Quedius (Raphirus) semiobscurus</i> (Marsham. 1802)	0.41	0.22	0.62	0.57	1.29	87.97
Rove beetles	<i>Amarochara cribripennis</i> Mulsant & Rey. 1874	0.43	0.00	0.58	0.62	1.20	89.16
Rove beetles	<i>Phacophallus parumpunctatus</i> (Gyllenhal. 1827)	0.54	0.00	0.56	0.58	1.16	90.32

NAT vs. AGR		NAT	AGR				
Taxonomic group	Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib. (%)	Cum. (%)
Ground beetles	<i>Laemostenus (Laemostenus) complanatus</i> (Dejean. 1828)	0.55	3.74	18.25	0.97	20.09	20.09
Ground beetles	<i>Laemostenus (Actenipus) carinatus</i> (Chaudoir. 1859)	1.27	0.00	9.14	0.95	10.06	30.14
Ground beetles	<i>Percus (Percus) strictus ellipticus</i> (Porta. 1901)	1.25	0.09	8.28	0.97	9.12	39.26
Ground beetles	<i>Calathus (Neocalathus) cinctus</i> Motschulsky. 1850	0.00	1.21	6.64	0.94	7.31	46.57
Ground beetles	<i>Percus (Percus) strictus oberleitneri</i> (Dejean. 1831)	0.31	0.87	6.43	0.75	7.08	53.64
Ground beetles	<i>Carabus (Macrothorax) morbillosus constantinus</i> Kraatz. 1899	0.58	0.52	5.34	0.70	5.87	59.52
Ground beetles	<i>Calathus (Neocalathus) mollis</i> (Marsham. 1802)	0.00	1.37	4.82	0.54	5.31	64.83
Ground beetles	<i>Agonum</i> gr. <i>viduum</i>	0.81	0.00	4.46	0.59	4.91	69.74
Ground beetles	<i>Laemostenus (Pristonychus) algerinus algerinus</i> (Gory. 1833)	0.34	0.36	3.46	0.70	3.80	73.54
Ground beetles	<i>Calathus (Neocalathus) solieri</i> Bassi. 1834	0.13	0.72	2.72	0.44	2.99	76.53
Ground beetles	<i>Paranchus albipes</i> (Fabricius. 1796)	0.60	0.00	2.44	0.44	2.69	79.22
Ground beetles	<i>Orthomus berytensis</i> (Reiche & Saulcy. 1855)	0.00	0.75	2.25	0.44	2.47	81.70
Ground beetles	<i>Calosoma (Campalita) maderae maderae</i> (Fabricius. 1775)	0.18	0.27	1.75	0.65	1.92	83.62
Ground beetles	<i>Ocys harpaloides</i> (Audinet-Serville. 1821)	0.30	0.13	1.71	0.41	1.88	85.51
Ground beetles	<i>Zabrus (Zabrus) ignavus ignavus</i> Csiki. 1907	0.09	0.09	1.58	0.39	1.73	87.24
Ground beetles	<i>Calosoma (Calosoma) sycophanta</i> (Linnaeus. 1758)	0.09	0.09	1.52	0.38	1.67	88.91
Ground beetles	<i>Leistus (Sardoleistus) sardous</i> Baudi di Selve. 1883	0.27	0.00	1.50	0.43	1.65	90.55

AGR vs. URB		AGR	URB				
Taxonomic group	Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib. (%)	Cum. (%)
Ground beetles	<i>Laemostenus (Laemostenus) complanatus</i> (Dejean. 1828)	3.74	9.85	27.78	1.73	33.84	33.84
Ground beetles	<i>Orthomus berytensis</i> (Reiche & Saulcy. 1855)	0.75	2.54	8.07	0.84	9.83	43.68
Ground beetles	<i>Calathus (Neocalathus) cinctus</i> Motschulsky. 1850	1.21	2.52	7.89	1.12	9.62	53.29
Ground beetles	<i>Calosoma (Campalita) maderae maderae</i> (Fabricius. 1775)	0.27	0.97	4.71	0.66	5.74	59.04
Ground beetles	<i>Percus (Percus) strictus oberleitneri</i> (Dejean. 1831)	0.87	0.00	4.52	0.54	5.51	64.54
Ground beetles	<i>Calathus (Neocalathus) mollis</i> (Marsham. 1802)	1.37	0.34	4.07	0.53	4.96	69.50
Ground beetles	<i>Carabus (Macrothorax) morbillosus constantinus</i> Kraatz. 1899	0.52	0.30	3.46	0.53	4.21	73.71

Ground beetles	<i>Laemostenus (Pristonychus) algerinus algerinus</i> (Gory. 1833)	0.36	0.56	2.29	0.66	2.79	76.50
Ground beetles	<i>Calathus (Neocalathus) solieri</i> Bassi. 1834	0.72	0.18	2.28	0.43	2.78	79.28
Ground beetles	<i>Phyla tethys</i> (Netolitzky. 1926)	0.09	0.46	1.58	0.59	1.93	81.21
Ground beetles	<i>Licinus (Licinus) punctatulus</i> (Fabricius. 1792)	0.00	0.34	1.54	0.47	1.88	83.09
Ground beetles	<i>Microlestes abeillei sardous</i> Holdhaus. 1912	0.09	0.13	1.54	0.38	1.87	84.96
Ground beetles	<i>Phyla rectangula</i> (Jacquelin du Val. 1852)	0.00	0.35	1.50	0.52	1.82	86.78
Ground beetles	<i>Tschitscherinellus cordatus</i> (Dejean 1825)	0.39	0.00	1.04	0.41	1.26	88.04
Ground beetles	<i>Acinopus (Acinopus) picipes</i> (Olivier. 1795)	0.09	0.00	0.93	0.24	1.13	89.18
Ground beetles	<i>Amara (Amara) aenea</i> (De Geer. 1774)	0.00	0.18	0.93	0.35	1.13	90.31

Taxonomic group	NAT vs. URB	NAT	URB	Av. Diss.	Diss/SD	Contrib. (%)	Cum. (%)
	Species	Av. Abund.	Av. Abund.				
Ground beetles	<i>Laemostenus (Laemostenus) complanatus</i> (Dejean. 1828)	0.55	9.85	28.66	1.64	30.36	30.36
Ground beetles	<i>Orthomus berytensis</i> (Reiche & Saulcy. 1855)	0.00	2.54	8.28	0.79	8.78	39.13
Ground beetles	<i>Laemostenus (Actenipus) carinatus</i> (Chaudoir. 1859)	1.27	0.00	8.06	0.84	8.54	47.67
Ground beetles	<i>Percus (Percus) strictus ellipticus</i> (Porta. 1901)	1.25	0.00	7.51	0.83	7.95	55.63
Ground beetles	<i>Calosoma (Campalita) maderae maderae</i> (Fabricius. 1775)	0.18	0.97	5.46	0.72	5.78	61.40
Ground beetles	<i>Calathus (Neocalathus) cinctus</i> Motschulsky. 1850	0.00	2.52	4.67	0.69	4.95	66.36
Ground beetles	<i>Agonum gr. viduum</i>	0.81	0.00	3.94	0.54	4.17	70.53
Ground beetles	<i>Carabus (Macrothorax) morbillosus constantinus</i> Kraatz. 1899	0.58	0.30	3.76	0.71	3.99	74.52
Ground beetles	<i>Laemostenus (Pristonychus) algerinus algerinus</i> (Gory. 1833)	0.34	0.56	2.88	0.62	3.05	77.57
Ground beetles	<i>Percus (Percus) strictus oberleitneri</i> (Dejean. 1831)	0.31	0.00	2.31	0.41	2.45	80.02
Ground beetles	<i>Paranchus albipes</i> (Fabricius. 1796)	0.60	0.00	2.17	0.42	2.29	82.31
Ground beetles	<i>Licinus (Licinus) punctatulus</i> (Fabricius. 1792)	0.00	0.34	1.76	0.48	1.86	84.17
Ground beetles	<i>Phyla rectangula</i> (Jacquelin du Val. 1852)	0.00	0.35	1.70	0.53	1.80	85.97
Ground beetles	<i>Phyla tethys</i> (Netolitzky. 1926)	0.00	0.46	1.50	0.53	1.59	87.56
Ground beetles	<i>Microlestes abeillei sardous</i> Holdhaus. 1912	0.00	0.13	1.48	0.35	1.57	89.13
Ground beetles	<i>Leistus (Sardoleistus) sardous</i> Baudi di Selve. 1883	0.27	0.00	1.32	0.40	1.40	90.53

Taxonomic group	NAT vs. AGR	NAT	AGR	Av. Diss.	Diss/SD	Contrib. (%)	Cum. (%)
	Species	Av. Abund.	Av. Abund.				
Ants	<i>Pheidole pallidula</i> (Nylander. 1849)	8.66	17.48	9.76	1.28	13.82	13.82
Ants	<i>Aphaenogaster senilis</i> Mayr. 1853	1.10	13.47	8.39	1.59	11.88	25.70
Ants	<i>Tetramorium semilaeve</i> André. 1883	1.84	8.90	5.06	1.13	7.17	32.87
Ants	<i>Aphaenogaster spinosa</i> Emery. 1878	7.53	0.00	5.01	1.61	7.09	39.96

Ants	<i>Lasius niger</i> (Linnaeus. 1758)	1.98	7.02	4.56	0.78	6.45	46.41
Ants	<i>Linepithema humile</i> (Mayr. 1868)	0.09	4.83	4.16	0.38	5.90	52.31
Ants	<i>Crematogaster scutellaris</i> (Olivier. 1792)	9.68	7.52	3.79	1.32	5.36	57.67
Ants	<i>Camponotus aethiops</i> (Latreille. 1798)	4.38	6.29	3.62	1.23	5.12	62.79
Ants	<i>Aphaenogaster ichnusa</i> Santschi. 1925	5.07	0.27	3.45	0.97	4.89	67.68
Ants	<i>Camponotus lateralis</i> (Olivier. 1792)	2.45	4.63	2.68	1.10	3.79	71.47
Ants	<i>Plagiolepis pygmaea</i> (Latreille. 1798)	4.22	4.03	2.60	1.38	3.69	75.16
Ants	<i>Myrmica spinosior</i> Santschi. 1931	2.80	0.00	2.18	0.58	3.08	78.24
Ants	<i>Solenopsis fugax</i> Latreille. 1798	1.41	3.25	1.92	0.78	2.72	80.97
Ants	<i>Tapinoma simrothi</i> Krausse. 1911	1.32	2.13	1.69	0.92	2.39	83.36
Ants	<i>Tapinoma madeirense</i> Forel. 1895	0.22	2.12	1.32	0.73	1.88	85.23
Ants	<i>Messor minor</i> (André. 1883)	0.36	1.82	1.24	1.01	1.75	86.99
Ants	<i>Messor capitatus</i> (Latreille. 1798)	0.18	1.85	1.17	0.88	1.66	88.65
Ants	<i>Formica cunicularia</i> Latreille. 1798	1.11	0.99	1.07	0.90	1.51	90.16

Taxonomic group	AGR vs. URB	AGR	URB	Av. Diss.	Diss/SD	Contrib. (%)	Cum. (%)
	Species	Av. Abund.	Av. Abund.				
Ants	<i>Lasius niger</i> (Linnaeus. 1758)	7.02	20.86	9.03	0.74	14.74	14.74
Ants	<i>Pheidole pallidula</i> (Nylander. 1849)	17.48	16.62	7.78	1.43	12.71	27.45
Ants	<i>Linepithema humile</i> (Mayr. 1868)	4.83	7.32	5.91	0.56	9.65	37.10
Ants	<i>Tapinoma magnum</i> Mayr. 1861	0.00	10.31	5.48	0.70	8.94	46.04
Ants	<i>Tetramorium semilaeve</i> André. 1883	8.90	3.72	4.08	1.21	6.66	52.70
Ants	<i>Aphaenogaster senilis</i> Mayr. 1853	13.47	14.88	3.83	1.20	6.25	58.95
Ants	<i>Camponotus aethiops</i> (Latreille. 1798)	6.29	0.58	3.05	1.01	4.98	63.93
Ants	<i>Crematogaster scutellaris</i> (Olivier. 1792)	7.52	4.70	2.62	1.38	4.28	68.21
Ants	<i>Camponotus lateralis</i> (Olivier. 1792)	4.63	3.33	2.31	1.18	3.77	71.98
Ants	<i>Plagiolepis pygmaea</i> (Latreille. 1798)	4.03	3.63	1.81	1.25	2.96	74.94
Ants	<i>Solenopsis fugax</i> Latreille. 1798	3.25	3.55	1.71	0.99	2.78	77.72
Ants	<i>Tapinoma simrothi</i> Krausse. 1911	2.13	2.12	1.52	0.90	2.48	80.20
Ants	<i>Tapinoma madeirense</i> Forel. 1895	2.12	2.32	1.51	0.91	2.46	82.66
Ants	<i>Messor capitatus</i> (Latreille. 1798)	1.85	1.84	1.32	0.98	2.16	84.82
Ants	<i>Temnothorax exilis</i> (Emery. 1869)	1.53	2.02	1.25	1.01	2.05	86.87
Ants	<i>Tetramorium immigrans</i> Santschi. 1927	0.35	2.17	1.16	0.45	1.89	88.76
Ants	<i>Messor minor</i> (André. 1883)	1.82	1.23	1.09	1.05	1.79	90.55

NAT vs. URB		NAT	URB				
Taxonomic group	Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib. (%)	Cum. (%)
Ants	<i>Lasius niger</i> (Linnaeus. 1758)	1.98	20.86	9.24	0.65	12.23	12.23
Ants	<i>Aphaenogaster senilis</i> Mayr. 1853	1.10	14.88	8.44	3.21	11.18	23.41
Ants	<i>Pheidole pallidula</i> (Nylander. 1849)	8.66	16.62	8.35	1.32	11.05	34.46
Ants	<i>Tapinoma magnum</i> Mayr. 1861	0.00	10.31	6.91	0.69	9.15	43.62
Ants	<i>Aphaenogaster spinosa</i> Emery. 1878	7.53	0.25	4.82	1.49	6.38	49.99
Ants	<i>Linepithema humile</i> (Mayr. 1868)	0.09	7.32	4.80	0.42	6.35	56.34
Ants	<i>Crematogaster scutellaris</i> (Olivier. 1792)	9.68	4.70	3.85	1.30	5.09	61.44
Ants	<i>Aphaenogaster ichnusa</i> Santschi. 1925	5.07	0.00	3.47	0.95	4.59	66.03
Ants	<i>Plagiolepis pygmaea</i> (Latreille. 1798)	4.22	3.63	2.80	1.15	3.70	69.73
Ants	<i>Tetramorium semilaeve</i> André. 1883	1.84	3.72	2.58	0.95	3.41	73.15
Ants	<i>Camponotus aethiops</i> (Latreille. 1798)	4.38	0.58	2.55	1.56	3.37	76.52
Ants	<i>Camponotus lateralis</i> (Olivier. 1792)	2.45	3.33	2.27	0.92	3.01	79.52
Ants	<i>Myrmica spinosior</i> Santschi. 1931	2.80	0.00	2.15	0.57	2.85	82.37
Ants	<i>Solenopsis fugax</i> Latreille. 1798	1.41	3.55	1.55	1.19	2.05	84.42
Ants	<i>Tapinoma simrothi</i> Krausse. 1911	1.32	2.12	1.54	0.85	2.04	86.47
Ants	<i>Temnothorax exilis</i> (Emery. 1869)	0.45	2.02	1.39	0.73	1.84	88.31
Ants	<i>Tapinoma madeirense</i> Forel. 1895	0.22	2.32	1.25	0.70	1.65	89.96
Ants	<i>Tetramorium immigrans</i> Santschi. 1927	0.00	2.17	1.24	0.39	1.65	91.61

NAT vs. AGR		NAT	AGR				
Taxonomic group	Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib. (%)	Cum. (%)
Vascular plants	<i>Olea europaea</i> L.	1.01	8.51	3.92	1.04	4.48	4.48
Vascular plants	<i>Arbutus unedo</i> L.	7.10	0.00	3.85	0.78	4.39	8.87
Vascular plants	<i>Eucalyptus camaldulensis</i> Dehnh. subsp. <i>camaldulensis</i>	4.17	7.20	3.48	1.11	3.97	12.84
Vascular plants	<i>Pistacia lentiscus</i> L.	2.47	6.60	2.71	1.51	3.09	15.93
Vascular plants	<i>Erica arborea</i> L.	4.84	0.00	2.53	0.78	2.88	18.81
Vascular plants	<i>Oloptum miliaceum</i> (L.) Röser & H.R.Hamasha	0.15	4.56	2.43	0.78	2.77	21.58
Vascular plants	<i>Salix atrocinerea</i> Brot. subsp. <i>atrocinerea</i>	4.68	0.00	2.08	0.59	2.37	23.95
Vascular plants	<i>Asphodelus ramosus</i> L. subsp. <i>ramosus</i>	3.99	0.96	1.68	1.31	1.92	25.87
Vascular plants	<i>Rubus ulmifolius</i> Schott	3.69	0.00	1.66	1.00	1.90	27.77
Vascular plants	<i>Erica terminalis</i> Salisb.	3.69	0.00	1.66	0.57	1.89	29.66
Vascular plants	<i>Rubia peregrina</i> L.	3.77	0.86	1.63	1.00	1.86	31.51
Vascular plants	<i>Asparagus acutifolius</i> L.	2.32	3.38	1.50	1.21	1.71	33.22

Vascular plants	<i>Cistus monspeliensis</i> L.	2.50	0.51	1.18	0.91	1.34	34.57
Vascular plants	<i>Pinus halepensis</i> Mill. subsp. <i>halepensis</i>	1.15	1.52	1.09	0.54	1.24	35.81
Vascular plants	<i>Sonchus tenerrimus</i> L.	0.30	2.37	1.03	1.41	1.17	36.98
Vascular plants	<i>Geranium purpureum</i> Vill.	1.76	1.12	0.99	1.07	1.13	38.11
Vascular plants	<i>Arundo donax</i> L.	0.67	1.69	0.96	0.60	1.10	39.20
Vascular plants	<i>Cistus salviifolius</i> L.	1.80	0.00	0.87	0.55	1.00	40.20
Vascular plants	<i>Asparagus albus</i> L.	0.18	1.83	0.83	1.05	0.95	41.15
Vascular plants	<i>Eucalyptus tereticornis</i> Sm.	0.00	1.55	0.83	0.31	0.94	42.09
Vascular plants	<i>Oxalis pes-caprae</i> L.	0.03	1.56	0.82	0.56	0.94	43.03
Vascular plants	<i>Smilax aspera</i> L.	1.70	0.35	0.81	0.73	0.92	43.95
Vascular plants	<i>Trifolium campestre</i> Schreb.	1.44	1.13	0.80	1.07	0.91	44.87
Vascular plants	<i>Carex distachya</i> Desf.	1.61	0.05	0.77	0.79	0.88	45.75
Vascular plants	<i>Carex hispida</i> Willd.	1.72	0.00	0.76	0.60	0.86	46.61
Vascular plants	<i>Oloptum thomasi</i> (Duby) Banfi & Galasso	0.66	1.06	0.72	0.46	0.82	47.44
Vascular plants	<i>Cynodon dactylon</i> (L.) Pers.	0.49	0.82	0.65	0.42	0.74	48.18
Vascular plants	<i>Acacia saligna</i> (Labill.) H.L.Wendl.	0.04	1.30	0.65	0.44	0.74	48.92
Vascular plants	<i>Quercus suber</i> L.	1.09	0.00	0.64	0.40	0.73	49.65
Vascular plants	<i>Populus canescens</i> (Aiton) Sm.	1.53	0.00	0.63	0.31	0.72	50.37
Vascular plants	<i>Phillyrea latifolia</i> L.	1.30	0.00	0.62	0.33	0.71	51.08
Vascular plants	<i>Brachypodium distachyon</i> (L.) P.Beauv.	1.14	1.08	0.62	1.16	0.71	51.79
Vascular plants	<i>Myrtus communis</i> L.	1.40	0.00	0.58	0.39	0.66	52.45
Vascular plants	<i>Asparagus horridus</i> L.	0.00	1.04	0.56	0.46	0.64	53.09
Vascular plants	<i>Cynosurus effusus</i> Link	1.06	0.00	0.53	0.66	0.60	53.69
Vascular plants	<i>Pteridium aquilinum</i> (L.) Kuhn subsp. <i>aquilinum</i>	1.15	0.00	0.52	0.46	0.59	54.28
Vascular plants	<i>Bromus hordeaceus</i> L. subsp. <i>hordeaceus</i>	1.18	0.00	0.52	0.53	0.59	54.87
Vascular plants	<i>Hypochaeris achyrophorus</i> L.	0.66	1.00	0.51	1.09	0.58	55.45
Vascular plants	<i>Stachys major</i> (L.) Bartolucci & Peruzzi	0.30	0.96	0.49	0.82	0.56	56.01
Vascular plants	<i>Ceratonia siliqua</i> L.	0.67	0.50	0.49	0.49	0.56	56.57
Vascular plants	<i>Dioscorea communis</i> (L.) Caddick & Wilkin	0.64	0.61	0.48	0.48	0.55	57.12
Vascular plants	<i>Agrostis stolonifera</i> L. subsp. <i>stolonifera</i>	1.10	0.00	0.48	0.44	0.55	57.67
Vascular plants	<i>Ornithopus compressus</i> L.	0.93	0.17	0.48	0.94	0.55	58.22
Vascular plants	<i>Cistus creticus</i> L. subsp. <i>eriocephalus</i> (Viv.) Greuter & Burdet	0.80	0.41	0.48	0.62	0.54	58.76
Vascular plants	<i>Juniperus oxycedrus</i> L.	0.00	1.12	0.46	0.46	0.53	59.29
Vascular plants	<i>Phillyrea angustifolia</i> L.	1.08	0.00	0.46	0.45	0.52	59.81
Vascular plants	<i>Rhamnus alaternus</i> L. subsp. <i>alaternus</i>	0.35	0.73	0.45	0.60	0.52	60.33
Vascular plants	<i>Cynosurus echinatus</i> L.	0.69	0.71	0.45	0.88	0.52	60.85

Vascular plants	<i>Anisantha madritensis</i> (L.) Nevski subsp. <i>madritensis</i>	0.64	0.45	0.44	0.69	0.50	61.35
Vascular plants	<i>Torilis africana</i> Spreng.	0.94	0.39	0.44	1.13	0.50	61.85
Vascular plants	<i>Scirpoides holoschoenus</i> (L.) Soják	0.99	0.00	0.43	0.75	0.49	62.33
Vascular plants	<i>Ranunculus macrophyllus</i> Desf.	0.95	0.00	0.41	0.59	0.47	62.81
Vascular plants	<i>Pulicaria odora</i> (L.) Rchb.	0.80	0.00	0.41	0.61	0.47	63.27
Vascular plants	<i>Holcus lanatus</i> L. subsp. <i>lanatus</i>	0.93	0.00	0.41	0.59	0.47	63.74
Vascular plants	<i>Nerium oleander</i> L. subsp. <i>oleander</i>	0.81	0.00	0.40	0.31	0.45	64.19
Vascular plants	<i>Dactylis glomerata</i> L. subsp. <i>hispanica</i> (Roth) Nyman	0.08	0.88	0.38	0.46	0.44	64.63
Vascular plants	<i>Briza maxima</i> L.	0.80	0.26	0.38	1.01	0.43	65.06
Vascular plants	<i>Allium subhirsutum</i> L. subsp. <i>subhirsutum</i>	0.44	0.47	0.37	0.64	0.42	65.48
Vascular plants	<i>Trifolium angustifolium</i> L. subsp. <i>angustifolium</i>	0.33	0.74	0.36	1.24	0.41	65.90
Vascular plants	<i>Daucus carota</i> L.	0.29	0.61	0.36	0.67	0.41	66.31
Vascular plants	<i>Lonicera implexa</i> Aiton subsp. <i>implexa</i>	0.68	0.20	0.36	0.54	0.41	66.72
Vascular plants	<i>Scorpiurus muricatus</i> L.	0.42	0.55	0.36	0.74	0.41	67.13
Vascular plants	<i>Lavandula stoechas</i> L. subsp. <i>stoechas</i>	0.77	0.00	0.35	0.53	0.40	67.53
Vascular plants	<i>Eucalyptus gomphocephala</i> DC.	0.73	0.00	0.35	0.31	0.40	67.93
Vascular plants	<i>Rosa sempervirens</i> L.	0.72	0.00	0.35	0.46	0.40	68.33
Vascular plants	<i>Urospermum dalechampii</i> (L.) F.W.Schmidt	0.47	0.43	0.35	0.76	0.40	68.73
Vascular plants	<i>Avena sterilis</i> L. subsp. <i>sterilis</i>	0.16	0.62	0.34	0.57	0.39	69.12
Vascular plants	<i>Lysimachia arvensis</i> (L.) U.Manns & Anderb. subsp. <i>latifolia</i> (L.) Peruzzi	0.23	0.83	0.34	1.10	0.39	69.51
Vascular plants	<i>Trifolium ligusticum</i> Loisel.	0.67	0.00	0.34	0.73	0.39	69.90

Taxonomic group	AGR vs. URB	AGR	URB	Av. Diss.	Diss/SD	Contrib. (%)	Cum. (%)
	Species	Av. Abund.	Av. Abund.				
Vascular plants	<i>Olea europaea</i> L.	8.51	2.07	4.78	1.01	5.66	5.66
Vascular plants	<i>Eucalyptus camaldulensis</i> Dehnh. subsp. <i>camaldulensis</i>	7.20	4.10	4.03	1.10	4.76	10.42
Vascular plants	<i>Pistacia lentiscus</i> L.	6.60	0.16	3.66	1.70	4.34	14.76
Vascular plants	<i>Pinus halepensis</i> Mill. subsp. <i>halepensis</i>	1.52	6.20	3.58	1.05	4.24	19.00
Vascular plants	<i>Oloptum miliaceum</i> (L.) Röser & H.R.Hamasha	4.56	1.75	2.88	0.84	3.41	22.41
Vascular plants	<i>Sonchus tenerrimus</i> L.	2.37	5.34	2.25	1.04	2.66	25.07
Vascular plants	<i>Hordeum murinum</i> L.	0.33	3.14	1.85	0.63	2.19	27.26
Vascular plants	<i>Pinus pinea</i> L.	0.00	3.14	1.84	0.52	2.17	29.44
Vascular plants	<i>Acacia saligna</i> (Labill.) H.L.Wendl.	1.30	2.18	1.78	0.67	2.10	31.54
Vascular plants	<i>Asparagus acutifolius</i> L.	3.38	1.00	1.61	1.08	1.90	33.45
Vascular plants	<i>Tamarix canariensis</i> Willd.	0.00	2.24	1.34	0.37	1.58	35.03

Vascular plants	<i>Cynodon dactylon</i> (L.) Pers.	0.82	1.48	1.32	0.49	1.57	36.60
Vascular plants	<i>Brachypodium distachyon</i> (L.) P.Beauv.	1.08	1.65	1.19	0.82	1.41	38.01
Vascular plants	<i>Oxalis pes-caprae</i> L.	1.56	0.82	1.04	0.62	1.23	39.24
Vascular plants	<i>Cynosurus echinatus</i> L.	0.71	1.38	1.03	0.56	1.21	40.46
Vascular plants	<i>Eucalyptus tereticornis</i> Sm.	1.55	0.00	1.02	0.31	1.20	41.66
Vascular plants	<i>Geranium molle</i> L.	0.27	1.67	1.02	0.64	1.20	42.86
Vascular plants	<i>Asparagus albus</i> L.	1.83	0.00	1.00	1.01	1.19	44.05
Vascular plants	<i>Lolium rigidum</i> Gaudin subsp. <i>rigidum</i>	0.31	1.68	0.96	0.62	1.14	45.19
Vascular plants	<i>Arundo donax</i> L.	1.69	0.00	0.93	0.51	1.11	46.30
Vascular plants	<i>Galactites tomentosus</i> Moench	0.48	1.28	0.89	0.61	1.05	47.35
Vascular plants	<i>Hedynois rhagadioloides</i> (L.) F.W.Schmidt	0.69	1.39	0.87	1.00	1.03	48.38
Vascular plants	<i>Geranium purpureum</i> Vill.	1.12	0.63	0.86	0.64	1.02	49.40
Vascular plants	<i>Anisantha sterilis</i> (L.) Nevski	0.14	1.30	0.85	0.55	1.00	50.40
Vascular plants	<i>Asparagus horridus</i> L.	1.04	0.28	0.78	0.56	0.93	51.32
Vascular plants	<i>Hypochaeris achyrophorus</i> L.	1.00	0.65	0.61	1.18	0.72	52.05
Vascular plants	<i>Anisantha madritensis</i> (L.) Nevski subsp. <i>madritensis</i>	0.45	0.81	0.61	0.86	0.72	52.77
Vascular plants	<i>Avena barbata</i> Pott ex Link	0.77	0.77	0.61	0.96	0.72	53.49
Vascular plants	<i>Melaleuca alternifolia</i> (Maiden & Betche) Cheel	0.00	1.05	0.60	0.37	0.71	54.20
Vascular plants	<i>Polycarpon tetraphyllum</i> (L.) L. subsp. <i>diphyllum</i> (Cav.) O.Bolòs & Font Quer	0.06	1.10	0.59	0.57	0.70	54.90
Vascular plants	<i>Lagurus ovatus</i> L. subsp. <i>ovatus</i>	0.51	0.89	0.59	0.90	0.70	55.59
Vascular plants	<i>Urospermum picroides</i> (L.) Scop. ex F.W.Schmidt	0.46	0.84	0.58	0.85	0.69	56.28
Vascular plants	<i>Oloptum thomasi</i> (Duby) Banfi & Galasso	1.06	0.00	0.58	0.31	0.68	56.96
Vascular plants	<i>Melia azedarach</i> L.	0.00	1.15	0.56	0.37	0.66	57.63
Vascular plants	<i>Vicia sativa</i> L.	0.32	0.74	0.56	0.49	0.66	58.29
Vascular plants	<i>Plantago lagopus</i> L.	0.36	0.98	0.56	0.86	0.66	58.95
Vascular plants	<i>Trifolium campestre</i> Schreb.	1.13	0.00	0.55	0.71	0.65	59.60
Vascular plants	<i>Glebionis coronaria</i> (L.) Spach	0.67	0.39	0.55	0.45	0.65	60.25
Vascular plants	<i>Juniperus oxycedrus</i> L.	1.12	0.00	0.54	0.46	0.64	60.89
Vascular plants	<i>Ceratonia siliqua</i> L.	0.50	0.68	0.53	0.48	0.63	61.52
Vascular plants	<i>Tolpis virgata</i> (Desf.) Bertol. subsp. <i>virgata</i>	0.31	0.79	0.53	0.53	0.62	62.14
Vascular plants	<i>Arisarum vulgare</i> O.Targ.Tozz. subsp. <i>vulgare</i>	0.34	0.67	0.53	0.67	0.62	62.77
Vascular plants	<i>Ligustrum</i> sp.	0.00	0.74	0.52	0.37	0.61	63.38
Vascular plants	<i>Stachys major</i> (L.) Bartolucci & Peruzzi	0.96	0.00	0.52	0.74	0.61	63.99
Vascular plants	<i>Ailanthus altissima</i> (Mill.) Swingle	0.00	1.05	0.51	0.37	0.60	64.59
Vascular plants	<i>Medicago truncatula</i> Gaertn.	0.61	0.63	0.51	0.93	0.60	65.19

Vascular plants	<i>Crepis vesicaria</i> L. subsp. <i>vesicaria</i>	0.00	0.81	0.50	0.37	0.59	65.78
Vascular plants	<i>Avena sterilis</i> L. subsp. <i>sterilis</i>	0.62	0.43	0.50	0.72	0.59	66.37
Vascular plants	<i>Rubia peregrina</i> L.	0.86	0.00	0.48	0.64	0.57	66.94
Vascular plants	<i>Lysimachia arvensis</i> (L.) U.Manns & Anderb. subsp. <i>latifolia</i> (L.) Peruzzi	0.83	0.57	0.48	1.22	0.57	67.51
Vascular plants	<i>Beta vulgaris</i> L. subsp. <i>maritima</i> (L.) Arcang.	0.00	0.91	0.48	0.37	0.57	68.08
Vascular plants	<i>Medicago praecox</i> DC.	0.46	0.54	0.47	0.89	0.55	68.63
Vascular plants	<i>Asphodelus ramosus</i> L. subsp. <i>ramosus</i>	0.96	0.00	0.46	0.60	0.54	69.17
Vascular plants	<i>Chenopodium murale</i> (L.) S.Fuentes. Uotila & Borsch	0.41	0.51	0.45	0.68	0.53	69.71

Taxonomic group	NAT vs. URB Species	NAT Av. Abund.	URB Av. Abund.	Av. Diss.	Diss/SD	Contrib. (%)	Cum. (%)
Vascular plants	<i>Arbutus unedo</i> L.	7.10	0.00	4.20	0.79	4.47	4.47
Vascular plants	<i>Pinus halepensis</i> Mill. subsp. <i>halepensis</i>	1.15	6.20	3.33	1.10	3.54	8.00
Vascular plants	<i>Eucalyptus camaldulensis</i> Dehnh. subsp. <i>camaldulensis</i>	4.17	4.10	2.82	1.04	3.00	11.00
Vascular plants	<i>Erica arborea</i> L.	4.84	0.00	2.75	0.79	2.93	13.93
Vascular plants	<i>Sonchus tenerrimus</i> L.	0.30	5.34	2.65	1.19	2.82	16.75
Vascular plants	<i>Salix atrocinerea</i> Brot. subsp. <i>atrocinerea</i>	4.68	0.00	2.23	0.60	2.38	19.12
Vascular plants	<i>Asphodelus ramosus</i> L. subsp. <i>ramosus</i>	3.99	0.00	2.09	1.64	2.22	21.34
Vascular plants	<i>Rubia peregrina</i> L.	3.77	0.00	1.90	1.04	2.02	23.36
Vascular plants	<i>Rubus ulmifolius</i> Schott	3.69	0.00	1.79	1.02	1.90	25.27
Vascular plants	<i>Erica terminalis</i> Salisb.	3.69	0.00	1.78	0.57	1.90	27.17
Vascular plants	<i>Pinus pinea</i> L.	0.00	3.14	1.64	0.53	1.75	28.91
Vascular plants	<i>Hordeum murinum</i> L.	0.00	3.14	1.59	0.60	1.69	30.61
Vascular plants	<i>Olea europaea</i> L.	1.01	2.07	1.34	0.61	1.43	32.04
Vascular plants	<i>Cistus monspeliensis</i> L.	2.50	0.00	1.24	0.85	1.32	33.36
Vascular plants	<i>Acacia saligna</i> (Labill.) H.L.Wendl.	0.04	2.18	1.23	0.54	1.31	34.67
Vascular plants	<i>Tamarix canariensis</i> Willd.	0.00	2.24	1.19	0.37	1.27	35.93
Vascular plants	<i>Pistacia lentiscus</i> L.	2.47	0.16	1.19	0.72	1.27	37.20
Vascular plants	<i>Asparagus acutifolius</i> L.	2.32	1.00	1.16	1.08	1.23	38.43
Vascular plants	<i>Brachypodium distachyon</i> (L.) P.Beauv.	1.14	1.65	1.10	0.91	1.17	39.60
Vascular plants	<i>Geranium purpureum</i> Vill.	1.76	0.63	0.99	1.06	1.06	40.66
Vascular plants	<i>Cistus salviifolius</i> L.	1.80	0.00	0.95	0.55	1.01	41.67
Vascular plants	<i>Cynosurus echinatus</i> L.	0.69	1.38	0.94	0.57	1.00	42.67
Vascular plants	<i>Cynodon dactylon</i> (L.) Pers.	0.49	1.48	0.93	0.46	0.99	43.66
Vascular plants	<i>Oloptum miliaceum</i> (L.) Röser & H.R.Hamasha	0.15	1.75	0.91	0.87	0.96	44.62

Vascular plants	<i>Geranium molle</i> L.	0.03	1.67	0.88	0.60	0.93	45.55
Vascular plants	<i>Lolium rigidum</i> Gaudin subsp. <i>rigidum</i>	0.00	1.68	0.86	0.60	0.91	46.46
Vascular plants	<i>Carex distachya</i> Desf.	1.61	0.00	0.83	0.78	0.89	47.35
Vascular plants	<i>Carex hispida</i> Willd.	1.72	0.00	0.81	0.61	0.87	48.22
Vascular plants	<i>Smilax aspera</i> L.	1.70	0.00	0.80	0.67	0.85	49.07
Vascular plants	<i>Trifolium campestre</i> Schreb.	1.44	0.00	0.76	0.89	0.81	49.88
Vascular plants	<i>Galactites tomentosus</i> Moench	0.27	1.28	0.75	0.58	0.80	50.68
Vascular plants	<i>Hedynois rhagadioloides</i> (L.) F.W.Schmidt	0.05	1.39	0.73	0.87	0.78	51.45
Vascular plants	<i>Anisantha sterilis</i> (L.) Nevski	0.00	1.30	0.72	0.52	0.77	52.22
Vascular plants	<i>Quercus suber</i> L.	1.09	0.00	0.70	0.40	0.74	52.96
Vascular plants	<i>Populus canescens</i> (Aiton) Sm.	1.53	0.00	0.68	0.31	0.72	53.68
Vascular plants	<i>Phillyrea latifolia</i> L.	1.30	0.00	0.67	0.33	0.72	54.40
Vascular plants	<i>Myrtus communis</i> L.	1.40	0.00	0.62	0.40	0.66	55.06
Vascular plants	<i>Ceratonia siliqua</i> L.	0.67	0.68	0.59	0.53	0.62	55.69
Vascular plants	<i>Cynosurus effusus</i> Link	1.06	0.00	0.57	0.66	0.61	56.29
Vascular plants	<i>Bromus hordeaceus</i> L. subsp. <i>hordeaceus</i>	1.18	0.04	0.57	0.55	0.60	56.89
Vascular plants	<i>Pteridium aquilinum</i> (L.) Kuhn subsp. <i>aquilinum</i>	1.15	0.00	0.56	0.47	0.60	57.49
Vascular plants	<i>Torilis africana</i> Spreng.	0.94	0.43	0.54	1.13	0.58	58.07
Vascular plants	<i>Melaleuca alternifolia</i> (Maiden & Betche) Cheel	0.00	1.05	0.54	0.37	0.57	58.64
Vascular plants	<i>Polycarpon tetraphyllum</i> (L.) L. subsp. <i>diphyllum</i> (Cav.) O.Bolòs & Font Quer	0.04	1.10	0.53	0.57	0.57	59.21
Vascular plants	<i>Anisantha madritensis</i> (L.) Nevski subsp. <i>madritensis</i>	0.64	0.81	0.53	1.01	0.56	59.77
Vascular plants	<i>Agrostis stolonifera</i> L. subsp. <i>stolonifera</i>	1.10	0.00	0.52	0.44	0.55	60.32
Vascular plants	<i>Ornithopus compressus</i> L.	0.93	0.00	0.51	0.91	0.54	60.87
Vascular plants	<i>Melia azedarach</i> L.	0.00	1.15	0.51	0.37	0.54	61.41
Vascular plants	<i>Lagurus ovatus</i> L. subsp. <i>ovatus</i>	0.31	0.89	0.50	0.82	0.54	61.95
Vascular plants	<i>Hypochaeris achyrophorus</i> L.	0.66	0.65	0.50	0.98	0.53	62.48
Vascular plants	<i>Phillyrea angustifolia</i> L.	1.08	0.00	0.49	0.45	0.52	63.00
Vascular plants	<i>Plantago lagopus</i> L.	0.00	0.98	0.47	0.72	0.50	63.50
Vascular plants	<i>Ailanthus altissima</i> (Mill.) Swingle	0.00	1.05	0.47	0.37	0.49	64.00
Vascular plants	<i>Scirpoides holoschoenus</i> (L.) Soják	0.99	0.00	0.46	0.75	0.49	64.48
Vascular plants	<i>Ligustrum</i> sp.	0.00	0.74	0.45	0.37	0.48	64.97
Vascular plants	<i>Urospermum picroides</i> (L.) Scop. ex F.W.Schmidt	0.03	0.84	0.45	0.75	0.48	65.45
Vascular plants	<i>Ranunculus macrophyllus</i> Desf.	0.95	0.00	0.45	0.59	0.47	65.92
Vascular plants	<i>Pulicaria odora</i> (L.) Rchb.	0.80	0.00	0.44	0.61	0.47	66.39
Vascular plants	<i>Crepis vesicaria</i> L. subsp. <i>vesicaria</i>	0.00	0.81	0.44	0.37	0.47	66.86

Vascular plants	<i>Holcus lanatus</i> L. subsp. <i>lanatus</i>	0.93	0.00	0.44	0.60	0.47	67.33
Vascular plants	<i>Briza maxima</i> L.	0.80	0.00	0.44	1.04	0.47	67.80
Vascular plants	<i>Beta vulgaris</i> L. subsp. <i>maritima</i> (L.) Arcang.	0.00	0.91	0.43	0.37	0.46	68.26
Vascular plants	<i>Nerium oleander</i> L. subsp. <i>oleander</i>	0.81	0.00	0.43	0.31	0.46	68.72
Vascular plants	<i>Arisarum vulgare</i> O.Targ.Tozz. subsp. <i>vulgare</i>	0.21	0.67	0.43	0.62	0.46	69.17
Vascular plants	<i>Oxalis pes-caprae</i> L.	0.03	0.82	0.42	1.17	0.45	69.62

References listed in the Appendix

- Anderson, M.J., 2017. Permutational Multivariate Analysis of Variance (PERMANOVA). Wiley StatsRef: Statistics Reference Online 1–15. <https://doi.org/10.1002/9781118445112.stat07841>
- Anderson, M.J., 2001. A new method for non-parametric multivariate analysis of variance. *Aust. Ecol.* 26, 32–46. <https://doi.org/10.1111/j.1442-9993.2001.01070.pp.x>
- Bacaro, G., Gioria, M., Ricotta, C., 2013. Beta diversity reconsidered. *Ecol. Res.* 28, 537–540. <https://doi.org/10.1007/s11284-013-1043-z>
- Bacaro, G., Gioria, M., Ricotta, C., 2012. Testing for differences in beta diversity from plot-to-plot dissimilarities. *Ecol. Res.* 27, 285–292. <https://doi.org/10.1007/s11284-011-0899-z>
- Bazzato, E., Lallai, E., Serra, E., Melis, M.T., Marignani, M., 2021. Key role of small woodlots outside forest in a Mediterranean fragmented landscape. *For. Ecol. Manag.* 496, 119389. <https://doi.org/10.1016/j.foreco.2021.119389>
- Brandmayr, P., Zetto, T., Pizzolotto, R., 2005. I coleotteri carabidi per la valutazione ambientale e la conservazione della biodiversità: manuale operativo, Manuali e Linee Guida 34/2005. APAT, Roma.
- Chao, A., Gotelli, N.J., Hsieh, T.C., Sander, E.L., Ma, K.H., Colwell, R.K., Ellison, A.M., 2014. Rarefaction and extrapolation with Hill numbers: a framework for sampling and estimation in species diversity studies. *Ecol. Monogr.* 84, 45–67. <https://doi.org/10.1890/13-0133.1>
- Skvarla, M.J., Larson, J.L., Dowling, A.P.G., 2014. Pitfalls and preservatives: a review. *J. Entomol. Soc. Ont.* 145.

Yi, Z., Jinchao, F., Dayuan, X., Weiguo, S., Axmacher, J.C., 2012. A Comparison of Terrestrial Arthropod Sampling Methods. JRE 3, 174–182.
<https://doi.org/10.5814/j.issn.1674-764x.2012.02.010>

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

1 **Abstract**

2 Land-use intensification exacerbates landscape fragmentation, increasing the negative effects on
3 biodiversity. In this context, the biodiversity value of Trees Outside Forests (TOF; scattered trees,
4 tree lines and small woodlots) is often overlooked by landscape planning and conservation
5 programs, which typically focus on protecting larger and more intact areas. More empirical studies
6 on taxa inhabiting TOF are needed to support and promote their conservation in human-altered
7 lands.

8 However, we are not aware of any study focusing on multiple taxa living in small woodlots outside
9 forests (SWOFs) in the Mediterranean basin. We investigated how diversity patterns of multiple
10 taxa in SWOFs respond to a land-use intensification gradient, from natural areas to more disturbed
11 ones (agricultural and urban areas), in a Mediterranean biodiversity hotspot.

12 We explored the influence of land-use types on species richness and composition of vascular plants
13 and six ground-dwelling invertebrate groups (pseudoscorpions, spiders, darkling beetles, rove
14 beetles, ground beetles, and ants). Species composition was more sensitive than species richness to
15 land-use change, highlighting the need to consider a suitable measure for interpreting ecological
16 processes. We observed a strong influence of land use embedding SWOFs on the mean composition
17 and beta diversity of taxa: land-use intensification led to a general homogenization of diversity
18 patterns, especially among agricultural and urban areas. In our study area, vascular plants responded
19 more sensitively to land-use change than invertebrates. For most invertebrates: the higher the land-
20 use intensity, the lower the species composition dissimilarity due to the dominance of good
21 dispersers or disturbance-tolerant species. More vagile species and disturbance-tolerant species can
22 move across open habitats and colonize new areas, reducing compositional differences and
23 potentially boosting species pools. We demonstrated that SWOFs play a key role in supporting
24 viable populations of invertebrates, also in human-altered lands, underlining the need to promote
25 their conservation in this Mediterranean fragmented landscape to avoid homogenization from
26 driving a generalized biodiversity loss.

27 **Keywords**

28 Land-use influence, Trees Outside Forests, multi-taxa diversity patterns, ground-dwelling
29 invertebrates, Coleoptera, Hymenoptera, Pseudoscorpiones, Araneae, vascular plants

30 1. INTRODUCTION

31 Land-use intensification are among the most important direct drivers of ecosystem service changes
32 from global to local scales. A large percentage of remnant forestland is projected to be converted to
33 other uses by 2050 due to agriculture and urban sprawl (MEA, 2005). In the Mediterranean basin,
34 we observed a constantly increasing rate of land consumption and different sprawling patterns at the
35 local scale (Strollo et al., 2020). The observed trend of land-use intensification (Newbold et al.,
36 2015) and habitat loss exacerbates landscape fragmentation, affecting biodiversity (Fischer and
37 Lindenmayer, 2007).

38 Although large, intact and well-connected patches are vitally important for the maintenance of
39 ecological processes (Lindenmayer, 2019), small isolated fragments and appropriate matrix
40 management are considered valuable complements (Fischer and Lindenmayer, 2002). The high
41 conservation value of small remnant patches in human-modified landscapes is demonstrated
42 (Fischer and Lindenmayer, 2002; Le Roux et al., 2015; Lindenmayer, 2019; Tulloch et al., 2016). In
43 this context, Trees Outside Forests are gaining increasing attention. They are scattered individual
44 trees, linear arboreal elements and small woodlots outside forests (hereafter SWOFs), distributed
45 along watercourses, canals, roads and highways or, in general, over all-natural and human-modified
46 lands (de Foresta et al., 2013). They play a crucial role in climate mitigation, soil and water
47 resources protection, agricultural crop protection and, thanks to their wide distribution, promote
48 biodiversity conservation by representing ecological corridors and offering habitats for animal and
49 plant species (Bellefontaine et al., 2001; Manning et al., 2006).

50 Despite this, small patches are excluded from most connectivity analyses and conservation
51 initiatives (Cadavid-Florez et al., 2020). Considering that policymakers, land planners and
52 conservation organizations generally focus their efforts on large, intact and well-connected areas by
53 underestimating the importance of small fragments (Wintle et al., 2019), more empirical studies on
54 taxa inhabiting these patches are urgently needed to support and promote their conservation
55 (Lindenmayer, 2019). However, only a few studies consider diversity patterns of multiple
56 taxonomic groups across different areas and landscape contexts with scattered trees (Le Roux et al.,
57 2018; Prevedello et al., 2018). Surprisingly enough, we are not aware of any study focusing on
58 multiple taxonomic groups in Mediterranean SWOFs along a land-use intensification gradient.

59 We conducted a study in a Mediterranean fragmented landscape located in Sardinia (Southern
60 Italy): we investigated diversity patterns of vascular plants and six groups of ground-dwelling
61 arthropods (pseudoscorpions, spiders, darkling, rove and ground beetles, ants) living in SWOFs

62 located in different land-use types. We focused on vascular plants and arthropods as potential
63 biological indicator taxa, considering that they constitute more than 80% of all currently described
64 species (Stork, 2018), showing multiple responses to disturbance levels (Noriega et al., 2018). We
65 specifically asked: what is the role of these small patches for biodiversity conservation of multiple
66 taxonomic groups along the gradient of land-use intensification? Does the gradient of land-use
67 intensification affect SWOF multi-taxa diversity?

68 Simultaneously examining the responses of multiple taxonomic groups to the same stressor-
69 environmental gradient could contribute to understanding the effect of land use on SWOFs diversity
70 patterns, with theoretical and applied implications for their management. In a perspective of an
71 increasing need for nature-based solutions, quantitative tests based on multiple taxonomic groups
72 would also provide evidence to explicitly consider SWOFs in future conservation programs
73 (Lindenmayer, 2019; Wintle et al., 2019), particularly in Mediterranean areas, recognized as one of
74 the main hotspots for biodiversity conservation (Médail, 2017).

75 **2. MATERIALS AND METHODS**

76 **2.1. Study area**

77 The study area, covering about 18,300 hectares, is located in the Metropolitan City of Cagliari
78 (Southern Sardinia, Italy), a medium-sized functional urban area characterized by three levels of
79 fragmentation degree (i.e., low, medium, high; Palumbo et al., 2020). The area is ascribable to the
80 Mediterranean pluvioseasonal oceanic bioclimate, with a class of continentality (strong euoceanic),
81 four thermotypic horizons (from lower thermomediterranean to upper mesomediterranean) and five
82 ombrothermic horizons (from lower dry to lower humid), resulting in a combination of 11
83 isobioclimates (Canu et al., 2015) and high climate variability (Bazzato et al., 2021b). Due to the
84 anthropic disturbance, a gradient of land-use intensification runs roughly in a north-east/south-west
85 direction from natural and semi-natural areas (NAT) at higher altitudes to more disturbed ones at
86 lower altitudes (agricultural areas, AGR; urban and artificial areas, URB) (Fig. 1; Table A.1 in
87 Appendix). Considering the vegetation (Bacchetta et al., 2009), the NE sector is characterized by
88 evergreen sclerophylls, dominated by *Quercus ilex* or *Quercus suber*, and different shrub species
89 (*Erica arborea*, *Arbutus unedo*, *Phyllirea latifolia*, *Myrtus communis* and *Juniperus oxycedrus*).
90 The high-shrub and pre-forest successions are distributed in the most thermo-xerophilous SW sector
91 with wild olive and juniper shrublands (*Olea europaea* var. *sylvestris*, *Pistacia lentiscus*, *Juniperus*
92 *turbinata* and *Euphorbia dendroides*). Halophilous and psammophilous communities dominate
93 coastal areas, ponds and lagoons.

94 **2.2. Sampling design**

95 Using photo-interpretation of digital colour orthophotos (RAS, 2016), we identified and mapped all
96 SWOFs ranging from 0.05 to 0.5 hectares. Hence, SWOFs were assigned to the corresponding land-
97 use type (NAT, AGR, URB) according to the first hierarchical level of the land-use map (RAS,
98 2008). We excluded SWOFs smaller than 0.1 hectares (about 42%), as well as those embedded in a
99 mixed land-use type (about 1.50%). A total of 201 SWOFs were retained (67 in URB, 70 in AGR,
100 64 in NAT): from this population, we carried out a proportional stratified random sampling to select
101 a total of 30 SWOFs along the land-use intensification gradient (NAT, AGR, URB; Bazzato et al.,
102 2021a). Due to the difficulties to survey in private estates and similar areas located in the URB
103 areas, 8 urban SWOFs were sampled, and the remaining SWOFs (up to 30) were equally assigned
104 to the other two land-use types (11 sites in NAT and AGR; Table A.1 in Appendix).

105 For each SWOF, we used the centroid as the central middle point of a linear transect, which was
106 radiated from the centroid to the farthest sides of SWOF boundaries. For each linear transect, we
107 identified 5 plots equally spaced along the longest axes of the patch (P1-P5; Fig. 1; Table A.2 in
108 Appendix).

109 **2.3. Data collection**

110 We recorded data of vascular plants and six groups of ground-dwelling invertebrates
111 (pseudoscorpions, spiders, darkling beetles, rove beetles, ground beetles, ants).

112 Vascular plant occurrences and abundances were recorded from April to August 2018. We visually
113 estimated vascular plant abundance as percentage cover within five replicate plots of 1 m² in each
114 transect per SWOF. Then, they were summed across the five plots in each transect per SWOF.

115 Ground-dwelling invertebrates were collected from April 2018 to May 2019 to optimize the capture
116 efficiency of seasonally active ground-dwelling groups using five replicate pitfall traps in each
117 transect per SWOF, located in the centre of each plot (see Appendix for further details on pitfall
118 trap design and trapping effort). The traps were emptied every 30-40 days; thus, nine trap-emptying
119 made up a year sample for each sampled SWOF. Hence, we pooled abundance data along the year
120 sample to optimize the catch and overcome occasional trap losses (Kotze et al., 2011). Since some
121 traps were found overturned or tampered, we expressed invertebrate abundances as absolute
122 abundance (aA, number of collected individuals) and annual activity density (aAD) to standardize

123 pitfall catches for the trapping effort (i.e., the number of active traps, and the duration of the
124 catching period; see Appendix and Saska et al., 2021).

125 The annual activity density of each species was calculated by dividing the number of collected indi-
126 viduals during the entire sampling period (tot indiv) with the total (yearly) trapping effort (TE) for
127 each sampled SWOF:

128 Eq. (A.1)
$$\text{aAD} = \text{tot indiv} / \text{TE}$$

129 with $\text{TE} = \sum \text{te}$ and $\text{te} = \text{trap} * (\text{dd}/15)$, where trap is the number of active traps and dd is the number
130 of days during which traps were active in each sampling session (Brandmayr et al., 2005).

131 The latest expression, originally proposed by Brandmayr et al. (2005) dividing by 10 (for periods of
132 10 days), was modified to obtain the active number of individuals who fall into the traps during that
133 period of the year within 15 days.

134 **2.4. Statistical analyses**

135 **2.4.1. Species richness**

136 To consider the bias due to different sampling efforts, sample-based rarefaction and extrapolation
137 approach (Colwell et al., 2012) was applied based on incidence data, using the *iNEXT* package
138 (Hsieh et al., 2016). This approach extends methods for rarefaction and extrapolation (R/E) of
139 species richness to higher-order Hill numbers: species richness ($q = 0$); Shannon diversity ($q = 1$),
140 the exponential of Shannon entropy interpreted as the effective number of frequent species in the
141 assemblage; Simpson diversity ($q = 2$), the inverse Simpson concentration interpreted as the
142 effective number of highly frequent species in the assemblage (Chao et al., 2020). Rarefaction was
143 used to compare the land-use types by correlating the three orders of taxonomic diversity with a
144 certain number of samples (i.e., the minimum number of samples overall land-use types). We
145 applied asymptotic estimators, via the functions *ChaoRichness* for $q = 0$, *ChaoShannon* for $q = 1$
146 and *ChaoSimpson* for $q = 2$, to compare the potential number of sampled species in a scenario of
147 maximized sampling intensity (Colwell et al., 2012). The 95% confidence intervals obtained by 200
148 replicate bootstrapping runs and associated with the estimates were also calculated. Whenever the
149 95% confidence intervals did not overlap, diversity measures differed significantly at $p < 0.05$
150 (Colwell et al., 2012).

151 We adopted a semi-parametric PERMANCOVA approach (Anderson, 2017) to investigate land use
152 effect (LU, fixed factor with three levels: NAT, AGR and URB) on species richness of each
153 taxonomic group, accounting for altitude (Z) and two-way interaction effects (ZxLU). We omitted
154 the interaction term from the full models when the p-values were not significant. Hence, we

155 calculated the pseudo variance components for each variation source, and post-hoc permutational
156 pairwise comparison tests with PERMANOVA t statistic for the main effect of land use in the final
157 reduced models (ZxLU; Anderson, 2017). All tests were performed using Euclidean distances of
158 untransformed species richness values aggregated at SWOF level, 999 random permutations and the
159 most conservative type III sum of squares for unbalanced designs in PRIMER v.6.1.12 software
160 (Anderson et al., 2008).

161 **2.4.2. Species composition**

162 We evaluated the influence of land-use types on species composition using (1) non-metric
163 multidimensional scaling (NMDS), (2) permutational multivariate analysis of covariance
164 (PERMANCOVA), (3) beta- dispersion analysis, and (4) SIMilarity PERcentages Procedure
165 (SIMPER). Analyses were carried out separately for each taxonomic group using Bray-Curtis
166 distances on square-root transformed abundance data at SWOF level. For invertebrates, all analyses
167 were conducted using both aA and aAD data and considering samples entirely defaunated (i.e., zero
168 animal species) through the use of the zero-adjusted Bray-Curtis coefficients (Clarke et al., 2006).

169 We indirectly visualized differences in species composition among land-use types via NMDS plots,
170 using the `metaMDS` function of the `vegan` package (Oksanen et al., 2019). PERMANCOVA was
171 applied to test the null hypothesis of no differences in the position of centroids (i.e., the average
172 community composition) (Anderson, 2017; Anderson and Walsh, 2013) among land-use types (LU,
173 fixed factor with three levels; NAT, AGR and URB), including altitude (Z) and two-way interaction
174 effects (ZxLU). We omitted the interaction term from the full models when the p-values were not
175 significant (Anderson, 2017). Hence, we calculated the pseudo multivariate variance components
176 and post-hoc permutational pairwise comparison tests with PERMANOVA t statistic for the main
177 effect of land use in the final reduced models (Anderson, 2017).

178 Differences in beta dispersion (hereafter beta diversity) among land-use types were assessed with
179 the `betadispersion2` R function (Bacaro et al., 2013, 2012) using 9999 permutations. This method
180 was used to test the null hypothesis of no differences in multivariate dispersion among groups
181 (Anderson, 2006), avoiding mixing within-group dissimilarities with between-group dissimilarities
182 (Bacaro et al., 2013). We evaluated differences between pairs of group mean dispersion by Tukey
183 HSD (Honestly Significant Difference) tests (Anderson, 2006).

184 Finally, a SIMPER was carried out to identify the most important species of each taxonomic group
185 typifying pairwise differences (Warton et al., 2012) among land-use types, setting a cut-off level of
186 90% for low contributions.

187 3. RESULTS

188 3.1. General results and species richness

189 We collected a total of 330 species of vascular plants and 269 species of ground-dwelling
190 invertebrates grouped into six taxonomic groups: 390 individuals belonging to 13 species of
191 pseudoscorpions; 2,821 spiders assigned to 106 species; 1,084 darkling beetles of 22 species; 7,215
192 rove beetles of 55 species; 2,777 ground beetles assigned to 38 species; 52,125 ants of 35 species.

193 The mean number of pseudoscorpions, spiders and ant species were higher in SWOFs embedded in
194 AGR areas than in those located in URB and NAT areas, but their abundance (aA and aAD)
195 reached the highest values in urban ones (Fig. A.1-A.3 in Appendix). The highest values of the
196 mean species richness and abundance of darkling beetles were in AGR SWOFs, followed by URB
197 and NAT SWOFs (Fig. A.1-A.3 in Appendix). Considering ground beetles, the mean richness and
198 abundance (aA and aAD) were highest in disturbed areas, particularly in URB SWOF. Rove beetles
199 and vascular plants reached the highest values in NAT SWOFs, both for richness and abundance
200 (Fig. A.1-A.3 in Appendix).

201 Sample-based rarefaction and extrapolation curves with 95% confidence intervals for the three Hill
202 numbers of order q based on the 30 samples showed similar patterns for almost all taxonomic
203 groups (Fig. 2; Table A.3 in Appendix). The analysis revealed that the number of samples was
204 sufficient for the representative sampling of the frequent and highly frequent species in the
205 communities (curves of $q = 1$ and $q = 2$ approached an asymptote, Fig. 2). However, infrequent
206 species might be underrepresented ($q = 0$, Fig. 2). For almost all invertebrate groups (except
207 pseudoscorpions, rove beetles and vascular plants), the 95% confidence intervals from different
208 land-use types overlap, implying that diversity estimates did not differ significantly. By contrast, the
209 empirical and estimated asymptotic Simpson's diversity profiles along with 95% confidence
210 intervals ($q = 2$ in Fig. 2) were disjoint for AGR and NAT samples, respectively, in
211 pseudoscorpions and rove beetles, indicating a significant difference from the other land-use types.
212 For vascular plants, the 95% confidence intervals for the URB samples in any
213 rarefaction/extrapolation curve were disjoint, implying a significant difference from both AGR and
214 NAT (Fig. 2).

215 PERMANCOVA showed the highest component of variation to the overall species richness model
216 was the residual for almost all taxonomic groups, except vascular plants, for which effects of land
217 use across altitudes contributed the most (Table A.4-A.5 in Appendix). Statistically significant two-
218 way interaction ($Z \times LU$, $p \leq 0.05$, Table A.4 in Appendix) appeared only for the richness of vascular
219 plants, suggesting that the land-use effects significantly differed across altitudes. Although there
220 was no evidence for a two-way interaction ($Z \times LU$, $p \geq 0.05$) in any other taxa, the main effect of
221 land use was significant only for spider richness (Table A.5 in Appendix). Post-hoc tests further
222 supported general results, underlining that species richness of spiders differed between NAT and
223 disturbed areas, while no significant differences were evident for any other taxonomic groups (Fig.
224 3; Table A.6 in Appendix).

225 **3.2. Species composition**

226 In NMDS, we observed the shift of group centroids among NAT and disturbed areas for almost all
227 taxa (except rove beetles) and high overlaps of 95% confidence ellipses around centroids. These
228 results suggested that differences in community composition were more related to the changing of
229 the mean composition rather than the increase in within-group variance (Fig. A.4-A.5 in Appendix).
230 This pattern was more evident in beetles than in other groups, using both aA and aAD data (Fig.
231 A.4-A.5 in Appendix). However, the use of aAD for darkling beetles led to the minimization of
232 within-group variance, maximizing the variance among NAT and disturbed areas (Fig. A.5 in
233 Appendix). Results of NMDS were supported by PERMANCOVA and beta diversity analyses.

234 PERMANCOVA analyses showed that the land use had a significant effect on the community
235 composition of almost all taxonomic groups, except rove and darkling beetles, even accounting for
236 altitude and two-way interaction effects (Table A.7-A.10 in Appendix). Statistically significant two-
237 way interaction ($Z \times LU$, $p \leq 0.05$) appeared only for darkling beetles using aAD data (compare
238 Table A.7 vs Table A.9 in Appendix).

239 Results of PERMANOVA t-test revealed that the mean community composition of spiders, ground
240 beetles, ants and vascular plants was significantly different among NAT vs AGR areas (Fig. 3;
241 Table A.11-A12 in Appendix). A significant contrast among NAT vs URB areas was identified for
242 all taxonomic groups, except darkling and rove beetles (Fig. 3; Table A.11-A12 in Appendix). No
243 significant differences in the mean community composition of all ground-dwelling invertebrates
244 were detected among AGR vs URB areas; remarkably, only vascular plants differed across these
245 two land-use types (Fig. 3; Table A.11-A12 in Appendix).

246 On average, beta diversity was slightly higher in NAT areas for spiders and rove beetles, AGR areas
247 for pseudoscorpions and ground beetles, and URB areas for ants and vascular plants (Table A.13-
248 A.14 in Appendix). Beta diversity average dissimilarities, from individual observation samples to
249 their group centroid, proved to be significantly different for pseudoscorpions and spiders, but also
250 darkling beetles using aAD data (Fig. 3; Table A.15-A.16 in Appendix). The Tukey HSD test
251 showed significant differences in beta diversity among NAT vs AGR areas for both of these
252 taxonomic groups, among NAT vs URB areas for spiders and darkling beetles, and among AGR vs
253 URB areas for pseudoscorpions (Fig. 3; Fig. A.6-A.7 in Appendix).

254 According to SIMPER analysis, a limited number of invertebrate species contributed to the
255 dissimilarity between disturbed areas (AGR vs URB; Table A.17 in Appendix).

256 **4. DISCUSSION**

257 Aside from studies on the role of scattered trees as keystone structures or biodiversity foci of
258 landscapes (Fischer et al., 2010; Manning et al., 2006), we are not aware of any other study
259 focusing on SWOF's diversity pattern using multiple taxonomic groups across different land-use
260 types in a Mediterranean fragmented landscape. Assessing diversity patterns is fundamental to
261 understanding the potential of animal and plant populations to persist in fragmented and disturbed
262 habitats. In this study, we simultaneously examined responses of multiple taxonomic groups to the
263 same stressor-environmental gradient to estimate the land-use intensification effects on SWOF
264 multi-taxa diversity, considering multiple diversity measures. The specific response patterns of taxa
265 to land-use is controversial: the effects of land-use intensity on diversity patterns are described as
266 neutral, positive or negative according to the considered taxa (Gosling et al., 2016), the trophic level
267 (Seibold et al., 2019), the urbanization intensity (McKinney, 2008), as well as the spatial scale
268 (Piano et al., 2020). Most literature focused on the impact of extensive urbanization on species
269 richness, especially for plants (McKinney, 2008). In our study, species richness and composition
270 responded differently to land use surrounding SWOFs, revealing that species composition was more
271 sensitive than species richness to land-use change.

272 To our knowledge, this is the first study comparing different measures of pseudoscorpion diversity
273 among small patches in different land-use types, corroborating the beta diversity sensitivity to land-
274 use change. This result could be promising to consider pseudoscorpions as good indicators to
275 monitor land-use changes (but see Aguiar et al., 2006), likely thanks to their high habitat
276 dependence and their adaptations to life in environments subject to temporal variations (Battirolo et
277 al., 2017; Liebke et al., 2021; Villarreal et al., 2019).

278 The contrasting pattern of richness and composition observed for the other taxonomic groups are in
279 line with previous studies focused on beetles (scarabs, rove and ground beetles) (Yong et al., 2020)
280 and plants (Aggemyr et al., 2018). The adoption of low-informative measures (e.g., total species
281 richness and abundance) to evaluate the impacts of disturbance intensity may conduct to insufficient
282 or even misleading descriptions of ecological community changes, underling the importance of the
283 use of high-informative measures (e.g., species composition and beta diversity) both in meta-
284 analyses and primary studies (Hekkala and Roberge, 2018).

285 The comparison of richness and compositional differences between land-use types allows the
286 understanding of how the diversity of multiple taxonomic groups can be affected by the increase of
287 human disturbance along the investigated gradient. According to studies demonstrating an
288 increasing species richness with moderate urbanization (McKinney, 2008), we observed that
289 agricultural and urban SWOFs sustained a relatively high richness of all ground-dwelling
290 invertebrates (except rove beetles) compared to natural and semi-natural SWOFs. Conversely, rove
291 beetles and vascular plants showed low levels of species richness in all disturbed areas. These
292 results were also confirmed by the variation in the abundances along the disturbance gradient, and
293 in all ground-dwelling invertebrates, the number of individuals in each land-use type reflected their
294 activity density. The positive effect of disturbance on the richness and abundances of ground-
295 dwelling invertebrates may be related to compositional and configurational spatial features at
296 landscape level, which describe the increase of fragmentation degree along the gradient: a reduction
297 of mean patch size, patch size standard deviation and mean shape, as well as an increment of the
298 number of patch, Shannon's Diversity and Evenness, but also edge habitat was previously described
299 for the study area from SWOFs embedded in natural areas to those located in agricultural and urban
300 areas (Bazzato et al., 2021a). Similar variations in invertebrate species richness and abundance
301 related to the variation of spatial habitat heterogeneity were documented elsewhere (McKinney,
302 2008). According to the intermediate disturbance hypothesis (Moi et al., 2020) and specifically to
303 the disturbance heterogeneity model (Porter et al., 2001), the disturbance may favour biodiversity
304 by increasing resource heterogeneity. It is also known that spatial diversity of habitats enhances the
305 beta diversity of taxonomic groups that can support viable populations in small areas, such as
306 insects (Fattorini et al., 2020; McKinney, 2008).

307 Our results suggest that an increase in land-use intensification homogenizes species composition,
308 reducing the difference in beta diversity (except in pseudoscorpions, spiders and darkling beetles)
309 without reducing species richness, as shown for groups occupying different trophic levels (Gossner
310 et al., 2016). The homogenization driven by land-use intensification observed in this study is

311 consistent with previous studies focusing on species richness (McKinney, 2006), beta diversity
312 patterns (Buhk et al., 2017) and functional traits (Bazzato et al., 2021c).

313 For most of the considered groups, the effects of land use on community composition were more
314 evident when we compared agricultural and urban areas, supporting evidence for biotic
315 homogenization among these land-use types in the study area. The mean composition of all ground-
316 dwelling invertebrates did not differ across disturbed areas considering either their absolute
317 abundance or their annual activity density, while only vascular plants changed their mean
318 composition.

319 Vascular plants responded more sensitively to land-use change than invertebrates, corroborating the
320 findings of other studies (McKinney, 2008). We observed a vertical structure simplification with
321 decreased presence of native trees and shrubs (e.g., *Arbutus unedo*, *Erica arborea*, *Erica terminalis*,
322 *Salix atrocinerea* subsp. *atrocinerea*) and an increased presence of cultivated or alien species (e.g.,
323 *Pinus halepensis* subs. *halepensis*, *Olea europaea*, *Eucalyptus camaldulensis* subsp. *camaldulensis*)
324 as the land-use intensity increases due to management practices adopted during the years (Bazzato
325 et al., 2021a), responsible for altering not only the vegetation structure but also the biodiversity in
326 managed lands (Rouvinen and Kuuluvainen, 2005) compared to irregular, unmanaged and uneven-
327 aged woodlands (Hansen et al., 1991; McComb et al., 1993).

328 Plant community composition and its vertical structure contribute to changes in higher trophic-level
329 organisms by altering light penetration, microclimate, resources, and habitat spaces (Schuldt et al.,
330 2019). This could be especially true for pseudoscorpions and spiders, known to be dependent on
331 lower trophic groups and their fluctuations (Cardoso et al., 2011; Jiménez-Hernández et al., 2020).

332 Plant composition can drive beta-diversity patterns of pseudoscorpions, influencing species
333 replacement (Jiménez-Hernández et al., 2020). Here, we observed that community changes along
334 the disturbance gradient were more related to the difference in beta diversity patterns than changes
335 in species richness, likely due to species replacement: two species were found to be almost
336 exclusive of SWOFs in natural areas (*Hysterochelifer tuberculatus*, *Roncus caralitanus*), others
337 showed a variable abundance in agricultural and urban areas (*Chthonius leoi*, *Hysterochelifer* cf.
338 *spinosus*, *Pselaphochernes lacertosus*), being absent in natural ones. On the other hand, the beta-
339 dissimilarity among disturbed areas was mainly due to species showing a high abundance (or
340 exclusiveness) in agricultural habitats (*Geogarypus minor*, *Geogarypus italicus*, *Occidenchthonius*
341 *berninii*) or urban ones (*C. leoi*, *P. lacertosus*).

342 Changes in land use can decrease spider species diversity and modify their composition, leading to
343 differentiated spider assemblages (Pinto et al., 2021). Our study confirmed that spider assemblages
344 responded more sensitively to land-use change from natural to disturbed areas than other
345 invertebrates, showing differences in the richness, mean composition, and beta diversity. As plant
346 communities' structure changes resulting from the increase in land-use intensity differed along the
347 disturbance gradient, it may have favoured different spider species according to their habitat
348 requirements. Most of the dissimilarities among natural and disturbed areas resulted from the
349 dominance of species with broad environmental tolerance (e.g., *Lycosoides coarctata*, *Dysdera*
350 *crocata*, *Marinarozelotes barbatus*, *Marinarozelotes lyonneti*, *Urozelotes rusticus*, *Zelotes callidus*,
351 *Zelotes tenuis*, *Loxosceles rufescens*, *Zodarion elegans*, *Zodarion ruffoi*) (Caria et al., 2021; Pantini
352 et al., 2013), in both agricultural and urban habitats.

353 Darkling beetles include species with different responses towards environmental gradients
354 (Fattorini, 2014), and species that occur in the soil do not seem to follow a rural-urban gradient
355 (Fattorini and Galassi, 2016). Our results showed that the beta-diversity of darkling beetles
356 responded to land-use intensification from natural to disturbed areas, due to activity density
357 differences: natural areas were dominated by high activity of habitat-specialist species, strictly
358 range-localized in local forested areas (*Asida androgyna*; Leo, 2012); agricultural and urban areas
359 showed no marked compositional differences, being dominated by species that can support a high
360 activity density even in altered areas (*Stenosis sardoa sardoa*, *Tentyria grossa sardiniensis*; Ruffo
361 and Stoch, 2006) or in a wide variety of environments (*Crypticus gibbulus*, *Pimelia goryi goryi*;
362 Aliquò et al., 2006).

363 Urbanization can reduce favourable conditions for forest specialist species, contributing to their
364 richness decline (Magura et al., 2013). Specialist species may perceive the surrounding matrix as a
365 stronger barrier than generalists or opportunists, which can exploit a wide variety of resources from
366 neighbouring green areas (Niemelä, 2001). As a result, species composition in human-altered areas
367 becomes more and more similar, which may lead to a decrease in functional diversity (Melliger et
368 al., 2018). Accordingly, we observed a reduction of compositional differences of rove beetles due to
369 the dominance of macrohabitat generalists (*Atheta laticollis*, *Atheta oblita*, *Ocypus olens*,
370 *Tachyporus nitidulus*, *Heterothops dissimilis*) (Lupi et al., 2006; Zanetti et al., 2016), both in
371 natural and disturbed areas. Nevertheless, the microhabitats requirements of rove beetles
372 demonstrate that SWOFs can provide suitable substrates (e.g., debris, litter, tree hole, tree base,
373 mosses) (Lupi et al., 2006; Parmain et al., 2015) for the persistence of their populations, also in
374 human-altered areas.

375 Taxa with active or high movement ability may have more chances of (re)colonizing surrounding
376 areas, keeping viable populations and reducing the compositional differences than groups with
377 lower or passive dispersal capacities, such as plants (Silva et al., 2017; Soininen et al., 2007).
378 Ground beetles in fragmented habitats show a higher dispersal power, expressed as the higher
379 frequency of macropterous or dimorphic species compared to more preserved habitats, to allow
380 dispersal to favourable sites when conditions turn difficult (Ribera et al., 2001). In line with these
381 studies, we showed that most of the similarities among agricultural and urban areas in ground beetle
382 communities resulted from the dominance of habitat-generalists and good dispersers (*Amara aenea*,
383 *Calathus cinctus*, *Laemostenus complanatus*, *Orthomus berytensis*) (Brigić et al., 2016; Pizzolotto
384 et al., 2008; Suárez et al., 2018), likely due to their better capacities to maintain populations in
385 altered areas than poor dispersers (Niemelä, 2001). In contrast, more poor dispersal species (e.g.,
386 *Percus strictus ellipticus*, *Laemostenus carinatus*; personally verified) were found in natural
387 habitats than disturbed ones, contributing to explain the compositional differences among these
388 land-use types.

389 As observed in other studies, disturbance has a stronger effect on ant species composition than on
390 species richness (Martinez & Amar, 2014). Disturbance-adapted species can disperse across open
391 habitats and colonize new areas, potentially boosting species pools (Filgueiras et al., 2021). The
392 higher the management intensity, the lower the dissimilarity of ant species composition due to the
393 high presence of disturbance-tolerant species (Escobar-Ramírez et al., 2020; Martins et al., 2022).
394 Coherently, we found a reduction of ant compositional differences as disturbance increases due to
395 the presence of highly-tolerant species absent or rare in natural SWOFs: this is a broad and
396 heterogeneous group of ants, generally linked to open or thermophilous habitats (*Aphaenogaster*
397 *senilis*, *Hypoconerops eduardi*, *Linepithema humile*, *Messor*, *Temnothorax sardous*, *Tapinoma*
398 *madeirense*), or highly disturbed areas and cities (*Tetramorium immigrans*, *Tapinoma magnum*)
399 (Reyes-López, et al., 2003; Castracani et al., 2010; 2020; Seifert, 2018; Zara et al., 2021). Most of
400 the ant species characterizing natural SWOFs are associated with moister, cooler conditions or
401 better-developed leaf litter layer (*Aphaenogaster ichnusa*, *Aphaenogaster spinosa*, *Myrmica*
402 *spinosior*, *Stenammina debile*, *Temnothorax tuberum*) (Seifert, 2018; Galkowski et al., 2019; Zara et
403 al., 2021). Others were detected in most SWOFs irrespective of disturbance levels. Among these,
404 the social parasite *Plagiolepis xene*. In the past, this species was suspected of poor dispersal
405 capability and fragmented populations, and its presence in Sardinia was recently discovered
406 (Mardulyn et al., 2014; Schifani et al., 2021a). We collected it across the whole disturbance gradient
407 alongside its host *P. pygmaea*. Since *P. xene* was the only social parasite species we found, we did

408 not detect a higher presence of socially parasitic ants in natural SWOFs, yet these were the only
409 ones not to host alien species. This pattern only partly resembles what found by Bernal & Espadaler
410 (2013), who suggested social parasite and invasive ant species as indicators of low-disturbance and
411 high-disturbance habitats respectively. The success of *P. xene* in disturbed areas apparently depends
412 on the high plasticity of its host *P. pygmaea*, and highlights that not all socially parasitic ants are
413 good indicators of low disturbance (see *Tetramorium atratum* (Schenck, 1852) as a further
414 example, Zhang et al. 2019). Unfortunately, dispersal ranges of ant sexuals responsible for colony
415 foundation are currently undocumented in most cases (Seifert, 2018), while they would be crucial to
416 understand how ants can deal with habitat fragmentation by exploiting ecological corridors such as
417 SWOFs. However, SWOFs investigated during this study hosted at least 35 ant species,
418 approximately 45% of the region's diversity (Schifani et al., 2021a, b) and significantly different
419 communities (including both open/dry habitat and forest/moist habitat specialists, see Castracani et
420 al., 2010; Zara et al., 2021). These results highlighted the importance that small wood patches (or
421 sometimes even isolated trees) may have to ant conservation similarly to what is observed in non-
422 Mediterranean regions (Majer & Delabie, 1999; Gove et al., 2005; Nooten et al., 2021).

423 5. CONCLUSIONS

424 Not all species are fully reliant on large patches (Fischer and Lindenmayer, 2002) and small patches
425 cannot provide sufficient habitat for viable populations of any organism type: taxa differ in their
426 responses to habitat fragmentation and land-use intensification (Gosling et al., 2016; McKinney,
427 2008). Our data demonstrated that SWOFs play an important role in supporting viable populations
428 of ground-dwelling invertebrates, particularly in agricultural and urban land-use types of this
429 Mediterranean fragmented landscape. Although further investigation is required to assess how
430 similar the ecological trends we documented in Sardinia are to those from other Mediterranean
431 areas, this finding re-iterates the high conservation value of green areas surrounded by altered areas
432 as focal habitat for species conservation (Fattorini, 2014), reinforcing the idea that few large patches
433 are not always better than several small (Fattorini, 2020; Le Roux et al., 2015).

434 If on the one hand, small patches can provide suitable habitats for the vast majority of ground-
435 dwelling invertebrate groups, on the other, an increase in disturbance level exacerbates a reduction
436 of compositional changes in the investigated area, potentially leading to cascading effects
437 concerning dispersal, foraging resources and related dynamic interactions (Driscoll et al., 2013).

438 Cascading effects could make the conservation outlook bleak as land use intensifies, underlining the
439 need to preserve these remaining patches to avoid homogenization from driving a generalized

440 biodiversity loss (Buhk et al., 2017; McKinney, 2006), and extinction of entire communities in the
441 long-term (Gámez-Virués et al., 2015).

442 Notwithstanding that the impacts of human disturbance are neither temporary nor entirely avoidable
443 (Araia et al., 2020), solutions to preserve species and communities with the inclusion of wildlife in
444 agricultural (Simons and Weisser, 2017) and urban areas (Apfelbeck et al., 2020, 2019) are possible
445 and needed (Capotorti et al., 2020). In this perspective, an improved understanding of land-use
446 effects on multi-diversity patterns living in small patches will help land-manager to adopt
447 successfully nature-based solutions to biodiversity loss offsets.

448 **Acknowledgements**

449 We are very grateful to Giulio Gardini and Jan Matějčiček, respectively, for the identification of
450 pseudoscorpions and rove beetles. We also thank Leonardo Rosati for supporting and confirming
451 the identification of plant species. Our gratitude also goes to the director Marco Valle and all the
452 staff of the Museo Civico di Scienze Naturali “E. Caffi” in Bergamo for their hospitality and for
453 placing their equipment at our disposal. We also thank Francesca Ganga, Elisa Serra, and Andrea
454 Ambus, who kindly helped with the fieldwork or laboratory activities.

455 **REFERENCES**

- 456 Aggemyr, E., Auffret, A.G., Jädergård, L., Cousins, S.A.O., 2018. Species richness and
457 composition differ in response to landscape and biogeography. *Landscape Ecol.* 33, 2273–
458 2284. <https://doi.org/10.1007/s10980-018-0742-9>
- 459 Aguiar, N.O., Gualberto, T.L., Franklin, E., 2006. A medium-spatial scale distribution pattern of
460 Pseudoscorpionida (Arachnida) in a gradient of topography (altitude and inclination), soil
461 factors, and litter in a central Amazonia forest reserve, Brazil. *Braz. J. Biol.* 66, 791–802.
462 <https://doi.org/10.1590/S1519-69842006000500004>
- 463 Aliquò, V., Rastelli, M., Rastelli, S., Soldati, F., 2006. Coleotteri Tenebrionidi d’Italia - Darkling
464 Beetles of Italy (DVD), Progetto Biodiversità Piccole Faune, CDROM. ed. Museo Civico di
465 Storia Naturale di Carmagnola (TO), Associazione Naturalistica Piemontese.
- 466 Anderson, M.J., 2017. Permutational Multivariate Analysis of Variance (PERMANOVA). Wiley
467 StatsRef: Statistics Reference Online 1–15.
468 <https://doi.org/10.1002/9781118445112.stat07841>
- 469 Anderson, M.J., 2006. Distance-Based Tests for Homogeneity of Multivariate Dispersions.
470 *Biometrics* 62, 245–253. <https://doi.org/10.1111/j.1541-0420.2005.00440.x>
- 471 Anderson, M.J., Gorley, R.N., Clarke, K.R., 2008. PERMANOVA+ for PRIMER: Guide to
472 Software and Statistical Methods. PRIMER-E, Plymouth.
- 473 Anderson, M.J., Walsh, D.C.I., 2013. PERMANOVA, ANOSIM, and the Mantel test in the face of
474 heterogeneous dispersions: What null hypothesis are you testing? *Ecol. Monogr.* 83, 557–
475 574. <https://doi.org/10.1890/12-2010.1>
- 476 Apfelbeck, B., Jakoby, C., Hanusch, M., Steffani, E.B., Hauck, T.E., Weisser, W.W., 2019. A
477 Conceptual Framework for Choosing Target Species for Wildlife-Inclusive Urban Design.
478 *Sustainability* 11, 6972. <https://doi.org/10.3390/su11246972>
- 479 Apfelbeck, B., Snep, R.P.H., Hauck, T.E., Ferguson, J., Holy, M., Jakoby, C., Scott MacIvor, J.,
480 Schär, L., Taylor, M., Weisser, W.W., 2020. Designing wildlife-inclusive cities that support
481 human-animal co-existence. *Landsc. Urban. Plan.* 200, 103817.
482 <https://doi.org/10.1016/j.landurbplan.2020.103817>

- 483 Araia, M.G., Chirwa, P.W., Assédé, E.S.P., 2020. Contrasting the Effect of Forest Landscape
484 Condition to the Resilience of Species Diversity in a Human Modified Landscape:
485 Implications for the Conservation of Tree Species. *Land* 9, 4.
486 <https://doi.org/10.3390/land9010004>
- 487 Bacaro, G., Gioria, M., Ricotta, C., 2013. Beta diversity reconsidered. *Ecol. Res.* 28, 537–540.
488 <https://doi.org/10.1007/s11284-013-1043-z>
- 489 Bacaro, G., Gioria, M., Ricotta, C., 2012. Testing for differences in beta diversity from plot-to-plot
490 dissimilarities. *Ecol. Res.* 27, 285–292. <https://doi.org/10.1007/s11284-011-0899-z>
- 491 Bacchetta, G., Bagella, S., Biondi, E., Farris, E., Filigheddu, R., Mossa, L., 2009. Vegetazione
492 forestale e serie di vegetazione della Sardegna (con rappresentazione cartografica alla scala
493 1:350.000). *Fitosociologia* 46, 3–82.
- 494 Battirola, L.D., Rosado-Neto, G.H., Batistella, D.A., Mahnert, V., Brescovit, A.D., Marques, M.I.,
495 2017. Vertical and time distribution of Pseudoscorpiones (Arthropoda: Arachnida) in a
496 floodplain forest in the Brazilian Pantanal. *Rev. Biol. Trop.* 65, 445–459.
497 <https://doi.org/10.15517/rbt.v65i2.24134>
- 498 Bazzato, E., Lallai, E., Serra, E., Melis, M.T., Marignani, M., 2021a. Key role of small woodlots
499 outside forest in a Mediterranean fragmented landscape. *For. Ecol. Manag.* 496, 119389.
500 <https://doi.org/10.1016/j.foreco.2021.119389>
- 501 Bazzato, E., Rosati, L., Canu, S., Fiori, M., Farris, E., Marignani, M., 2021b. High spatial resolution
502 bioclimatic variables to support ecological modelling in a Mediterranean biodiversity
503 hotspot. *Ecol. Modell.* 441, 109354. <https://doi.org/10.1016/j.ecolmodel.2020.109354>
- 504 Bazzato, E., Serra, E., Maccherini, S., Marignani, M., 2021c. Reduction of inter- and intraspecific
505 seed mass variability along a land-use intensification gradient. *Ecol. Indic.* 129, 107884.
506 <https://doi.org/10.1016/j.ecolind.2021.107884>
- 507 Bellefontaine, R., Petit, S., Pain-Orcet, M., Deleporte, P., Bertault, J.-G., 2001. Les arbres hors
508 forêt. Vers une meilleure prise en compte, *Cahier FAO Conservation*. Food and Agriculture
509 Organization of the United Nations (FAO), Rome.
- 510 Bernal, V., Espadaler, X. 2013. Invasive and socially parasitic ants are good bioindicators of habitat
511 quality in Mediterranean forest remnants in NE Spain. *Ecol. Res.* 28, 1011–1017.
512 <https://doi.org/10.1007/s11284-013-1083-4>
- 513 Brigić, A., Vujčić-Karlo, S., Slivar, S., Alegro, A., Kepčija, R.M., Peroš, R., Kerovec, M., 2016.
514 Distribution and life-history traits of *Calathus cinctus* Motschulsky, 1850 (Coleoptera:
515 Carabidae) in Croatia, with distribution of closely related species. *Ital. J. Zool.* 83, 549–562.
516 <https://doi.org/10.1080/11250003.2016.1247921>
- 517 Buhk, C., Alt, M., Steinbauer, M.J., Beierkuhnlein, C., Warren, S.D., Jentsch, A., 2017.
518 Homogenizing and diversifying effects of intensive agricultural land-use on plant species
519 beta diversity in Central Europe - A call to adapt our conservation measures. *Sci. Total
520 Environ.* 576, 225–233. <https://doi.org/10.1016/j.scitotenv.2016.10.106>

- 521 Cadavid-Florez, L., Laborde, J., Mclean, D.J., 2020. Isolated trees and small woody patches greatly
522 contribute to connectivity in highly fragmented tropical landscapes. *Landsc. Urban. Plan.*
523 196, 103745. <https://doi.org/10.1016/j.landurbplan.2020.103745>
- 524 Canu, S., Rosati, L., Fiori, M., Motroni, A., Filigheddu, R., Farris, E., 2015. Bioclimate map of
525 Sardinia (Italy). *J. Maps* 11, 711–718. <https://doi.org/10.1080/17445647.2014.988187>
- 526 Capotorti, G., Bonacquisti, S., Abis, L., Aloisi, I., Attorre, F., Bacaro, G., Balletto, G., Banfi, E.,
527 Barni, E., Bartoli, F., Bazzato, E., Beccaccioli, M., Braglia, R., Bretzel, F., Brighetti, M.,
528 Brundu, G., Burnelli, M., Calfapietra, C., Cambria, V., Caneva, G., Canini, A., Caronni, S.,
529 Castello, M., Catalano, C., Celesti-Grapow, L., Cicinelli, E., Cipriani, L., Citterio, S.,
530 Concu, G., Coppi, A., Corona, E., Del Duca, S., Del Vico, E., Di Gristina, E., Domina, G.,
531 Faino, L., Fano, E., Fares, S., Farris, E., Farris, S., Fornaciari, M., Gaglio, M., Galasso, G.,
532 Galletti, M., Gargano, M., Gentili, R., Giannotta, A., Guarino, C., Guarino, R., Iaquina, G.,
533 Iiriti, G., Lallai, A., Lallai, E., Lattanzi, E., Manca, S., Manes, F., Marignani, M.,
534 Marinangeli, F., Mariotti, M., Mascia, F., Mazzola, P., Meloni, G., Michelozzi, P., Miraglia,
535 A., Montagnani, C., Mundula, L., Muresan, A., Musanti, F., Nardini, A., Nicosia, E., Oddi,
536 L., Orlandi, F., Pace, R., Palumbo, M., Palumbo, S., Parrotta, L., Pasta, S., Perini, K.,
537 Poldini, L., Postiglione, A., Prigioniero, A., Proietti, C., Raimondo, F., Ranfa, A., Redi, E.,
538 Reverberi, M., Roccotiello, E., Ruga, L., Savo, V., Scarano, P., Schirru, F., Sciarrillo, R.,
539 Scuderi, F., Sebastiani, A., Siniscalco, C., Sordo, A., Suanno, C., Tartaglia, M., Tilia, A.,
540 Toffolo, C., Toselli, E., Travaglini, A., Ventura, F., Venturella, G., Vincenzi, F., Blasi, C.,
541 2020. More Nature in the City. *Plant Biosyst.* 154, 1003–1006.
542 <https://doi.org/10.1080/11263504.2020.1837285>
- 543 Cardoso, P., Pekár, S., Jocqué, R., Coddington, J.A., 2011. Global Patterns of Guild Composition
544 and Functional Diversity of Spiders. *PLoS One* 6, e21710.
545 <https://doi.org/10.1371/journal.pone.0021710>
- 546 Caria, M., Pantini, P., Alamanni, F., Ancona, C., Cillo, D., Bazzato, E., 2021. New records and
547 interesting data for the Sardinian spider fauna (Arachnida, Araneae). *Fragm. Entomol.* 53,
548 321–332. <https://doi.org/10.13133/2284-4880/555>
- 549 Castracani, C., Grasso, D.A., Fanfani, A., Mori, A. 2010. The ant fauna of Castelporziano
550 Presidential Reserve (Rome, Italy) as a model for the analysis of ant community structure in
551 relation to environmental variation in Mediterranean ecosystems. *J. Insect Conserv.* 14,
552 585–594. <https://doi.org/10.1007/s10841-010-9285-3>
- 553 Castracani, C., Spotti, F.A., Schifani, E., Giannetti, D., Ghizzoni, M., Grasso, D.A., Mori, A., 2020.
554 Public Engagement Provides First Insights on Po Plain Ant Communities and Reveals the
555 Ubiquity of the Cryptic Species *Tetramorium immigrans* (Hymenoptera, Formicidae).
556 *Insects* 11, 678. <https://doi.org/10.3390/insects11100678>
- 557 Chao, A., Kubota, Y., Zelený, D., Chiu, C.-H., Li, C.-F., Kusumoto, B., Yasuhara, M., Thorn, S.,
558 Wei, C.-L., Costello, M.J., Colwell, R.K., 2020. Quantifying sample completeness and
559 comparing diversities among assemblages. *Ecol. Res.* 35, 292–314.
560 <https://doi.org/10.1111/1440-1703.12102>
- 561 Clarke, K.R., Somerfield, P.J., Chapman, M.G., 2006. On resemblance measures for ecological
562 studies, including taxonomic dissimilarities and a zero-adjusted Bray–Curtis coefficient for

- 563 denuded assemblages. *J. Exp. Mar. Biol. Ecol.*, A Tribute to Richard M. Warwick 330, 55–
564 80. <https://doi.org/10.1016/j.jembe.2005.12.017>
- 565 Colwell, R.K., Chao, A., Gotelli, N.J., Lin, S.-Y., Mao, C.X., Chazdon, R.L., Longino, J.T., 2012.
566 Models and estimators linking individual-based and sample-based rarefaction, extrapolation
567 and comparison of assemblages. *J. Plant Ecol.* 5, 3–21. <https://doi.org/10.1093/jpe/rtr044>
- 568 de Foresta, H., Somarriba, E., Temu, A., Boulanger, D., Feuily, H., Gauthier, M., 2013. Towards
569 the assessment of trees outside forests: a thematic report prepared in the framework of the
570 Global Forest Resources Assessment. Food and Agriculture Organization of the United
571 Nations (FAO), Rome.
- 572 Driscoll, D.A., Banks, S.C., Barton, P.S., Lindenmayer, D.B., Smith, A.L., 2013. Conceptual
573 domain of the matrix in fragmented landscapes. *Trends Ecol. Evol.* 28, 605–613.
574 <https://doi.org/10.1016/j.tree.2013.06.010>
- 575 Escobar-Ramírez, S., Tschardtke, T., Armbrecht, I., Torres, W., Grass, I., 2020. Decrease in β -
576 diversity, but not in α -diversity, of ants in intensively managed coffee plantations. *Insect*
577 *Conserv. Divers.* 13, 445–455. <https://doi.org/10.1111/icad.12417>
- 578 Fattorini, S., 2020. Conservation Biogeography of Tenebrionid Beetles: Insights from Italian
579 Reserves. *Diversity* 12, 348. <https://doi.org/10.3390/d12090348>
- 580 Fattorini, S., 2014. Urban biodiversity hotspots are not related to the structure of green spaces: a
581 case study of tenebrionid beetles from Rome, Italy. *Urban Ecosyst.* 17, 1033–1045.
582 <https://doi.org/10.1007/s11252-014-0375-y>
- 583 Fattorini, S., Galassi, D.M.P., 2016. Role of urban green spaces for saproxylic beetle conservation:
584 a case study of tenebrionids in Rome, Italy. *J. Insect Conserv.* 20, 737–745.
585 <https://doi.org/10.1007/s10841-016-9900-z>
- 586 Fattorini, S., Mantoni, C., Bergamaschi, D., Fortini, L., Sánchez, F.J., Biase, L.D., Giulio, A.D.,
587 2020. Activity density of carabid beetles along an urbanisation gradient. *Acta zool. Acad.*
588 *Sci. Hung.* 66, 21–36. <https://doi.org/10.17109/AZH.66.Suppl.21.2020>
- 589 Filgueiras, B.K.C., Peres, C.A., Melo, F.P.L., Leal, I.R., Tabarelli, M., 2021. Winner–Loser Species
590 Replacements in Human-Modified Landscapes. *Trends Ecol. Evol.* 36, 545–555.
591 <https://doi.org/10.1016/j.tree.2021.02.006>
- 592 Fischer, J., Lindenmayer, D.B., 2007. Landscape Modification and Habitat Fragmentation: A
593 Synthesis. *Glob. Ecol. Biogeogr.* 16, 265–280.
- 594 Fischer, J., Lindenmayer, D.B., 2002. Small patches can be valuable for biodiversity conservation:
595 two case studies on birds in southeastern Australia. *Biol. Conserv.* 106, 129–136.
596 [https://doi.org/10.1016/S0006-3207\(01\)00241-5](https://doi.org/10.1016/S0006-3207(01)00241-5)
- 597 Fischer, J., Stott, J., Law, B.S., 2010. The disproportionate value of scattered trees. *Biol. Conserv.*
598 143, 1564–1567. <https://doi.org/10.1016/j.biocon.2010.03.030>

- 599 Galkowski, C., Aubert, C., Blatrix, R., 2019. *Aphaenogaster ichnusa* Santschi, 1925, bona species,
600 and Redescription of *Aphaenogaster subterranea* (Latreille, 1798) (Hymenoptera,
601 Formicidae). *Sociobiology* 66, 420–425. <https://doi.org/10.13102/sociobiology.v66i3.3660>
- 602 Gámez-Virués, S., Perović, D.J., Gossner, M.M., Börschig, C., Blüthgen, N., de Jong, H., Simons,
603 N.K., Klein, A.-M., Krauss, J., Maier, G., Scherber, C., Steckel, J., Rothenwöhrer, C.,
604 Steffan-Dewenter, I., Weiner, C.N., Weisser, W., Werner, M., Tschardtke, T., Westphal, C.,
605 2015. Landscape simplification filters species traits and drives biotic homogenization. *Nat.*
606 *Commun.* 6, 8568. <https://doi.org/10.1038/ncomms9568>
- 607 Gosling, L., Sparks, T.H., Araya, Y., Harvey, M., Ansine, J., 2016. Differences between urban and
608 rural hedges in England revealed by a citizen science project. *BMC Ecol.* 16, 15.
609 <https://doi.org/10.1186/s12898-016-0064-1>
- 610 Gossner, M.M., Lewinsohn, T.M., Kahl, T., Grassein, F., Boch, S., Prati, D., Birkhofer, K., Renner,
611 S.C., Sikorski, J., Wubet, T., Arndt, H., Baumgartner, V., Blaser, S., Blüthgen, N., Börschig,
612 C., Buscot, F., Diekötter, T., Jorge, L.R., Jung, K., Keyel, A.C., Klein, A.-M., Klemmer, S.,
613 Krauss, J., Lange, M., Müller, J., Overmann, J., Pašalić, E., Penone, C., Perović, D.J.,
614 Purschke, O., Schall, P., Socher, S.A., Sonnemann, I., Tschapka, M., Tschardtke, T., Türke,
615 M., Venter, P.C., Weiner, C.N., Werner, M., Wolters, V., Wurst, S., Westphal, C., Fischer,
616 M., Weisser, W.W., Allan, E., 2016. Land-use intensification causes multitrophic
617 homogenization of grassland communities. *Nature* 540, 266–269.
618 <https://doi.org/10.1038/nature20575>
- 619 Gove, A.D., Majer, J.D., Rico-Gray, V. 2005. Methods for conservation outside of formal reserve
620 systems: The case of ants in the seasonally dry tropics of Veracruz, Mexico. *Biol. Conserv.*,
621 126, 328–338. <https://doi.org/10.1016/j.biocon.2005.06.008>
- 622 Hansen, A.J., Spies, T.A., Swanson, F.J., Ohmann, J.L., 1991. Conserving Biodiversity in Managed
623 Forests: Lessons from natural forests. *BioScience* 41, 382–392.
624 <https://doi.org/10.2307/1311745>
- 625 Hekkala, A.-M., Roberge, J.-M., 2018. The use of response measures in meta-analyses of land-use
626 impacts on ecological communities: a review and the way forward. *Biodivers. Conserv.* 27,
627 2989–3005. <https://doi.org/10.1007/s10531-018-1583-1>
- 628 Hsieh, T.C., Ma, K.H., Chao, A., 2016. iNEXT: an R package for rarefaction and extrapolation of
629 species diversity (Hill numbers). *Methods Ecol. Evol.* 7, 1451–1456.
630 <https://doi.org/10.1111/2041-210X.12613>
- 631 Jiménez-Hernández, V.S., Villegas-Guzmán, G.A., Casasola-González, J.A., Vargas-Mendoza,
632 C.F., 2020. Altitudinal distribution of alpha, beta, and gamma diversity of pseudoscorpions
633 (Arachnida) in Oaxaca, Mexico. *Acta Oecol.* 103, 103525.
634 <https://doi.org/10.1016/j.actao.2020.103525>
- 635 Kotze, D.J., Brandmayr, P., Casale, A., Dauffy-Richard, E., Dekoninck, W., Koivula, M., Lovei, G.,
636 Mossakowski, D., Noordijk, J., Paarmann, W., Pizzoloto, R., Saska, P., Schwerk, A.,
637 Serrano, J., Szyszko, J., Palomares, A.T., Turin, H., Venn, S., Vermeulen, R., Brandmayr,
638 T.Z., 2011. Forty years of carabid beetle research in Europe – from taxonomy, biology,
639 ecology and population studies to bioindication, habitat assessment and conservation.
640 *ZooKeys* 100, 55–148. <https://doi.org/10.3897/zookeys.100.1523>

- 641 Le Roux, D.S., Ikin, K., Lindenmayer, D.B., Manning, A.D., Gibbons, P., 2018. The value of
642 scattered trees for wildlife: Contrasting effects of landscape context and tree size. *Divers.*
643 *Distrib.* 24, 69–81. <https://doi.org/10.1111/ddi.12658>
- 644 Le Roux, D.S., Ikin, K., Lindenmayer, D.B., Manning, A.D., Gibbons, P., 2015. Single large or
645 several small? Applying biogeographic principles to tree-level conservation and biodiversity
646 offsets. *Biol. Conserv.* 191, 558–566. <https://doi.org/10.1016/j.biocon.2015.08.011>
- 647 Leo, P., 2012. Tre nuove specie di Asida della Sardegna (Coleoptera, Tenebrionidae). *Annali del*
648 *Museo civico di storia naturale Giacomo Doria* 104.
- 649 Liebke, D.F., Harms, D., Widyastuti, R., Scheu, S., Potapov, A.M., 2021. Impact of rainforest
650 conversion into monoculture plantation systems on pseudoscorpion density, diversity and
651 trophic niches. *Soil Org.* 93, 83–96. <https://doi.org/10.25674/so93iss2id147>
- 652 Lindenmayer, D., 2019. Small patches make critical contributions to biodiversity conservation.
653 *Proc. Natl. Acad. Sci. USA* 116, 717–719. <https://doi.org/10.1073/pnas.1820169116>
- 654 Lupi, D., Colombo, M., Zanetti, A., 2006. The rove beetles (Coleoptera Staphylinidae) of three
655 horticultural farms in Lombardy (Northern Italy). *Boll. Zool. agr. Bachic.*, II 38, 143–165.
- 656 Magura, T., Nagy, D., Tóthmérész, B., 2013. Rove beetles respond heterogeneously to urbanization.
657 *J. Insect Conserv.* 17, 715–724. <https://doi.org/10.1007/s10841-013-9555-y>
- 658 Majer, J. D., Delabie, J.H.C. 1999. Impact of tree isolation on arboreal and ground ant communities
659 in cleared pasture in the Atlantic rain forest region of Bahia, Brazil. *Insectes Soc.* 46, 281–
660 290. <https://doi.org/10.1007/s000400050147>
- 661 Manning, A.D., Fischer, J., Lindenmayer, D.B., 2006. Scattered trees are keystone structures –
662 Implications for conservation. *Biol. Conserv.* 132, 311–321.
663 <https://doi.org/10.1016/j.biocon.2006.04.023>
- 664 Mardulyn, P., Thurin, N., Piou, V., Grumiau, L., Aron, S., 2014. Dispersal in the inquiline social
665 parasite ant *Plagiolepis xene*. *Insect. Soc.* 61, 197–202. <https://doi.org/10.1007/s00040-014-0345-7>
666
- 667 Martins, I.S., Ortega, J.C.G., Guerra, V., da Costa, M.M.S., Martello, F., Schmidt, F.A., 2022. Ant
668 taxonomic and functional beta-diversity respond differently to changes in forest cover and
669 spatial distance. *Basic Appl. Ecol.* <https://doi.org/10.1016/j.baae.2022.02.008>
- 670 McComb, W.C., Spies, T.A., Emmingham, W.H., 1993. Douglas-Fir Forests: Managing for Timber
671 and Mature-Forest Habitat. *J. For.* 91, 31–42. <https://doi.org/10.1093/jof/91.12.31>
- 672 McKinney, M.L., 2008. Effects of urbanization on species richness: A review of plants and animals.
673 *Urban Ecosyst.* 11, 161–176. <https://doi.org/10.1007/s11252-007-0045-4>
- 674 McKinney, M.L., 2006. Urbanization as a major cause of biotic homogenization. *Biol. Conserv.*,
675 *Urbanization* 127, 247–260. <https://doi.org/10.1016/j.biocon.2005.09.005>

- 676 MEA, 2005. Ecosystems human well-being: Biodiversity Synthesis, A Report of the Millennium
677 Ecosystem Assessment (MEA). World Resources Institute, Washington, DC.
- 678 Médail, F., 2017. The specific vulnerability of plant biodiversity and vegetation on Mediterranean
679 islands in the face of global change. *Reg. Environ. Change* 17, 1775–1790.
680 <https://doi.org/10.1007/s10113-017-1123-7>
- 681 Melliger, R.L., Braschler, B., Rusterholz, H.-P., Baur, B., 2018. Diverse effects of degree of
682 urbanisation and forest size on species richness and functional diversity of plants, and
683 ground surface-active ants and spiders. *PLoS One* 13, e0199245.
684 <https://doi.org/10.1371/journal.pone.0199245>
- 685 Martinez, J.J.I., Amar, Z. 2014. The preservation value of a tiny sacred forest of the oak *Quercus*
686 *calliprinos* and the impact of livestock presence. *J. Insect Conserv.* 18, 657–665.
687 [https://doi.org/10.1016/S1146-609X\(03\)00086-9](https://doi.org/10.1016/S1146-609X(03)00086-9)
- 688 Moi, D.A., García-Ríos, R., Hong, Z., Daquila, B.V., Mormul, R.P., 2020. Intermediate Disturbance
689 Hypothesis in Ecology: A Literature Review. *Ann. Zool. Fenn.* 57, 67–78.
690 <https://doi.org/10.5735/086.057.0108>
- 691 Newbold, T., Hudson, L.N., Hill, S.L.L., Contu, S., Lysenko, I., Senior, R.A., Börger, L., Bennett,
692 D.J., Choimes, A., Collen, B., Day, J., De Palma, A., Díaz, S., Echeverria-Londoño, S.,
693 Edgar, M.J., Feldman, A., Garon, M., Harrison, M.L.K., Alhousseini, T., Ingram, D.J., Itescu,
694 Y., Kattge, J., Kemp, V., Kirkpatrick, L., Kleyer, M., Correia, D.L.P., Martin, C.D., Meiri,
695 S., Novosolov, M., Pan, Y., Phillips, H.R.P., Purves, D.W., Robinson, A., Simpson, J.,
696 Tuck, S.L., Weiher, E., White, H.J., Ewers, R.M., Mace, G.M., Scharlemann, J.P.W., Purvis,
697 A., 2015. Global effects of land use on local terrestrial biodiversity. *Nature* 520, 45–50.
698 <https://doi.org/10.1038/nature14324>
- 699 Niemelä, J., 2001. Carabid beetles (Coleoptera: Carabidae) and habitat fragmentation: a review.
700 *Eur. J. Entomol.* 98, 127–132. <https://doi.org/10.14411/eje.2001.023>
- 701 Nooten, S.S., Lee, R.H., Guénard, B. (2021). Evaluating the conservation value of sacred forests for
702 ant taxonomic, functional and phylogenetic diversity in highly degraded landscapes. *Biol.*
703 *Conserv.*, 261, 109286. <https://doi.org/10.1016/j.biocon.2021.109286>
- 704 Noriega, J.A., Hortal, J., Azcárate, F.M., Berg, M.P., Bonada, N., Briones, M.J.I., Del Toro, I.,
705 Goulson, D., Ibanez, S., Landis, D.A., Moretti, M., Potts, S.G., Slade, E.M., Stout, J.C.,
706 Ulyshen, M.D., Wackers, F.L., Woodcock, B.A., Santos, A.M.C., 2018. Research trends in
707 ecosystem services provided by insects. *Basic Appl. Ecol., Insect Effects on Ecosystem*
708 *services* 26, 8–23. <https://doi.org/10.1016/j.baae.2017.09.006>
- 709 Oksanen, J., Blanchet, F.G., Friendly, M., Kindt, R., Legendre, P., McGlinn, D., Minchin, P.R.,
710 O’Hara, R.B., Simpson, G.L., Solymos, P., Stevens, M.H.H., Szoecs, E., Wagner, H., 2019.
711 *vegan: Community Ecology Package.*
- 712 Palumbo, M.E., Mundula, L., Balletto, G., Bazzato, E., Marignani, M., 2020. Environmental
713 Dimension into Strategic Planning. The Case of Metropolitan City of Cagliari, in: Gervasi,
714 O., Murgante, B., Misra, S., Garau, C., Blečić, I., Taniar, D., Apduhan, B.O., Rocha,
715 A.M.A.C., Tarantino, E., Torre, C.M., Karaca, Y. (Eds.), *Computational Science and Its*

- 716 Applications – ICCSA 2020, Lecture Notes in Computer Science. Springer International
717 Publishing, Cham, pp. 456–471. https://doi.org/10.1007/978-3-030-58820-5_34
- 718 Pantini, P., Sassu, A., Serra, G., 2013. Catalogue of the spiders (Arachnida Araneae) of Sardinia.
719 Biodiversity Journal 4, 3–104.
- 720 Parmain, G., Bouget, C., Müller, J., Horak, J., Gossner, M.M., Lachat, T., Isacson, G., 2015. Can
721 rove beetles (Staphylinidae) be excluded in studies focusing on saproxylic beetles in central
722 European beech forests? Bull. Entomol. Res. 105, 101–109.
723 <https://doi.org/10.1017/S0007485314000741>
- 724 Piano, E., Souffreau, C., Merckx, T., Baardsen, L.F., Backeljau, T., Bonte, D., Brans, K.I., Cours,
725 M., Dahirel, M., Debortoli, N., Decaestecker, E., Wolf, K.D., Engelen, J.M.T., Fontaneto,
726 D., Gianuca, A.T., Govaert, L., Hanashiro, F.T.T., Higuti, J., Lens, L., Martens, K.,
727 Matheve, H., Matthysen, E., Pinseel, E., Sablon, R., Schön, I., Stoks, R., Doninck, K.V.,
728 Dyck, H.V., Vanormelingen, P., Wichelen, J.V., Vyverman, W., Meester, L.D., Hendrickx,
729 F., 2020. Urbanization drives cross-taxon declines in abundance and diversity at multiple
730 spatial scales. Glob. Chang. Biol. 26, 1196–1211. <https://doi.org/10.1111/gcb.14934>
- 731 Pinto, C.M., Pairo, P.E., Bellocq, M.I., Filloy, J., 2021. Different land-use types equally impoverish
732 but differentially preserve grassland species and functional traits of spider assemblages. Sci
733 Rep 11, 10316. <https://doi.org/10.1038/s41598-021-89658-7>
- 734 Pizzolotto, R., Mazzei, A., Belfiore, T., Bonacci, T., 2008. Biodiversità dei Coleotteri Carabidi
735 (Coleoptera: Carabidae) nell'agroecosistema oliveto in Calabria. Entomologica 41, 5–11.
736 <https://doi.org/10.15162/0425-1016/793>
- 737 Porter, E.E., Forschner, B.R., Blair, R.B., 2001. Woody vegetation and canopy fragmentation along
738 a forest-to-urban gradient. Urban Ecosyst. 5, 131–151.
739 <https://doi.org/10.1023/A:1022391721622>
- 740 Prevedello, J.A., Almeida-Gomes, M., Lindenmayer, D.B., 2018. The importance of scattered trees
741 for biodiversity conservation: A global meta-analysis. J. Appl. Ecol. 55, 205–214.
742 <https://doi.org/10.1111/1365-2664.12943>
- 743 RAS, 2016. Orthophoto 2016 AGEA [WWW Document]. Sardegna Geoportale. URL
744 <http://www.sardegnageoportale.it/index.php?xsl=2425&s=338354&v=2&c=14469&t=1&tb=14401> (accessed 12.22.20).
- 746 RAS, 2008. Land use map [WWW Document]. Sardegna Geoportale. URL
747 http://webgis2.regione.sardegna.it/catalogodati/card.jsp?uuid=R_SARDEG:WBMEW
748 (accessed 12.29.20).
- 749 Reyes-López, J., Ruiz, N., Fernández-Haeger, J. 2003. Community structure of ground-ants: the
750 role of single trees in a Mediterranean pastureland. Acta Oecol., 24, 195–202.
751 [https://doi.org/10.1016/S1146-609X\(03\)00086-9](https://doi.org/10.1016/S1146-609X(03)00086-9)
- 752 Ribera, I., Dolédec, S., Downie, I.S., Foster, G.N., 2001. Effect of Land Disturbance and Stress on
753 Species Traits of Ground Beetle Assemblages. Ecology 82, 1112–1129.
754 [https://doi.org/10.1890/0012-9658\(2001\)082\[1112:EOLDAS\]2.0.CO;2](https://doi.org/10.1890/0012-9658(2001)082[1112:EOLDAS]2.0.CO;2)

- 755 Rouvinen, S., Kuuluvainen, T., 2005. Tree diameter distributions in natural and managed old *Pinus*
756 *sylvestris*-dominated forests. *For. Ecol. Manag.* 208, 45–61.
757 <https://doi.org/10.1016/j.foreco.2004.11.021>
- 758 Ruffo, S., Stoch, F. (Eds.), 2006. Checklist and distribution of the Italian fauna: 10,000 terrestrial
759 and inland water species, Memorie del Museo civico di storia naturale di Verona. Comune
760 di Verona, Verona. Saska, P., Makowski, D., Bohan, D.A., van der Werf, W., 2021. The
761 effects of trapping effort and sources of variability on the estimation of activity-density and
762 diversity of carabids in annual field crops by pitfall trapping; a meta-analysis. *Entomol. Gen.*
763 41, 553–566. <https://doi.org/10.1127/entomologia/2021/1211>
- 764 Schifani, E., Nalini, E., Gentile, G., Alamanni, F., Ancona, C., Caria, M., Cillo, D., Bazzato, E.,
765 2021a. Ants of Sardinia: an updated checklist based on new faunistic, morphological and
766 biogeographical notes. *Redia* 104, 21–35. <https://doi.org/10.19263/REDIA-104.21.03>
- 767 Schifani, E., Scupola, A., Menchetti, M., Bazzato, E., Espadaler, X. 2021b. Morphology and
768 Phenology of Sexuels and New Distribution Data on the Blind Mediterranean Ant
769 *Hypoconerops abeillei* (Hymenoptera, Formicidae). *Sociobiology* 68, e7261.
770 <https://doi.org/10.13102/sociobiology.v68i4.7261>
- 771 Schuldt, A., Ebeling, A., Kunz, M., Staab, M., Guimarães-Steinicke, C., Bachmann, D., Buchmann,
772 N., Durka, W., Fichtner, A., Fornoff, F., Härdtle, W., Hertzog, L.R., Klein, A.-M., Roscher,
773 C., Schaller, J., von Oheimb, G., Weigelt, A., Weisser, W., Wirth, C., Zhang, J., Bruehlheide,
774 H., Eisenhauer, N., 2019. Multiple plant diversity components drive consumer communities
775 across ecosystems. *Nat. Commun.* 10, 1460. <https://doi.org/10.1038/s41467-019-09448-8>
- 776 Seibold, S., Gossner, M.M., Simons, N.K., Blüthgen, N., Müller, J., Ambarlı, D., Ammer, C.,
777 Bauhus, J., Fischer, M., Habel, J.C., Linsenmair, K.E., Nauss, T., Penone, C., Prati, D.,
778 Schall, P., Schulze, E.-D., Vogt, J., Wöllauer, S., Weisser, W.W., 2019. Arthropod decline
779 in grasslands and forests is associated with landscape-level drivers. *Nature* 574, 671–674.
780 <https://doi.org/10.1038/s41586-019-1684-3>
- 781 Seifert, B., 2018. The Ants of Central and North Europe. Lutra Verlags - und Vertriebsgesellschaft,
782 Tauer, Germany.
- 783 Silva, V.X. da, Sacramento, M., Hasui, É., Cunha, R.G.T. da, Ramos, F.N., Silva, V.X. da,
784 Sacramento, M., Hasui, É., Cunha, R.G.T. da, Ramos, F.N., 2017. Taxonomic groups with
785 lower movement capacity may present higher beta diversity. *Iheringia Ser. Zool.* 107.
786 <https://doi.org/10.1590/1678-4766e2017005>
- 787 Simons, N.K., Weisser, W.W., 2017. Agricultural intensification without biodiversity loss is
788 possible in grassland landscapes. *Nat. Ecol. Evol.* 1, 1136–1145.
789 <https://doi.org/10.1038/s41559-017-0227-2>
- 790 Soininen, J., Lennon, J.J., Hillebrand, H., 2007. A Multivariate Analysis of Beta Diversity across
791 Organisms and Environments. *Ecology* 88, 2830–2838.
- 792 Stork, N.E., 2018. How Many Species of Insects and Other Terrestrial Arthropods Are There on
793 Earth? *Annu. Rev. Entomol.* 63, 31–45. <https://doi.org/10.1146/annurev-ento-020117-043348>
794

- 795 Stollo, A., Smiraglia, D., Bruno, R., Assennato, F., Congedo, L., Fioravante, P.D., Giuliani, C.,
796 Marinosci, I., Riitano, N., Munafò, M., 2020. Land consumption in Italy. *J. Maps* 16, 113–
797 123. <https://doi.org/10.1080/17445647.2020.1758808>
- 798 Suárez, D., Hernández-Teixidor, D., Oromí, P., 2018. First report of wing dimorphism in the genus
799 *Orthomus* (Coleoptera: Carabidae). *Ann. Soc. Entomol. Fr.* 54, 67–72.
800 <https://doi.org/10.1080/00379271.2017.1414632>
- 801 Tulloch, A.I.T., Barnes, M.D., Ringma, J., Fuller, R.A., Watson, J.E.M., 2016. Understanding the
802 importance of small patches of habitat for conservation. *J. Appl. Ecol.* 53, 418–429.
803 <https://doi.org/10.1111/1365-2664.12547>
- 804 Villarreal, E., Martínez, N., Ortiz, C.R., 2019. Diversity of Pseudoscorpiones (Arthropoda:
805 Arachnida) in two fragments of dry tropical forest in the colombian Caribbean region.
806 *Caldasia* 41, 139–151. <https://doi.org/10.15446/caldasia.v41n1.72189>
- 807 Warton, D.I., Wright, S.T., Wang, Y., 2012. Distance-based multivariate analyses confound
808 location and dispersion effects. *Methods Ecol. Evol.* 3, 89–101.
809 <https://doi.org/10.1111/j.2041-210X.2011.00127.x>
- 810 Wintle, B.A., Kujala, H., Whitehead, A., Cameron, A., Veloz, S., Kukkala, A., Moilanen, A.,
811 Gordon, A., Lentini, P.E., Cadenhead, N.C.R., Bekessy, S.A., 2019. Global synthesis of
812 conservation studies reveals the importance of small habitat patches for biodiversity. *Proc.*
813 *Natl. Acad. Sci. USA* 116, 909–914. <https://doi.org/10.1073/pnas.1813051115>
- 814 Yong, D.L., Barton, P.S., Okada, S., Crane, M., Cunningham, S.A., Lindenmayer, D.B., 2020.
815 Conserving focal insect groups in woodland remnants: The role of landscape context and
816 habitat structure on cross-taxonomic congruence. *Ecol. Indic.* 115, 106391.
817 <https://doi.org/10.1016/j.ecolind.2020.106391>
- 818 Zanetti, A., Sette, A., Poggi, R., Tagliapietra, A., 2016. Biodiversity of Staphylinidae (Coleoptera)
819 in the Province of Verona (Veneto, Northern Italy). *Mem. Soc. Entomol. Ital.* 93, 3–237.
820 <https://doi.org/10.4081/MemorieSEI.2016.3>
- 821 Zhang, Y.M., Vitone, T.R., Storer, C.G., Payton, A.C., Dunn, R.R., Hulcr, J., McDaniel, S.F.,
822 Lucky, A., 2019. From Pavement to Population Genomics: Characterizing a Long-
823 Established Non-native Ant in North America Through Citizen Science and ddRADseq.
824 *Front. Ecol. Evol.* 7. <https://doi.org/10.3389/fevo.2019.00453>
- 825 Zara, L., Tordoni, E., Castro-Delgado, S., Colla, A., Maccherini, S., Marignani, M., Panepinto, F.,
826 Trittoni, M., Bacaro, G. 2021. Cross-taxon relationships in Mediterranean urban ecosystem:
827 A case study from the city of Trieste. *Ecol. Indic.*, 125, 107538.
828 <https://doi.org/10.1016/j.ecolind.2021.107538>
- 829