Journal of Biogeography

WILEY

SPECIAL ISSUE Leveraging Country-Scale Assessments of Biodiversity for Achieving Terrestrial 30x30 Conservation Commitments Through Systematic Planning

Journal of Biogeography

DATA ARTICLE OPEN ACCESS

Mapping Italy's Sacred Natural Sites to Support the Establishment of Other Effective Area-Based Conservation Measures (OECMs)

Lorenzo Ricci[1,2] | Piero Zannini[2] | Michele Di Musciano[1,2] | Carlo Rondinini[3] | Moreno Di Marco[3] | Luca Santini[3] | Michela Pacifici[3] | Michele Lussu[2] | Duccio Rocchini[2] | Fabrizio Frascaroli[2] | Alessandro Chiarucci[2]

[1]Department of Life, Health & Environmental Science, University of L'Aquila, L'Aquila, Italy | [2]BIOME Lab, BiGeA Department, University of Bologna, Bologna, Italy | [3]Department of Biology and Biotechnologies "Charles Darwin", Sapienza University of Rome, Rome, Italy

Correspondence: Michele Di Musciano (michele.dimusciano@univaq.it)

Received: 22 December 2025 | **Revised:** 22 April 2026 | **Accepted:** 22 May 2026

Keywords: 30 × 30 target | biodiversity conservation | conservation planning | OECMs | sacred natural sites

ABSTRACT

Aim: Sacred natural sites (SNS) are culturally governed places that often retain remnants of natural vegetation, safeguard species of conservation concern and maintain landscape continuity, positioning them as potential Other Effective Area-Based Conservation Measures (OECMs). Despite increasing ecological interest, national datasets remain unavailable, limiting reproducibility of studies and preventing systematic evaluation of SNS as OECMs. Here we release the first harmonised, openly accessible, geospatial inventory of SNS in Italy, comprising 2332 records, explicitly designed to support their assessment as potential OECMs at the national scale. The dataset provides detailed information on the types of SNS, their ecological attributes and their landscape context, offering a valuable resource for biodiversity conservation, enabling systematic evaluation of SNS within conservation planning applications, as well as research in biogeography, landscape ecology and biocultural science.

Location: Italy.

Feature: SNS of Catholic tradition (e.g., shrines, hermitages, monasteries, chapels, pilgrimage sites, groves, springs).

Methods: The dataset derives from a standardised nationwide identification protocol combining documentary sources, remote-sensing geolocation and land cover filtering to identify sites embedded within natural or semi-natural landscapes. We provide a georeferenced point vector dataset, with each point representing the location of an SNS. For each site, we report geographic coordinates, elevation, bioclimatic variables, proximity to road infrastructure, surrounding land cover composition and indicators of formal protection status.

Results: The dataset contains 2332 georeferenced SNS distributed across Italy, mainly concentrated in central and northern regions. Only a small proportion of SNS occur within protected areas (17%), with the greatest proportion corresponding to sites lacking an assigned IUCN category (38%). SNS are predominantly situated at low- to mid-elevations (mean = 458 m, SD = 343 m) and in landscapes dominated by agricultural (45%) and natural land covers (38%). Their climatic space overlaps with, but extends beyond, that encompassed by the protected area network, indicating potential complementarity in conservation representation.

Main Conclusions: This dataset represents the first standardised and policy-relevant national resource for assessing SNS as potential OECMs, providing a useful baseline for their integration into conservation planning and contributing to the global target of protection (i.e., 30% coverage by 2030) in Italy—a country that still lacking official OECMs. While our analytical framework

is transferable, its application depends on the availability of comparable national datasets and may require adaptation to local ecological, cultural and institutional contexts.

1 | Introduction

Sacred natural sites (SNS) represent one of the oldest and most widespread forms of area-based conservation, where cultural and spiritual practices have contributed to the conservation of species, habitats and ecological processes (Dudley et al. 2009; Verschuuren 2012). Through taboos, customary governance, pilgrimage traditions and ritual restrictions, communities have historically protected forest patches, groves, springs, mountains and other natural features, often preserving ecological integrity in otherwise intensively used landscapes across a broad spectrum of geographical and cultural contexts (Zannini et al. 2021). For this reason, SNS are increasingly interpreted as biocultural refugia, where long-term cultural practices align with biodiversity persistence (Verschuuren and Furuta 2016).

This growing recognition of SNS contributions to biodiversity has strategically positioned them within the current debate on Other Effective Area-Based Conservation Measures (OECMs). OECMs complement protected areas by delivering positive biodiversity outcomes as a by-product of governance systems not primarily aimed at conservation (IUCN WCPA 2019). In this context, the Kunming-Montreal Global Biodiversity Framework explicitly calls for conservation targets to be achieved through integrated systems of protected areas and OECMs, prompting many countries to identify, report and incorporate OECMs into national biodiversity strategies (Convention on Biological Diversity 2022). Because many SNS safeguard old-growth forest structures, sustain rare or threatened species or enhance habitat continuity in fragmented landscapes, several studies suggest they could qualify as OECMs and contribute to achieving the Convention on Biological Diversity's 30 × 30 target (Frascaroli and Verschuuren 2016; Zannini et al. 2021, 2022).

In Italy, SNS range from mountain sanctuaries and hermitages to chapels, springs, groves and monastic complexes embedded within diverse natural or semi-natural contexts (Frascaroli et al. 2016, 2019). Many of them coincide with areas of high conservation interest, such as remnant forest patches, ecotonal habitats or landscapes partly included in the national protected area network, yet they remain largely absent from conservation policy. The national inventory of Italian SNS was first compiled by Frascaroli et al. (2019), following methodological criteria developed for Central Italy (Frascaroli 2013). Subsequent studies used versions of these data to evaluate bio-cultural relationships (Frascaroli and Verschuuren 2016) and to examine long-term forest-area dynamics around sites (Zannini et al. 2022), showing that SNS often coincide with areas of long-term ecological stability, underscoring their potential relevance for conservation. However, despite these advances, previous efforts have relied on datasets that were not fully standardised, consistently structured or readily reusable for broader analyses, limiting reproducibility and preventing their integration into conservation planning applications. As a result, a coherent, harmonised and policy-focused national dataset of SNS remains unavailable, constraining a comprehensive evaluation of their role as potential OECMs.

Here, we fill this gap by providing the first openly accessible, harmonised and quality-controlled geospatial dataset of Italian SNS, comprising 2332 georeferenced sites and their associated attributes, available via an open data repository (see Data Availability Statement). Beyond compiling existing information, this work standardises and integrates a suite of environmental and conservation variables, including bioclimatic variables, elevation, road proximity, land cover composition at multiple spatial buffers and overlap with protected areas and IUCN management categories, within a unified and reproducible framework. This dataset provides the first standardised and policy-relevant resource for evaluating SNS as potential OECMs, supporting their integration into conservation planning and assessment of the 30 × 30 target in Italy. The systematic and harmonised mapping of SNS enables the identification of sites with potential conservation value and establishes a reproducible baseline for their possible inclusion as OECMs.

2 | Methods

2.1 | Data Origin and Scope

The dataset presented here originates from a standardised protocol for identifying and mapping SNS originally developed for Central Italy (Frascaroli 2013) and later expanded nationwide (Frascaroli et al. 2019). The earlier version provided only SNS locations and was not structured in a standardised or readily reusable format for broader analytical applications. The present release provides the first harmonised, quality-checked and openly accessible version of the national SNS dataset. We integrated multiple data sources into a unified dataset in which classifications, spatial referencing and attribute structures were checked and standardised to ensure consistency and comparability. Our dataset includes 2332 SNS distributed across mainland Italy and its major and minor islands, spanning a wide range of Catholic devotional contexts, including shrines, hermitages, chapels, monasteries, pilgrimage destinations, sacred groves and springs. Each SNS is represented as a single georeferenced point (with no surface area information). The same set of environmental and conservation attributes is provided both as a spatial vector dataset and as a non-spatial tabular file (see Supporting Information). Both formats include geographic coordinates and a suite of environmental and conservation attributes, including elevation, bioclimatic variables, minimum distance to the road network, land cover composition at multiple spatial buffers, overlap with protected areas, IUCN management categories and, for unprotected SNS, the distance to the nearest protected area.

2.2 | Environmental Variables

We extracted elevation for each SNS using the nationwide Tinitaly digital elevation model (DEM) v 1.1 (Tarquini et al. 2023; https://tinitaly.pi.ingv.it/), ensuring topographic accuracy, particularly in mountainous terrain. To characterise the bioclimatic context of SNS, we also extracted the full set of CHELSA v2.1 bioclimatic variables (BIO1-BIO19—Brun et al. 2022; https://chelsa-climate.org/), representing long-term climatic averages for the period 1981–2010 at 30 arc-second resolution (~1 km). Climate values were extracted at point locations; as such, they describe macroclimatic conditions.

Landscape structure was retrieved from Corine Land Cover (CLC) 2018—a pan-European land cover dataset with a spatial resolution of 100 m (EEA 2019; https://land.copernicus.eu/). For each SNS site, we calculated the proportion of land cover classes within buffers of 50, 100, 150, 200 and 250 m using the official Level 1 CLC classification scheme. These include (1) artificial surfaces (e.g., urban fabric, industrial areas and infrastructure), (2) agricultural areas (e.g., arable land and permanent crops), (3) natural areas (e.g., forests and semi-natural vegetation), (4) wetlands, (5) water bodies. To capture both the immediate environment of SNS and its larger landscape context, we selected these distances to represent multiple spatial scales commonly used in landscape ecology studies (Frascaroli 2013; Riva and Fahrig 2023). We estimated proximity to roads as the minimum distance from each SNS to the nearest road segment from the OpenStreetMap (OSM) network (https://www.openstreetmap.org/), used as a proxy for accessibility and potential anthropogenic pressure.

Finally, to assess the conservation context of each site, SNS locations were intersected with the World Database on Protected Areas (WDPA)—a global database maintained by UNEP-WCMC and IUCN (https://www.protectedplanet.net/; accessed 28 March 2024). WDPA data were used without applying pre-processing or filtering steps beyond those inherent to the original release, except for the exclusion of marine protected areas, as SNS locations are exclusively terrestrial and no spatial overlap with marine features occurred. Currently, Italy has not officially recognised OECMs recorded in either global or national databases. As a result, their inclusion would not have allowed for a consistent or reproducible comparison.

Sites falling within protected areas were reclassified into three management groups: 'Conservation focused' (IUCN Categories Ia–IV), 'Non strictly protected' (protected areas with less restrictive IUCN management, e.g., Category V–VI) and 'Protected (N.C.—non-categorised)' (designated protected areas lacking an assigned IUCN management category in the database, typically due to incomplete or inconsistent reporting). This classification follows widely used approaches distinguishing between strictly managed protected areas (IUCN Categories I–IV) and those allowing more flexible or mixed-use management (Categories V–VI), while also accounting for areas without an assigned category (e.g., Lewin et al. 2024). Sites located outside any protected area were classified as 'Unprotected'.

2.3 | Data Verification

The core identification and mapping of SNS follow a standardised methodological protocol established in Frascaroli (2013) and subsequently implemented nationwide in Frascaroli et al. (2019). Candidate sites were first identified through documentary sources with national coverage. Each candidate location was georeferenced using high-resolution satellite imagery, enabling visual verification of churches, hermitages, chapels, monastic complexes and associated landscape features and ensuring the correction of obvious geolocation inaccuracies.

The dataset focuses exclusively on the SNS of Catholic tradition, reflecting the availability of systematic and nationwide documentary sources for this category. While other types of SNS may exist in Italy, to our knowledge, no systematic and spatially explicit datasets comparable in scope and resolution are currently available. Their exclusion is therefore primarily due to data availability constraints and is acknowledged as a limitation of the study. However, given the historical and cultural context of Italy, non-Catholic SNS are likely to represent a relatively small proportion of the overall SNS network, suggesting that their omission may have limited influence on the spatial coverage of the dataset.

2.4 | Analytical and Visualisation Methods

To characterise the dataset and provide reproducible descriptive summaries, we carried out a set of exploratory analyses based on the environmental and conservation variables described above. Distances from each SNS to the nearest protected area and associated road proximity measures were summarised to characterise the conservation setting and accessibility of the sites. Land cover proportions calculated at multiple buffer distances were also examined to describe variation in the immediate and peri-site landscape context.

To assess whether the observed spatial relationships between SNS and protected areas differ from random expectations, we implemented a set of simulation-based analyses designed to compare observed patterns against null models of spatial randomness. Patterns in the proximity of unprotected SNS to protected areas were evaluated by focusing on the subset of sites located outside protected areas ($n = 1993$). We generated 999 random sets of sampling points from the unprotected portion of the Italian land area. For each simulated dataset, distances to the nearest protected area were recalculated, producing a reference distribution against which the observed distances were compared.

In addition, we evaluated the representation of SNS inside versus outside protected areas using the full dataset ($n = 2332$). In this case, 999 simulations were performed, generating 2332 random points across the Italian land area and recording how many intersected protected area polygons. The observed number of SNS located inside protected areas was then compared to this distribution using a chi-square goodness-of-fit test. Finally, to provide an overview of the climatic conditions occupied by SNS, we performed a principal component analysis to visualise the positioning of SNS within the broader climatic space of Italy and its protected areas.

All analyses were conducted in R (v. 4.2.3) (R Core Team 2025), using the terra (Hijmans et al. 2022) and sf (Pebesma 2018) packages.

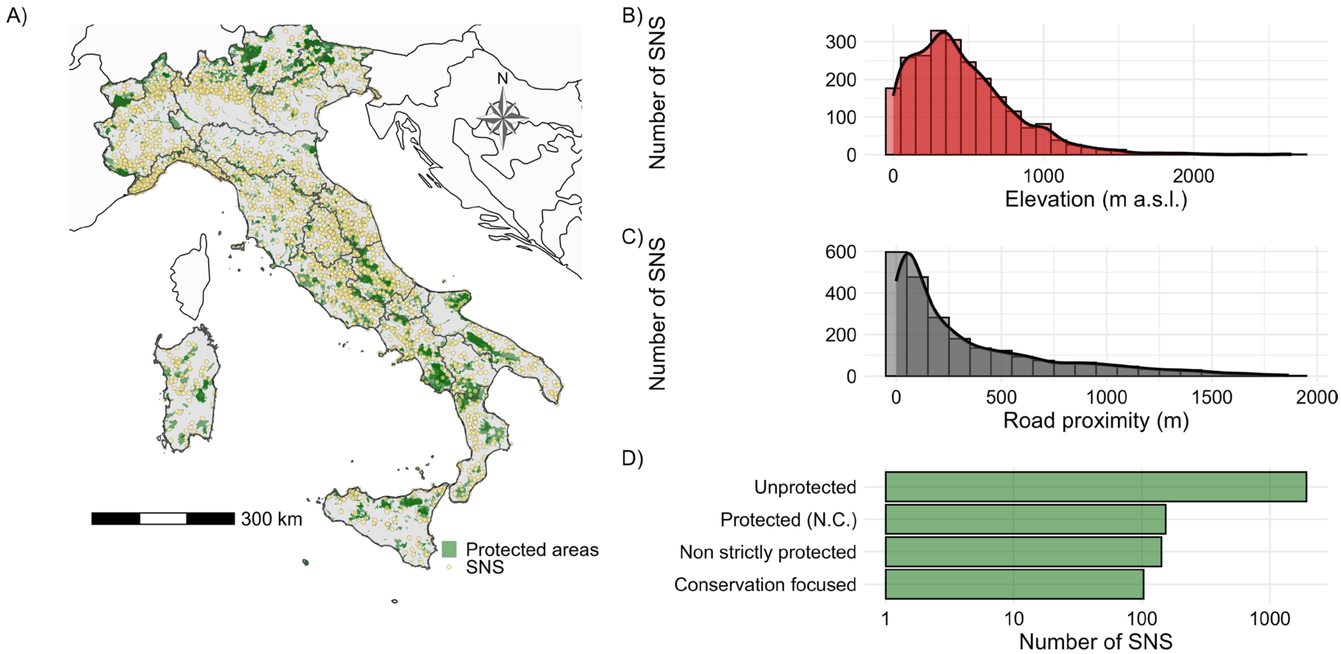

FIGURE 1 | (A) Spatial distribution of SNS across Italy (yellow points) in relation to national and regional protected areas (green polygons). (B) Elevation distribution of SNS. (C) Distribution of SNS by proximity to roads. (D) Number of SNS located within protected areas, grouped into three management classes: 'Conservation focused' (IUCN categories Ia–IV), 'Non strictly protected' (protected areas with less restrictive IUCN management, e.g., categories V–VI) and 'Protected (N.C.)' (designated protected areas lacking an assigned IUCN management category in the database, typically due to incomplete or inconsistent reporting). Sites situated outside protected areas are shown as 'Unprotected'.

3 | General Overview and Prospects

The spatial distribution of the 2332 SNS reveals a dense and widespread presence across the Italian peninsula, with pronounced clusters in central and northern regions and along the Apennine chain (Figure 1A). Elevation patterns indicate that SNS are predominantly located in low- to mid-elevation zones with a median elevation of 389 m above sea level (asl) (Figure 1B). Most sites occur below 800 m asl (85%), followed by a sharp decline at higher elevations. Nonetheless, 176 SNS are found above 1000 m, especially in the Alps and central Apennines (7%). Road proximity metrics show that SNS have a mean distance of 342 m (median = 177 m) from the nearest road (Figure 1C), indicating that most sites are easily accessible.

Despite their broad distribution and overlap with areas of ecological relevance, most SNS (1933 sites, 83%) fall outside formally designated protected areas (Figure 1D). The remaining 399 sites (17%) occur within protected areas, with the largest proportion lacking an assigned IUCN management category (protected [N.C.]; 154 sites; 6.6% of all SNS). Only 6.2% are located within conservation-focused areas.

SNS frequency declines steadily with increasing distance from protected areas. More than half of all SNS occurrences are located within 4 km of the nearest protected areas (Figure 2). Only a small fraction of sites were located beyond 10 km. Sites closest to protected areas (0–2 km) were predominantly associated with protected (N.C.) areas, while the relative contribution of non-strictly protected areas decreased with distance. Conservation-focused areas follow a similar decreasing trend with increasing distance from protected areas, although they represent a smaller proportion across all distance classes (Figure 2).

The spatial distribution of distances between SNS and protected areas also deviates clearly from the expected distribution. Unprotected SNS were, on average, 3.11 km from the nearest protected area, whereas randomly placed points (restricted to unprotected land) exhibited a larger mean distance of 3.90 km (Figure S1). This corresponds to an absolute effect size of −0.80 km, indicating that unprotected SNS are approximately 20% closer to protected areas than expected under random spatial placement. A similar pattern emerged for the median: the observed median distance (2.32 km) was markedly lower than the null expectation (3.05 km), with an effect size of −0.74 km (Figure S1). According to these findings, SNS are systematically located closer to protected areas than randomly placed points.

A further divergence from random expectations emerged when considering all SNS ($n = 2332$) (Figure S2). The observed number of SNS located inside protected areas was markedly lower than the values produced by the random simulations, all of which generated higher counts of points within protected area polygons (Figure S2). This deviation was statistically significant ($\chi^2 = 25.71$, $p = 3.96 \times 10^{-7}$), confirming that SNS occur inside protected areas far less frequently than expected under spatial randomness. These patterns suggest that SNS, despite being systematically located near the boundaries of existing protected areas, largely remain outside their boundaries and may function as candidate OECMs. By making this spatial relationship explicit and reproducible at the national scale, the dataset provides a novel basis for integrating SNS into conservation planning frameworks. This further highlights its relevance for identifying

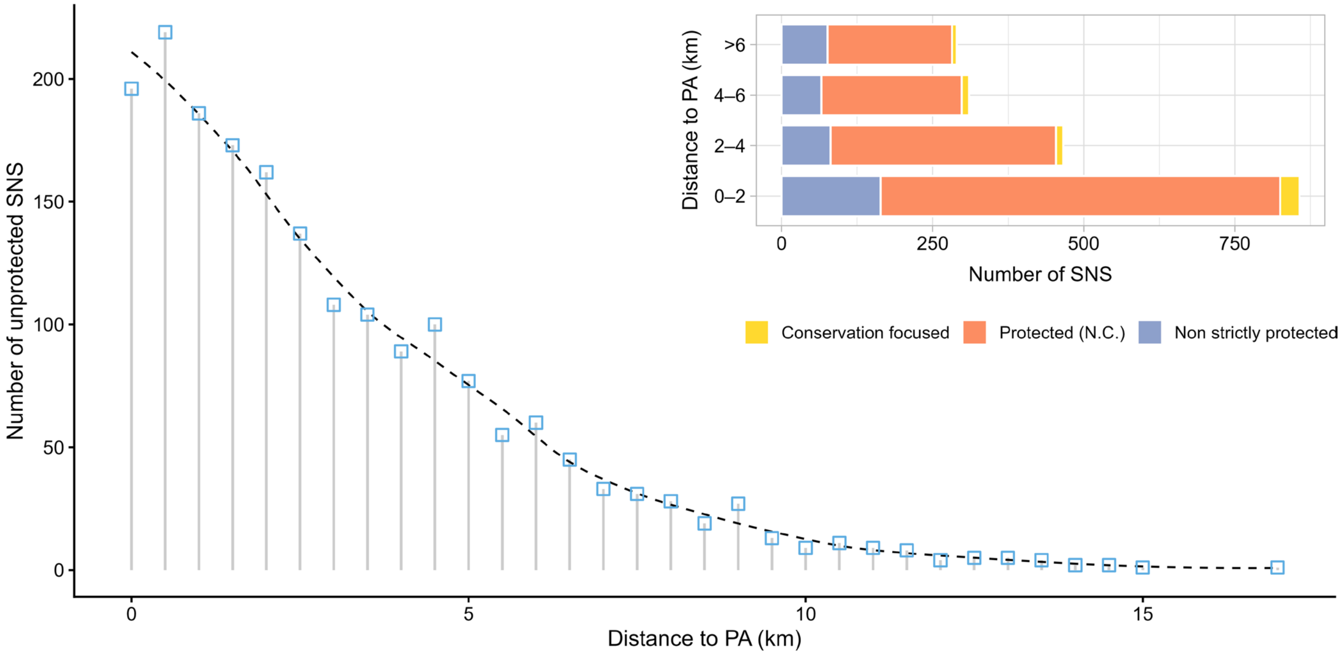

FIGURE 2 | Number of SNS located outside a protected area (PA) as a function of distance to the nearest protected area. Distances are grouped into 0.5-km bins; each blue square represents the number of unprotected SNS in each distance bin and grey vertical segments show the corresponding frequencies. The black dashed line represents a locally weighted regression curve fitted to the binned data, illustrating the overall trend in SNS frequency with increasing distance from protected areas. The inset shows the distribution of unprotected SNS in broader distance classes (e.g., 0–2, 2–4, 4–6, 6–8 km) broken down by the category of the nearest protected area: 'Conservation focused' (IUCN categories Ia–IV), 'Non strictly protected' (protected areas with less restrictive IUCN management, e.g., categories V–VI) and 'Protected [N.C.]' (designated protected areas lacking an assigned IUCN management category in the database, typically due to incomplete or inconsistent reporting).

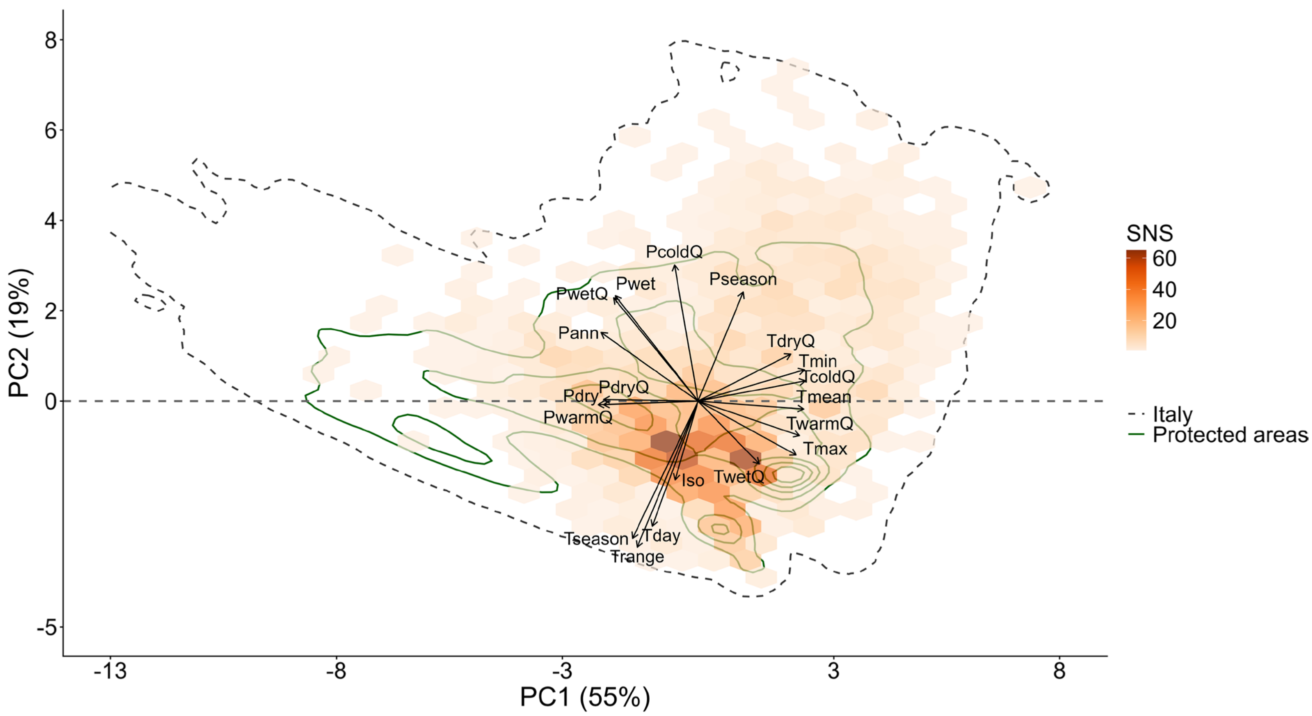

FIGURE 3 | Plot of the first two PCA axes computed from the 19 CHELSA bioclimatic variables (PC1 = 55% variance; PC2 = 19%). Hexagonal bins show the density of SNS occurrences across climatic space (warm colours indicate higher density). The black dashed contour outlines the full climatic space of Italy, whereas the green contours show kernel-density isopleths of the climatic space encompassed by the national protected area network, with the outermost line approximating the full climatic space currently occupied by protected areas. Black arrows indicate the loadings of the most influential bioclimatic variables on the first two PCA axes. Acronyms of bioclimatic variables: Iso, isothermality; Pann, annual precipitation; Pseason, precipitation seasonality; Pwet/Pdry, precipitation of the wettest/driest month; PwetQ/PdryQ/PwarmQ/PcoldQ, precipitation of the wettest/driest/warmest/coldest quarter; Tday, diurnal temperature range; Tmean, annual mean temperature; Trange, annual temperature range; Tseason, temperature seasonality; TwetQ/TdryQ/TwarmQ/TcoldQ, mean temperature of the wettest/driest/warmest/coldest quarter.

and assessing candidate OECMs in contexts where formal reporting is still limited.

SNS are typically embedded in landscapes where agricultural and natural land covers dominate (Figure S3). Agricultural areas are most prevalent in the immediate surroundings of SNS, whereas the proportion of natural land cover increases with distance from sites. Urban surfaces contribute minimally within the smallest buffer (50 m) but increase at larger buffers, indicating that many SNS occur in peri-urban or rural–urban transition zones rather than in densely urbanised areas (Figure S3). Wetlands and water bodies are associated with only a small subset of sites (0.1% and 1.2%, respectively), reflecting their occurrence in specific cultural-ecological contexts (Figure S3). The PCA of the 19 bioclimatic variables shows that SNS occupy a broad but non-random portion of Italy's climatic space (Figure 3).

Most sites cluster within intermediate-temperature and intermediate-precipitation conditions, corresponding largely to low- and mid-elevation zones of the peninsula. The density of SNS steeply decreases towards the cold, high-elevation climatic conditions and towards the warm-dry extremes typical of Mediterranean lowlands. When compared with the climatic envelope of the national protected area network—that is, the range of climatic conditions represented across protected areas—SNS largely overlap with protected area climatic space (i.e., the multidimensional bioclimatic conditions encompassed by protected areas) but extends slightly beyond it, suggesting potential complementarity in representing bioclimatic conditions not fully encompassed by existing protected areas.

One limitation of the dataset is that SNS are represented as point features rather than spatial polygons, which constrains applications requiring precise estimates of site extent or area-based conservation metrics. This choice reflects the nature of the original data sources, which systematically document site locations but do not provide consistent information on spatial boundaries. However, this limitation does not affect analyses based on relative spatial positioning (e.g., distance to protected areas), which remain robust under a point-based representation.

To partially address this limitation, users may approximate the spatial extent of SNS by applying buffer-based approaches around point locations. While the appropriate buffer size will depend on the specific research question and local context, small buffers (e.g., 50–250 m) can provide a reasonable approximation of the immediate ecological surroundings of sites, consistent with the spatial scales adopted in the landscape analyses presented here. Nevertheless, such approximations should be interpreted with caution, as the actual spatial extent of SNS can vary substantially depending on site typology (e.g., isolated chapels vs. monastic complexes or sacred groves). Improving the spatial delineation of SNS boundaries, therefore, represents an important priority for future research.

Author Contributions

Lorenzo Ricci: conceptualisation, data curation, formal analysis, investigation, methodology, software, visualisation, writing – original draft, writing – review and editing. **Piero Zannini:** data curation, writing – review and editing. **Michele Di Musciano:** conceptualisation, data curation, methodology, investigation, visualisation, writing – original draft, writing – review and editing. **Carlo Rondinini:** writing – review and editing. **Moreno Di Marco:** writing – review and editing. **Luca Santini:** writing – review and editing. **Michela Pacifici:** writing – review and editing. **Michele Lussu:** writing – review and editing. **Duccio Rocchini:** writing – review and editing. **Fabrizio Frascaroli:** data curation, writing – review and editing. **Alessandro Chiarucci:** conceptualisation, data curation, investigation, methodology, supervision, writing – original draft, writing – review and editing.

Acknowledgements

The research was supported by the Italian Ministry of Education, University and Research, Italy (MIUR) through the PRIN 2015 project 2015P8524C '*Biodiversity and ecosystem services in sacred natural sites* (*BIOESSaNS*)' and by the European Union-NextGenerationEU under the National Recovery and Resilience Plan (NRRP), project title 'National Biodiversity Future Center—NBFC' (project code CN_00000033) CUP J33C22001190001. Open access publishing facilitated by Universita degli Studi dell'Aquila, as part of the Wiley - CRUI-CARE agreement.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The dataset supporting this study is archived in the Dryad Digital Repository at https://doi.org/10.5061/dryad.8gtht772z. The dataset is released in two complementary formats: a geopackage (.gpkg) containing the full georeferenced point dataset with all associated environmental and conservation attributes and an equivalent tabular version in .csv format with the same attributes. The R code used to process the data and generate the figures is also archived in Dryad.

References

Brun, P., N. E. Zimmermann, C. Hari, L. Pellissier, and D. N. Karger. 2022. "Global Climate-Related Predictors at Kilometer Resolution for the Past and Future." *Earth System Science Data* 14, no. 12: 5573–5603.

Convention on Biological Diversity. 2022. "Decision Adopted by the Conference of the Parties (COP 15) to the Convention on Biological Diversity." Paper presented at the Conference of the Parties to the Convention on Biological Diversity Fifteenth Meeting—Part II, Montreal, Canada, December 7–19.

Dudley, N., L. Higgins-Zogib, and S. Mansourian. 2009. "The Links Between Protected Areas, Faiths, and Sacred Natural Sites." *Conservation Biology* 23, no. 3: 568–577.

EEA. 2019. "Corine Land Cover (CLC) 2018, Version 2020_20u1." https://land.copernicus.eu/pan-european/corine-land-cover/clc2018?tab=download.

Frascaroli, F. 2013. "Catholicism and Conservation: The Potential of Sacred Natural Sites for Biodiversity Management in Central Italy." *Human Ecology* 41, no. 4: 587–601.

Frascaroli, F., S. Bhagwat, R. Guarino, A. Chiarucci, and B. Schmid. 2016. "Shrines in Central Italy Conserve Plant Diversity and Large Trees." *Ambio* 45, no. 4: 468–479.

Frascaroli, F., and B. Verschuuren. 2016. "Linking Biocultural Diversity and Sacred Sites: Evidence and Recommendations in the European Framework." In *Biocultural Diversity in Europe*, edited by M. Agnoletti and F. Emanueli, 389–417. Springer.

Frascaroli, F., P. Zannini, A. T. R. Acosta, A. Chiarucci, M. d'Agostino, and J. Nascimbene. 2019. "Sacred Natural Sites in Italy Have Landscape

Characteristics Complementary to Protected Areas: Implications for Policy and Planning." *Applied Geography* 113: 102100.

Hijmans, R. J., R. Bivand, K. Forner, J. Ooms, E. Pebesma, and M. D. Sumner. 2022. *Package 'Terra'*. CRAN.

IUCN WCPA. 2019. *Guidelines for Recognising and Reporting Other Effective Area-Based Conservation Measures*. IUCN.

Lewin, A., G. Murali, S. Rachmilevitch, and U. Roll. 2024. "Global Evaluation of Current and Future Threats to Drylands and Their Vertebrate Biodiversity." *Nature Ecology & Evolution* 8, no. 8: 1448–1458.

Pebesma, E. 2018. "Simple Features for R: Standardized Support for Spatial Vector Data." *R Journal* 10: 2073–4859.

R Core Team. 2025. "A Language and Environment for Statistical Computing." R Foundation for Statistical Computing. https://www.R-project.org/.

Riva, F., and L. Fahrig. 2023. "Landscape-Scale Habitat Fragmentation Is Positively Related to Biodiversity, Despite Patch-Scale Ecosystem Decay." *Ecology Letters* 26, no. 2: 268–277.

Tarquini, S., I. Isola, M. Favalli, A. Battistini, and G. Dotta. 2023. *TINITALY, a Digital Elevation Model of Italy With a 10 Meters Cell Size (Version 1.1)*. Istituto Nazionale Di Geofisica e Vulcanologia (INGV).

Verschuuren, B. 2012. "Integrating Biocultural Values in Nature Conservation: Perceptions of Culturally Significant Sites and Species in Adaptive Management." In *Sacred Species and Sites: Advances in Biocultural Conservation*, edited by G. Pungetti, G. Oviedo, and D. Hooke, 231–246. Cambridge University Press.

Verschuuren, B., and N. Furuta. 2016. *Asian Sacred Natural Sites: Philosophy and Practice in Protected Areas and Conservation*. Routledge.

Zannini, P., F. Frascaroli, J. Nascimbene, et al. 2021. "Sacred Natural Sites and Biodiversity Conservation: A Systematic Review." *Biodiversity and Conservation* 30, no. 13: 3747–3762.

Zannini, P., F. Frascaroli, J. Nascimbene, et al. 2022. "Investigating Sacred Natural Sites and Protected Areas for Forest Area Changes in Italy." *Conservation Science and Practice* 4, no. 8: e12695.

Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Figure S1:** (A) Distribution of mean distances from 999 simulations, with the observed SNS mean (orange line) and the random mean (blue dashed line). (B) Distribution of median distances from the same simulations, with the observed SNS median (orange line) and the random median (blue dashed line). In both panels, the position of the observed value relative to the random distribution indicates whether observed distances are unusually small or large compared to expectations under spatial randomness. **Figure S2:** Distribution of the number of points falling inside protected areas across 999 random spatial simulations (grey bars). The dashed blue line indicates the mean expected value under spatial randomness, while the dashed orange line marks the observed number of SNS located inside protected areas. **Figure S3:** Proportion of land-cover classes surrounding sacred natural sites (SNS) across five spatial buffers (50, 100, 150, 200, 250 m). Boxplots show the distribution of percent cover for each land-cover class across SNS, with points representing individual sites. Extreme outliers (values beyond $1.5 \times \text{IQR}$) were removed for visualisation purposes. For water bodies and wetlands, only non-zero values are shown because most observations were equal to zero. Percentages are plotted on a $\log(x+1)$ scale to enhance comparability among land-cover classes.