Data Article

Long-term monitoring of plant diversity data in the "Montagna di Torricchio" Strict Nature Reserve, Italy

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ARTICLE INFO

ABSTRACT

Long-term monitoring is pivotal for the collection of data capable of unravelling spatio-temporal changes in plant diversity. Here we present a dataset including plant presence and abundance data collected using a probabilistic sampling design in the "Montagna di Torricchio" Strict Nature Reserve, central Apennines, Italy. Five surveys were conducted in 35 plots during a period spanning 22 years (2002–2024). This dataset allows for the study of plant diversity changes over space and time across different habitat types by using statistical inference based on solid sampling theory.

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Specifications Table

Subject	Ecology, Biodiversity, Nature and Landscape Conservation
Specific subject area	Community plant ecology
Type of data	Table
Data collection	Information on the presence and percentage cover-abundance of vascular plant species across three vertical layers (tree, shrub, herbaceous) were collected by trained botanists. The data area is embedded in the "Montagna di Torricchio" Strict Nature Reserve and forms part of the International Long-Term Ecological Research Network (ILTER). Data were recorded in different habitats, covering two types included in the EU Habitat Directive (92/43/CEE): *Fagus sylvatica* forests (9210*) and semi-natural dry grasslands (6210*). The monitoring scheme adopted is probabilistic, resulting in a multi-scale design with nested sampling units of different sizes: 1 m² (subplot), 100 m² (main monitoring unit, plot), and 10,000 m² (macroplot). The survey period spanned 22 years, with a total of 35 permanent plots (10 m × 10 m) sampled during each of the five survey sessions (2002, 2003, 2015, 2020, and 2024). In each plot, four subplots of 1 m × 1 m were selected for the survey.
Data source location	Montagna di Torricchio Strict Nature Reserve, Marche Region, Italy. Coordinate Reference System - EPSG:4326 - WGS 84 Minimum longitude (x min in decimal degree): 13,006731 Maximum longitude (x max in decimal degree): 13,035296 Minimum latitude (y min in decimal degree): 42,962589 Maximum latitude (y max in decimal degree): 42,970377
Data accessibility	Repository name: b2share EUDAT Data identification number: https://doi.org/10.34730/044c89dc80f648d18d0ce236600b8584 Instructions for accessing these data: Data are accessible at the following link https://doi.org/10.34730/044c89dc80f648d18d0ce236600b8584
Related research article	Chelli, S.; Simonetti, E.; Campetella, G.; Chiarucci, A.; Cervellini, M.; Tardella, F.M.; Tomasella, M.; Canullo, R., 'Plant diversity changes in a nature reserve: a probabilistic sampling method for quantitative assessments', Nature Conservation, 145–161, May 2019, doi:10.3897/natureconservation.34.30043 [1].

1. Value of the Data

- This dataset represents a long-lasting collection of data as a result of a long-term standardised monitoring (from 2002 to 2024) of plant communities in a Strict Nature Reserve in Italy.
- Due to the probabilistic sampling scheme with permanent plots this dataset allows statistically sound inferences on spatio-temporal and cross-scale plant diversity changes.
- The dataset could be used to assess grassland and forest habitat change over time for conservation management (e.g., EU Directives 92/43/CEE - Habitat Directive).
- The sampling scheme is a benchmark potentially replicable in other protected areas.
- Informing national and international regulations and strategies related to climate change, biodiversity conservation, and forest management.

2. Background

Global changes and the intensification of human activities at various spatial scales may threaten biodiversity, thereby compromising nature's contributions to people [2]. Long-term standardised monitoring surveys are pivotal for measuring biodiversity changes. This need is in line with the targets of the EU Biodiversity Strategy for 2030 which aimed to strengthen the protected areas, including the Nature 2000 network designated in compliance with the EU Directives 92/43/CEE (Habitats Directive) [3].

The "Montagna di Torricchio" protected area is a Strict Nature State Reserve in the Italian Central Apennines. The Reserve is part of the Natura 2000 network as a Special Area of Conservation (SAC) and Special Protection Area (SPA). Since 2006, it has been included in the International Long-Term Ecological Research Network (ILTER) [4] through the national network LTER-Italy and the European network of distributed research sites (eLTER) [5]. ILTER focuses on long-term, site-based research and monitoring encompassing hundreds of research sites located in a wide array of ecosystems that can help understand environmental change across the globe [6]. The dataset represents a long-lasting collection of data on vascular plant species presence and abundance useful for measuring spatio-temporal changes in diversity and habitat dynamics.

3. Data Description

The dataset presented here provides plot-level (100 m^2) and subplot-level (1 m^2) presences and abundances of vascular plant species in the "Montagna di Torricchio" Strict Nature Reserve. The surveys were initially carried out in the summer of 2002, followed by resurveys during the summer in 2003, 2015, 2020, and 2024. At the plot level, species presence only (indicated as "p" in the dataset) was recorded in 2002 and 2003, while plant species presence and abundance (the latter measured as Braun-Blanquet scale (1964) [7]) were recorded in 2015, 2020, and 2024. At the sub-plot level, species presence and abundance were recorded in 2002 and 2003, while species presence only was recorded in 2015, 2020, and 2024. At the plot level, species abundance was also visually estimated separately for three vegetation layers (herbaceous - "C", shrub - "B", and tree - "A"). Data were collected in 35 10 m × 10 m permanent quadrat plots, located between 1015 and 1482 m a.s.l. (Fig. 1). The plots cover two macro-categories of Habitat Directive habitats: grasslands (habitat code 6210*) and forests (9210*) [5,8].

Inside each plot, four 1 m × 1 m subplots were preferentially selected by observers with the criteria of avoiding spatial overlap with the subplots selected in the previous years.

The dataset is a table consisting of six sheets. The first sheet named "Plot info" includes topographic data and habitat description.

The second and third sheets, named "Flora plot" and "Flora subplot" respectively, include information on plant species presence and/or abundance in the 10 m × 10 m plots and 1 m × 1 m subplots.

The last three sheets named "metadata info discovery", "metadata info context", "metadata info technical" include metadata with description of the dataset.

4. Experimental Design, Materials and Methods

The plant diversity monitoring is based on a probabilistic sampling scheme providing a final design with multiple scale sampling units: 10,000 m^2 (macroplot), 100 m^2 (the main unit, plot) and 1 m^2 (subplot). This approach has a solid theoretical background, enabling statistically valid inferences on plant species richness at different spatial scales [9] and has been applied in the Torricchio nature reserve for monitoring purposes [1] as well as in other protected areas to relate plant diversity data to remotely sensed information [10,11] or even to analyse cross-taxon congruence [12,13]. For the selection of sampling sites, the Regional Technical Map 325010 (Marche Region - 1:10,000) was originally georeferenced through the UTM (ED50) coordinates. The map was divided into 500 m × 500 m cells covering the entire Nature Reserve, and one macroplot of 100 m × 100 m was randomly selected within each cell. Each macroplot was divided into four quadrants of 2500 m^2, and a point was randomly selected in each quadrant. Thus, a final cluster of four random points was generated within each single macroplot, each point was identified as the southwest (SW) vertex of the corresponding 10 m × 10 m plots. Only the nine clusters fully located in the Nature Reserve were considered, resulting in 36 plots; however, one of these was
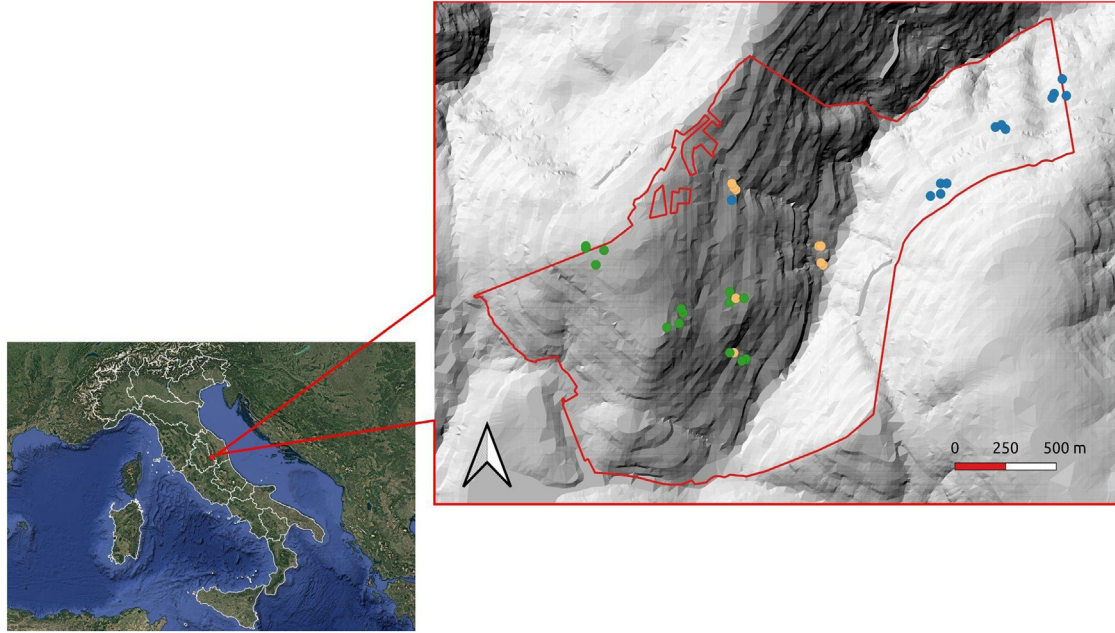
Fig. 1. Geographic location and morphology (DTM - Digital Terrain Model - hillshade) of the "Montagna di Torricchio" Strict Nature State Reserve in the Italian Central Apennines. The red line indicates the border of the Reserve, while the dots symbolise the 35 10 m × 10 m permanent quadrat plots, selected using a probabilistic sampling scheme, in which presence and abundance of vascular plant species in three vertical layers of vegetation (herbaceous, shrub, and tree) were recorded in the summer of 2002, with subsequent re-surveys in 2003, 2015, 2020, and 2024 [1]. Dots have different colours in compliance with the EU Directives 92/43/CEE Habitat classification: blue dots represent the habitat code 9210*, green dots represent the habitat code 6210(*), while yellow dots are not classifiable or communities in transition to shrubland/forest.

excluded because of problems with plot identification in the field, resulting in a total of 35 plots sampled. During field activities of the first survey, the SW corner of each plot was localised with GPS (error $\pm$ 10 m) and materialised with a wooden pole. The subsequent surveys were based on this materialised position, permitting almost perfect relocalisation of sampling units and removing site location errors. Original taxonomic nomenclature follows the Flora d'Italia, 1982 [14]. Additionally, an extra column is provided with standardized species names based on the updated list of vascular flora of Italy [15].

Limitations

Over the long-term monitoring time frame (2002–2024), the frequency of surveys was initially higher (2002 and 2003), becoming more uniform later (2015-2020-2024). Long-term monitoring requires ongoing financial support to ensure continuity; sampling effort has been optimised to ensure that cumulative commitments and costs do not undermine this continuity. The results of the field surveys may have been affected by extreme weather events; a drought was documented during the 2003 sampling.

Ethics Statement

The authors confirm that they have read and followed the ethical requirements for publication in Data in Brief. The authors also confirm that the work does not involve human subjects, animal experiments or any data collected from social media platforms.

CRediT Author Statement

Marco Cervellini: Conceptualization, Writing - original draft, Data curation, and Supervision. **Leonardo Salvatori:** Writing - original draft, Data curation, Formal analysis. **Roberto Canullo:** Conceptualization, Funding acquisition, Writing - review & editing. **Alessandro Chiarucci:** Conceptialization, Writing - review & editing **Federico Maria Tardella:** Data curation, Writing - review & editing. Note: Marco Cervellini* and Leonardo Salvatori* are equally contributing authors.

Data Availability

Long-term monitoring of plant diversity data in the "Montagna di Torricchio" strict Nature Reserve, Italy (Original data) (b2share - EUDAT).

Acknowledgements

Declaration of Competing Interest

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.

Supplementary Materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.dib.2025.111355.

References

[1] S. Chelli, E. Simonetti, G. Campetella, A. Chiarucci, M. Cervellini, F.M. Tardella, M. Tomasella, R. Canullo, Plant diversity changes in a nature reserve: a probabilistic sampling method for quantitative assessments, Nat. Conserv. (2019) 145–161, doi:10.3897/natureconservation.34.30043.

[2] Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (Version 1), Zenodo, 2019, doi:10.5281/zenodo.6417333.

[3] L. Fattorini, M. Cervellini, S. Franceschi, M. Di Musciano, P. Zannini, A. Chiarucci, A sampling strategy for assessing habitat coverage at a broad spatial scale, Ecol. Indic. (2022) 109352, doi:10.1016/j.ecolind.2022.109352.

[4] International Long Term Ecological Research (ILTER). https://www.ilter.network/, 2025 (accessed 13 Jan 2025).

[5] Long-Term Ecological Research network. https://elter-ri.eu/, 2025 (accessed 13 Jan 2025).

[6] International Long Term Ecological Research (LTER). https://www.ilter.network/operations/purpose, 2024 (accessed 18 Nov 2024).

[7] J. Braun-Blanquet, Pflanzensoziologie, Grundzüge der Vegetationskunde, 3rd ed., Springer-Verlag, Berlin, 1964, doi:10.1007/978-3-7091-8110-2.

[8] Habitats Directive (Council Directive 92/43/EEC; Annex I) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A01992L0043-20130701, 1992 (Accessed 02 Feb 2025).

[9] F. Baffetta, G. Bacaro, L. Fattorini, D. Rocchini, A. Chiarucci, Multi-stage cluster sampling for estimating average species richness at different spatial grains, Community Ecol. 8 (2007) 119–127, doi:10.1556/ComEc.8.2007.1.14.

[10] D. Rocchini, S. Andreini Butini, A. Chiarucci, Maximizing plant species inventory efficiency by means of remotely sensed spectral distances, Glob. Ecol. Biogeogr. 14 (2005) 431–437, doi:10.1111/j.1466-822x.2005.00169.x.

[11] D. Rocchini, C. Ricotta, A. Chiarucci, Using satellite imagery to assess plant species richness: the role of multispectral systems, Appl. Veg. Sci. 10 (2007) 325–331, doi:10.1111/j.1654-109X.2007.tb00431.x.

[12] E. Santi, S. Maccherini, D. Rocchini, I. Bonini, G. Brunialti, L. Favilli, C. Perini, F. Pezzo, S. Piazzini, E. Rota, E. Salerni, A. Chiarucci, Simple to sample: vascular plants as surrogate group in a nature reserve, J. Nat. Conserv. 18 (2010) 2–11, doi:10.1016/j.jnc.2009.02.003.

[13] E. Santi, G. Bacaro, D. Rocchini, A. Chiarucci, I. Bonini, G. Brunialti, L. Muggia, S. Maccherini, Methodological issues in exploring cross-taxon congruence across vascular plants, bryophytes and lichens, Folia Geobot. 51 (2016) 297–304, doi:10.1007/s12224-016-9265-9.

[14] Pignatti, S., Flora d'Italia 1982. Edagricole, Bologna.

[15] F. Bartolucci, L. Peruzzi, G. Galasso, A. Alessandrini, N.M.G. Ardenghi, G. Bacchetta, E. Banfi, G. Barberis, L. Bernardo, D. Bouvet, M. Bovio, G. Calvia, M. Castello, L. Cecchi, E. Del Guacchio, G. Domina, S. Fascetti, L. Gallo, G. Gottschlich, R. Guarino, L. Gubellini, N. Hofmann, M. Iberite, P. Jiménez-Melías, D. Longo, D. Marchetti, F. Martini, R.R. Masin, P. Medagli, S. Peccenini, F. Prosser, F. Roma-Marzio, L. Rosati, A. Santangelo, A. Scoppola, A. Selvaggi, F. Selvi, A. Soldano, A. Stinca, R.P. Wagensommer, T. Wilhalm, F. Conti, A second update to the checklist of the vascular flora native to Italy, Plant Biosyst. 158 (2024) 219–296, doi:10.1080/11263504.2024.2320126.