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Data Paper

Restoration information: A European database of ecological restoration knowledge from stakeholder surveys

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Abstract

Anthropogenic pressure has led to the degradation of most natural areas in Europe. However, there is growing concern amongst both citizens and public administrations regarding the need to improve the conservation status of natural spaces through ecological restoration projects. The greatest challenge faced by ecological restoration managers is determining the most appropriate measures to ensure successful restoration, given the highly variable case-specific conditions, differing interests and objectives amongst stakeholders and limited knowledge of which measures have succeeded or failed in past restoration projects. The objective of this study is to address this issue by compiling an exhaustive database of European ecological restoration initiatives through surveys targeting stakeholders (including managers, landowners, workers, researchers and interested citizens) in relation to restoration projects already implemented, in progress or planned. The questionnaire was designed to cover all aspects related to restoration projects: general characteristics (e.g. geographic scope,

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duration, funding sources), ecological restoration approaches (e.g. techniques applied, target species), socio-economic and governance dimensions (e.g. stakeholder engagement, policy frameworks) and standardised success indicators for quantifying project outcomes. The published database includes responses from a total of 404 participants. This database contains extensive information on ecological restoration practices across Europe, including the reported causes of success or failure and captures the diverse perspectives associated with respondents' different roles in restoration. It is, therefore, of interest to researchers, policy-makers and other stakeholders involved in ecological restoration.

Keywords

ecosystem restoration, forest policy, indicator, practical knowledge, restoration expertise, survey, questionnaire, database, answers, responses

Overview and background

Ecological restoration is shaped by the interplay of three main dimensions. The ecological component focuses on the recovery of species, habitats and ecosystem functions. The socioeconomic dimension addresses stakeholder engagement, local livelihoods and the provision of ecosystem services (Fischer et al. 2021). Finally, the policy and governance framework establishes legal, institutional and financial conditions that guide, enable or constrain restoration efforts.

Although the benefits of ecological restoration are widely recognised, substantial knowledge gaps remain regarding the long-term effectiveness of such initiatives, particularly in terms of ecosystem service provision (Menéndez-Miguélez et al. 2024). Addressing this challenge requires enhanced monitoring strategies spanning decades to evaluate both biodiversity and ecosystem outcomes, as emphasised by the EU's Nature Restoration Regulation (EU 2024). In the EU, ecological restoration has been shaped by a combination of policies from multiple sectors, including the Common Agricultural Policy, the Nature Directives (EU 1992, EU 2009) and the Water Framework Directive (EU 2000). However, the conservation status of forest habitats and species in the EU continues to decline, with 85% being assessed as having an unfavourable conservation status (European Environmental Agency 2019). Recent policy developments, such as the European Green Deal's pledge to plant 3 billion trees (European Commission 2019) and the 2030 Biodiversity Strategy's restoration ambitions (European Commission 2020), aim to reverse this trend. The newly-adopted Nature Restoration Regulation (EU 2024) introduces legally binding goals, aiming to restore at least 20% of degraded land and sea by 2030, while promoting close-to-nature forest management.

Beyond EU-level policies, national and regional restoration strategies have emerged. For instance, Germany has implemented the "Blaues Band Deutschland" programme to enhance the hydromorphological functionality and ecological connectivity of federal

waterways (Federal Government of Germany 2025); Spain has adopted the "Estrategia Nacional de Infraestructura Verde y de la Conectividad y Restauración Ecológicas", which provides a legal and strategic framework to structure a coherent ecological network and to guide ecosystem conservation, restoration and connectivity measures (Spain 2021); and France, for its part, has consolidated its "Trame Verte et Bleue" as a national policy for preserving and restoring ecological continuities across terrestrial and aquatic landscapes (France 2009).

Moreover, emerging data platforms, such as Restor (Restor Eco AG. 2025), the IUCN Restoration Barometer (IUCN 2025) and the Framework for Ecosystem Restoration Monitoring (FAO 2025), have made significant strides towards providing data on the restoration initiatives undertaken. Restor offers an open-access geospatial platform that integrates satellite imagery and key biophysical layers to support project design and monitoring. The Restoration Barometer standardises national reporting on restoration progress, documenting governance frameworks, investments and socioecological outcomes. FERM defines the official indicators and methodological guidance for monitoring the United Nations Decade on Ecosystem Restoration. Together, these tools enhance transparency and improve the consistency of restoration assessment across scales.

Nevertheless, ecological restoration constitutes a complex socio-ecological process shaped by interacting direct drivers, such as land-use dynamics, altered disturbance regimes and accelerated climate change, and indirect drivers, including governance structures, institutional capacity and economic capacity. The complexity of feedbacks amongst these drivers (Jacobs et al. 2015), combined with limited knowledge of which restoration and monitoring approaches are most effective under specific ecological and socio-economic contexts (Menéndez-Miguélez et al. 2024), as well as the political and financial constraints often faced by implementing agencies, can lead to interventions that are inadequate or insufficient to achieve long-term restoration outcomes (Höhl et al. 2020). Advancing effective and durable restoration, therefore, requires an integrated framework that explicitly incorporates ecological, social, economic and policy dimensions. Recent research has sought to address these challenges by surveying restoration practitioners (Jalonen et al. 2017), assessing freely available information on ecological restoration (Oluwajuwon et al. 2024) and analysing global restoration targets (Leadley et al. 2022).

The main aim of this study is to compile a comprehensive survey-based database on European ecological restoration initiatives, by providing a systematic overview of restoration activities implemented across European countries and synthesising practitioner insights regarding the key drivers of project outcomes. Survey respondents were restoration practitioners, researchers, stakeholders and interested citizens throughout Europe. This database will enable analysis of the ecological, socioeconomic and political factors influencing restoration initiatives, along with their associated assessment methodologies. It has already been partially analysed in Menéndez-Miguélez et al. (2025), although the database itself had not yet been published, motivating the preparation of the present data paper.

Methods

This dataset provides a systematic compilation of practical knowledge on completed, ongoing and planned ecological restoration and adaptation initiatives across Europe. To achieve this, we designed and implemented a standardised, multilingual questionnaire targeting stakeholders involved in restoration activities. The questionnaire was developed through a collaborative process led by the Spanish National Research Council (CSIC, Spain), with key contributions from the Austrian Federal Forestry Research Centre (BFW, Austria) and the Forest Science and Technology Centre of Catalonia (CTFC, Spain). The initial draft underwent multiple rounds of expert review, including the European Forest Institute (EFI), the Swiss Federal Research Institute for Forest, Snow and Landscape (WSL), Wageningen University & Research (WUR), the University of Freiburg (ALUFR), the University of Copenhagen (UCPH), the Swedish University of Agricultural Sciences (SLU) and the Swiss Federal Institute of Technology (ETH Zürich), ensuring a balanced representation of ecological, socio-economic and governance perspectives across European regions. All these institutions are consortium partners of the SUPERB (Systemic solutions for upscaling of urgent ecosystem restoration for forest-related biodiversity and ecosystem services; SUPERB Project (2025)) project, under which the questionnaire was conducted.

The final questionnaire comprised 112 questions, organised into key thematic blocks (Fig. 1): general project characteristics (e.g. geographic scope, objectives, duration, funding sources), ecological restoration approaches (e.g. techniques applied, target species), socio-economic and governance dimensions (e.g. stakeholder engagement, policy frameworks) and standardised success indicators to quantify the outcomes of projects. A total of 45 indicators were integrated, including 35 project-specific quantitative indicators and 10 broader evaluation criteria aligned with the Society for Ecological Restoration's Primer (SER 2004) to ensure methodological robustness (Fig. 2).

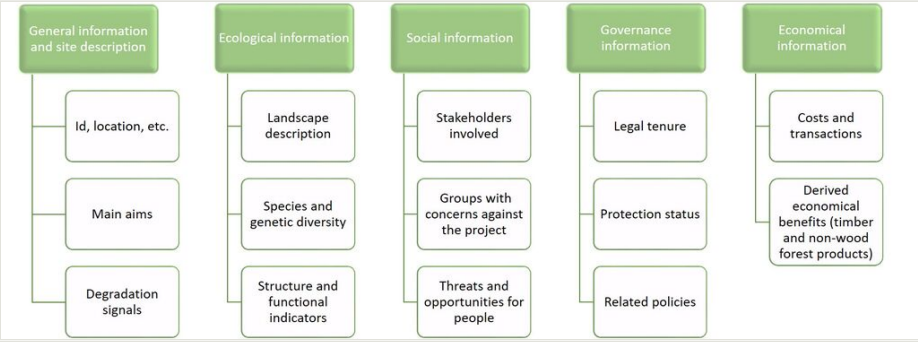

Figure 1.

Information requested in the survey for each restoration project.

Amongst the 35 project-specific quantitative indicators are, for example, the abundance or density of the target species and the total number of species (when the restoration

objective is to increase the population of species); the regeneration cover (when the aim is to promote tree or plant regeneration); and the number of connections or corridors between habitat patches, the average patch size and the number of patch types (when the objective is to enhance landscape connectivity). For the selection of the project-specific quantitative indicators included in the survey, we conducted a review of the existing literature. For each potential restoration objective, we identified the indicators most widely used in published studies and those that were the easiest to generalise and apply across a broad range of restoration contexts. For further details on the literature review, see Menéndez-Miguélez et al. (2024).

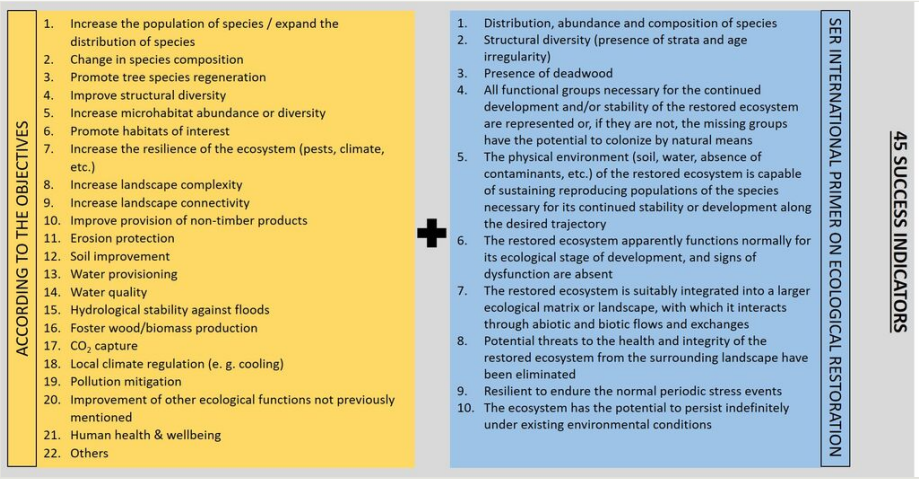

Figure 2.

Left: the twenty-two potential ecological restoration objectives included in the stakeholder survey, each of which has its own specific indicator(s) (35 in total). Right: the ten indicators defined in the Society for Ecological Restoration's Primer (SER 2004).

The indicators proposed in the Society for Ecological Restoration's Primer (SER 2004) are crucial for assessing restoration success, as they provide a standardised, widely recognised framework to evaluate ecological and functional outcomes. Unlike project-specific quantitative indicators, SER-aligned criteria enable comparability across projects and regions, ensuring assessments reflect ecological integrity and sustainability. To optimise respondent engagement and data quality, the questionnaire employed adaptive question logic, dynamically adjusting the sequence and depth of questions, based on respondent profile (practitioner, policy-maker, researcher), restoration project implementation stage (planned, ongoing, completed) and restoration type and objectives. This adaptive design resulted in a variable questionnaire length (ranging from 50 to 88 questions), while preserving its coherence (Fig. 3).

Questionnaire dissemination was conducted through a multilingual online platform (hosted on TickStat; TickStat (2025)), available in English, Spanish, German, Polish, Italian and French from April 2023 to December 2024. Respondents are encouraged to answer regarding the project or projects they consider most appropriate, based on their

knowledge of them and their relevance. Suppl. material 1 provides the complete questionnaire, displaying the questions presented to the respondents, as well as the internal survey constraints that determined the allowable response types and the specific set of questions shown, based on each respondent's profile and the restoration project's characteristics. To maximise geographic and institutional coverage, we implemented a multi-channel recruitment strategy, including: (I) targeted email campaigns (1500+ personalised invitations); (II) presentations at international and national congresses (in Spain, Sweden, Portugal and Estonia); and (III) on-site workshops (in Spain and Italy) where practitioners, landowners and other potential initiative leaders were also engaged and helped to fill in the questions. Periodic reminders were issued to enhance participation rates. Given the length of the questionnaire and with the aim of maximising both the number of respondents and the information collected, respondents were allowed to answer only the questions they deemed relevant and partially completed surveys were, therefore, also retained. All responses were systematically consolidated into a relational database to facilitate cross-comparative analysis and knowledge synthesis.

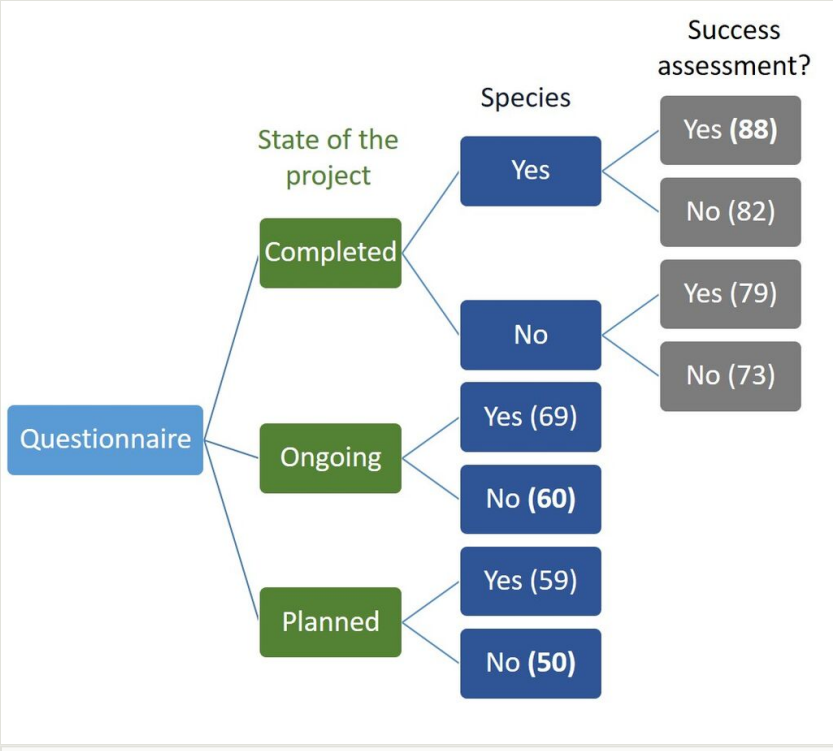

Figure 3.

Number of survey questions, based on restoration status, whether species have been introduced and whether restoration outcomes have been assessed. The indicated number of questions also varies depending on the number of introduced species (the values in this graph assume one introduced species), the restoration objective and the respondent's profile (this graph assumes the respondent is the restoration manager).

Dataset description

The database (Suppl. material 2) is presented in ODB format (OpenDocument Database) and can be opened using free, open-source software, such as LibreOffice Base (The Document Foundation 2025) or Apache OpenOffice Base (Apache Software Foundation 2025). It contains responses from 404 surveys, though the information is smaller for many of the questions due to the adaptive logic of the questionnaire and the fact that some respondents did not complete the survey. This results in the database having 404 entries for general participant information, 227 for general data on implemented restoration actions and 209 for restoration objectives. Each respondent (each entry) provided information about one or more restorations carried out in one or more countries. The number of restorations per country is shown in Fig. 4.

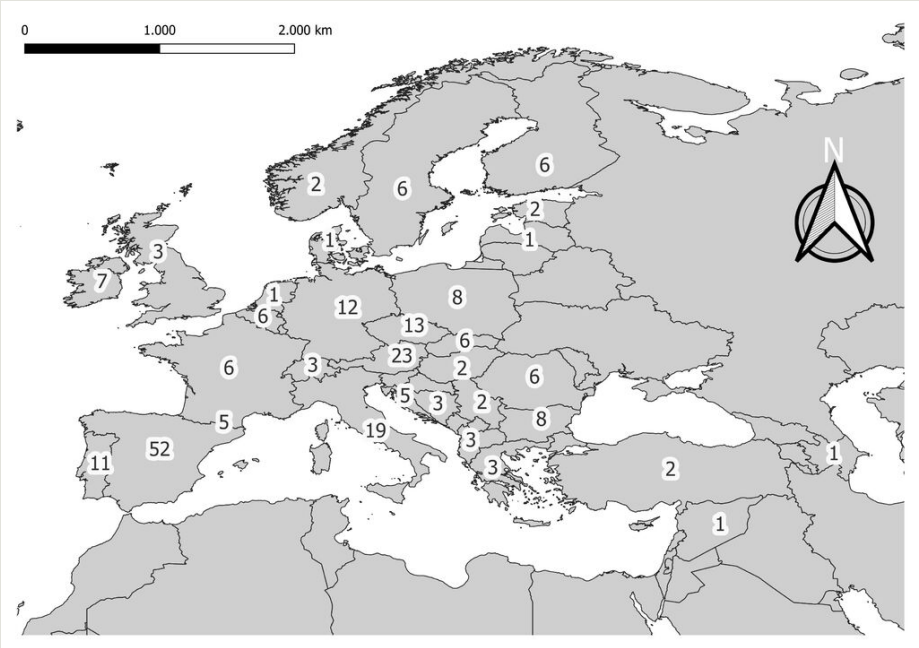

Figure 4.

Number of restorations per country. Note that not all respondents indicated the country where the restoration was carried out.

The database is organised thematically according to the online questionnaire's structure, featuring 57 interconnected tables. These tables can be cross-referenced using the unique ID_User assigned to each respondent. Variations in ID_User counts across tables occur because not all respondents completed the survey and the questionnaire's adaptive logic guided users through different paths, based on their answers.

A systematic codification system classifies tables into three types. (I) The AT00-DATABASE_EXPLANATION table serves as the primary reference point, containing

comprehensive descriptions of all tables (see Table 1). Following this, (II) descriptor tables (D-T) provide code explanations corresponding to their respective data tables. The database then presents (III) the actual survey data tables (T), some of which may remain empty for specific sections (e.g. the pollution mitigation objective table contains no entries as no respondents selected this option). In these data tables, the description of each field or column (accessible by opening the table in edit mode in LibreOffice Base) includes the corresponding survey question linked to the responses stored in that field.

Table 1.

Database tables and the information they contain (also presented in Table AT00-DATABASE_EXPLANATION in the database file).

Table name	Explanation
D-T01-Certification_type	Descriptor for table T01 with the explanation of the codes corresponding to the answers for the question "Type of certification in the restoration area".
D-T01-Experience	Descriptor for table T01 with the explanation of the codes for the level of experience of the person who answer the questionnaire.
D-T01-Relation	Descriptor for table T01 with the explanation of the codes for the relation of the person answering the questionnaire with the restoration activity.
D-T02-Activities	Descriptor for table T02 with the explanation of the codes corresponding to the answers for the question "Indicate the activities and measures applied in this restoration".
D-T02-Causes & Signs	Descriptor for table T02 with the explanation of the codes corresponding to the answers for the question "Given that restorations generally seek to recover a degraded or lost ecosystem, what was the main cause or sign of degradation?"
D-T02-Country	Descriptor for table T02 with the explanation of the codes for the different countries.
D-T02-Pre/ post-rest-landuse	Descriptor for table T02 with the explanation of the codes corresponding to the answers for the question "If there is a change in land uses following restoration, please specify the post-restoration land use type(s) affected".
D-T02-Success_obst	Descriptor for table T02 with the explanation of the codes corresponding to the answers for the question "What were the main obstacles to the success of the restoration?"
D-T03-1-Objectives	Descriptor for table T03-1 with the explanation of the codes for all the possible objectives of the restoration action.
D-T03-2-Select_reason	Descriptor for table T03-2 with the explanation of the codes for the possible reasons of selecting one species or other in the restoration action.
D-T03-2-Silvic_techni	Descriptor for table T03-2 with the explanation of the codes corresponding to the answers for the question "Which were the silvicultural techniques and protection measures used for its establishment?"

D-T03-2-SP_origin	Descriptor for table T03-2 with the explanation of the codes corresponding to the answers for the question "Was the provenance area of the species introduced taken into account?"
D-T04-Goverance_chall	Descriptor for table T04 with the explanation of the codes for any potential governance challenges present in the restoration project.
D-T04-Stakeholder_country	Descriptor for table T04 with the explanation of the codes for the possible answers related to the stakeholder involvement in each country.
D-T04-Stakeholder_degree	Descriptor for table T04 with the explanation of the codes for the possible answers related to the degree involvement of the stakeholders.
D-T04-Stakeholder_diffic	Descriptor for table T04 with the explanation of the codes for the possible answers related to the difficulties in the involvement of stakeholders.
D-T04-Stakeholder_group	Descriptor for table T04 with the explanation of the codes corresponding to the answers for the question "What stakeholder groups were most involved in the restoration project?"
D-T04-Stakeholder_phase	Descriptor for table T04 with the explanation of the codes corresponding to the answers for the question "In which phase of the project was it most difficult to involve stakeholders?"
D-T04-Stakeholder_topic	Descriptor for table T04 with the explanation of the codes corresponding to the answers for the question "What were the main conflicting interests related to?"
D-T05-Benefit	Descriptor for table T05 with the explanation of the codes for the possible answers related to the benefit of the restoration action with different objectives.
D-T05-Compat_Obj	Descriptor for table T05 with the explanation of the codes for the possible answers related to the compatibility of different objectives with the restoration action.
D-T07-Legal	Descriptor for table T07 with the explanation of the codes corresponding to the answers for the question "What is the legal tenure of the land?"
D-T07-Status	Descriptor for table T07 with the explanation of the codes for the possible answers related to the legal status of the restoration area.
D-T08-Moment	Descriptor for tables T08 (applies to all T08 tables across all objectives) with the explanation of the codes for the possible answers related to when the reference value was achieved in the restoration action.
D-T08-Non-timber_prod	Descriptor for table T08 (Obj_10_Non-timber_prod) with the explanation of the codes corresponding to the answers for the question "What kind of non-timber products are obtained in the restored area?"
D-T08-Refarea	Descriptor for tables T08 (applies to all T08 tables across all objectives) with the explanation of the codes for the possible answers related to the size of the reference area.

D-T08-Timber_prod	Descriptor for table T08 (Obj_16_Wood_biomass_prod) with the explanation of the codes corresponding to the answers for the question "What kind of timber products are obtained in the restored area?"
T01-General_data	Table with respondent profile data as well as general data on the restoration project.
T02-General_data_restoration	Table with the general data of the restoration project.
T03-1-Restoration_objectives_area	Table with the objectives of the restoration action and the corresponding areas for each of the three main objectives.
T03-2-Restoration_activities	Table with the restoration activities implemented in the restoration action.
T04-Actors_Governance	Table with all the questions related to the actors involved in the restoration action and aspects related to governance.
T05-Compatibility_Ecological	Table with all the questions related to compatibility of ecological aspects in the restoration action.
T06-Economic	Table with all the questions related to economic aspects in the restoration action.
T07-Legal	Table with all the questions related to legal aspects of the restoration action.
T08-Success_indicators_Obj_01	Table with all the information related to success/failure indicators if the restoration objective was 01: Increase the population of species / expand the distribution of species.
T08-Success_indicators_Obj_02	Table with all the information related to success/failure indicators if the restoration objective was 02: Change in species composition.
T08-Success_indicators_Obj_03	Table with all the information related to success/failure indicators if the restoration objective was 03: To promote tree/plant regeneration.
T08-Success_indicators_Obj_04	Table with all the information related to success/failure indicators if the restoration objective was 04: Improve structural diversity.
T08-Success_indicators_Obj_05	Table with all the information related to success/failure indicators if the restoration objective was 05: Increase microhabitat abundance or diversity.
T08-Success_indicators_Obj_06	Table with all the information related to success/failure indicators if the restoration objective was 06: Promote habitats of interest.
T08-Success_indicators_Obj_07	Table with all the information related to success/failure indicators if the restoration objective was 07: Increase the resilience of the ecosystem.
T08-Success_indicators_Obj_08	Table with all the information related to success/failure indicators if the restoration objective was 08: Increase landscape complexity.
T08-Success_indicators_Obj_09	Table with all the information related to success/failure indicators if the restoration objective was 09: Increase landscape connectivity.
T08-Success_indicators_Obj_10	Table with all the information related to success/failure indicators if the restoration objective was 10: Improve provision of non-timber products.

T08-Success_indicators_Obj_11	Table with all the information related to success/failure indicators if the restoration objective was 11: Erosion protection.
T08-Success_indicators_Obj_12	Table with all the information related to success/failure indicators if the restoration objective was 12: Soil improvement.
T08-Success_indicators_Obj_13	Table with all the information related to success/failure indicators if the restoration objective was 13: Water provisioning.
T08-Success_indicators_Obj_14	Table with all the information related to success/failure indicators if the restoration objective was 14: Water quality.
T08-Success_indicators_Obj_15	Table with all the information related to success/failure indicators if the restoration objective was 15: Hydrological stability against floods.
T08-Success_indicators_Obj_16	Table with all the information related to success/failure indicators if the restoration objective was 16: Foster wood/biomass production.
T08-Success_indicators_Obj_17	Table with all the information related to success/failure indicators if the restoration objective was 17: CO2 capture.
T08-Success_indicators_Obj_18	Table with all the information related to success/failure indicators if the restoration objective was 18: Local climate regulation.
T08-Success_indicators_Obj_19	Table with all the information related to success/failure indicators if the restoration objective was 19: Pollution mitigation.
T08-Success_indicators_Obj_20	Table with all the information related to success/failure indicators if the restoration objective was 20: Improvement of other ecological functions not previously mentioned.
T08-Success_indicators_Obj_21	Table with all the information related to success/failure indicators if the restoration objective was 21: Human health & well-being.

To facilitate the use and interpretation of the database, Suppl. material 3 provides, for each table of the database, all associated fields together with the questionnaire item from which each field is derived. In addition, for coded variables, it identifies the corresponding descriptor table containing the code definitions. This file is provided in ODS format (OpenDocument Spreadsheet) and can be opened using free and open-source software, such as LibreOffice Base or Apache OpenOffice Base, as well as commercial programmes such as Microsoft Excel.

Re-use potential

The collected data provides critical insights into multiple dimensions of restoration efforts, including their ecological effectiveness, socioeconomic impacts, relevant policy frameworks and implementation challenges. This dataset offers researchers and practitioners a robust tool for analysing restoration practices across multiple dimensions throughout Europe. Analysis of these data has the potential to generate evidence-based knowledge to guide more effective ecological management and restoration strategies

throughout Europe. For a systematic analysis of the database, we refer to the paper by Menéndez-Miguélez et al. (2025). Note that this paper employs a slightly smaller number of responses, as some participants submitted their answers after it was closed.

Amongst the results reported in Menéndez-Miguélez et al. (2025), one of the most notable finding concerns the types of restoration projects being implemented. The most frequent initiatives were those aimed at increasing species populations or expanding their distribution ranges, whereas restorations targeting other objectives, considered priorities in several policy frameworks, such as landscape connectivity and contributions to human well-being (both explicitly promoted in the EU Biodiversity Strategy for 2030; European Commission (2020)) or the provision of non-timber forest products (highlighted in the EU Forest Strategy; European Commission (2021)), were scarcely represented. This imbalance highlights potential gaps in current restoration practice and may help guide ecological restoration policy towards strengthening under-represented objectives. Another key result relates to the suitability of the different indicators proposed in the survey for the specific restoration projects evaluated by respondents. These findings offer a preliminary basis for developing a set of standardised and broadly applicable indicators that could be employed across future restoration efforts, thereby improving the assessment, comparability and synthesis of restoration outcomes.

However, the dataset presented here enables a much broader range of analyses that have not yet been conducted. For instance, future studies could examine differences in responses and perceptions across stakeholder groups or geographical regions; investigate the determinants of restoration success or failure; or assess how responses vary according to the restoration objectives pursued (for instance, whether stakeholder participation or perceptions of restoration success differ amongst objectives). These examples illustrate only a subset of the research opportunities provided by this dataset.

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Author contributions

Álvaro Rubio-Cuadrado: Conceptualisation, Methodology, Writing - Original draft, Writing - Review and Editing

María Menéndez-Miguélez: Investigation, Data Curation, Writing - Review and Editing

Isabel Cañellas: Conceptualisation, Project administration, Funding Acquisition, Writing - Review and Editing

Sergio de-Miguel: Validation, Writing - Review and Editing

Maitane Erdozain: Validation, Writing - Review and Editing

Johanna Hoffmann: Investigation, Validation

Katharina Lapin: Investigation, Validation

Leland K. Werden: Writing - Review and Editing

Iciar Alberdi: Conceptualisation, Methodology, Project administration, Funding Acquisition, Writing - Review and Editing

Álvaro Rubio-Cuadrado and María Menéndez-Miguélez contributed equally to this work.

Conflicts of interest

The authors have declared that no competing interests exist.

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Supplementary materials

Suppl. material 1: Questionnaire doi

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Both authors contributed equally
Data type: Questionnaire
Download file (1.40 MB)

Suppl. material 2: Restoration practices database doi

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Data type: Survey responses
Brief description: Database containing all the answers from the survey respondents.
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Suppl. material 3: Descriptive file of the database doi

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Data type: Descriptive file of the database.
Brief description: This document includes, for each table, all corresponding fields together with the questionnaire item from which each field originates. For coded variables, the file also specifies the descriptor table that contains the associated code definitions.
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