

Guide to Biodiversity Indicators for Quarrying and Mining Sites

2024 Data Report

Beatriz Gordo Infante
César Luaces Frades
Íñigo de Amescua Fernández de Casadevante
Samuel Bouchoms
Grégory Mahy
Víctor Pérez Domínguez
Elena Herrero Esteban
Miquel París Coderch
Petra Gradischnig



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Authors



Beatriz Gordo Infante
César Luaces Frades
Íñigo de Amescua Fernández de Casadevante



Víctor Pérez Domínguez
Elena Herrero Esteban



Samuel Bouchoms
Grégory Mahy



Petra Gradischnig
Miquel París Coderch



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Mythagos Estudio, S.L.



Executive summary

The conservation and enhancement of biodiversity have become key priorities for the [European Commission](#) and European environmental policy, reinforcing the growing importance of integrating biodiversity considerations into responsible quarrying and mining, from site management and restoration to long-term environmental stewardship.

The European extractive industry, particularly the aggregates sector, has been promoting biodiversity initiatives at extraction sites across Europe for decades. It is widely recognised as a pioneering industrial sector and a leader in species conservation and protection, with hundreds of examples of good practices and numerous agreements and partnerships with national and international nature conservation organisations.

In this context, the European [ROTATE Project](#) (Circular, Ecological Essential & Critical Raw Materials), funded by the European Commission and coordinated by [ANEFA](#), in collaboration with [Aggregates Europe \(AE\)](#) and the [Spanish Aggregates Federation \(FdA\)](#), has developed a harmonised biodiversity indicator system specifically adapted to quarrying and mining sites. The methodology was jointly developed by the [University of Liège](#), [ANEFA](#) and [Fundación Tormes-EB](#), bringing together scientific, technical and practical expertise to create a robust and applicable framework for biodiversity assessment and management. The active participation of Aggregates Europe and the Spanish Aggregates Federation ensured its relevance and applicability across the European extractive sector.

For this first reporting cycle, biodiversity data for 2024 were collected through surveys conducted during 2025–2026. The Level 1 survey covered 191 mining and quarrying sites in 12 European countries, while the more detailed Level 2 & 3 survey involved 121 sites across 14 countries. Together, these data provide the first harmonised baseline generated through the ROTATE framework and demonstrate that a common methodology can be successfully applied across different countries, geological settings and operational conditions.

The results highlight the significant biodiversity value of participating extractive sites. 66% report protected species, 39% host species included on the European IUCN Red List, and around three quarters are located within 5 km of a Natura 2000 site. In addition, 64% of participating sites report active biodiversity management measures, reflecting the sector's growing commitment to integrating biodiversity into site management. Together, these findings demonstrate that quarries and mining sites can provide important habitats and ecological resources and, when appropriately managed, can make a meaningful contribution to biodiversity conservation and ecological connectivity.

The results also provide a strong basis for taking biodiversity management to the next level. The wealth of habitat information, species records and management experience already available across participating sites creates an important opportunity to further integrate biodiversity monitoring into operational decision-making,

strengthen the measurement of biodiversity outcomes and increase the visibility of the sector's contribution to European biodiversity objectives.

Overall, this first assessment sends a strong and positive message about the role of the European extractive industry in biodiversity. Quarries and mining sites can provide valuable spaces for nature, offering diverse and dynamic habitats capable of supporting protected and threatened species and contributing to ecological restoration and landscape connectivity. The results also

demonstrate the value of collective participation in building a strong and representative evidence base for the sector for the years to come. Continued and broader participation of companies and sites in future survey campaigns will further strengthen this evidence base, demonstrate progress over time, showcase the industry's contribution to biodiversity and reinforce its position as an active partner in achieving European biodiversity objectives. Every participating site adds value to this collective effort and helps make the sector's contribution to nature more visible, measurable and recognised.

2

Introduction

The conservation and enhancement of biodiversity have become key priorities for the European Commission, and this shift has steadily trickled down to the quarrying and mining sector. It reflects a growing recognition that biodiversity considerations must be woven into site management, restoration planning and long-term environmental stewardship.

To support this objective, the European [ROTATE Project](#) (Circular, Ecological Essential & Critical Raw Materials), funded by the European Commission and coordinated by [ANEFA](#), in collaboration with [Aggregates Europe \(AE\)](#) and the [Spanish Aggregates Federation \(FdA\)](#), developed a biodiversity indicator system specifically adapted to quarrying and mining sites. The methodology was jointly developed by the [University of Liège](#), [ANEFA](#) and [Fundación Tormes-EB](#), bringing together scientific, technical and practical expertise to create a robust and applicable framework for biodiversity assessment and management. The active participation of Aggregates Europe and the Spanish Aggregates Federation ensured its relevance and applicability across the European extractive sector. This combination allows the framework to bridge the gap between scientific ambition and practical, site-level application.

The resulting framework proposes a progressive approach, moving through increasing levels of complexity while keeping each level's questions simple enough to be completed directly by quarry personnel.

This guide presents the outcome of putting that framework into practice: the biodiversity data

collected from participating companies through the Level 1 and Level 2 & 3 surveys conducted during 2025 and 2026. Beyond presenting and analysing these results, it also lays the groundwork for a common methodology that other sites and companies can use to assess and track their own biodiversity performance going forward.

During this first reporting cycle, the Level 1 survey gathered 191 responses from 12 European countries, while the Level 2 & 3 survey collected detailed biodiversity information from 121 sites across 14 European countries. These results provide the first harmonised overview of biodiversity management practices within the European quarrying and mining sector and establish a robust baseline for future annual assessments.



Grey gravel mound with wild vegetation growing around it. [1]

As a European initiative, this guide is intended to become an annual reference publication. Future editions will progressively expand participation to additional countries and sites, strengthening the representativeness of the dataset, improving

the comparability of results and supporting the continuous improvement of biodiversity management across the European quarrying and mining sector.

3

European legal context EU framework: relevant policies and good practices

3.1 European legal framework

The European Union has established a comprehensive environmental legislative framework that provides the legal basis for environmental protection, the sustainable management of natural resources and the restoration of ecosystems across Member States. This framework encompasses a broad range of environmental topics, including environmental assessment, environmental liability, public participation, biodiversity conservation, landscape protection, soil monitoring, water management and climate neutrality. The main European environmental legislation is summarised in [Table 1](#).

The European environmental legal framework encompasses a broad range of environmental topics, including environmental assessment, environmental liability, public participation and access to environmental information. Together, these instruments ensure that environmental considerations are incorporated throughout the life cycle of extractive activities, from project planning and permitting to site restoration and post-closure management.

The [EU Biodiversity Strategy for 2030](#) establishes ambitious objectives to protect and restore nature, reinforcing the implementation of the [Habitats Directive](#) (92/43/EEC) and the [Birds Directive](#) (2009/147/EC), which constitute the

legal basis for the conservation of Europe's most valuable habitats and species through the [Natura 2000 network](#).

The legal framework also includes legislation covering landscape protection, soil monitoring and resilience, water management and climate neutrality. Together, these instruments promote the sustainable use of natural resources, improve ecosystem resilience and contribute to achieving the environmental and climate objectives established by the European Union.

Although these legislative instruments establish common objectives at European level, their implementation is carried out through national legislation and competent authorities in each Member State. Consequently, quarrying and mining operators must ensure that environmental management and restoration activities comply with both European legislation and the specific regulatory requirements applicable at national and regional levels.

Table 1.
List of relevant European environmental legislation.

TOPIC	SUBTOPIC	EUROPE
Environmental	General	Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment Directive 2004/35/EC on environmental liability with regards to the prevention and remedying of environmental damage Directive 2003/35/EC providing for public participation in respect of the drawing up of certain plans and programs relating to the environment Directive 2003/4/EC on public access to environmental information
	Rehabilitation / Restoration	Regulation (EU) 2024/1991 of the European Parliament and of the Council of 24 June 2024 on nature restoration and amending Regulation (EU) 2022/869 (Text with EEA relevance)
	Biodiversity	Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds (Codified version)
	Landscaping	Council of Europe Landscape Convention
	Soil	Directive (EU) 2025/2360 of the European Parliament and of the Council of 12 November 2025 on soil monitoring and resilience
	Water	Directive (EU) 2026/805 of the European Parliament and of the Council of 30 March 2026 amending Directive 2000/60/EC establishing a framework for Community action in the field of water policy, Directive 2006/118/EC on the protection of groundwater against pollution and deterioration and Directive 2008/105/EC on environmental quality standards in the field of water policy Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008 on environmental quality standards in the field of water policy, amending and subsequently repealing Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, Regulation (EU) 2020/741 of the European Parliament and of the Council of the 25 May 2020 on minimum requirements for water reuse Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks
	Climate neutrality	Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 (European Climate Law)

3.2 European relevant policies

In addition to the legislative framework, the European Union has developed a broad range of environmental policies, strategies and guidance documents that support the implementation of

its environmental objectives. These initiatives promote the integration of environmental considerations into economic activities and encourage a more sustainable approach to the management of natural resources, ecosystem restoration and climate action. The principal European environ-

mental policies and guidance relevant to this guide are summarised in [Table 2](#).

European environmental policies address a wide range of topics, including biodiversity conservation, ecosystem restoration, sustainable landscape management, soil protection, water resources and climate neutrality. Together, they provide strategic direction for implementing European legislation while encouraging best environmental practices, innovation and continuous improvement across different economic sectors.

Within this policy framework, particular importance is given to the EU Biodiversity Strategy for 2030, which establishes a long-term vision for protecting and restoring Europe’s biodiversity while integrating nature conservation into

sectoral policies. Other key initiatives, including the [European Green Deal](#), the [8th Environment Action Programme](#) and the [Fit for 55 package](#), complement these objectives by promoting a resource-efficient, climate-neutral and environmentally sustainable economy.

For the quarrying and mining sector, these policies provide a strategic framework that encourages the integration of biodiversity conservation, ecological restoration and sustainable resource management into site planning, operation and post-closure management. Although they do not generally establish direct legal obligations, they play a fundamental role in guiding environmental decision-making, supporting the implementation of European legislation and promoting harmonised approaches across Member States.

Table 2.
Relevant European environmental policies and guidance.

TOPIC	SUBTOPIC	EUROPE
Environmental	General	8th Environment Action Programme: Decision (EU) 2022/591 of the European parliament and of the council of 6 April 2022 on a general union environment action Programme to 2030
	Rehabilitation / Restoration	Pioneering proposals to restore Europe’s nature by 2050 and halve pesticide use by 2030
	Biodiversity	Non-energy mineral extraction and Natura 2000 Communication from the commission to the European parliament, the council, the European economic and social committee and the committee of the regions EU biodiversity Strategy for 2030 Bringing nature back into our lives
	Landscaping	Policy recommendations for sustainable landscape management strategies
	Soil	Communication from the commission to the European parliament, the council, the European economic and social committee and the committee of the regions EU soil strategy for 2030 reaping the benefits of healthy soils for people, food, nature and climate
	Water	Groundwater - Ensuring groundwater quantity and quality across the EU Surface water - Supporting surface water ecosystems and protecting EU surface waters from chemical pollution Water reuse - Managing water resources more efficiently and facilitating water reuse in the EU Water scarcity and droughts - Preventing and mitigating water scarcity and droughts in the EU Floods - EU measures to manage the risks floods pose to human health, the environment, the economy and cultural heritage
	Climate neutrality	European Green Deal Communication: ‘Fit for 55’ - delivering the EU’s 2030 climate target on the way to climate neutrality

3.3 European good practices for Quarrying and Mining Sites

The implementation of European environmental legislation and policy has been accompanied by the development of numerous technical guidance documents, best practice publications and collaborative initiatives aimed at supporting the practical integration of biodiversity conservation and ecological restoration into quarrying and mining activities. Produced through cooperation between European institutions, research organisations, industry associations and environmental NGOs, these publications translate European environmental objectives into practical methodologies that help operators implement environmental management measures throughout the life cycle of extractive sites.

One of the earliest and most influential technical references is the European Commission *Guidance on Non-Energy Mineral Extraction and Natura 2000*, which demonstrates how extractive activities can be planned, operated and restored in accordance with the requirements of the Habitats and Birds Directives. Beyond explaining the legislative framework, the guidance presents practical examples illustrating how well-managed extractive sites can contribute to habitat creation, species conservation and the long-term enhancement of ecological value.

The growing recognition of the ecological potential of extractive sites has also encouraged greater collaboration between industry and conservation organisations. An important milestone was the publication of the *Extractive Sector Species Protection Code of Conduct*, jointly developed by BirdLife Europe & Central Asia, Cement Europe (formerly CEMBUREAU), Eurogypsum, Aggregates Europe and Heidelberg Materials. The Code promotes the concept of temporary habitats created by extractive activities and pro-

vides practical recommendations for integrating species protection into operational management while maintaining productive activities. It demonstrates that biodiversity conservation and mineral extraction can be mutually supportive when appropriate management measures are implemented.

European sector organisations have further expanded this knowledge through the publication of technical guidance and restoration initiatives. For example, *Biodiversity Stewardship in Gypsum Quarrying*, published by Eurogypsum, compiles restoration experiences from gypsum quarries across Europe, showcasing successful examples of habitat creation, ecological monitoring and stakeholder engagement. Likewise, *Cement Europe Biodiversity Roadmap* promotes the integration of biodiversity into quarry planning, operation, progressive restoration and post-closure management, encouraging collaboration with scientific institutions and conservation organisations.

Another landmark European initiative is the *Life in Quarries* project, coordinated by FEDIEX under the European Union's LIFE Programme. The project demonstrated how active and restored quarry sites can provide valuable habitats for numerous protected and threatened species through the implementation of practical biodiversity management measures. By developing habitat creation techniques, species-specific conservation actions and long-term monitoring protocols, Life in Quarries has become an important reference for integrating biodiversity conservation into quarry management. The project also produced a wide range of technical guidance documents, practical tools and demonstration experiences that continue to support biodiversity management across the European extractive sector.

The Spanish Aggregates Federation (FdA) has also made a significant contribution to environmental knowledge through a series of technical publications and awareness initiatives promoted by ANEFA and the Spanish Aggregates Federation (FdA). One of the principal references is the *Guide to Biodiversity Management in Aggregate Quarries* (spanish version only), which provides practical guidance for integrating biodiversity conservation throughout the life cycle of extractive operations, from planning and operation to restoration and long-term site management.

On the occasion of the annual Trees, Aggregates and Biodiversity Day, the Spanish Aggregates Federation (FdA), in collaboration with Fundación Tormes-EB, has developed a series of educational videos that facilitate the implementation of practical initiatives aimed at enhancing biodiversity and promoting social well-being. These videos are available on the [Spanish Aggregates Federation's YouTube channel](#) and cover topics such as the construction of *insect hotels*,

seed bombs, *nest boxes*, *Sand Martin* (*Riparia riparia*), *rock piles*, *biodiversity ponds*, *bird footprints*, *bird feeders* and the enhancement of biodiversity through the use of *native aromatic plants*.



Insect hotel designed to encourage the presence of pollinators and other beneficial invertebrates. [2]

Reproduction of an animal track based on a footprint identified in the field. [3]



Additional technical resources developed by [Fundación Tormes-EB](#) are available to support the planning and implementation of biodiversity conservation and ecological restoration measures in quarrying and mining sites. These complementary tools provide practical methodologies to facilitate restoration planning and habitat management. The [LIDAR-REFAUNA Tool](#) supports the design of ecologically functional revegetation through structural habitat analysis using LIDAR technology and bioindicator wildlife data, while the [COREOBIOM Tool](#) provides an operational protocol for identifying and prioritising suitable areas for the conservation and translocation of terrestrial orchids within quarrying and mining sites. Both resources are available for download and can support practitioners in applying biodiversity-based restoration approaches in extractive sites.

The Aggregates Europe Sustainable Development Awards provide one of the most comprehensive overviews of good practices implemented by the European quarrying and mining sector. The initiatives presented demonstrate how extractive operations can successfully integrate environmental protection, biodiversity conservation, climate action, circular economy principles and social responsibility into their day-to-day activities. Beyond recognising outstanding individual projects, the Awards promote the exchange of practical experience and encourage the wider adoption of innovative solutions that contribute to more sustainable and responsible quarry and mining site management across Europe. Further examples of these initiatives are available in the [Aggregates Europe Sustainable Development Awards 2025 brochure](#).

Building upon these national and European initiatives, the ROTATE project, funded by the European Commission under the Horizon Europe programme and coordinated by ANEFA,

has considerably expanded the technical resources available to the European extractive sector. Beyond developing the biodiversity indicator methodology presented in this guide, the project has produced an extensive collection of technical publications addressing the principal environmental aspects of quarrying and mining operations, including the [Preliminary Assessment of Biodiversity Indicators in Aggregate Extraction Sites, Water Management – Good Practices in Aggregate Quarries](#), together with a wide range of environmental communication materials.

As part of its knowledge transfer activities, the ROTATE project translated the [FEDIEX](#) publication [Quarries and Pollinators](#) into [English](#) and [Spanish](#), supporting the wider dissemination of practical guidance on pollinator conservation across Europe.



Butterfly on an aggregate substrate at a quarry site. [4]

A cornerstone of the ROTATE legacy is the publication of the *ROTATE Environmental Handbook Series* (English and Spanish versions), comprising seven specialised technical handbooks covering *Energy Efficiency, Resource Efficiency and Water Management, Life Cycle Assessment, Air Emissions and Noise, Soil Quality Management, Solutions for Biodiversity Management, Rehabilitation and Visual Impact Reduction*, and *Human-Health and Ecosystem Risk Assessment*. Among these publications, particular relevance is given to the *Handbook on Biodiversity Management, Rehabilitation and Visual Impact Reduction*, which represents one of the most comprehensive technical references currently available for biodiversity management in quarrying and mining sites. The handbook provides practical methodologies for integrating biodiversity throughout the entire life cycle of extractive operations, covering habitat creation, species protection, ecological restoration, monitoring programmes and long-term environmental management, and establishes the technical basis upon which the biodiversity indicator methodology presented in this guide has subsequently been developed and expanded.

The methodology presented in this guide builds directly upon the experience and technical knowledge generated through these European



Progressive restoration of an aggregate extraction site, with land preparation to promote habita recovery. [5]

and national initiatives. While previous publications have provided practical recommendations for biodiversity management, ecological restoration and environmental good practices, the present guide advances this work by introducing a harmonised biodiversity indicator system specifically designed for quarrying and mining sites. Together, these publications contribute to a common European framework that supports biodiversity assessment, restoration monitoring and continuous environmental improvement while remaining sufficiently flexible to accommodate the diversity of ecological, operational and regulatory conditions across Europe.

Naturalised slope designed for the relocated nesting of a Sand Martin (*Riparia riparia*) colony. [6]



4

Defining objectives for biodiversity and habitats

Establishing clear and explicit goals is the first critical step in any ecological restoration or nature management strategy, as all subsequent decisions — indicator selection, data collection, monitoring design and evaluation — depend on what the restoration aims to achieve and how success will be assessed.

Goals can span a wide range of ambitions, from improving landscape structure and connectivity to restoring fully functional ecosystems, and may target specific attributes such as carbon capture, pollination support or the recovery of particular species or communities.



Aggregate stockpile integrated into the restoration process. [7]

They should be set within the broader ecological and operational context of the site. This means accounting for the habitats and species already present, the degree of degradation across each functional zone — active extraction, unexploited areas, post-operation zones and any restored areas — the trajectory of the site through its exploitation stages, and the connectivity to surrounding landscapes including any Natura 2000 designations in proximity.

Each functional zone plays a distinct ecological role and carries different restoration potential: unexploited areas act as biodiversity reservoirs and reference points, while post-operation zones are the primary focus for long-term habitat recovery. Goals should reflect this spatial and temporal heterogeneity rather than treating the site as a uniform entity and should evolve as the share of each zone changes over the exploitation cycle.

Stakeholder involvement in defining goals is both practically necessary and ecologically beneficial. Cultural ecosystem services — recreation, education, heritage, local identity — are as legitimate a component of restoration objectives as regulating or provisioning services, and goals that account for the full range of values associated with a site are more likely to be sustained over time.

Finally, goals need not always replicate a prior state. Where irreversible physical transformations have occurred, or where an alternative tra-

jectory would deliver greater ecological or social value, objectives may deliberately aim beyond the historical condition.

Key point is that goals are explicit, realistic within the site’s operational and landscape constraints, agreed upon by the parties involved, and expressed in a form that allows targets to be defined, indicators to be selected, and progress to be evaluated over the long term.

4.1 Biodiversity indicators

4.1.1 General concepts

Biodiversity indicators are measurable variables used to assess, monitor and communicate the state and evolution of biodiversity over time. They provide a consistent and objective basis for evaluating ecological conditions, identifying trends and supporting evidence-based decision-making. Because biodiversity is inherently complex and dynamic, no single indicator can fully describe it; instead, a complementary set of indicators is required to capture its different components.

Indicators should be scientifically robust, practical to implement, sensitive to environmental change and time and space-independent, producing consistent response regardless of the ecological setting. They should also be sufficiently simple to facilitate their application and interpretation by different stakeholders while providing meaningful information to support biodiversity management.

The selection of biodiversity indicators should be guided by clearly defined objectives and context: from an early portrait of the site’s biodiversity to the effectiveness of biological conservation/restoration measures.

An effective framework should consider multiple dimensions of biodiversity encompassing eco-

system structure and functions: species compositions and abundance as well as ecological processes (invasive species, population trends, etc).

Capturing biological variations across time and space requires repeated monitoring carefully planned, using standardized methods, allowing changes to be detected and comparison zones of sites and sites. The data will then be supporting the evaluation of biodiversity management actions throughout the life cycle of mining and quarrying operations.

Several biodiversity assessment frameworks have been developed for the extractive sector. In the present guide, we based our indicators on the framework proposed by Pitz and Mahy (2016) which resulted from a participatory approach with stakeholders [Table 3](#).

Table 3.
Example of biodiversity indicators categories in quarry, following by Pitz and Mahy (2016).

Status and trends of the components of biological diversity, in the quarry	Number of species in selected taxonomic group
	Abundance of selected species in the quarry
	Number of protected species in the quarry
	Number of red list species in the quarry
	Abundance of protected / red list species in the quarry
	Number of habitats in the quarry
	Size of the habitats in the quarry
	Number of protected habitats in the quarry
	Size of the protected habitats in the quarry
Impact outside / indirect impacts	Adjacent protected areas of high biodiversity value outside the quarry
	Impact due to noise on animal disturbance outside the quarry
	Impact due to lighting on animal outside the quarry
	Impact due to dust emissions on animal or habitats outside the quarry
Threat to biodiversity	impact due to quarry activities on water quality in freshwater and riparian environments outside the quarry
	Number of invasive alien species in the quarry
Ecosystem integrity and ecosystem goods and services	Fragmentation of natural and semi-natural areas
	Fragmentation of river systems
	Trophic integrity of ecosystems
	Freshwater quality
Sustainable use	Forest: growing stock, increment and felling
	Surface of habitats restored
Means implemented for biodiversity	Percentage of quarries that calculate biodiversity indicators
Public opinion	Percentage of quarries that implement communication and participation actions

4.1.2 Developing biodiversity indicators

The development of biodiversity indicators should follow a structured and objective approach, aligned with European biodiversity and climate policies and adapted to the specific characteristics of quarrying and mining sites. Indicators should be designed to support biodiversity management throughout the different phases of site operation and restoration, while remaining practical and feasible for implementation.



Reptiles show emerging communities in active extraction areas, with their presence increasing as the restoration process progresses. [8]

The process of developing a biodiversity indicator framework begins by defining the objectives of the assessment, identifying the information required and selecting indicators capable of measuring progress towards these objectives. **Figure 1** illustrates the main steps involved in developing a biodiversity indicator framework, from the initial definition of objectives to the selection and implementation of appropriate indicators.

Given the diversity of quarrying and mining sites and the different levels of ecological information

Figure 1.
Workflow toward defining biodiversity indicators.



available, biodiversity indicators can be organised according to increasing levels of complexity. Building on this approach, the ROTATE Project methodology defines three complementary levels of biodiversity indicators (**Figure 2**).

Level 1 provides a preliminary assessment based on simple questions that can be answered without specialised biodiversity expertise and focuses primarily on the spatial characteristics of biodiversity, including the presence, extent and conservation status of habitats.

Level 2 describes the ecological structure such as habitat type, spatial distribution and suitability to species, based on environmental infor-

mation and requires a basic level of technical knowledge.

Level 3 focuses on the functional aspects of biodiversity, including the occurrence of species and other ecological attributes that reflect biodiversity quality. It therefore requires a certain level of expertise to carry out habitat and species inventories, identify species and habitats, and interpret monitoring data, species counts and ecological trends.

The progressive relationship between these three complementary levels of complexity is illustrated in [Figure 2](#).

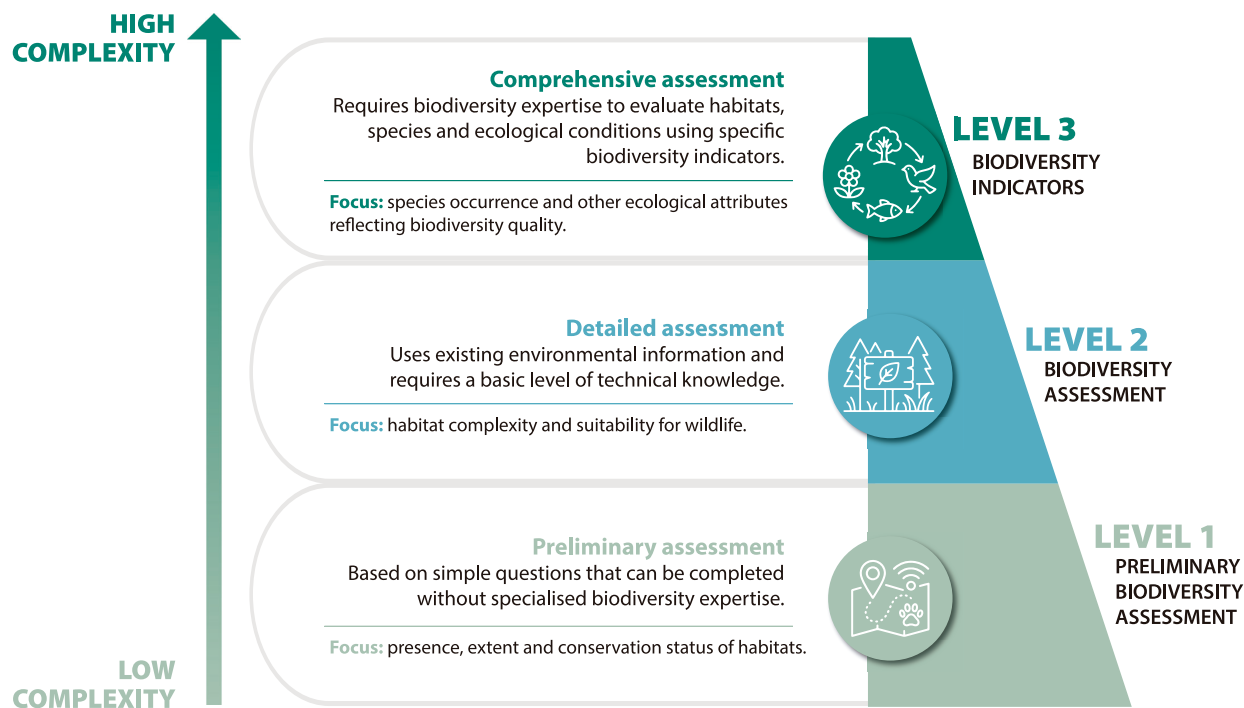
The successful implementation of biodiversity indicators also requires a harmonised methodology for data collection and reporting.

In this guide, we developed surveys, questionnaires and supporting documents to help operators identify available information, determine additional data requirements and apply the indicators consistently. This approach minimises unnecessary effort while ensuring that the information collected is relevant, comparable and scientifically robust.

Indicators should be measured regularly using consistent methods to capture biodiversity inherent evolution. Monitoring plans should be

Figure 2.
Levels of complexity.

FRAMEWORK OF BIODIVERSITY INDICATORS BY LEVEL OF COMPLEXITY



Biodiversity indicators are organised according to increasing levels of complexity, from basic information on spatial characteristics to the evaluation of functional aspects related to biodiversity quality.

adapted to the ecological characteristics of each site and updated throughout the different phases of quarry operation and restoration.

Although not all indicators need to be measured simultaneously, data should be collected pro-

gressively using standardised and repeatable procedures. This allows biodiversity trends to be assessed over time, supports adaptive management and provides a reliable basis for decision-making.



Water body created at an aggregate extraction site, with the development of wetland vegetation and associated aquatic habitats. [9]

5

Analysis of biodiversity indicators in European quarrying and mining sites: 2024 data

5.1 Introduction

Biodiversity conservation is now central to European environmental policy, driving demand for tools that can objectively assess how different productive sectors contribute to it. In aggregates extraction, several studies show that quarries, both while operating and after restoration, can support habitats and species of conservation interest, contributing to biodiversity and landscape-scale ecological connectivity.

However, the lack of harmonised methodologies at the European level makes it difficult to assess

and compare these environmental benefits, as well as to monitor the effectiveness of the management and restoration measures implemented.

To meet this need, the European [ROTATE](#) project developed a biodiversity indicator system specifically adapted to aggregates extraction sites.

The initiative aims to establish a common methodology for the standardised assessment of biodiversity management, facilitate the monitoring of actions undertaken by the sector, and promote the continuous improvement of its environmental performance.



Little Ringed Plover (Charadrius dubius) on an aggregate stockpile used as habitat within the extraction site. [10]

5.2 Methodology

5.2.1 Surveys

During the ROTATE project, 10 biodiversity KPIs [Table 4](#) were selected as relevant to evaluate quarry site diversity from the habitat and species perspectives. The important aspect was to create a series of simple questions which would allow for gathering and quantifying these indicators across a wide range of contexts.

Table 4.
Biodiversity indicators (adapted from Pitz and Mahy, 2016).

	Biodiversity Indicator
1.	Number of native species in selected taxonomic group in the quarry
2.	Abundance of selected species in the quarry
3.	Number of protected species in the quarry
4.	Number of Red List species in the quarry
5.	Abundance of protected / red list species in the quarry
6.	Number of habitats in the quarry
7.	Surface of selected habitats in the quarry
8.	Number of invasive alien species in the quarry
9.	Freshwater quality
10.	Surface of habitats restored after use for natural purposes

After several rounds of development, testing and stakeholder feedback, two complementary biodiversity surveys were developed within the ROTATE project. They were first implemented in the ROTATE pilot sites to validate their structure and applicability, before being distributed more widely through the networks of Aggregates Europe (AE), ANEFA and the Federación de Áridos (FdA).

The first survey is a pre-assessment acting as a data inventory and context definition. It requires no specialist biodiversity expertise and captures baseline information on site characteristics, biodiversity management practices, regulatory compliance, restoration planning and stakeholder engagement, while identifying strengths and gaps in the biodiversity information available at site or company level.

The second survey is a comprehensive biodiversity assessment structured around three components planning (habitat diversity and species diversity) combining qualitative characterisation of habitat types and taxonomic groups with quantitative data (countings and surfaces). A particular emphasis was put on protected species, [IUCN European Red List](#), invasive alien

Web-building spider in its web, illustrating the diversity of arthropods found in habitats associated with aggregate extraction sites. [11]



species and habitats of conservation interest. It therefore requires a higher level of technical expertise and access to existing biodiversity inventories and monitoring data (See Annex B for the survey questionnaires).

The questionnaires and their support documents were circulated by e-mail through the network of AE, ANEFA and FdA, with direct links also made available via the official ROTATE and ANEFA websites to facilitate access. Participants received continuous technical support throughout to help ensure the consistency and reliability of the data collected.

At European level, the combined data from both surveys provides a harmonised overview of biodiversity management in quarrying and mining sites, helping to identify strengths, knowledge gaps and opportunities for improvement, and supporting the development of common biodiversity indicators across the sector.

5.2.2 Support

Support for Survey 1 (Level 1)

To support stakeholders in completing Survey 1 (Level 1) and to ensure the consistency and quality of the responses, a comprehensive set of sup-

porting materials was developed. A Guidance Document, available in English, Spanish, French and German, was prepared to explain the purpose of each question, its relevance to biodiversity assessment and the recommended approach for completing the questionnaire. This guidance document is not publicly available and is distributed exclusively to survey participants together with the questionnaire.

Following the first data collection campaign, a Survey 1 Results Report was produced, summarising the main findings and providing the basis for the development of this Biodiversity Indicators for Quarrying and Mining sites: 2024 Data Report. In addition, a series of explanatory webinars, available in English, Spanish and French, were developed to present the objectives of the survey, explain the questionnaire and provide practical guidance for its completion. Unlike the guidance document, these webinars are publicly available and can be accessed online.

Support for Surveys 2 and 3 (Levels 2 and 3)

For Surveys 2 (Levels 2 and 3), additional support materials were developed to facilitate participation and ensure a harmonised interpretation of the questionnaires. A Guidance Document,



Water body at an aggregate extraction site with the presence of waterbirds. [12]

also available in English, Spanish, French and German, provides detailed explanations of each question together with practical recommendations for completing the surveys. As with Survey 1, this guidance document is distributed exclusively to survey participants together with the questionnaire and is not publicly available.

To further support respondents, explanatory webinars were produced in [English](#), [Spanish](#) and [French](#), presenting the methodology, explaining the questionnaires and providing practical examples for their completion. These webinars are publicly available and can be consulted online.

At the time of publication of this guide, the Results Report for Surveys 2 and 3 was still under development and had not yet been published. The report will provide a comprehensive analysis of the data collected through these surveys once it becomes available.

5.2.3 Certificate of participation

To recognise and encourage participation in the biodiversity assessment programme, companies that successfully complete both biodiversity surveys will receive a Certificate of Participation.

This certificate acknowledges their contribution to the collection of harmonised biodiversity data and their commitment to improving biodiversity knowledge and management within the mining and quarrying sector.

As the surveys are conducted on an annual basis, participating companies will have the opportunity to obtain a new certificate each year, reflecting their continued involvement in the initiative and enabling them to build a record of sustained participation over time.

Certificates of Participation will be provided in four languages—English, Spanish, French and German—to ensure their accessibility and use by all participating companies across Europe ([Figure 3](#)).

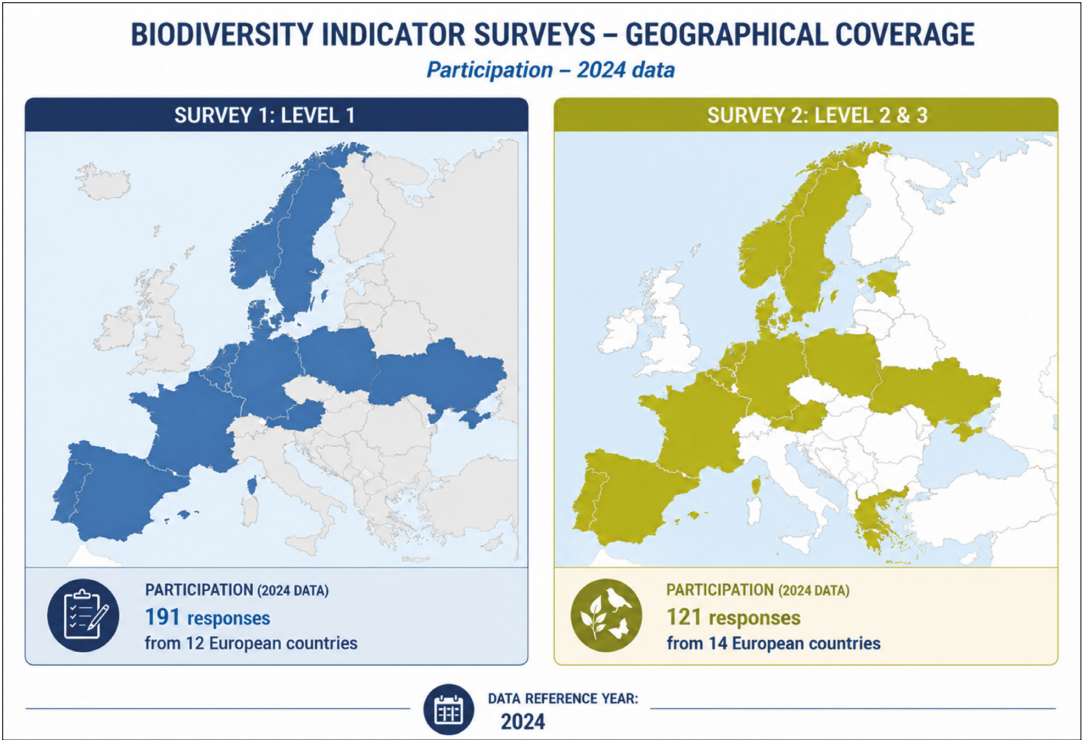
5.3 Results of surveys: Level 1 and Level 2&3

During the 2025–2026 season, the Level 1 survey gathered 191 answers from 12 countries while the Level 2 and 3 survey covered 121 quarry sites in 14 European countries [Figure 4](#).

Figure 3.
English certificate of Participation awarded to participating sites.



Figure 4.
Biodiversity indicators survey- Geographical coverage



The data encompass various biogeographical settings — spanning from the Mediterranean area to the Boreal zone, while the Atlantic and Continental regions are well represented — along with different quarry contexts, sizes and regulatory frameworks with nature management obligations that vary from country to country.

The two-survey structure, by combining a broader Level 1 reach with the deeper Level 2 and 3 coverage, partially compensates for this unevenness — and the consistency of several findings across both instruments, despite their different scopes and country compositions, strengthens confidence that the broad trends identified here reflect sector-wide patterns rather than artefacts of sampling geography



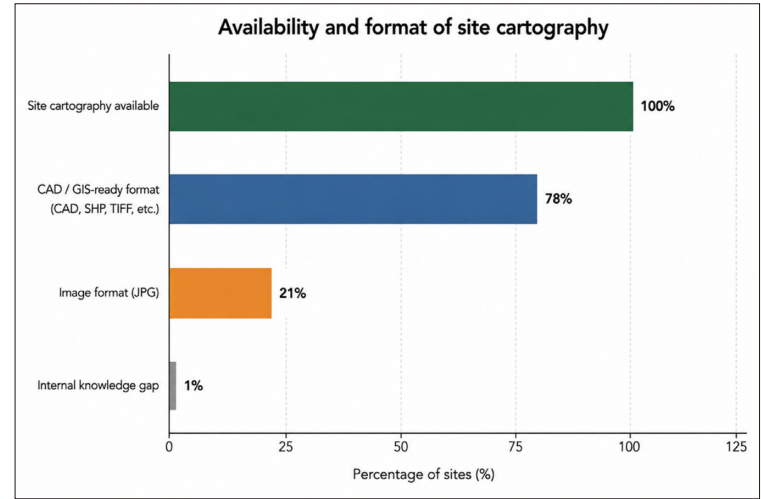
Wildlife at an aggregate extraction site, reflecting its role as a habitat and refuge area. [13]

5.3.1 Site environmental context

As shown on Figure 5 for the survey 1, all responding sites confirm detailed site cartography in digital or physical format, providing the spatial infrastructure on which habitat mapping, restoration planning and regulatory compliance depend. Furthermore, 78% of the sites maintain their cartography in GIS-compatible formats (e.g. CAD, SHP or TIFF), facilitating habitat mapping, restoration planning and spatial biodiversity monitoring. In addition, 21% of the sites also use image-based formats (JPG) to support environmental management. Only 1% of respondents reported an internal knowledge gap regarding the availability or management of cartographic information.

This 100% baseline is the sector’s strongest single indicator of institutional readiness for more structured biodiversity reporting.

Figure 5.
Availability and format of site cartography.



Almost three quarters of Level 1 sites are located inside or within 5 kilometres of at least one Natura 2000 designation — SCI, SAC, SPA or other protected area (Figure 6). The sector therefore operates mostly in close ecological proximity to

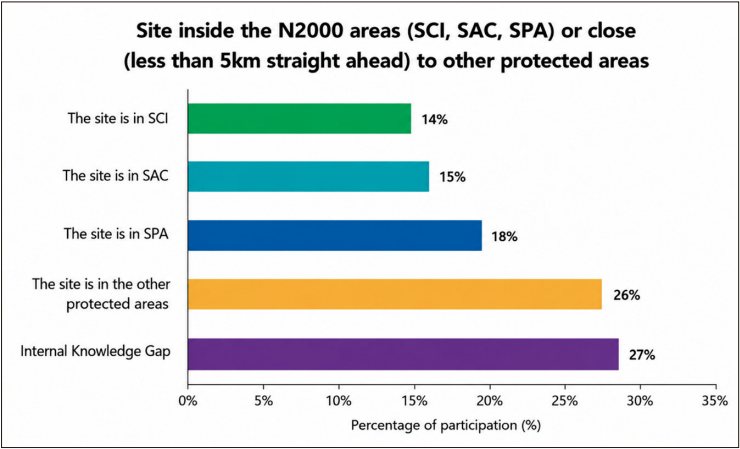
the EU’s conservation network without being formally embedded in it — a spatial relationship that supports the direct impact and relevance of on-site biodiversity practice.

Among the different protection categories, other protected areas represent the largest proportion of responses (26%), followed by Special Protection Areas (SPA) (14%), Special Areas of Conservation (SAC) (15%) and Sites of Community Importance (SCI) (14%). The distribution across the different designations demonstrates that the surveyed sites interact with a wide range of protected areas established under both European and national conservation frameworks.

The relatively high proportion of sites located within or close to protected areas underlines the important role that the extractive sector can play in supporting biodiversity conservation and ecological connectivity. It also reinforces the value of implementing harmonised biodiversity indicators capable of monitoring ecological conditions and restoration outcomes in landscapes where quarrying activities coexist with areas of recognised conservation importance.

Finally, 27% of responses correspond to an internal knowledge gap, indicating that, for a considerable number of sites, respondents were unable to confirm whether the operation was located within or close to protected areas. This finding highlights the need to improve access to spatial environmental information and strengthen internal awareness of the regulatory and ecological context of quarry sites. Addressing this knowledge gap would enhance the accuracy of future biodiversity assessments and support more informed environmental decision-making across the sector.

Figure 6.
Site inside the N2000 areas (SCI, SAC, SPA) or close (less than 5 km straight ahead) to other protected areas.



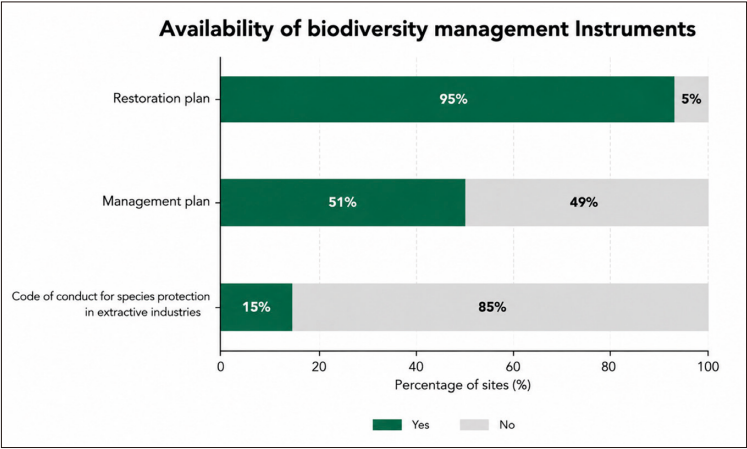
5.3.2 Natural Habitats Management and Biodiversity plans

Restoration plans are the most widely declared form of active management in the Level 1 survey. **Figure 7** shows that 95% of participating sites report having a Restoration Plan, reflecting the fact that this is a legal requirement for mining and quarrying operations. The remaining 5% most likely reflects an internal knowledge gap – respondents unaware of the site’s existing restoration documentation – rather than an actual absence of a plan.

By comparison, 51% of sites have a dedicated biodiversity management plan and 15% report a code of conduct for species protection. Restoration planning is therefore already well established across the sector, though there is clear scope to strengthen dedicated biodiversity management instruments and to improve internal awareness of existing environmental documentation.

Looking beyond the existence of a plan to its content, **Figure 8** shows that 71% of sites report their restoration plan includes specific actions to rehabilitate natural ecosystems, and 57% report that these actions explicitly consider protected species – confirming that ecological intent,

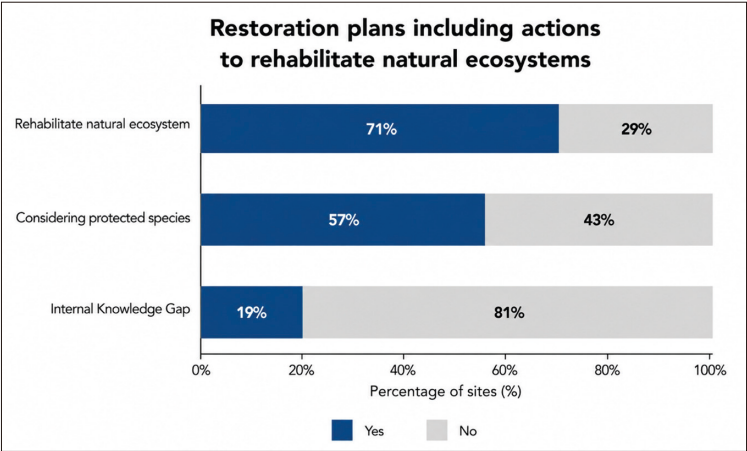
Figure 7.
Availability of biodiversity management instruments.



not just legal compliance, is already embedded in the majority of restoration commitments. A further 19% of respondents were unable to confirm these details, pointing again to an internal awareness gap rather than a gap in practice.

Taken together, these results show a sector with a strong underlying commitment to ecosystem rehabilitation, where the main opportunity lies in improving internal awareness and accessibility of restoration planning information, not in changing the plans themselves.

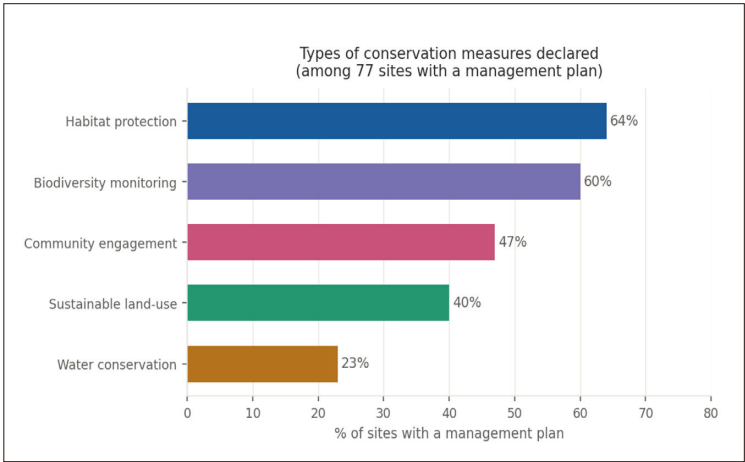
Figure 8.
Restoration plans including actions to rehabilitate natural ecosystems.



At site level, the Level 2 and 3 survey (121 sites) shows a similar pattern of active engagement:

64% of sites declare at least one active conservation measure, led by habitat protection (64% of sites with a plan), followed by biodiversity monitoring (60%), community engagement (47%), sustainable land-use (40%) and water conservation (23%) (Figure 9). The concentration of declared measures at the ecologically most meaningful end of the spectrum is a positive structural signal. The remaining 36% of these 121 sites without any declared measure largely already hold the habitat inventory data a plan would be built on. Addressing the gap in a cost-effective way would require a formalization of existing practice into a documented plan.

Figure 9.
Types of conservation measures declared among the 77 sites with a management plan (% of sites).



5.3.3 Types of biodiversity data

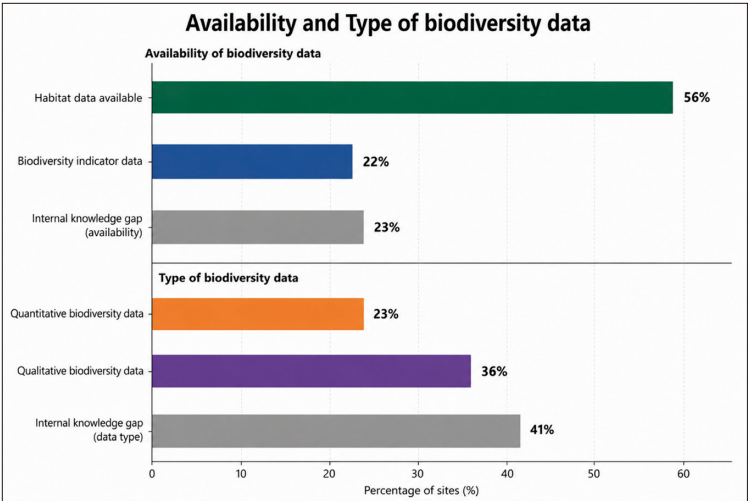
Figure 10 presents the availability and type of biodiversity data currently managed by participating quarrying and mining sites. More than half of the sites (56%) reported having information on habitat types, indicating that habitat mapping and inventories are already incorporated into environmental management in a substantial proportion of operations. However, only 22% of the sites reported having data specifically related to biodiversity indicators, while 23% identified an internal knowledge gap

regarding the availability of such information. These findings suggest that, although habitat information is relatively widespread, its transformation into structured biodiversity indicators remains limited.

Regarding the type of biodiversity information collected, qualitative data are more frequently available (36%) than quantitative data (23%), whereas 41% of the respondents reported an internal knowledge gap concerning the nature of the information available. This indicates that biodiversity information is often based on descriptive observations rather than on standardized measurements that allow changes to be assessed over time.

Overall, the results highlight an important opportunity to strengthen biodiversity monitoring by promoting standardized habitat inventories, improving the collection of quantitative ecological data, and progressively implementing harmonized biodiversity indicators. The availability of reliable, comparable and measurable datasets is essential for assessing restoration outcomes, monitoring biodiversity trends and supporting evidence-based environmental management across quarrying and mining sites.

Figure 10.
Availability and types of biodiversity data.



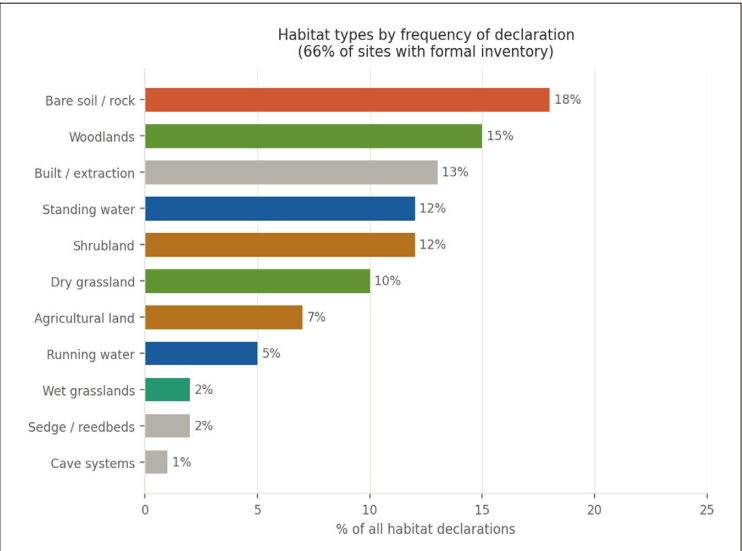
5.3.4 Natural habitat monitoring and conservation measures

With almost three quarters of Level 1 sites operating within 5 km of a Natura 2000 designation, knowledge of the habitats within the concession becomes key information for nature management and restoration, ensuring good connectivity with the surrounding landscape.

Habitat classification in both surveys follows the standardised EUNIS classification (Annex C), providing ecologically coherent categories while limiting the level of expertise required for identification.

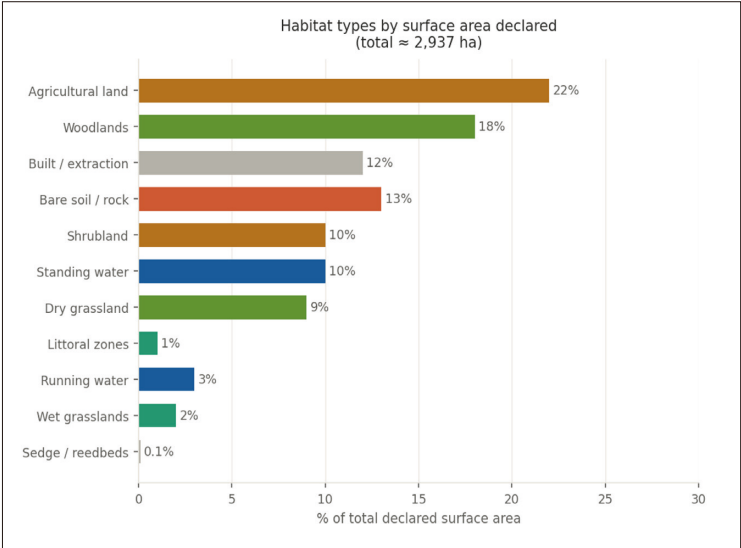
At EU scale (Figure 11), 66% of sites maintain a formal habitat inventory. Among those, bare soil and rock and built and extraction areas logically dominate declarations — as open-pit quarries are mostly covered by these (31% combined) — followed by woodlands (15%), standing water (12%) and shrubland (12%). Dry grassland (10%), agricultural land (7%) and running water (5%) complete the upper tier. Wetland categories together account for under 7% of declarations, directly reflecting the physical character of active extraction and the geographical heterogeneity of the data.

Figure 11. Habitat types by frequency of declaration (% of all declarations, among 66% of sites with a formal inventory).



Analysis of the surfaces of each recorded habitat reveals a different picture (Figure 12): agricultural land occupies 22% of total declared surface, ahead of woodlands (18%), bare soil (13%), built and extraction areas (12%), shrubland (10%) and standing water (10%). Wetland categories remain at the bottom, covering under 100 hectares combined across the full sample. Woodland and standing water rank similarly in both frequency and surface, reflecting their dual role as both widespread and extensive habitat types, and as a dominant focus of restoration effort.

Figure 12. Habitat types by surface area declared (% of total declared surface, approximately 2,937 ha).

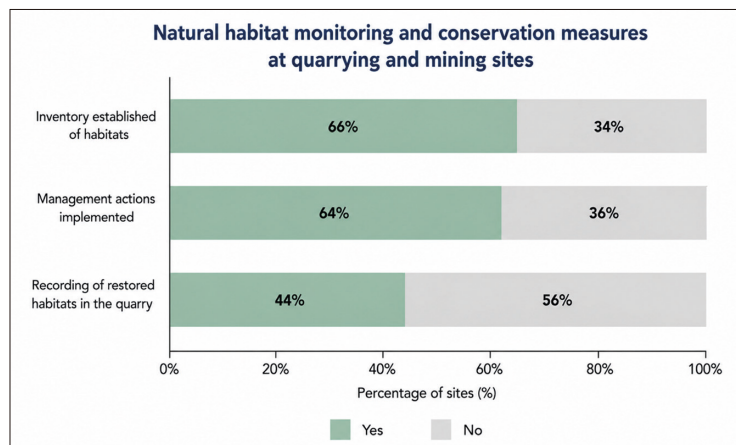


The divergence between the two rankings is ecologically and operationally significant: it illustrates a paradox in quarry habitat management in which the habitats covering the most ground are not those with the greatest intrinsic ecological value, while the habitats offering the greatest restoration potential — bare soil, pioneer vegetation, water margins — are highly suitable for biodiversity but are rarely restored to an extent that covers a large area.

Figure 13 shows that habitat monitoring and conservation measures are widely implemented across the surveyed mining and quarrying sites. Habitat inventories are the most frequently reported measure, with 66% of sites having established an inventory of habitats. Similarly, 64% of sites reported implementing habitat management actions, indicating that biodiversity conservation is integrated into site management practices beyond the initial assessment phase.

By contrast, the recording of restored habitats is less common, with 44% of sites documenting habitats following restoration activities. This suggests that, although restoration measures are being implemented, the systematic monitoring and recording of restoration outcomes remains an area with potential for improvement. Strengthening post-restoration habitat monitoring would enhance the evaluation of restoration success, support adaptive management and provide more robust evidence of the biodiversity benefits achieved at mining and quarrying sites.

Figure 13.
Natural habitat monitoring and conservation measures at quarrying and mining sites.



5.3.5 Species conservation

The Natura 2000 proximity documented in the Level 1 survey makes systematic species recording a priority for relevant nature management practices across the sector. In the Level 2 and

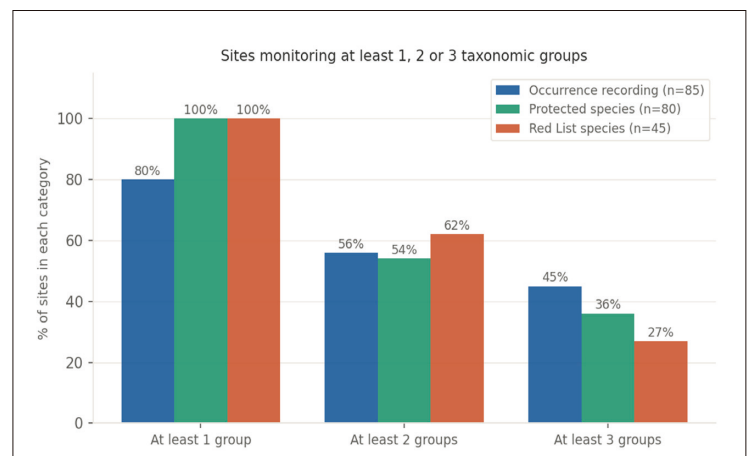
3 survey, 70% of sites (85/121) record species occurrences — 46% through presence/absence and 32% with population counts; the remainder did not specify a method.

Crucially, of those 85 sites recording species, 88% report protected species presence and 49% identified threatened Red List species — indicating that monitoring systematically leads to finding species under protection status. This conversion rate underlines that quarry environments are a structural hotspot for rare biodiversity.

The biodiversity assessment presented in this study considered seven main taxonomic groups: arthropods, fish, amphibians, reptiles, birds, mammals and flora. In addition, an “Other” category was included to record species that did not fall within these predefined groups, ensuring that all relevant biodiversity observations could be reported.

The following Figure 14 presents the distribution of participating sites according to the number of taxonomic groups monitored.

Figure 14.
Percentage of sites monitoring at least 1, 2 or 3 taxonomic groups, across occurrence recording, protected species and Red List categories.



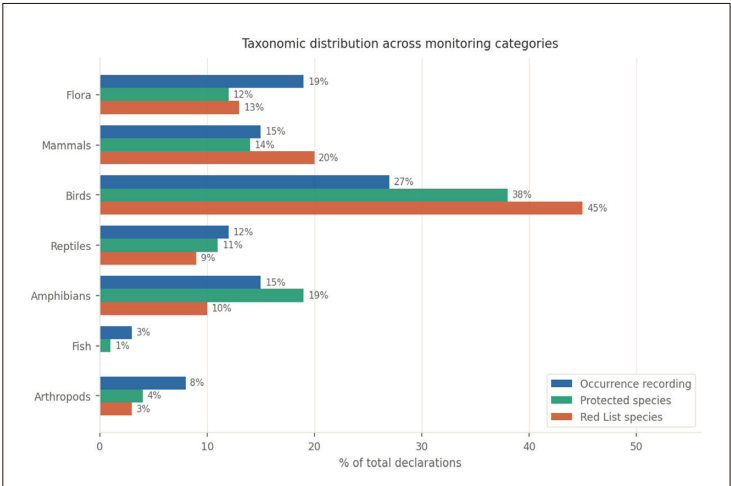
The Figure 15 shows that among the 85 sites recording occurrences, 80% specify at least one taxonomic group and 56% cover two or more

groups. Concerning protected species, 46% of sites report only one group, while 62% of the 45 sites recording Red List species cover two or more groups and 27% cover three or more – suggesting that where Red List identification has been undertaken, it tends to involve a more thorough multi-taxa survey effort.

Taxa analysis shows that birds dominate all three monitoring categories – accounting for 27% of occurrence declarations, 38% of protected species declarations and 45% of Red List declarations, consistent with their detectability and strong legal coverage. Flora shows the inverse pattern: well represented in occurrence recording (19%) but declining in protected species (12%) and Red List (13%) categories.

Amphibians and reptiles maintain a consistent share across all three categories (10–19%), consistent with their ecological affinity for quarry microhabitats and their established legal protection status. Arthropods and fish remain structurally marginal across all categories – 8% and 3% of occurrence declarations respectively – declining further in protected species and reaching zero for fish in Red List. These patterns reflect genuine habitat constraints for fish and a survey capacity gap for invertebrates rather than ecological absence.

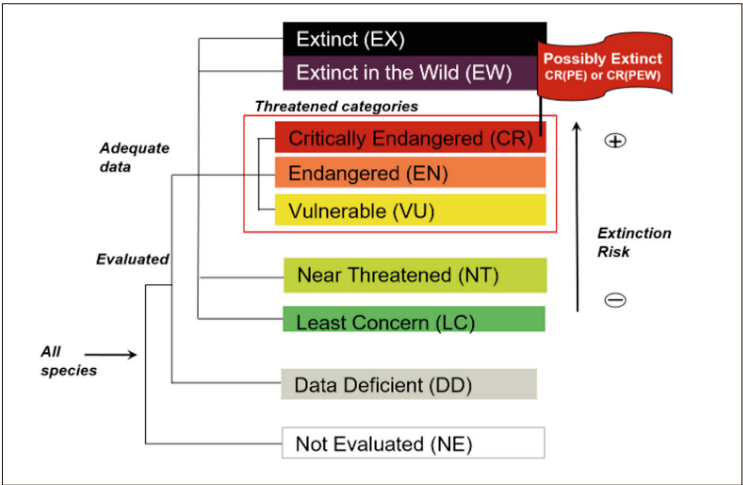
Figure 15. Taxonomic distribution across monitoring categories (% of total declarations per category).



The **Annex D (Table D 1)** presents the compilation of species records reported by participating quarrying and mining sites through Levels 2 and 3 of the biodiversity survey. These records demonstrate that both active and restored extractive sites can provide suitable habitats and ecological resources for a wide range of fauna and flora, offering refuge, breeding opportunities, feeding resources and ecological connectivity within increasingly modified landscapes. The dataset also illustrates the capacity of quarrying and mining sites to support biodiversity despite the operational conditions associated with extractive activities, including noise, vibrations, dust and the movement of machinery. When biodiversity is effectively integrated into restoration planning, habitat management and environmental monitoring, many species are able to coexist with ongoing operations, highlighting the ecological value that these sites can provide throughout their life cycle.

Beyond documenting species occurrence, the collected information provides robust scientific evidence of the contribution that the extractive industry makes to biodiversity conservation across Europe. The classification of the recorded species according to the European IUCN Red List (**Figure 16**) enables a better understanding of their conservation significance and demonstrates that quarrying and mining sites support species with different levels of conservation concern.

Figure 16. IUCN Red List Categories of Threat.



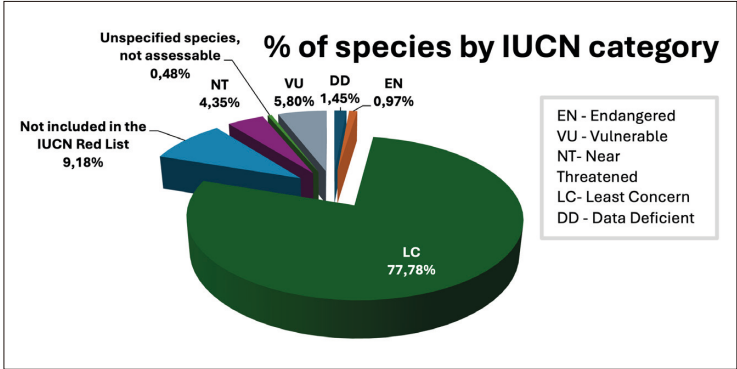
As illustrated in [Figure 17](#), most recorded species are classified as Least Concern (77.8%), while a significant proportion belongs to categories of higher conservation concern, including Near Threatened (4.35%), Vulnerable (5.80%), Endangered (0.97%) and Data Deficient (1.45%). These findings confirm that well-managed quarrying and mining sites support not only common species that sustain ecosystem functioning but also species requiring increased conservation attention.

The predominance of Least Concern species should not be interpreted as reflecting low ecological value. On the contrary, it demonstrates that quarrying and mining sites maintain functional ecosystems capable of supporting diverse biological communities and the ecological processes on which biodiversity depends. At the same time, the occurrence of Near Threatened, Vulnerable and Endangered species highlights the importance of the diverse habitat mosaic created through extraction and restoration activities—including rock faces, temporary ponds, wetlands, bare substrates, early successional vegetation and restored natural areas—which provides suitable ecological conditions for species that have become increasingly scarce in many surrounding landscapes.

The presence of European IUCN Red List species provides strong scientific evidence that quarrying and mining sites can function as substitute habitats, contributing to landscape connectivity, ecological resilience and biodiversity conservation at the European scale. Through responsible site management, progressive restoration and long-term environmental stewardship, the extractive industry is creating and maintaining habitats that complement the wider ecological network and support species of conservation concern. Furthermore, biodiversity monitoring programmes implemented by the sector generate valuable scientific information, includ-

ing records of Data Deficient species, directly improving knowledge of species distribution and supporting future European conservation assessments. Together, these findings demonstrate that well-managed quarrying and mining sites are not only compatible with biodiversity conservation but also represent an increasingly important component of Europe’s green infrastructure, providing measurable environmental benefits that should be recognised within future conservation policies and biodiversity strategies.

Figure 17.
European IUCN Red List categories of species recorded at participating sites.



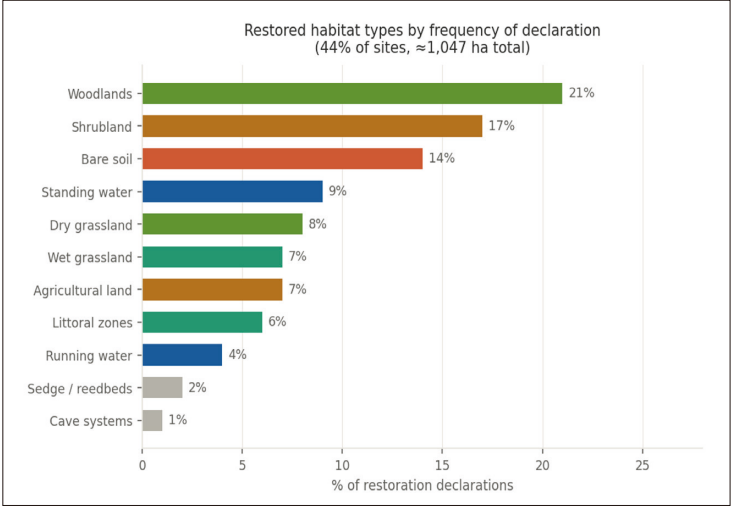
5.3.6 Restoration and rehabilitation

Of participating sites, 95% report having a Restoration Plan ([Figure 7](#)), and among these, 71% explicitly include ecosystem rehabilitation actions and 57% integrate protected species considerations ([Figure 8](#)) — positioning restoration as an ecological commitment rather than a purely operational obligation across the majority of the sector.

44% of Level 2 and 3 sites record at least one restored habitat, covering approximately 1,047 hectares. Woodlands lead (21% of restoration declarations), followed by shrubland (17%) and bare soil stabilisation (14%). Dry grassland (8%), standing water (9%), agricultural land (7%), wet grassland (7%), littoral zones (6%) and running water (4%) follow. The ranking of restored habitats broadly mirrors the ranking of habitats

present — restoration is following inventory data, which is the right direction (Figure 18).

Figure 18.
Restored habitat types by frequency of declaration (% of restoration declarations, 44% of sites).



As highlighted above, restoration effort appears to focus on the habitat types already dominant in the landscape, while the fragmented, early-successional and wetland categories that are most distinctive to quarry environments — and most ecologically valuable precisely because they are rare elsewhere — remain systematically under-restored relative to both their extent and their conservation significance.

If restoration effort is well understood and applied across the sector, with a 66% inventory rate and structured EUNIS categorisation, the difference between the occurrence of habitats and their relative size points to an improvement path regarding a higher degree of diversity of habitats restored, as well as habitats of higher intrinsic ecological value — contributing to the goals of the Nature Restoration Law on wetlands and pollinators, for example.

The consistent divergence is in wetland and grassland categories: present in meaningful proportions but under-restored relative to their

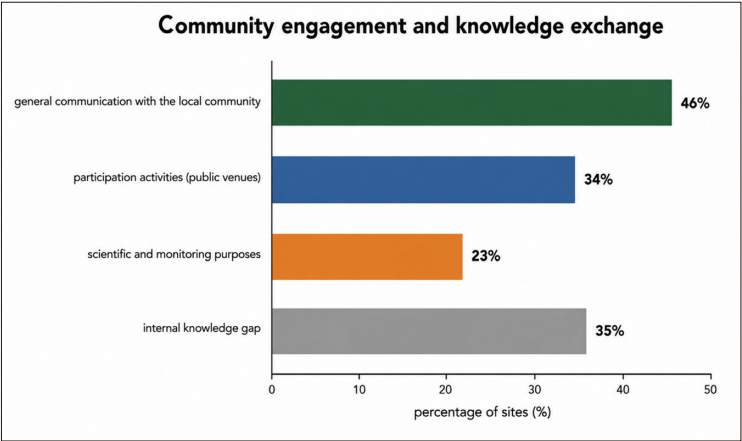
ecological value. Extending restoration toward these categories represents the area of greatest potential gain for biodiversity outcomes across the sector.

5.3.7 Community engagement

Figure 19 illustrates the main forms of community engagement and knowledge exchange implemented by the participating quarrying and mining sites. General communication with the local community represents the most common initiative, reported by 46% of the sites, reflecting the sector’s commitment to maintaining dialogue with local stakeholders. Public participation activities, including site visits and outreach events, were reported by 34% of the sites, highlighting the growing interest in improving transparency and public awareness of extractive activities.

Furthermore, 23% of the sites indicated that they support scientific research and biodiversity monitoring through collaboration with universities, researchers and other scientific institutions. Such initiatives contribute to improving ecological knowledge, validating restoration outcomes and strengthening biodiversity monitoring. However, 35% of respondents reported an internal knowledge gap regarding community engagement activities, indicating that these initiatives are not yet consistently documented or communicated across all operations.

Figure 19.
Community engagement and knowledge exchange.



77 sites out of 121 present at least one declared conservation measure. Within this subset, community engagement is the third most common, reported by 47% (36 sites) – behind habitat protection (64%) and biodiversity monitoring (60%), and ahead of sustainable land-use (40%) and water conservation (23%).

The most actionable finding here is not a capacity gap but a documentation one: converting existing, undocumented outreach into recorded practice is the step that would most rapidly strengthen the sector’s social and governance profile.

Overall, the results demonstrate that community engagement is becoming an increasingly important component of environmental management within the extractive sector. Strengthening collaboration with local communities and scientific institutions can improve biodiversity knowledge, promote the exchange of best practices and reinforce the role of quarrying and mining sites as active contributors to nature conservation and ecological restoration.

5.4 Discussion

To provide a clearer picture of what these data mean in terms of ecological knowledge, we synthesised them into 8 biodiversity KPIs developed in the ROTATE project. The KPIs were assessed on a 0–5 composite index, combining representativity (share of sites contributing data, weighted by a precision term derived from the site-level margin of error and actionability (informational depth and specificity as a management or regulatory signal), each weighted at 50%. Scores reflect what the current dataset can support as a descriptive diagnostic rather than a performance ranking.

All coverage figures carry an estimated $\pm 8\text{--}9\%$ margin of error representing the heterogeneity of spatial coverage and potential bias when recording data; indicators conditioned on a smaller base (abundance of selected species, $n=85$; abundance of protected/RL species, $n=80$) carry $\pm 10.5\text{--}11\%$.

The eight assessed indicators score between 2.49 and 3.54 out of 5. The habitat indicators (Ind.6, Ind.10) and protected species count (Ind.3) form the strongest cluster, combining coverage rates of 44–66% with high actionability – the indicators best positioned to support reporting and decision-making today. Red List count (Ind.4) scores comparably despite lower coverage (37%), because where data exist they carry direct regulatory specificity.

Species diversity (Ind.1) has the highest coverage rate (70%) but is moderated by the limited depth of presence/absence data and narrow taxonomic scope (heavy influence of bird occurrence). This discrepancy reveals that widespread recognition of ecological value has not yet translated into monitoring practices of sufficient depth to support adequate management decisions. Importantly, this indicator captures occurrence recording across taxonomic groups without reference to protection status, which is assessed independently through Ind.3 and Ind.4. The two abundance indicators (Ind.2 and Ind.5) score lowest: constrained by a smaller respondent base (44% and 46% respectively, $\pm 10.5\text{--}11\%$) and the near-absence of structured quantitative monitoring, they represent the highest decision-making value in the set but the widest gap between potential and current data. Communication and participation (Ind.11) are broadly declared but inconsistently documented, placing it in the mid-range despite reasonable coverage (Figure 20)

Figure 20. KPI achieveness scores. Error bars = 95% margin of error. Colour = topic (blue: species, green: habitat, pink: plan). Pink overlay = actionability contribution.

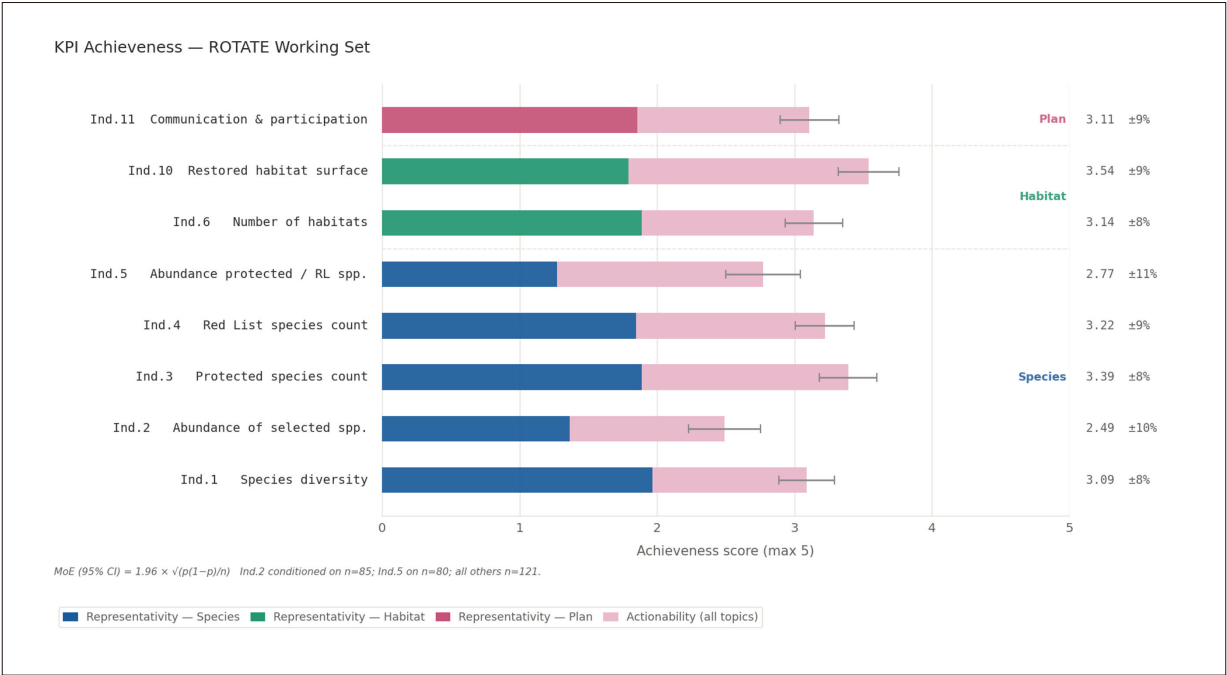


Table 5. KPI achieveness scores summary.

Ind.	Indicator	Coverage	MoE (95%)	Score /5	Topic
Ind. 1	Species diversity	70%	±8.1%	3.09	Species
Ind. 2	Abundance of selected spp.	44%*	±10.5%	2.49	Species
Ind. 3	Protected species count	66%	±8.4%	3.39	Species
Ind. 4	Red List species count	37%**	±8.6%	3.22	Species
Ind. 5	Abundance protected/RL spp.	46%***	±10.9%	2.77	Species
Ind. 6	Number of habitats	66%	±8.4%	3.14	Habitat
Ind. 10	Restored habitat surface	44%	±8.8%	3.54	Habitat
Ind. 11	Communication & participation	64%	±8.6%	3.11	Plan

*Conditioned on sites recording occurrences (n=85).
**Corrected from 47 to 45 sites following site-level verification.
***Conditioned on sites with protected species present (n=80). All other indicators n=121.

6

The way forward

6.1 Current gaps

The survey confirms that biodiversity monitoring is now a widespread practice across European quarries, though the depth of information held varies from site to site. Of the 121 sites assessed, 64% actively manage nature on site through at least one declared measure, and a similar share maintain structured inventories: 70% record species occurrences and 66% hold a formal habitat inventory. Species data are particularly informative — 88% of sites that conduct species surveys go on to find protected species, confirming that quarry environments are structural hotspots for rare biodiversity rather than occasional exceptions.

Restoration is framed as an ecological commitment in the majority of plans, and community engagement is practised widely across the sector, using stakeholders feedback, spatial documentation, habitat characterisation, species recording and management planning simultaneously.

The survey highlights the main challenge to tackle at the sector level, from a biodiversity point of view. If the documentation exists, it rarely makes cross-connection, as illustrated in the difference between present habitats and restored habitats, underlying a difference of suitable conditions to host protected or threatened species before, during and after exploitation.

Sites record habitats, protected species and the European Red List taxa, but these data streams rarely talk to each other: restoration targets rarely look derived from species occurrence data, and without quantitative abundance moni-

toring it is impossible to evaluate whether restoration actions are benefiting the biodiversity present on the site.

This disconnect carries particular weight given that three quarters of sites operate within 5 km of a Natura 2000 designation, underlining that quarries can have an important role in the ecological connectivity of European landscapes.

The KPI achieveness scores summarizes: coverage is reasonable across most indicators, but actionability remains limited by the absence of quantitative monitoring, structural geographic concentration of this survey and taxonomic bias toward birds.

All in all, the path forward relies on:

- (i) connecting what already exists — linking occurrence data to conservation databases, habitat inventories to restoration priorities, and management declarations to measurable outcomes, and
- (ii) addressing key data gaps at the site scale and through methodological standardization and improvement across the sector. The provided KPI framework and survey's is a first step in addressing the second point.

6.2 Good practices

The successful implementation of biodiversity indicators depends not only on selecting appropriate indicators but also on the quality,

consistency and integration of the biodiversity data collected. Reliable assessments require the involvement of qualified environmental professionals, such as ecologists, biologists and other biodiversity specialists, whose expertise improves habitat and species inventories, supports the interpretation of monitoring results and strengthens decision-making throughout the life cycle of quarrying and mining operations. Up-to-date biodiversity inventories provide the essential baseline for defining objectives, selecting indicators and establishing robust monitoring programmes capable of evaluating ecological changes over time.

Biodiversity monitoring should be based on standardised methodologies that generate consistent, repeatable and comparable information while covering the full diversity of habitats and species present within a site. Particular attention should be given to habitats that naturally develop during extraction and restoration, such as temporary wetlands, rock faces, scree slopes and early successional habitats, as these often provide important opportunities for biodiversity conservation.

Presence of wildlife in an active extraction area, illustrating the coexistence of extractive activities and biodiversity. [14]



Progressive restoration and revegetation measures at an aggregate extraction site to promote ecological recovery and landscape integration. [15]

Monitoring results should be integrated into biodiversity management, and restoration plans to support adaptive management, evaluate the effectiveness of implemented measures and identify opportunities for continuous improvement.

Additional best practices include the application of simple and harmonised monitoring protocols for key taxonomic groups, the promotion of progressive restoration techniques that enhance habitat diversity, the adoption of a landscape mosaic approach to improve ecological connectivity, and collaboration with research institutions, universities and conservation organisations. The use of digital tools, including Geographic Information Systems (GIS), wildlife camera trapping and biodiversity databases, further strengthens data management, traceability and long-term monitoring, contributing to more robust biodiversity indicators and supporting continuous improvement of biodiversity management across the extractive sector.

7

Recommendations for biodiversity management and restoration in quarries

Start with what exists

Before launching new surveys or drafting a restoration plan, existing data should be reviewed: past inventories, impact studies, permits and previous strategies. A simple checklist of available information — mapped against the three levels of biodiversity indicators — allows genuine knowledge gaps to be distinguished from redundant effort and ensures that only missing data are collected. This approach saves time, reduces operational disruption, and grounds subsequent planning in the full picture of what is already documented.

Define a reference state

A reference state for the site should be established before any restoration goal is defined. This means mapping land cover and habitat types, identifying species of interest — including protected and Red List taxa — detecting invasive species, and characterising the hydrological and geomorphological context of each functional zone.

Where direct field assessment is not possible, existing literature, regional biodiversity data-



Spontaneous vegetation colonisation on an aggregate substrate, promoting the ecological recovery of areas undergoing restoration. [16]

bases and the Natura 2000 network provide a starting point. Sites located within 5 km of a Natura 2000 designation — which applies to three quarters of surveyed quarries — should use adjacent protected areas as ecological reference points and potential connectivity corridors when defining the baseline.

Set clear, measurable goals and targets

Restoration goals should be defined in terms of ecological outcomes — habitat types to restore, species to support, ecosystem services to improve — within the operational and landscape context of the site. Stakeholder involvement is essential, as community expectations, legal obligations and site-specific constraints all shape what is achievable. Goals should then be translated into specific, time-bound targets: a defined surface of a given habitat type, a measurable improvement in a pollinator indicator, the establishment of a connectivity corridor. Targets that are not measurable cannot be evaluated; targets that are not discussed cannot be sustained.

Choose indicators that match the targets

A set of biodiversity indicators should be selected in direct relation to the restoration targets defined above. The 10 KPIs proposed in the ROTATE project cover the key dimensions — species richness, abundance, protection status, habitat number and surface, invasive species and restored area — and can be populated progressively as monitoring capacity grows. Indicators should be sensitive to the management actions being implemented, measurable with available resources, and relevant on a timescale meaningful to decision-making. A smaller number of indicators consistently applied outperforms a complex system used once.



Specialist amphibians, such as the Natterjack Toad (*Epidalea calamita*), find suitable breeding habitats in temporary water bodies present at aggregate extraction sites. [17]

Implement, monitor and adapt

Restoration actions should be implemented by zone — active extraction areas, reserve areas and post-extraction areas each require a distinct monitoring approach. In active areas, the priority is protecting species of interest and managing temporary habitats. In reserve areas, early systematic inventories are the highest-value investment, as these zones carry the greatest biodiversity potential and allow long-term planning. In post-extraction areas, habitat evolution should be tracked against the targets defined at the outset, and ecosystem service assessments updated to support prioritisation decisions. Monitoring protocols should be standardised and replicable to allow meaningful comparison over time and across sites.

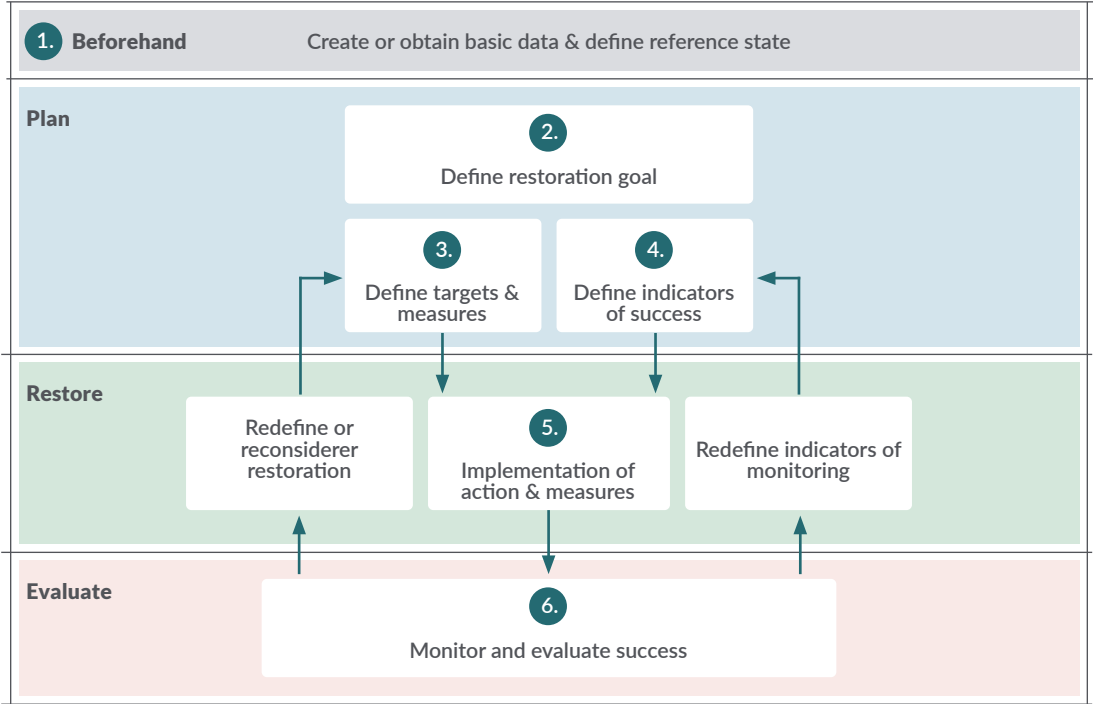
Evaluate and correct course

Monitoring results should be compared against targets at regular intervals. Where outcomes diverge from expectations, the cause should be diagnosed before adapting: the problem may lie in the measure, the indicator, the target or the timescale. Honest evaluation is the mechanism

through which restoration plans improve – and the basis on which progress can be reported credibly to regulators, local communities and

the sector as a whole **Figure 21**. The goal is not a perfect plan from the outset, but a responsive one that learns from what the data show.

Figure 21.
Flowchart of the restoration plan design and implementation (adapted from Prach et al., 2019)



8

Conclusion

The biodiversity indicator system presented in this guide, developed through the European ROTATE project by a multidisciplinary team of experts in biodiversity, restoration ecology and the extractive sector, provides a harmonised methodology for assessing biodiversity management in quarrying and mining sites. Based on biodiversity data for the 2024 reporting year collected from participating companies through the Level 1 and Level 2 & 3 surveys conducted during 2025–2026, the methodology demonstrates that a common assessment framework can be successfully applied across different countries, geological settings and operational conditions, generating comparable information to support biodiversity monitoring throughout the European extractive sector.

The results confirm that quarrying and mining sites support a genuine diversity of habitats and species. 66% of sites report protected species and 39% host species on the IUCN European Red List, with three quarters of sites located within 5 km of a Natura 2000 designation – placing much of the sector in direct ecological proximity to Europe’s core conservation network. These findings highlight the ecological role that well-managed extractive sites can play in providing habitat, ecological resources and landscape connectivity, and show that biodiversity can coexist with, and even benefit from, extractive activity where planning, environmental management and restoration are properly implemented.



Wetland created through the restoration of an aggregate extraction site, promoting habitat recovery and colonisation by flora and fauna. [18]

The assessment also points to clear opportunities for improvement. Restoration plans, habitat information and species records are all widely available — 64% of sites declare active management measures and 95% report a restoration plan — but these data sources are not yet consistently connected. Habitat inventories are rarely linked to restoration objectives and management actions, species records are seldom cross-referenced against their protection status, and only around half of the sites with an inventory subsequently monitor species abundance or diversity over time. Strengthening the integration of these existing data sources and linking biodiversity monitoring with restoration planning and management actions represents one

of the main opportunities to improve the evaluation of restoration outcomes and biodiversity performance across the sector.

Finally, this guide establishes a practical and scalable framework that can be progressively expanded through future survey campaigns. Continued implementation of the methodology will enable the collection of harmonised biodiversity data across Europe, support the evaluation of long-term trends and further demonstrate the contribution of quarrying and mining sites to biodiversity conservation, ecological restoration and the objectives of European environmental policies.

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Annex A: Glossary of terms

Abundance: the total number of individuals of a species present in a given area over a specific period. It may be expressed as absolute or relative abundance and is a key indicator of a species' population status.

Biodiversity: the variability amongst living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.

Conservation status: it is a measure of the probability that a species will continue to exist in the present or in the near future, given not only the size of the current population, but also the trends they have shown over time, the existence of predators or other threats, the expected changes in their habitat, etc. From the state of conservation derives (or should) its legal protection.

Diversity: a measure that integrates species richness and the relative abundance of each species within a community, reflecting the biological complexity of an ecosystem.

Ecological restoration: refers to the process of managing or assisting the recovery of an ecosystem that has been degraded, damaged or destroyed as a means of sustaining ecosystem resilience and conserving biodiversity. Degradation is characterized by a decline or loss of biodiversity or ecosystem functions. Degradation and restoration are context-specific and refer to both the state of ecosystems and to ecosystem processes.

Ecological niche: the set of environmental conditions, resources, and ecological functions that define the position and role of a species within an ecosystem. It includes both abiotic factors (climate, soil, water) and biotic interactions (competition, predation, mutualism) that influence its survival and reproduction.

Ecological vocation: set of plant and animal communities to which an altered landscape tends due to ecological succession processes.

Ecosystem: set of species in each area that interacts with each other and with their abiotic environment.

Ecosystem restoration is a complement to conservation activities and provides many benefits both inside and outside of protected areas, which brings multiple benefits. Priority should be given to conserving biodiversity and preventing the degradation of natural habitats and ecosystems by reducing pressures and maintaining ecological integrity and provision of ecosystem services.

Ecosystem services: those benefits that an ecosystem provides to society and that improve people's health, economy and quality of life and that result from the proper functioning of ecosystems.

Endemism: biological term to indicate that the distribution of a taxon is limited to a geographic area smaller than a continent and that it is not found naturally in any other part of the world.

Environmental Impact Statement (EIS): an administrative decision that determines the environmental feasibility of a project, establishing conditions and measures to protect species, habitats, and ecosystems.

EUNIS classification: a European hierarchical habitat classification system that allows habitats to be identified, compared, and assessed at a continental scale. [Link](#).

Geomorphology: it is a branch of geography and geology whose objective is the study of the forms of the earth's surface focused on describing them, understanding their genesis and their current behaviour.

Habitat: set of physical and geographical factors that affect the development of an individual, a population, a species or group of determined species.

Indicator is in ecology and environmental planning, a component or a measure of environmentally relevant phenomena used to depict or evaluate environmental conditions or changes or to set environmental goals.

Invasive Alien Species (IAS): animals and plants that are introduced accidentally or deliberately into a natural environment where they are not normally found, with serious negative consequences for their new environment. They are a major threat to native plants and animals in Europe and are one of the five major causes of biodiversity loss (European Commission).

Inventory: a systematic and documented compilation of species or habitats present in a given area, carried out using standardized methods.

IUCN Red List species: a species assessed by the IUCN and included in one of its conservation categories (from Least Concern to Extinct), according to its risk of extinction.

IUCN Red List: the global system for assessing the risk of species extinction, developed by the International Union for Conservation of Nature (IUCN), based on standardized scientific criteria. [Link](#).

Monitoring: a continuous or periodic process of data collection and analysis used to assess changes in the status of species or habitats over time.

Nature 2000: is a network of protected areas covering Europe's most valuable and threatened species and habitats. It is the largest coordinated network of protected areas in the world, extending across all 27 EU Member States, both on land and at sea. The sites within Natura 2000 are designated under the [Birds and the Habitats Directives](#). [Link](#).

Natural environment restoration plan: it is the process of reducing, even reversing in some cases, the damage produced in the physical environment to return as far as possible to the structure, functions, diversity, and dynamics of the original ecosystem. For this, the original conditions must be restored, and the environmental impacts caused by the action carried out in the environment must be corrected.

Taxonomic group: a set of organisms grouped according to their evolutionary relationships within a taxonomic category (e.g. birds, mammals, reptiles, vascular plants).

Trophic chain: flow of energy and nutrients that is established between the different species of an ecosystem in relation to their nutrition.

Rehabilitation: an action that aims to recover degraded ecosystem functions and increases its capacity to provide ecosystem goods and services. It does not consider necessarily the recovery of the structure, composition, and diversity of the historical ecosystem. A rehabilitated ecosystem may contain species that perform similar functions to the historical reference ecosystem, but these are not necessarily the same species that were present in the ecosystem before the disturbance.

Restored habitat: a degraded habitat that has been subject to actions aimed at recovering its structure, ecological functions, and capacity to support characteristic species.

Richness: the total number of different species present in an area or biological community, regardless of the number of individuals of each species.

Population survey: a set of systematic sampling methods used to estimate the size, abundance, density, structure, and distribution of a population of one or more species in a given area, without the need to census all individuals. Population surveys are a fundamental tool for assessing conservation status and monitoring wild populations.

Passive refaunation: colonization processes by different faunal taxa that take place spontaneously, without direct anthropogenic intervention (that is, without introduction of species). These processes can be facilitated or expedited by adapting the intervening terrain to the needs of the target species.

Protected species: a species included in legal instruments that establish specific measures to prevent its capture, damage, trade, or the destruction of its habitat.

Site of Community Importance (SCI): site which, in the biogeographical region or regions to which it belongs, contributes significantly to the maintenance or restoration at a favourable conservation status of a natural habitat type in Annex I or of a species in Annex II and may also contribute significantly to the coherence of Natura 2000 referred to in Article 3, and/or contributes significantly to the maintenance of biological diversity within the biogeographic region or regions concerned. For animal species ranging over wide areas, sites of Community importance shall correspond to the places within the natural range of such species which present the physical or biological factors essential to their life and reproduction.

Special Area of Conservation (SAC): site designated according to the Habitats Directive. Special area of conservation means a site of Community importance designated by the Member States through a statutory, administrative and/or contractual act where the necessary conservation measures are applied for the maintenance or restoration, at a favourable conservation status, of the natural habitats and/or the populations of the species for which the site is designated.

Special Protection Area (SPA): special protection areas are areas classified by a Member State of the European Union as a special protection area for the conservation of species of birds which are: in danger of extinction; vulnerable to specific changes in their habitat; considered rare because of small populations or restricted local distribution; or requiring particular attention for reasons of the specific nature of their habitat, in a geographical sea or land area where Directive 2009/147/EC on the conservation of wild birds applies.

Species: basic unit of biological classification. It is a set of organisms or natural populations capable of interbreeding and producing fertile offspring, although—in principle—not with members of populations belonging to other species.

Threatened species: a species whose medium- or long-term viability is compromised by factors such as habitat loss, overexploitation, or climate change, and which faces a high risk of extinction.

Vegetation series: the successional and landscape geobotanical unit that tries to express the entire set of plant communities that can be found in related tessellar spaces because of the succession process, which includes both the types of vegetation representative of the mature stage of the plant ecosystem as the initial or subserial communities that replace them.

Annex B: Questionnaires

I. Level 1: pre-assessment

Table A1
Questionnaire Level 1.

Question	Answer	
Location of the mining site:		
Country:		
Name and surname of the contact person:		
Email address of the contact person:		
Do you have a mining site cartography?	Yes ☐	No ☐
If yes, is it in digital version?	Yes ☐	No ☐
Is the site inside Natura 2000 area (SCI, SAC, SPA) or close (less than 5km straight ahead) to other protected areas?	Yes ☐	No ☐
Does the site contain Natura 2000 area in the limit of the concession site?	Yes ☐	No ☐
Do you manage nature inside the concession area?	Yes ☐	No ☐
Does the Restoration Plan also include actions to rehabilitate natural ecosystem?	Yes ☐	No ☐
Does the site have a Biodiversity Management Plan (BMP)?	Yes ☐	No ☐
Do you have data on natural habitats and/or biodiversity in the site?	Yes ☐	No ☐
If yes on habitats, please indicate the percentage of the site already rehabilitated for nature end use:	Yes ☐	No ☐
If yes on biodiversity, specify of data?	Yes ☐	No ☐
Does the site monitor the invasive species?	Yes ☐	No ☐
If answering yes to any of the aforementioned questions - could you detail de type of biodiversity data gathered and the type of monitoring of invasive species?	Yes ☐	No ☐
Does the site an inventory of protected habitats?	Yes ☐	No ☐
Does the site engage with local community?	Yes ☐	No ☐

II. Level 2&3 : Provisioning ESS, structural and fuctional KPI´s

Table A2
Questionnaire Level 2 and 3.

Provisioning ESS questions	Answer	
Are there any commercial crops cultivated on the site?	Yes ☐	No ☐
If yes, please indicate the estimated area (ha)?		
If yes, please indicate the estimated production (t):		
Are there any breeding animals on the site?	Yes ☐	No ☐
If yes, please indicate the estimated area dedicated to grazing (ha)?		
Is there wild terrestrial animals hunting?	Yes ☐	No ☐
If yes, please indicate the estimated area dedicated to hunting activities (ha):		
Indicate the estimated area occupied by water? (ha):		
If there are water ponds, is any of them suitable for fishing activities?	Yes ☐	No ☐
Indicate the estimated area occupied by woodlands? (ha):		
If there is woodlands, is any of them used for timber exploitation?	Yes ☐	No ☐
Indicate the estimated area occupied by grasslands and fodder crops? (ha)		

Structural & functional KPI	Answer	
Do you record species occurrence in the quarry site?	Yes ☐	No ☐
Do you conduct inventories to keep track of species?	Yes ☐	No ☐
Select the groups you're monitoring:	arthropod; fish; amphibian; reptiles; birds; mammals; flora	
Do you have protected species in the quarry site?	Yes ☐	No ☐
Select the groups to which the protected species belong:	arthropod; fish; amphibian; reptiles; birds; mammals; flora	
How many protected species are present?		
Please enter their scientific name:		
Do you have IUCN Red List threatened species in the quarry site?		
Select the groups to which the red list species belong:	arthropod; fish; amphibian; reptiles; birds; mammals; flora	
How many UICN Red list species are present?		
Please enter their scientific name:		
Do you keep track of protected / Red List species abundance in the quarry site?	Yes, protected ☐	No ☐
	Yes, Red List ☐	
	Yes, both ☐	
Is there any inventory of habitats present in the quarry?		
If yes, select which habitat category:	EUNIS List-level 3	
From the habitat selected above, specify each one's surface:		
Is there any inventory of restored habitats present in the quarry?		
If yes, select which habitat category:	EUNIS List-level 3	
From the habitat selected above, specify each one's surface:		
Do you perform more nature-oriented management?	habitat protection / sustainable land-use practice / water resources conservation / community engagement and stakeholder involvement	

Annex C: EUNIS Habitats list

Table C1

Correspondence between EUNIS Habitat Categories and the Biodiversity Survey Habitat Classification.

EUNIS code	Habitat type (EUNIS level 3)	Description	Questionnaire category
C1	Surface standing waters	Natural and artificial standing freshwater bodies	Category 1: surface standing waters (including human made)
C2	Surface running waters	Rivers, streams and other running freshwater habitats	Category 2: surface running waters
C3	Littoral zone of inland surface waterbodies	Shorelines and margins of inland waters	Category 3: littoral zone of inland surface waterbodies
D5	Sedge and reedbeds, normally without free-standing water	Wet herbaceous wetlands with high water table	Category 4: sedge and reedbeds normally
E1	Dry grasslands	Dry low-productivity grasslands dominated by herbs	Category 5: dry Grasslands
E3	Seasonally wet and wet grasslands	Wet meadows and tall herb communities	Category 6: (seasonnaly-) wet grasslands / meadows
G1-G5	Woodland, forest and other wooded land	Woodlands dominated by trees with canopy	Category 7: woodlands
F	Heathland, scrub and tundra	Shrublands dominated by woody low vegetation	Category 8: shrubland (scrub, heathland, hedgerows)
H3	Inland cliffs, rock pavements and outcrops	Bare rock, cliffs and rock pavements inland	Category 9: bare soil (scree, cliffs, rock pavement)
H1	Terrestrial underground caves, cave systems, passages and waterbodies	Natural caves and subterranean underground habitats	Category 10: cave system
I1	Arable land and market gardens	Agricultural land	Category 11: agricultural lands
J3	Extractive industrial sites	Quarries, mines and other extraction sites, including associated built areas	Category 12: built areas, including extraction site

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Annex D: Compilation of species records provided by participating sites

Table D1
Compilation of species records provided by participating sites.

Group and taxon	Species			
Group 1 Arthropods	Aeshna grandis	Chelostoma campanularum	Gomphus vulgatissimus	Oxygastra curtisii
	Boloria dia	Cochlostoma tessellatum	Iphiclides podalirius	Paracaloptenus caloptenoides
	Boyeria irene	Conocephalus dorsalis	Lindenia tetrphylla	Satyrrium pruni
	Buprestis splendens	Cordulegaster boltonii	Mecostethus parapleurus	Somatochlora metallica
	Calopteryx virgo	Dolichopoda bakolitsasi	Melitta nigricans	Stethophyma grossum
Group 2 Fish	Cobitis taenia			
	Misgurnus fossilis			
Group 3 Amphibians	Bombina bombina	Hyla arborea	Pelobates fuscus	Rana arvalis
	Bombina variegata	Hyla meridionalis	Pelophylax epeiroticus	Rana temporaria
	Bufo bufo	Ichthyosaura alpestris	Pelophylax kl. esculentus	Triturus cristatus
	Bufo viridis	Lissotriton helveticus	Pelophylax spp.	
	Epidalea calamita	Pelobates cultripes	Pleurodeles waltl	
Group 4 Reptiles	Algyroides nigropunctatus	Lacerta agilis	Ophisops elegans	Telescopus fallax
	Anguis fragilis	Lacerta bilineata	Podarcis cretensis	Testudo hermanni
	Chalcides acellatus	Lacerta trilineata	Podarcis muralis	Testudo marginata
	Coluber najadum	Macropododon mauritanicus	Podarcis pityusensis	Timon lepidus
	Coronella austriaca	Malpolon monspessulanus	Podarcis vaucheri	Zamenis scalaris
	Elaphe quatuorlineata	Mauremys leprosa	Psammmodromus algeris	Zamenis situla
	Hemidactylus turcicus	Natrix maura	Pseudopus apodus	
	Hierophis gemonensis	Natrix natrix	Tarentola mauritanica	
Group 5 Birds	Accipiter gentilis	Columba oenas	Lanius collurio	Picus viridis
	Actitis hypoleucos	Corvus monedula	Linaria cannabina	Podiceps cristatus
	Alauda arvensis	Crex crex	Lullula arborea	Poecile montanus
	Alcedo atthis	Cuculus canorus	Merops apiaster	Prunella modularis
	Apus apus	Cygnus cygnus	Milvus milvus	Riparia riparia
	Aquila fasciata	Delichon urbicum	Motacilla alba	Saxicola rubicola
	Botaurus stellaris	Dryocopus martius	Muscicapa striata	Sterna hirundo
	Bubo bubo	Emberiza citrinella	Neophron percnopterus	Sylvia borin
	Buteo buteo	Falco naumanni	Numenius arquata	Tachybaptus ruficollis
	Caprimulgus europaeus	Falco tinnunculus	Oriolus oriolus	Tadorna tadorna
	Carduelis carduelis	Fringilla coelebs	Otus scops	Tringa totanus
	Charadrius dubius	Gallinula chloropus	Parus major	Tyto alba
	Chloris chloris	Grus grus	Passer montanus	Upupa epops
	Ciconia ciconia	Gyps fulvus	Phoenicurus phoenicurus	Vanellus vanellus
	Circus gallicus	Hirundo rustica	Phylloscopus trochilus	
	Circus aeruginosus	Jynx torquilla	Pica pica	

Group and taxon	Species			
Group 6 Mammals	Canis lupus	Lutra lutra	Myotis myotis	Rhinolophus ferrumequinum
	Capra pyrenaica	Lynx lynx	Nyctalus lasiopterus	Rhinolophus hipposideros
	Castor fiber	Lynx pardinus	Nyctalus leisleri	Tadarida teniotis
	Eptesicus isabellinus	Martes foina	Nyctalus noctula	Ursus arctos
	Eptesicus nilssonii	Meles meles	Oryctolagus cuniculus	Vulpes vulpes
	Genetta genetta	Mustela nivalis	Pipistrellus nathusii	
	Hypsugo savii	Myotis dasycneme	Pipistrellus pipistrellus	
	Lepus europaeus	Myotis daubentonii	Plecotus austriacus	
Group 7 Flora	Adonis annua	Epipactis palustris	Malcolmia graeca	Ranunculus paludosus
	Anacamptis pyramidalis	Euphorbia palustris	Myriophyllum verticillatum	Samolus valerandi
	Anthemis cotula	Euphorbia platyphyllos	Nasturtium microphyllum	Silene noctiflora
	Bidens cernua	Fritillaria meleagris	Neotinea tridentata	Sisymbrium supinum
	Campanula cervicaria	Galium intricatum	Nymphaea alba	Stipa tenacissima
	Carex disticha	Goodyera repens	Oenanthe fistulosa	Ulmus laevis
	Carex flava	Hippuris vulgaris	Ophrys sp.	Valerianella dentata
	Colchicum cupanii	Inula salicina	Orchis militaris	Veronica catenata
	Cyclamen hederifolium	Lathyrus palustris	Orobanche pallidiflora	Viola elatior
	Dactylorhiza incarnata	Legousia speculum-veneris	Pimpinella major	Vitis vinifera subsp. sylvestris
	Delphinium consolida	Lupinus angustifolius	Potamogeton berchtoldii	
	Epipactis helleborine	Lycopodium annotinum	Ranunculus circinatus	

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Guide to Biodiversity Indicators for Quarrying and Mining Sites: 2024 Data Report

Authors



Beatriz Gordo Infante
César Luaces Frades
Íñigo de Amescua Fernández de Casadevante



Víctor Pérez Domínguez
Elena Herrero Esteban



Samuel Bouchoms
Grégory Mahy



Petra Gradischnig
Miquel París Coderch