EuroGEO

Analysing the pattern dynamics in Earth Observation Research & Innovation

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COMBINE, COORDINATE, COOPERATE

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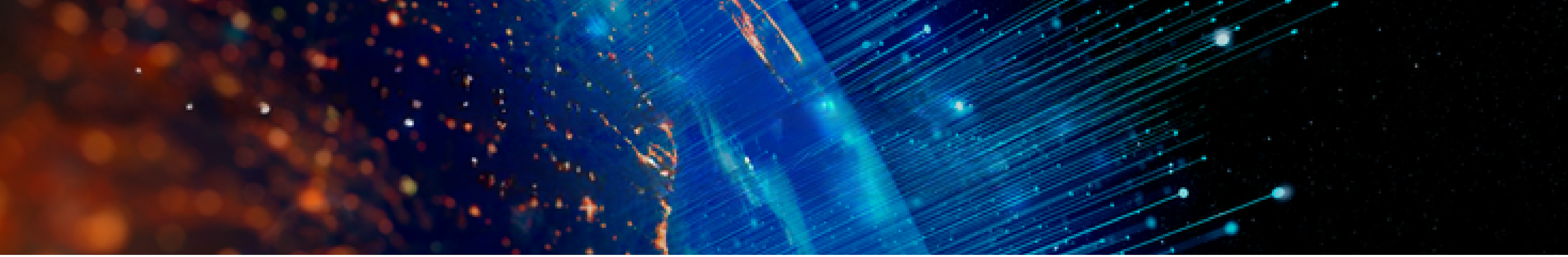


Introduction

In recent years, there has been an **increasing uptake of Earth Observation** (EO) as a tool in support of the implementation of various policies and the execution of a wide range of operational tasks. Users across the value chains of different sectors can utilise EO-based solutions in support of their work, **realising significant benefits** (economic, environmental, societal, etc.). Market demand for such solutions is driven by policies and sector-specific needs. Technological advances have the potential to enable solutions that match the specific needs.

EuroGEO, Europe's part of the Group on Earth Observation, stands at the intersection of research, policy, and markets. This **strategic position** allows it to identify and monitor relevant developments and trends, to engage stakeholders, and to assess the evolving EO landscape in Europe and beyond. Capturing insights relevant for the different stakeholders allows EuroGEO to document the current state of play of EO, its trajectory, and the required steps for broader adoption and increased benefits.

With the support of the ***EuroGEOSec* project**, and with the aim of **maximising the impact of Research and Innovation** (R&I), a dedicated effort has been made to establish the **R&I Observatory for Earth Observation** (RIO). This includes a team of analysts and an online tool to monitor and analyse past and ongoing R&I in EO in order to identify trends and support strategic decisions on future R&I activities. Relying on the RIO, the so-called **R&I State-of-Play Reports** are created presenting a concise overview of the policy context, technological perspectives, and market trends within the thematic areas covered by the EuroGEO Action Groups (AG). This present report focuses on analysing patterns in the **Biodiversity, Ecosystems, and Geodiversity (BEG) segment**. Research has been complemented by multiple other reports and studies, including studies performed by and for EuroGEO's BEG AG.

The aim of this report is to **support EuroGEO and its stakeholders in decision-making** regarding future work programmes and strategic innovation agendas (such as those of the Knowledge Centre on Earth Observation – KCEO), inform the review of the **EuroGEO Implementation Plan**, and contribute to the production of institutional outputs.

The following EuroGEO **Action Groups** develop application pilots/conduct other actions foreseen in the EuroGEO roadmap: Agriculture, Land Cover and Land Intelligence (LC&LI), Urban, Disaster Resilience and Health, Energy, Biodiversity, ecosystems and geodiversity (BEG), Marine, Climate, and Green Deal Data Spaces.

Methodology

The browser-based tool of the **R&I Observatory for Earth Observation** (RIO) allows retrieving relevant information from a variety of sources, including project information (e.g., descriptions, partners, budgets, results, timelines) for the majority of relevant European R&I programmes. Sources include information related to e.g., Horizon Europe (HE) and its predecessors, the LIFE programme, the Connecting Europe Facility, Eurostars, COSME, the European Defence Fund, and the European Defence Industrial Development Programme. Additional sources are being incorporated as part of the continuous development of the RIO.

The RIO structures the information into a standardised format for the uniform documentation of R&I activities. Functions of search, bookmarking, filtering, visualisation, and export allow the processing and analysis of the pre-curated information.

The focus of the analysis is on **mapping R&I efforts across segments** by analysing data on projects, core applications, budgets, and timelines. The full list of the analysed projects, filtered from the database of projects and mapped against segment-specific EO applications can be found in the original deliverable🔗. The segment's **core applications** have been identified and mapped based on the most prominent and important themes, as determined by the Action Group and its leads. They are derived from **AG expert studies**🔗 and further validated by sector experts such as AG leads. See the classification below:

- **Biodiversity Monitoring:** Habitat mapping and classification; Species distribution modelling; Change detection; Ecosystem health indicators
- **Ecosystem Assessment and Management:** Ecosystem extent and condition mapping; Ecosystem service assessment; Land degradation and desertification monitoring; Wetland and peatland monitoring
- **Geodiversity and Geomorphology:** Mapping geological features and landforms; Soil and substrate characterisation; Hazard mapping
- **Conservation and Protected Area Management:** Baseline mapping for protected areas; Illegal activity detection; Connectivity analysis

To address the research questions – i.e., to identify trends in EO-related R&I for BEG applications and the drivers behind them – the following limitations or simplifications were applied:

Data Processing

- Project information sourced from the RIO (including acronym, title, coordinators, topic, programme, pillar, objectives, work programme, status, start and end dates, budget, grant, and links) has been filtered using segment-specific keywords to ensure that only relevant projects are included and no projects are overlooked. This relies on full-text search in existing descriptions and meta data, along with the use of consistent terminology. Where data might be missing or unexpected terminology is used, certain projects may have been missed.
- The filtered list of projects considered relevant has been extracted (i.e., exported into a spreadsheet) for processing.
- Data has been manually checked for relevance and further cleaned accordingly, then augmented by segment-specific categorisation for more detailed analysis.

Methodology

Timeframe

In order to restrict the analysis to relevant activities while drawing from a significant enough sample size, a (roughly) **10-year timeframe** is used, covering the period **from 2014 to 2024** (i.e., only projects that have started before 2025 and have not ended before 2014 have been analysed). This timeframe is used to capture long-term trends, technological developments, and measurable outcomes of concluded projects. It also ensures that typical project lifecycles, such as those in Horizon Europe, are included. It coincides with the launch of the first Sentinel-1 satellite in 2014, the free and open data of Copernicus being considered as one driver of EO-related R&I, which has been attempted to confirm through the analysis.

Sample Size

The sample data is limited to the sources **currently included in the RIO**, expected to cover relevant European R&I projects to a large extent, but with further potentially relevant projects not included in the analysis where the data source has not been included yet. It is further limited to the keywords and queries applied (see data processing above) and timeframe selected (see timeframe above).

Budget allocations per application

Breaking down budgets of projects that address more than one segment-specific application and dividing them across these applications has been done following a simplified approach assuming an (unlikely) even distribution. Therefore, budget sizes per application can only **reflect trends** and may not be fully accurate.

To interpret and complement the findings from the RIO tool, **desk research** has been conducted across reports and studies, including:

- European Space Agency (ESA) application or industry articles
- European Commission (EC) documents, e.g., Climate factsheets, Reports on uptake barriers of EU space services
- EUSPA EO and Global Navigation Satellite System (GNSS) 2024 Market Report
- Stocktaking Reports from related Group on Earth Observations (GEO) initiatives
- Horizon Europe's Strategic Research and Innovation Agendas
- Segment-specific as well as EO-related strategic research and innovation agendas including outcomes of the Horizon 2020 (H2020) project *FIRE*
- EuroGEO Workshop Reports
- 🔗**EuroGEO BEG AG Expert Study**

These **sources** were carefully reviewed to extract relevant content that addressed the questions raised during the analysis. They were particularly useful in identifying gaps and barriers in each segment, as well as R&I trends and technologies that are (or can be) applied to address these issues.

BEG Overview

Biodiversity encompasses the diversity within species, between species, and of ecosystems. It is foundational to the stability and resilience of the planet's natural systems, supporting critical functions such as air and water purification, pollination, climate regulation, and food production. Closely intertwined with biodiversity is **geodiversity**, which refers to the variety of geological, geomorphological, soil, and hydrological features that underpin ecosystem health and sustainability. Together, they constitute essential components of natural capital: the **stock of natural resources and ecosystems** that **humanity depends on for survival and well-being**.

However, this natural capital is undergoing alarming erosion. Global **wildlife populations have decreased by an average of 73% since 1970**, with numerous ecosystems now approaching irreversible tipping points. In Europe, over 80% of natural habitats are currently classified as being in poor condition. Key drivers of this crisis include habitat degradation, the spread of invasive species, overexploitation of natural resources, pollution, and the accelerating impacts of climate change. In particular, species displacement, disrupted ecological interactions, and altered ecosystem functions are all being intensified by changing climate dynamics.

Restoration of ecosystems (including wetlands, rivers, forests, grasslands, and marine environments) has emerged as a crucial countermeasure. Restoration not only enhances climate resilience and contributes to mitigation, but also yields strong socio-economic returns. Studies estimate that **for every euro invested in nature restoration, up to €38 in benefits may be generated**, demonstrating a compelling case for ambitious, timely action.

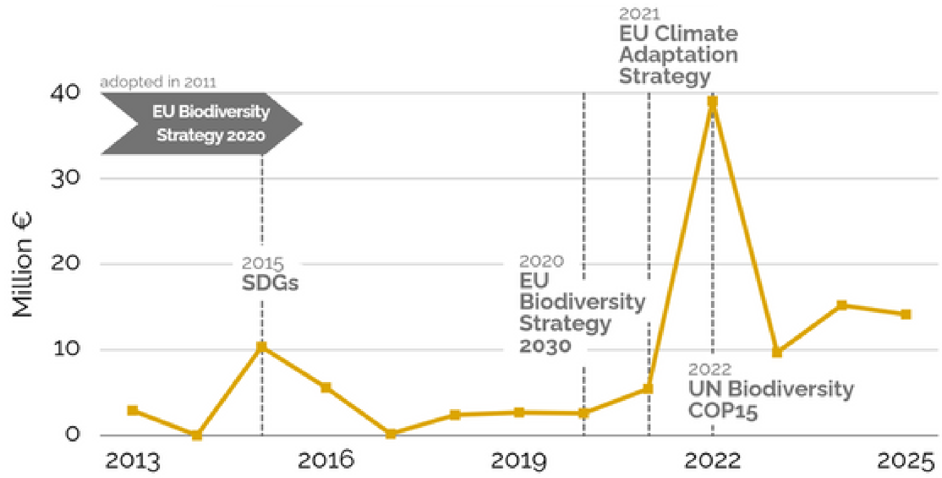
In response to these complex challenges, **geospatial and EO technologies** have become essential tools for **assessing and managing** biodiversity, ecosystems, and geodiversity. These tools allow for the consistent monitoring of environmental changes, support biodiversity reporting obligations, and contribute to the effective implementation of EU strategies. Monitoring biodiversity requires an integrated approach, combining genetic, species, and ecosystem-level indicators, and assessing not only compositional and structural attributes but also functional ones.

EuroGEO, Europe's part of the Group on Earth Observations (GEO), aims to support this evolving landscape through its dedicated **Biodiversity, ecosystems and geodiversity Action Group** (BEG AG), aligning EO assets and biodiversity knowledge with European and global policy goals. Its overarching objective is to enable more effective conservation, restoration, and sustainable use of land and sea, through improved access to high-quality data, technological innovation, and stakeholder engagement.

These efforts contribute directly to **GEO**'s global strategic objectives of sustainable development, climate resilience, disaster risk reduction, and the preservation of biodiversity and ecosystems.

Policy Context

Fig. 1: Evolution of EO R&I BEG Budget (€M) and Key Policy Shifts



EO supports biodiversity conservation by enabling **large-scale monitoring of ecosystems**, habitats, and species, detecting land cover changes, habitat fragmentation, invasive species, and other pressures. EO data provides timely, accurate information for conservation planning, tracking progress toward targets, and meeting national and international reporting obligations.

This growing recognition is reflected in the progressive uptake of EO in BEG-related policy implementation and the upward trend in investments in EO-based R&I. The evolution of this investment over time is shown on the right, based on data collected via the R&I Observatory.

Figure 1 shows European funding for EO-related BEG R&I from 47 EU projects, with policy milestones annotated to highlight links between regulation and investment. Analysis reveals four main application areas: **Ecosystem Assessment and Management** (41 projects, €77.7M), **Biodiversity Monitoring** (10 projects, €19.3M), **Conservation and Protected Area Management** (9 projects, €12.2M), and **Geodiversity and Geomorphology** (3 projects, €1.02M), **totalling €110.2M** in biodiversity-focused EO research and innovation.

At the centre of EU biodiversity policy is the **EU Biodiversity Strategy for 2030**🔗, a key pillar of the **European Green Deal**🔗. Adopted in 2020 to follow the 2020 Strategy, it sets a long-term vision to reverse biodiversity loss and restore Europe's ecosystems by mid-century. The 2030 Strategy has driven funding in the sector, with 30 biodiversity-focused projects launched between 2020–2025, totalling €86.1M. Six of these specifically address biodiversity monitoring, with a combined budget of €16.1M.

The Strategy introduced ambitious restoration and protection targets – most notably, the legally binding restoration goals later formalised through the **EU Nature Restoration Law** (2022)🔗. This law mandates the **restoration of at least 20% of the EU's land and sea areas by 2030**, and all degraded ecosystems by 2050. In this context, EO data plays a pivotal role in establishing ecosystem baselines, measuring restoration progress, and verifying national reporting commitments.

Supporting the Strategy are **targeted instruments and initiatives** providing clear guidance for Member States. These include the **Guidelines on Biodiversity-Friendly Afforestation, Reforestation and Tree Planting**🔗, and the **Guidelines on Old-Growth Forests**🔗, which set a precedent for harmonised monitoring and mapping. The Commission's proposals for a **Soil Health Law**🔗 and an **EU Forest Monitoring Framework**🔗 further reinforce the need for consistent EO-based environmental monitoring. These policies aim to improve **soil quality**, enhance **ecosystem resilience**, and ensure harmonised, **high-quality biodiversity data** – areas where EO offers substantial added value. The Strategy also introduced ambitious restoration and protection targets, most notably the legally binding goals formalised in the EU Nature Restoration Law (2022). This law mandates restoring at least 20% of the EU's land and sea areas by 2030, and all degraded ecosystems by 2050. EO data is pivotal for establishing ecosystem baselines, tracking restoration progress, and verifying national reporting commitments.

In parallel, the **EU Nature Restoration Law** requires all Member States to submit **National Restoration Plans** by mid-2026, detailing how they will achieve the law's targets. EO-based monitoring is expected to play a central role in assessing and verifying these plans, particularly for pollinators, wetlands, peatlands, forest ecosystems, and river connectivity. Since 2021, **five restoration-focused projects** have been launched with a combined budget of €29.1M, directly supporting the law's objectives.

Foundational to the EU's biodiversity protection framework are the **Birds**🔗 and **Habitats Directives**🔗, which underpin the **Natura 2000 network**🔗. The **Habitats Directive (92/43/EEC)** requires Member States to monitor the conservation status of habitats and species (Article 11) and report every six years (Article 17); EO offers an efficient, scalable way to support habitat mapping, species distribution assessment, and conservation trend monitoring.

Policy Context

Complementing this, the **Birds Directive (2009/147/EC)** protects around 500 wild bird species and requires three-year reporting on national implementation. The **INSPIRE Directive (2007/2/EC)** further supports this framework by establishing common standards for spatial data, including Natura 2000 sites.

In addition, the **Birds@Farmland** initiative, launched in 2020 under the Birds Directive, illustrates the shift toward EO-supported conservation. It set up 22 conservation schemes across Europe to tackle farmland bird declines driven by habitat loss from agricultural intensification, pesticide use, and land-use change. Many of these pressures can be monitored via EO, and related R&I projects use satellite and in-situ data to assess habitat quality and species viability. The **CAP 2023–2027** further supports this through eco-schemes that promote biodiversity-friendly practices such as organic farming and agroecology.

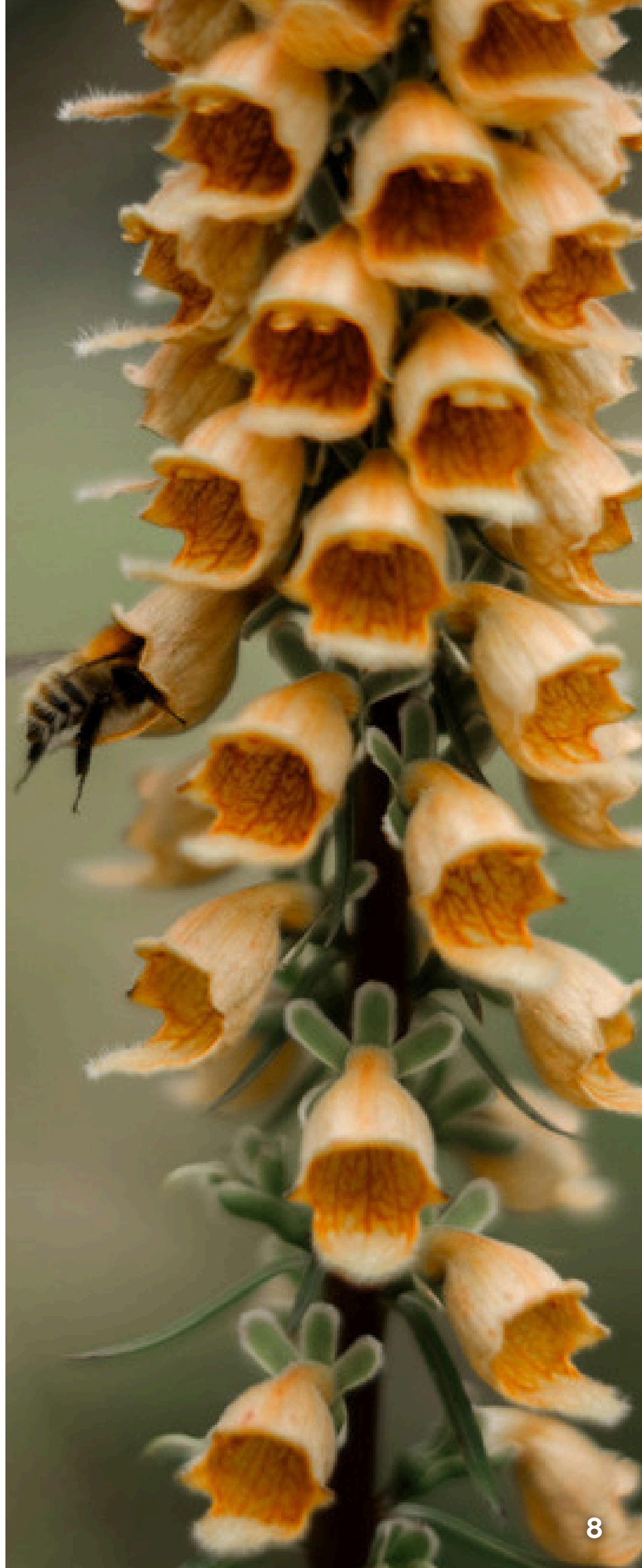
The **EU Biodiversity Strategy for 2030** aligns with the **Soil Strategy for 2030**, which highlights healthy soil functions and monitors indicators such as soil organic carbon and erosion using EO data. The **LULUCF Regulation (2018/841/EC)** sets binding land use and forestry targets, including a 310 million tonnes CO_2 equivalent sink by 2030. Since 2021, eight soil-focused projects with a combined €35M budget have been launched. Both strategies also support broader Green Deal goals, particularly the **2021 EU Adaptation Strategy**, which treats biodiversity loss as urgent as climate change and emphasises its role in climate resilience and ecosystem stability.

The **Marine Strategy Framework Directive (MSFD) (2008/56/EC)** requires Member States to achieve Good Environmental Status of marine waters, with biodiversity as the first of 11 descriptors. EO data – especially from the Copernicus Marine Service – supports implementation through ocean-colour data used to monitor marine biodiversity, eutrophication, and ecosystem health.

Beyond the EU, BEG-related policies are closely linked to international frameworks such as the **Convention on Biological Diversity (CBD)**, established at the 1992 Rio Earth Summit. At COP15, parties adopted the Kunming-Montreal Global Biodiversity Framework with 23 action goals to 2030. The EU has committed to this framework, including the target to protect 30% of terrestrial and marine areas by 2030, mirroring the EU Biodiversity Strategy. EO is also recognised by the CBD as a key enabler for tracking biodiversity trends and global indicators.

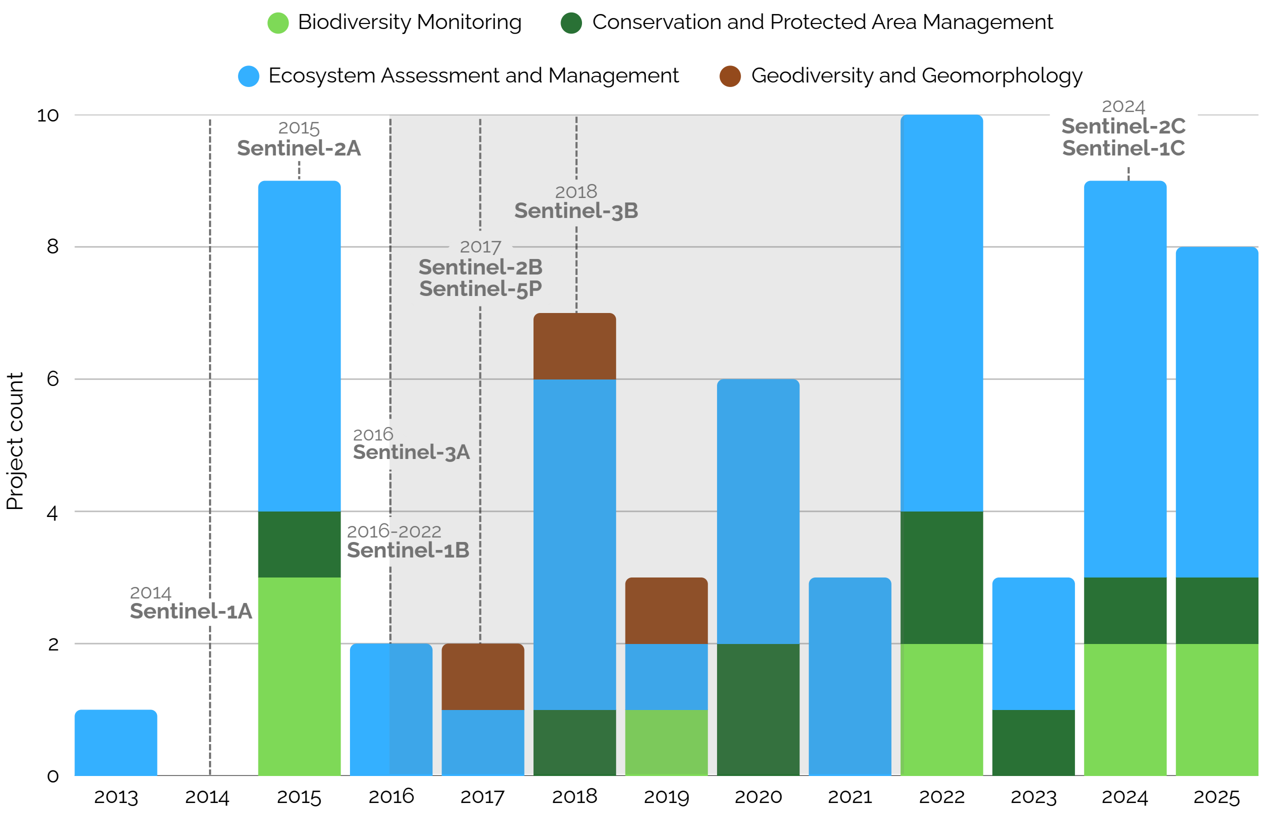
Other global conventions – such as the **UN Convention to Combat Desertification (UNCCD)** and the **UN Framework Convention on Climate Change (UNFCCC)** – also emphasise nature-based solutions for tackling climate change and land degradation. EO is a key tool for monitoring land cover changes, desertification trends, and ecosystem carbon storage.

Given these interlinked policy drivers, EO integration into biodiversity policy is expected to accelerate. Rising data needs, growing policy complexity, and urgent ecosystem challenges increase demand for high-resolution, actionable EO data. Initiatives like EuroGEO are positioned to support evidence-based biodiversity action by aligning R&I investment with EU policy and sustainability goals.



Technological Perspectives

Fig. 2: Biodiversity Project Count Timelines by Application & Sentinel Missions



Technological innovation is progressively transforming the way biodiversity, geodiversity and ecosystems are monitored and managed, with EO playing a pivotal role. While the application of EO for biodiversity is not as immediate or widespread as in climate or agricultural domains, its relevance is steadily growing. Satellite data now underpin many efforts to **assess ecosystem health**, **map habitats**, and **monitor species distributions** and **changes in land cover** at scale.

Within the Sentinel constellation, several satellites are particularly instrumental to BEG monitoring. **Sentinel-1**'s radar capabilities allow for all-weather, day-and-night monitoring, proving especially valuable in **forested, coastal, and wetland ecosystems** that are frequently obscured by cloud cover or impacted by water turbidity. Studies have even shown Sentinel-1's radar backscatter to be comparable to Airborne Laser Scanning (ALS) in capturing forest structure, underscoring its utility for structural habitat analysis. Meanwhile, **Sentinel-2**'s multispectral optical imagery offers high spatial and temporal resolution, enabling fine-scale monitoring of **vegetation dynamics**, **habitat fragmentation**, and **land-use change**. It is widely used in habitat mapping and biodiversity assessment, especially where consistent, repeatable observations are essential.

In addition, the **Sentinel-3** missions serve as precursors to the upcoming **Land Surface Temperature Monitoring (LSTM)** mission (e.g. Sentinel 8), scheduled for launch in 2028🔗, and play a particularly important role in monitoring **marine ecosystems**. Each Sentinel-3 satellite carries three key instruments that systematically observe the Earth's oceans, land, ice, and atmosphere. The data they generate is well-suited for advanced atmospheric correction and radiometric calibration, enabling the reliable production of **biophysical variables and indices** (known as Sentinel-3 Level 2 products)🔗.

Sentinel-5P, equipped with the **TROPOspheric Monitoring Instrument (TROPOMI)**, provides high-resolution data on atmospheric composition and serves as a precursor for future missions in this area. While not designed specifically for biodiversity, its measurements of **pollutants** such as nitrogen dioxide (NO_2), sulphur dioxide (SO_2), ozone (O_3), and carbon monoxide (CO) are highly relevant. These pollutants can harm ecosystems directly or indirectly (for example, nitrogen deposition can lead to soil acidification and eutrophication, disrupting species composition and reducing biodiversity in sensitive habitats)🔗.

Technological Perspectives

Although the link between Sentinel launches and biodiversity projects is less direct than in other EO fields, Copernicus missions – especially Sentinel-2A/B (optical) and Sentinel-5P (atmospheric) – have strongly influenced European biodiversity research. **Forest-related projects rose 217% after Sentinel-2A**, including PANTROP (2019), FORbEST (2025), CabaKarst (2018), and RESTORE4Cs (2023). In the mature Copernicus era (2020–2023), project density **peaked at 4.5 per year versus 1.2 pre-Sentinel**, with ecosystem assessment and management initiatives surging 2022–2025, reflecting the integration of advanced EO capabilities with evolving policies, notably the EU Biodiversity Strategy for 2030.

The **integration of EO data with AI and ML** is accelerating biodiversity monitoring by automating analysis of large datasets, such as daily Sentinel-2 imagery. These approaches enhance detection of ecological changes, map habitat degradation, track species distributions, and support predictive ecosystem modelling and conservation planning.

The **miniaturisation of satellites** and lower launch costs have increased commercial EO data availability. Nanosatellites and CubeSats provide high-resolution, frequent observations, enabling near real-time, localised ecosystem monitoring. At the same time, **EO's integration with IoT** is expanding data collection in remote areas, improving reliability through tools like wildlife tracking collars, anti-poaching systems, and field-deployable air and water sensors.

Ground-based measurements are increasingly complemented by **citizen science (CS)** and **community-based monitoring (CBM) networks**, providing valuable ground-truth data that improve the accuracy, resolution, and context of EO products. CS and CBM contribute significantly to species distribution and population data, especially in Europe, North America, South Africa, India, and Australia. Despite taxonomic and geographic gaps, these networks have strong potential for expansion and integration with satellite observations.

Among the analysed projects, several demonstrate advanced technology and multi-platform data integration, marking a shift toward predictive ecosystem management. For example, the **SPACETWIN project** (€1.5M, 2022–2027) advances forest monitoring through digital twins for optical and microwave radiative transfer modelling, enabling near-real-time analysis of forest disturbances. It is creating the most detailed 3D structural and radiometric forest model to date, covering 57 disturbed sites and roughly 11,500 individual trees using terrestrial laser scanning.

From an AI perspective, the **ZOE project** (€4.0M, 2024–2027) demonstrates the integration of EO with epidemiological modelling and AI to develop frameworks linking biodiversity loss to zoonotic disease emergence. Similarly, the **FORbEST project** (€6.0M, 2025–2029) exemplifies multi-actor innovation in forest ecosystem management, combining stakeholder engagement platforms with real-time EO monitoring to support evidence-based forest policy across Europe.

Despite these advances, challenges remain. **Interpreting EO data** for biodiversity often **requires specialised ecological expertise** and ground validation, while integration and standardisation across sources and platforms can be difficult. Nonetheless, technology is trending toward more accessible, scalable, and intelligent monitoring solutions.

Looking ahead, missions such as **Sentinel-4 and -5** (supporting Copernicus Atmospheric Monitoring Services) and Sentinel-8 (LSTM) are expected to expand data availability for biodiversity monitoring. Advances in AI, cloud computing, and distributed sensor networks will further enhance EO's role in supporting conservation and restoration, enabling data-driven responses to the biodiversity crisis with greater precision and effectiveness.

Fig. 3: Budget Distribution for EO-Related R&I in Biodiversity

Growing global awareness of biodiversity loss and ecosystem degradation is increasingly influencing market dynamics, investment flows, and regulatory frameworks. As biodiversity rises to the top of international agendas – reflected in mechanisms such as the **EU Biodiversity Strategy for 2030** and global initiatives like the **Kunming-Montreal Global Biodiversity Framework – EO is emerging as a key enabler** for tracking, assessing, and safeguarding natural capital.

According to the 2024 EUSPA Market Report, ecosystem monitoring already represents a substantial share of the overall EO data and services market in the environmental domain. Out of an estimated **€700 million** in total annual revenues from EO across climate, environment, and biodiversity applications, approximately **25%** is generated by **ecosystem monitoring** alone, highlighting a growing demand for spatially explicit, timely, and reliable ecological data 🔗. This market evolution toward commercial-grade products is exemplified by the **DIABOLO** project 🔗 (€5 million, 2015-2019), which demonstrates the transformation of research capabilities into integrated information systems for bioeconomy applications. By creating distributed, integrated and harmonised forest information systems, DIABOLO represents the shift toward standardized, interoperable data products that meet market demands for comprehensive ecosystem monitoring solutions tailored to economic decision-making.

A notable trend is the **increasing integration** of EO data into **financial and disclosure frameworks**. The **Taskforce on Nature-related Financial Disclosures** (TNFD), for instance, is catalysing the development of nature-related risk and impact assessments for companies and investors. This has spurred demand for geospatial services capable of quantifying ecosystem dependencies, pressures, and changes. New market entrants (e.g. SMEs, specialised service providers) are responding by offering EO-based analytics tailored to financial actors seeking to meet emerging environmental, social, and governance (ESG) expectations. The **NATURE-FIRST** project 🔗 (€4.5 million, 2022-2025) exemplifies this trend toward intelligent platforms for compliance and conservation through its innovative use of forensic intelligence and advanced remote sensing technologies. The project's focus on nature conservation enforcement demonstrates how AI-driven approaches can create market-ready solutions that directly address the needs of policy makers and private sector stakeholders navigating environmental compliance and nature-related risk assessments.

Market Trends

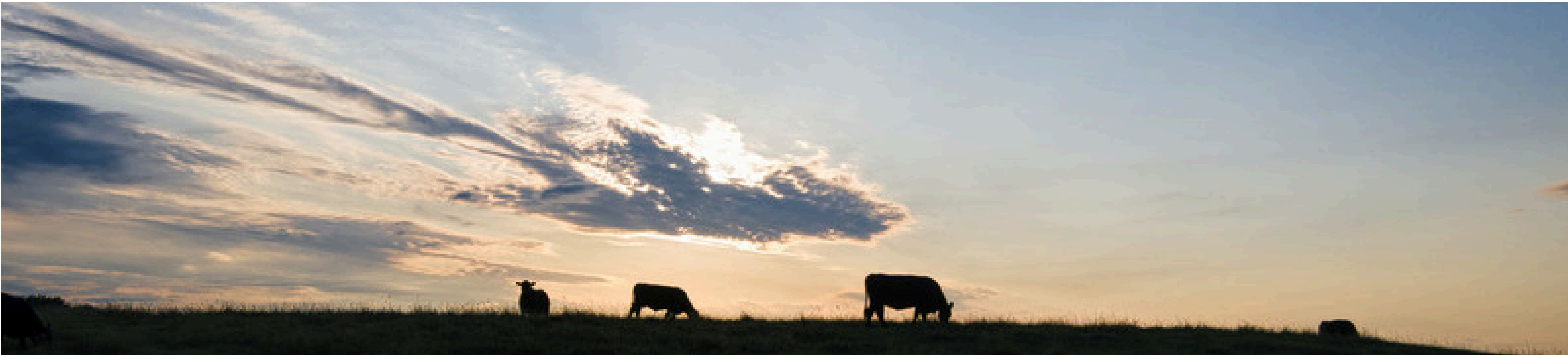
Another nascent but potentially transformative trend is the **rise of the biodiversity credits market**. Although still in its infancy, EO is expected to play a central role in enabling the monitoring, reporting, and verification (MRV) of biodiversity outcomes, crucial for ensuring transparency, credibility, and scalability of nature-based investments. Projections from the World Economic Forum suggest that under an ambitious scenario, demand for biodiversity credits could reach **$2 billion by 2030**, scaling up to **$69 billion by 2050**. Even under more moderate conditions, demand could grow to $760 million by 2030 and $6 billion by 2050, signalling a potentially major EO-supported market for ecosystem services and restoration🔗.

Figure 3 illustrates the share of EO-related revenues in the environmental domain, highlighting the growing economic relevance of ecosystem assessment and management relative to other applications such as biodiversity monitoring.

Our data show that approximately **70%** of the total funding is directed toward projects focused on **ecosystem assessment and management**. In comparison, **less than 18%** goes to **biodiversity monitoring**, **11%** to **conservation and protected area management**, and **under 1%** to **geodiversity and geomorphology**. These funding shares are reflected in the per-capita funding allocated to each application areas. When comparing the share of funding to the number of projects, we find that the average funding per project is fairly consistent between biodiversity monitoring and ecosystem assessment and management. However, **projects** focused on **conservation and protected** areas receive, on average, about **three-quarters** of the funding allocated to the other two categories. Notably, **geodiversity and geomorphology** not only have the fewest projects but also receive significantly less funding per project, highlighting a clear underinvestment in this area.

As data users expand beyond traditional environmental agencies to include private investors, insurers, asset managers, and ESG data providers, the **BEG EO ecosystem is becoming more diversified**. This shift is opening opportunities for start-ups and SMEs to offer bespoke services in habitat mapping, ecosystem trend detection, and biodiversity impact forecasting.

In the coming years, as biodiversity regulations tighten and market incentives for ecosystem stewardship mature, EO will become increasingly embedded in value chains that link environmental integrity with economic performance. Investment in data infrastructure, MRV protocols, and cross-sectoral integration will be essential to fully unlock EO's potential in the BEG domain. This infrastructure investment is becoming commercially viable, as demonstrated by the **FORWARDS** project🔗 (€14.6 million, 2022-2027), which establishes the ForestWard Observatory as a prototype for observatory-based business models in forest monitoring. By combining ground-based networks with remote sensing across over 50 demonstration sites and dedicated grant calls for third-party implementation, this project illustrates how large-scale monitoring infrastructure can support both local management decisions and regional policy implementation, creating scalable solutions that link environmental integrity with economic performance.



Projections

Biodiversity monitoring is entering a **transformative phase**, driven by growing global concern, new policy initiatives, and emerging markets centred on the provision of environmental data. According to the EO and GNSS Market Report, demand for biodiversity-relevant EO services is expected to grow substantially, fuelled by **conservation and restoration efforts**, **regulatory frameworks**, and increasing financial mechanisms such as **biodiversity credits**. A new market is emerging around ecosystem monitoring services, with EO positioned as a key enabler in supporting reporting obligations, land management, and nature-based solutions.

Advancements in satellite missions will play a critical role in this shift. **Future EO missions** are expected to deliver higher spatial, temporal, and spectral resolution, expanding capabilities for biodiversity monitoring. These improvements will support **more refined indicators**, enable change detection at **local scales**, and enhance **early-warning systems** for ecosystem degradation. A clear example is the use of Sentinel-2 data to monitor bleaching events in Australia's Great Barrier Reef under ESA's Sen2Coral project, which enables 3D mapping and continuous health assessments of coral reef ecosystems – an approach that could be replicated globally as EO technology evolves. Another example, listed in our database, is the **SAV-EO project** (€225K, 2022-2024), focused on developing EO-based early warning systems specifically for savannah degradation monitoring.

At the same time, **integration with advanced digital technologies** is accelerating. AI and ML are increasingly used to process and analyse vast EO datasets, offering scalable solutions for species mapping, land cover change detection, and habitat modelling. IoT is also opening new frontiers in real-time environmental sensing, which, when combined with EO, can deliver **more holistic ecosystem insights**.

Environmental and conservation centres are progressively incorporating EO services into their standard practices, both to improve monitoring accuracy and to comply with new policy requirements. Parallel to this, **CS and CBM networks are expanding**, contributing ground-truth data that complements EO and strengthens public engagement. These participatory approaches, already showing strong contributions to species distribution and abundance data, are expected to become increasingly integrated with EO platforms, improving data quality and fostering **broader ecological awareness**.

Together, these developments point to a future in which biodiversity monitoring is more comprehensive, automated, participatory, and policy-aligned, driven by the synergies between EO, technological innovation, and citizen engagement.

EuroGEO Contribution

EuroGEO's **inclusive, interdisciplinary approach** – linking science, policy, and practice – positions the Biodiversity, Ecosystems, and Geodiversity Action Group (BEG AG) to support Europe's biodiversity monitoring and ecosystem management. Since relaunching at the 2022 Athens Workshop, the BEG AG has worked to connect fragmented expertise and build synergies among projects and monitoring initiatives. A follow-up meeting at the 2023 Bolzano Workshop strengthened this vision and initiated collaborations, including a review paper on biodiversity–geodiversity linkages .

EuroGEO can help address **key gaps** in biodiversity monitoring, such as limited integration of geodiversity in ecosystem assessments, inconsistent use of remote sensing for restoration tracking, and underuse of EO by authorities and practitioners. By **convening stakeholders**, it can advance Essential Biodiversity and Geodiversity Variables, promote standardised EO-based monitoring, and support co-designed, scalable indicators for conservation and restoration.

A key conservation challenge is the **underrepresentation of geodiversity** and the limited use of EO for monitoring restoration, protected areas, and species distributions, often due to **gaps in capacity, data integration, and standardisation**. EuroGEO can help by coordinating harmonised methods for observing biodiversity and geodiversity Essential Variables and by combining EO with in-situ data to track change across scales. The **BACI project** (€3.3M, 2015–2019) illustrates this approach, integrating multiple EO sources into a Biosphere Atmosphere Change Index to detect ecosystem and biodiversity change and support scalable monitoring.

Building technical capacity is essential. EuroGEO BEG can support this through training, co-design with policymakers and practitioners, and standardised indicators and workflows that ensure interoperability and consistent monitoring. **Linking EO more closely with ecosystem modelling** can improve understanding of biodiversity–geodiversity dynamics and inform timely decisions. At a wider scale, EuroGEO can **align efforts with global frameworks** such as the post-2020 Global Biodiversity Framework and the UN Decade on Ecosystem Restoration, while **helping scale EO from research to operations**. Integrating Sentinel-2 and Sentinel-5P data with AI, alongside citizen science and community-based data, could enable near real-time tracking of environmental pressures and ecosystem health.

In conclusion, EuroGEO BEG plays a key role in **advancing integrated, evidence-based** ecosystem monitoring and conservation. By linking geodiversity and biodiversity in shared observation frameworks and combining EO, in-situ data, and modelling, it can support the EU Biodiversity Strategy for 2030 and wider Green Deal goals. This work is vital for building the capacities needed to protect Europe's natural heritage amid accelerating environmental change.

Glossary

AI	Artificial Intelligence
ALS	Airborne Laser Scanning
BEG	Biodiversity, Ecosystems, and Geodiversity
BEG AG	Biodiversity, Ecosystems, and Geodiversity Action Group
CAP	Common Agricultural Policy
CBM	Community-Based Monitoring
CBD	Convention on Biological Diversity
CS	Citizen Science
CAMS	Copernicus Atmospheric Monitoring Services
EBVs	Essential Biodiversity Variables
EGD	European Green Deal
EGVs	Essential Geodiversity Variables
EO	Earth Observation
ESA	European Space Agency
EU	European Union
EUSPA	European Union Agency for the Space Programme
ESG	Environmental, Social, and Governance
EVs	Essential Variables
GEO	Group on Earth Observations
GNSS	Global Navigation Satellite System
IoT	Internet of Things
INSPIRE	Infrastructure for Spatial Information in the European Community
LSTM	Land Surface Temperature Monitoring
LULUCF	Land Use, Land Use Change and Forestry
ML	Machine Learning
MRV	Monitoring, Reporting, and Verification
RIO	R&I Observatory
R&I	Research and Innovation
SDG	Sustainable Development Goal
SME	Small and Medium-sized Enterprise
SO_2	Sulphur Dioxide
TNFD	Taskforce on Nature-related Financial Disclosures
TROPOMI	TROPOspheric Monitoring Instrument
UN	United Nations
UNCBD	United Nations Convention on Biological Diversity
UNCCD	United Nations Convention to Combat Desertification
UNFCCC	United Nations Framework Convention on Climate Change
WWF	World Wide Fund for Nature
NO_2	Nitrogen Dioxide
O_3	Ozone
CO	Carbon Monoxide

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