European Commission

JRC CONFERENCE AND WORKSHOP REPORT

KCEO Stakeholder Workshop on Biodiversity and Earth Observation

Summary of the interventions

KCEO Secretariat

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Abstract

The Knowledge Centre on Earth Observation (KCEO) aims to maximize the uptake of products and information from Earth Observation (EO) to support European Union (EU) Policies and to establish best practices to translate EU policy needs into concrete requirements for EO products and services.

In this respect, KCEO runs thematic assessments ("deep dives") analysing EU policy needs in selected policy domains with the ambition to verify how and to what extent existing EO products and services meet these needs, highlight existing gaps and provide recommendations on future evolution of products and services.

The first deep dive assessment has been on EO and biodiversity and, as part of the process, a Stakeholder Workshop was organised by KCEO on November 16th, 2022. The workshop was intended to present the findings of the deep dive assessment and meet with representatives from technical implementing entities and partners associated with Copernicus, EU Member States institutions and agencies, the research community and the private sector. It was meant to discuss which EO products and applications are available from Copernicus to support EU policy needs regarding biodiversity, but also what existing technologies and opportunities are available outside Copernicus to address those needs.

The outcomes of the workshop provided inputs for the biodiversity deep dive assessment and are summarised in this report.

Acknowledgements

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1 Introduction

Speakers: Ivan KULIS – Head of Unit JRC D.6, Mauro FACCHINI– Head of Unit DG DEFIS C.3

The European Commission Knowledge Centre on Earth Observation (KCEO) ([1]) aims to provide an efficient internal coordination mechanism inside the EU Commission to maximise the uptake of products and information from Copernicus to support EU Policies in various sectors. It would establish best practices in efforts to translate policy needs into concrete requirements for products and services, provide a Forum for dialogue with the technical implementing entities associated with Copernicus, and raise awareness on next-generation Earth Observation (EO) science and associated technologies to enhance the exploitation on Copernicus throughout the policy cycle.

The KCEO has proposed a series of thematic deep dive assessments starting from 2022, to address specific EU policy needs. The first Deep Dive on Biodiversity aims at investigating how (in-situ and space) EO products and services can be used in monitoring biodiversity assessment. This study is currently analysing EU policy needs in the biodiversity domain with the ambition (1) to verify how and to what extent existing EO products and services meet these needs, (2) to highlight existing gaps and (3) to provide recommendations on future evolution of products and services.

The KCEO Deep Dive on Biodiversity Stakeholder Workshop presented the preliminary findings of the deep dive assessment and brought together representatives from Copernicus Entrusted Entities and Partners, EU Member States (MS) institutions and agencies, the research community and the private sector. The panel discussions developed around EO products and applications available within the Copernicus programme, and discussed what existing technologies and opportunities are available outside Copernicus to support policy needs in the context of biodiversity.

[1] https://knowledge4policy.ec.europa.eu/earthobservation_en

2 KCEO Activities and Implementation

Speakers: Richard GILMORE - DG DEFIS & KCEO, Mark DOWELL - JRC KCEO

The 2016 Space Strategy for Europe ([2]) mandates the EU Commission Copernicus Programme to encourage the uptake of the use of EO for EU policy: "The Commission will thus encourage the use of space services, data and applications in EU policies whenever they provide effective solutions [...] the Commission will promote the uptake of Copernicus, EGNOS and Galileo solutions in EU policies where justified and beneficial..." The KCEO created in 2021 and co-chaired by JRC and DG DEFIS, responds to the necessity of a dedicated mechanism to support the uptake of EO in support of EU policy using the Copernicus Programme to its full potential. Important for the current Copernicus uptake framework, duties and responsibilities are shared among different actors in a broad landscape of EO activities:

- Member States (MS): Copernicus User Forum (FPCUP), MS needs (Core Users)
- Copernicus Entrusted Entities/Services: ECMWF, Mercator Ocean, EEA, EMSA, Frontex, SatCen, JRC, EUMETSAT and ESA - link to their own thematic users
- European Union Agency for the Space Programme (EUSPA) and the Cassini Space Entrepreneurship Initiative: Uptake by Other Users (private sector)
- KCEO: Focus on EU policy uptake for core Users inside the Commission, namely the policy DGs

The KCEO is a forum of discussion for the Commission Directorates-General (DGs), and it allows to identify their complementary needs for policymaking and contributing to policy-coherence. The KCEO network includes external actors and stakeholders, and it is built on two main pillars (1) Policy Uptake and Coherence, and (2) Mainstreaming R&I for EO. The first pillar focuses on how to best enable policy uptake of EO data throughout the policy cycle and to analyse where EO can support policy coherence. Joint initiatives led by DEFIS and JRC namely Steering Committee meetings including the relevant Services of the EU Commission to define the overall KCEO strategy, Working Groups involving representatives of the Commission's DGs, Copernicus Entrusted Entities (EEs) and partners working on aspects related to Research and Innovation priorities for EO and on Data System and Interfaces. Moreover, the KCEO provides opportunities for dialogue with the broader EO communities through specific workshops/conferences.

One of the activities of the first pillar of KCEO are the deep dive assessments, i.e., thematic studies analysing EU policy needs of selected policy domains with the ambition to verify how and to what extent existing EO products and services meet these needs, to highlight existing gaps and to provide recommendations on future evolution of products and services. The KCEO identified 28 relevant policy areas of interest around which developing deep dives also aiming to provide assessments and ad-hoc support for specific pieces of legislation and upcoming proposals. In this context, the thematic area of biodiversity was chosen to elaborate the first pilot study. The policy areas chosen for the deep dives are agreed with the policy DGs prior to the development of the 2022-2024 Deep Dive roadmap including biodiversity (first pilot 2022-2023), Climate Change Adaptation with a focus on urban areas (in 2023), Compliance Assurance (in 2023). Other topics under discussion as possible focus for deep dives in 2024 include Cultural and Natural Heritage, Sustainable Development Goals (SDGs), Energy, Raw Materials, Health. Building on previous experience of Copernicus Services, needs and requirements are structured into a User Requirement Database to guide the deep dive assessments. The EO value chain is applied to each specific study, and it follows four main steps. (1) The identification of decision-making needs; (2) the study of what applications and services are required to provide support; (3) the assessment of needed data products, and (4) the analysis of sensing capabilities required to underpin long-term products and services including both Copernicus and contributing missions. Importantly, the fitness for purpose carried out for each of these assessments is essential to provide information on the implications for future evolution. The second pillar focuses on where EO can incentivise research and innovation activities and programmes. EO is a dynamic field of research and the availability of new technologies and methods for sensing, data-processing and analysis contributes to better support policymaking. There are many relevant R&I investments across the Commission's programmes including Horizon 2020, Horizon Europe (HE), Copernicus Evolution, Destination Earth, and JRC institutional work programme. Within this frame of reference, the KCEO aims at addressing three key areas and it should (1) give visibility and policy traceability to EU Research Investments on EO, (2) establish a longer-term Strategic Research Agenda for EO to help the guidance and prioritisation EO capacities and programmes, (3) facilitate the mainstreaming of EO research in thematic areas of research programmes.

[2] COM(2016)705

3 Biodiversity Policy Context: the EU and the Global Dimensions

Speakers: Camino LIQUETE, Grégoire DUBOIS - JRC KCBD

The Knowledge Centre on Biodiversity (KCBD) ([3]) is currently working to support the implementation of the EU Biodiversity strategy (EUBDS) for 2030 ([4]) which is the overarching structure to foster the implementation of all activities contributing to meet biodiversity targets, to enable transformative change, and to contribute to the ambitious global agenda on biodiversity. In order to do this, the KCBD is proposing and collecting specific indicators linked to each target of the Strategy. The KCEO and the KCBD are working in synergy to propose and elaborate indicators that can be supported by EO and Remote Sensing (RS). These indicators will be useful to inform policymaking and to support the Commission in reporting on the progress of the EUBDS, e.g., the assessment of biodiversity governance assessment (in 2023), and the implementation progress review of the EUBDS for 2030 (in 2024) led by DG Environment.

Objectives of the new EU Biodiversity governance: (1) engagement and co-responsibility of key players (e.g., the Commission expert groups and other bodies), (2) Transparent progress tracking and corrective action (i.e., using tracking tools), (3) Knowledge based policy (e.g., through KCBD R&I programmes), and (4) resources and capacities (e.g., financial commitments, Integration across EU instruments). The main activities of the KCBD are (1) to develop tools to track progress on the implementation of the EUBDS for 2030; (2) to highlight interlinkages between policies on complex topics related to biodiversity; (3) to orchestrate ad-hoc replies to specific and urgent policy needs; (4) to act as a knowledge broker between research and policy making.

3.1 Online tracking tools for the EU Biodiversity Strategy for 2030

The KCBD is mandated to develop a tracking tool ([5]) and a EUBDS for 2030 dashboard ([6]) where suitable indicators are published and made available to the public. Currently, there are 7 indicators to inform 4 out of the 16 targets of the EUBDS. The KCBD will support the tracking and reporting of progress of EU and its MS on actions and targets of the EUBDS for 2030.

The list of candidate indicators is maintained and regularly updated by the KCBD Secretariat. The network composed of EEA, EUROSTAT and JRC, as well as a number of researchers, presents inputs to identify the link between the EUBDS for 2030 targets and available indicators. The most relevant and developed indicators are thus presented and discussed within the EU Biodiversity Platform Monitoring and Assessment Working Group. Following, the indicators are scrutinised by the EU Biodiversity Platform Expert Group: if the indicators would be approved, the collection of indicator values and documentation process would start, and eventually the selected indicators would be published in the online dashboard.

3.2 The Global Dimension: The Global Knowledge Support Service for Biodiversity (GKSSB)

KCBD is currently studying the potentials for global biodiversity targets, and it is contributing to the identification of a suitable platform for the EU Nature Restoration Law ([7]) indicators. The EC contributed to the launch of the Global Knowledge Support Service for Biodiversity (GKSSB) ([8]) during COP15 (proposal submitted in March 2022). GKSSB is a service to support parties and stakeholders' implementation of the Post-2020 Global Biodiversity Framework (GBF), and it is an initiative of the EU and UNEP to support the monitoring, reporting and reviewing progress towards the global goals and targets ([9]). The draft Post-2020 GBF has 21 action targets for 2030 to be assessed and monitored. JRC is expected to contribute to the scientific and technical developments of a global platform and EO shall play an essential role in this process. Importantly, there is a need for better integration, support, coherence, coordination of existing tools, standardised products to deliver results and support policies at a global scale. In this context, capacity building for EO use is necessary to help parties to report on biodiversity targets at local, national and global scales, and to foster collaboration among all contributing actors.

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(3) https://knowledge4policy.ec.europa.eu/biodiversity_en
(4) COM(2020) 380 final
(5) https://dopa.jrc.ec.europa.eu/kcbd/actions-tracker/
(6) https://dopa.jrc.ec.europa.eu/kcbd/dashboard/
(7) COM(2022) 304 final
(8) https://gkssb.chm-cbd.net/
(9) CBD/SBI/REC/3/10 available at: https://www.cbd.int/doc/recommendations/sbi-03/sbi-03-rec-10-en.pdf

4 KCEO Deep Dive on Biodiversity: Methodology and Preliminary Results

Speaker: Andrea CAMIA, JRC KCEO

The aim of the deep dives in KCEO is to identify and analyse policy needs in a defined policy area and across the whole policy cycle, to verify that these are being met, to present available EO products and their features and highlight existing gaps, providing recommendations on how to address these. The deep dive on biodiversity has been developed as a first exercise and it served as pilot to test the methodology.

Actors involved in this exercise:

- DG DEFIS, JRC-KCEO, JRC-KCBD
- EU Commission DGs: ENV, CLIMA, REGIO, INTPA, MARE, AGRI, EUROSTAT, RTD, CONNECT
- Copernicus Entrusted Entities (EEs) and Copernicus Services
- External experts and stakeholders

4.1 Deep dive methodology

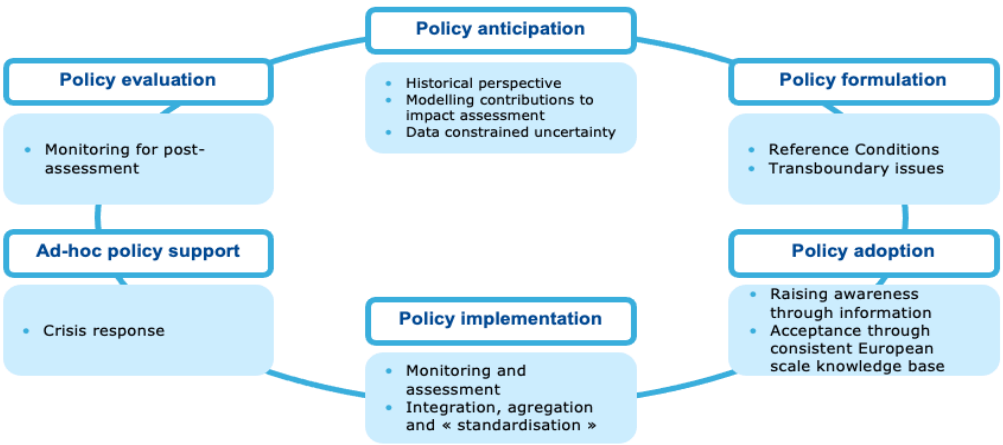
The following steps are addressed in a deep dive:

- Assessment of policy context and needs
- Earth Observation Value Chain
- Translation of needs into technical requirements
- Fit-for-purpose of existing solutions
- Gap analysis and recommendations

1. Assessment of policy context and needs

The aim is to understand the key areas of EO interest in the EU policy files related to biodiversity and at what stage of the policy cycle further EO support would be needed. The data collection methods includes general consultations, workshops, interviews and questionnaires to identify (a) what is the question to address in the policy arena and how EO products and services can support/facilitate the policy uptake; (b) policy context; (c) needs across the entire policy cycle; (d) preparedness of users towards EO; (e) current and past EO practices/applications; (f) obstacles/constraints; (g) type of assessments needed; (h) direct or integrated use of EO products and services; (i) type of support needed (Commission and/or Member States services, timing, duration, relevance, ...). The outcomes are compiled into ad-hoc Use Cases to develop and inform specific policy needs.

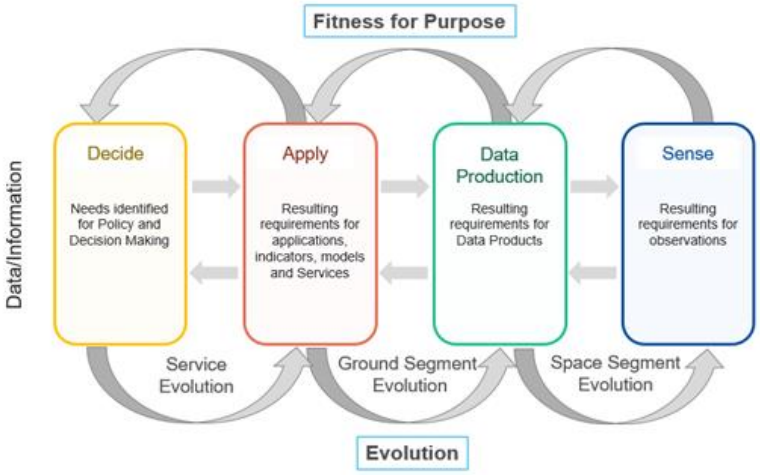
Figure 1. Policy cycle



2. Earth Observation Value Chain

The four key steps of the EO value chain are assessed focusing on those cases where policy needs are met through specific requirements/features of EO products. The process aims to define best practices in the translation of users' needs into quantitative requirements, to review existing practices, and to define whether existing EO products and services are fit for purpose.

Figure 2. EO Value Chain



3. Translation of needs into technical requirements

The policy needs emerging from the use cases are translated at this stage into technical requirements for EO products and services.

4. Fitness for purpose of existing solutions

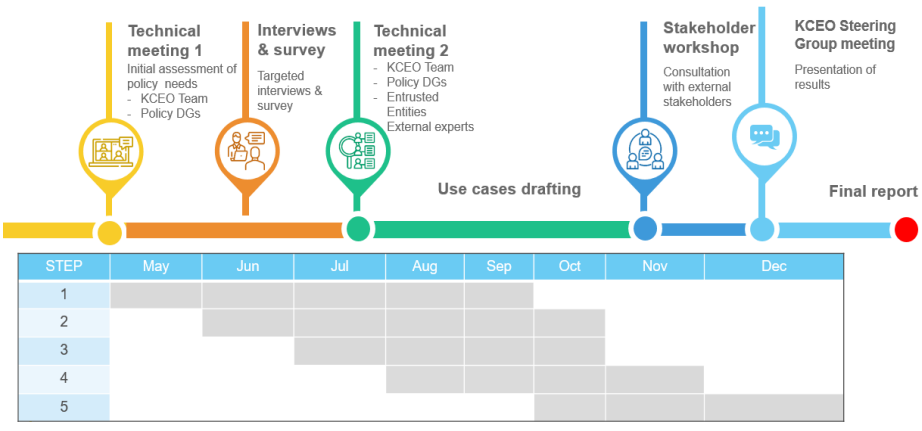
The fitness-for-purpose assessment focuses on existing EO products, services, infrastructure, capacities with respect to expressed needs and related technical requirements. The assessment could consider what is made available beyond Copernicus by other space agencies and providers, considering the accessibility of the products and the capacity for uptake of the different DGs.

5. Gap analysis and recommendations

The final step consists in a gap analysis highlighting current gaps of the observation capacities and in formulating recommendations for evolution. Such recommendations should suggest priority requirements and possible improvements for the ground and space segments, services, infrastructures and R&I investment.

4.2 Timeline

Figure 3. Biodiversity Deep Dive Timeline



4.3 Use Cases

The deep dive methodology is policy-driven and it focuses on current EC DGs' policy needs to understand how EO can support EU policies at the present-day stage and in the future. The analysis is organised into "use cases" to focus on specific biodiversity related aspects[10]. The synergies and coherence emerged across the different policy DGs and they contribute to better connect the assessment.

4.3.1 Monitoring the EU Biodiversity Strategy for 2030

Indicators are being discussed for tracking and reporting progress of EU and MS towards the targets of the EUBDS for 2030. The list of candidate indicators is based on the contributions from EEA, EUROSTAT and JRC and these are being developed for each one of the 16 targets of the EUBDS for 2030. A proposal of the most suitable indicators is shared and discussed with the subgroup on "Monitoring and Assessment" of the EU Biodiversity Platform (EUBP) twice a year.

In the context of the deep dive on biodiversity, the potential contribution of EO to the assessment of the indicators is being assessed. The preliminary results of this study suggest that a number of EU biodiversity targets could be monitored with the help of EO products and services, including targets related to marine and terrestrial protected areas, nature restoration, agriculture, and loss of nutrients.

4.3.2 DG MARE (1) – Monitoring marine biodiversity supporting Marine Protected Areas (MPAs)

The Use of EO products and services would be used to complement existing data collection frameworks for the assessment of environmental conditions and changes in MPAs. EO would also support the spatial and temporal distribution/abundance of marine species and their biodiversity dynamics in the oceans associated to the tracking of human activities, of pressures and impacts (i.e., fishing fleets and gears, offshore windfarms) within and around MPAs.

4.3.3 DG MARE (2) – Monitoring essential fish habitats and vulnerable marine ecosystems to support an ecosystem-based approach

The use of EO would be employed to support the identification and mapping of Vulnerable Marine Ecosystems (VME) and Essential Fish Habitats (EFH) which are increasingly integrated in EU fisheries management plans. EO would contribute to the promotion, monitoring and assessment of VME and EFH's evolution through time according to management measures (e.g., Target 15 of the EUBDS for 2030). For this, EO and in-situ data are pivotal to support the identification and mapping as well as the monitoring and assessment of their evolution through time.

4.3.4 DG REGIO – Monitoring ecosystems health to support biodiversity investments

To implement the use of EO data for EU wide assessment of ecosystem conditions and degradation to support the allocation of regional funds on nature restoration projects according to the Cohesion Report, as well as to monitor any detectable impact of local funded projects on ecosystem conditions. Specifically, this use case addresses the support of remote sensing biodiversity products with in-situ data to map ecosystems, their conditions and evolution over time, identifying degraded areas where funding is justified and linking ecosystems' changes to the targets and outcomes of funded projects.

4.3.5 DG ENV (1) – Monitoring key habitats for biodiversity with a focus on wetlands

The is a need of an interactive online platform to monitor wetlands in Europe and to support the detection and classification of wetland ecosystems, the identification of hotspots of changes/degradation, the provision of site-specific details and evolution over time (yearly) by experts and local authorities would play a key role to gather this type of information. The use case has identified a number of key requirements including long-term monitoring of trends, a yearly/seasonal monitoring would work best, the tracking of humid habitats (beyond Natura 2000 sites) would be useful when coupled with land cover mapping, surface water and soil moisture indicators.

(10) The summary description of the use cases in this report is to be taken as work in progress.

4.3.6 DG ENV (2) – Monitoring of Urban Green Spaces

EO products and services may contribute to the monitoring of urban green areas in the EU to track the progress of Nature Restoration Law targets on urban greening, also identifying different types of green areas to map. The monitoring would support the development of urban green areas in cities, towns and suburbs, and it would be achieved through the implementation of high spatial resolution and very high spatial resolution mapping and updated every three years (or annually).

4.3.7 DG CLIMA – Regular assessment and monitoring of EU forests health conditions

Will forests be able to maintain their services in a changing climate? The study identified a link between forest biodiversity and climate resilience to inform adaptive forest management. Thus, EO would be useful to assess forest health and resilience to climate change, to monitor forest ecosystem services in a changing climate and effects of growing disturbances on forestry biodiversity indicators at stand or landscape level (i.e., Indicators for forest disturbances, ecosystem structure and functions).

4.3.8 DG AGRI – Biodiversity monitoring in agriculture landscape

EO products and services may contribute to the high-resolution mapping of landscape features (e.g., buffer zones, rotational or non-rotational fallow land, hedges, non-productive trees, terrace walls, and ponds) in rural areas with potential support to maintain biodiversity to inform CAP landscape-level indicators.

4.3.9 DG INTPA – Biodiversity monitoring in Key Landscapes for Conservation (NaturAfrica)

In the context of the EU NaturAfrica initiative, which supports biodiversity conservation in Africa, EO products and indicators would be used to monitor biodiversity in Key Landscapes for Conservation (KLC) sites. The identification of KLC where ecosystems and wildlife would be further supported by EO products such as HR land cover and land cover change, biodiversity indicators (Lead Area Index (LAI), biomass, vegetation dynamics) with a regular update every 3 to 5 years.

5 Panel Discussions

The panels brought together the stakeholder community that actively contributes to provide relevant data and research that could be relevant to the Biodiversity Deep Dive. The speakers presented how their products are contributing to EO products and services for biodiversity.

5.1 Contributions from Copernicus Services and Partners

Moderator: Mark DOWELL, JRC - KCEO

The aim of this session was to bring together the Copernicus services and implementing partners in the Programme connected to the Biodiversity Deep Dive.

5.1.1 Usue DONEZAR, European Environment Agency Copernicus Land Monitoring Service (EEA CLMS)

EEA CLMS provides products for the European and Priority Areas monitoring frame, namely Urban Atlas, Riparian Zones, N2K, Coastal Zones, the CLC & CLCC, High Resolution Layers, Biophysical parameters and the European Ground Motion Service.

The EEA is also entrusted with the maintenance and update of the EU-DEM and EU-Hydro, and with the creation and distribution of the mosaic based on VHR optical images (2-5m pixels). Currently, the EEA CLMS addresses only terrestrial and freshwater biodiversity. However, within the Thematic Hub on Biodiversity, the EEA will also include products related to marine biodiversity. The Thematic Hub is considered as an opportunity to improve BISE ([11]). The outcomes of KCEO Biodiversity Deep Dive are considered key inputs for the Thematic Hub as they cover main EU policy areas related to biodiversity which will be addressed by the Thematic Hub.

Contributions to the use cases

- The EEA is responsible for the development of Thematic Hub on Biodiversity (currently at its earlier stages), and it is now working on the development of the Copernicus Land Data Store to make sure that data will be accessible. In general, the concept of the "Thematic Hub" is the single-entry point for data access and therefore it does not entail the development of new products
- With the evolutions of the services and capacity building, products are gaining complexity, and this might entail that they are becoming more difficult to use. In this context, the fit-for-purpose assessment of the Use Cases approach is valuable
- EEA is working on the Land-Use, Land-Use Change and Forestry (LULUCF) derived from the CORINE Land Cover ([12]). CLC is also used to map EU habitats. EEA products could be used as inputs for species mapping although, currently, there is no species mapping assessment
- EEA is working on the Nature Restoration Law, particularly regarding urban and forest monitoring
- EEA is responsible for the cross-cutting coordination of Copernicus access of in-situ data. EEA is working on how to obtain more biodiversity related in-situ data and how to make them accessible. This need has been expressed also by MS during the Copernicus User Forum

Contributions to Research & Development

- There is a need to further complement EO and in-situ data for validation and verification
- Targets on the Nature Restoration Law Framework present a challenge to increase the mapping extent including semi-natural habitats e.g., extensive grazing (not focusing only on PAs)

[11] https://biodiversity.europa.eu/
[12] https://land.copernicus.eu/pan-european/corine-land-cover

5.1.2 Nadine GOBRON, JRC Copernicus Land Monitoring Service (CLMS) Global

The Copernicus Global Land Service ([13]) components (2014-2017) includes:

- Biophysical Variables ([14]) and Land Cover (CGLOPS): 23 biophysical variables: vegetation, cryosphere, energy, water at four resolutions: 100m, 250/300m, 500m, 1km
- Land Cover Forest Monitoring (LCFM) (public in 2023)
- Ground Based Observations for Validation (GBOV): is used to validate some of the biophysical terrestrial variables provided by the service
- Hot Spot Monitoring ([15]) and Sectoral Information (HSM): provides information on landscapes at high resolution. Currently, the HSM works upon requests of EU Delegations (mostly in Africa).
- Sentinel-2 Global Mosaic Service (S2GM) ([16]) provides Sentinel-2 "analysis ready" data, i.e., intermediate products allow users to generate their own products (10m, 20m, 60m). It is possible to obtain mosaics of different parts of the world over time (useful for time series analysis). This service can be very useful to inform Indicators such as the percentage of habitats deteriorated by fire disturbance.

Contributions to the use cases

EO is a powerful tool to study and assess the ecosystem, however, is not able to address the species-level of biodiversity. Ecosystem modelling would be useful to make the link between EO and biodiversity, however it is not currently provided by the global land service. Consistent time series analysis to understand progress and changes, need to be linked to Indicators and confidence from the policy perspective. To do this, it is required to have associated uncertainties of EO products (not available now). In order to make consistent assessment on quality assessment of changes over time, it is necessary to make sure that products have high quality and high confidence.

The HSM service may inform two Indicators within the EU Biodiversity Strategy: Indicator A1.1.1 – Terrestrial protected area coverage, and Indicator A1.1.3 – Nationally designated terrestrial protected area coverage.

Contributions to Research & Development

To future development the Service in terms of biodiversity, it could be useful to expand the research on ecosystem modelling to be able to make the link with biodiversity assessments.

5.1.3 Stefano CIAVATTA, Mercator Ocean Copernicus Marine Environment Monitoring Service (CMEMS)

The oceans' biodiversity provides vital services and it sustains 32 out of the 33 known animal phyla and supports the livelihoods of people. However, oceans and seas are highly impacted by climate change, pollution, and overexploitation of their resources (e.g., overfishing). CMEMS provides products to observe and study the "blue ocean" (physics), the "green ocean" (biogeochemistry), and the "white ocean" (ice). CMEMS obtains information though observations (in-situ and satellites), numerical models (data assimilation), multi-year (10-45 years), real-time (daily/hourly), forecast (2-10 days) analysis.

This type of analysis is useful to understand how variables are changing over time in relation to climate change and anthropogenic impacts. Information is collected in the *Ocean State Report* (2022) ([17]) which provides an outlook on the health of marine system. CMEMS engages with users to provide indications on environment, policy, and economy. CMEMS provides key data to monitor marine biodiversity and Marine Protected Areas (MPAs), preserving endangered ecosystems.

Major evolutions planned in Copernicus Marine Service phase 2 (2021-2028) via R&D projects (e.g., Horizon Europe and Horizon 2020) will expand marine biodiversity monitoring and protection supporting EU biodiversity policy needs, and will include:

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[13] https://land.copernicus.eu/global/index.html
[14] https://land.copernicus.eu/pan-european/biophysical-parameters
[15] https://land.copernicus.eu/global/hsm
[16] https://s2gm.land.copernicus.eu/
[17] Report available at: https://marine.copernicus.eu/access-data/ocean-state-report/ocean-state-report-6

- Gathering and processing new biogeochemical and biology in-situ and satellite observations
- New processes in biogeochemical models (benthic/pelagic coupling, riverine inputs)
- Advanced data assimilation techniques (e.g., stochastic BGC ensembles)
- Ecosystem modelling from low (plankton), mid (micronekton) to high (fish) trophic levels
- Habitats for key protected species (e.g., marine mammals), MPAs design
- Assessing scenarios for climate change impacts on stocks and protected species
- Critical role of the present (S2, S3) and future (CHIME) Sentinel missions and in-situ observations (e.g., acoustic data, plankton imaging, omics, pollutants, plastic, fish surveys, and landings)
- Copernicus Thematic Hubs hosted by Mercator Ocean could include biodiversity components such as for (1) the Coastal Zones and (2) Arctic can target biodiversity in critical areas
- Digital Twin of the Oceans (DTOs) includes ecosystem models and data, MPAs DTO useful to test future and eventual "what-if" scenarios

Figure 4. Ocean Monitoring Indicators (OMIs).

Source: Mercator Ocean.

Contributions to the use cases

Focus on DG MARE use cases: Products provided by CMEMS e.g., turbidity, temperature, salinity, and chlorophyll go beyond the higher trophic levels and can inform both biodiversity-related issues, such as species presence and abundance, and biodiversity-related policies. Although the service does not provide complete information on the trophic levels, available resources may contribute to understand policy-relevant habitat, ecosystems and species' suitability. Moreover, it is possible to evaluate historical trends to study climate change and anthropogenic impacts by means of reanalysis products. Further contributions of current/upcoming R&D projects which will bring the capacities for the operational systems to simulate high trophic levels or monitoring pollutants: these projects may contribute to understand marine-related elements of concern such as current and future food provision. CMEMS would collaborate with different stakeholders such as International Union for Conservation of Nature (IUCN) and provide trainings for biodiversity assessment.

Contributions to Research & Development

Opportunities in the use of spectral data are sometimes used directly for biodiversity assessment through species characterisation in the marine and oceanic environments. The simulation of spectral properties and the interactions with different biological components in the operational system is under development. Finally, additional exploration such as Omics data would add complexity to the models in use.

5.1.4 Samuel ALMOND, European Centre for Medium Range Weather Forecast – Copernicus Climate Change Service (C3S)

C3S ([18]) provides Essential Climate Variables (ECVs) to monitor the state of the climate, EO data for the reanalysis which is useful to study past weather events, and climate models for future scenarios. The service is exploring climate impacted indicators related to biodiversity, for this they have created several datasets to allow biodiversity users to visualise and explore bioclimatic indicators through interactive applications. It is possible to explore per country or by Natura 2000 sites across Europe and MPAs across the globe. The user can explore "climatic envelopes" to help identify if and/or when species may be stressed or impacted by climate change. There are also dedicated applications for European grasslands, hedge species (flora), marine fish species, and marine protected areas, which are helpful to explore the impact of climate suitability on species and European landscapes. For instance, Forest Forward ([19]) aims at showing climatic suitability for forest health to map future tree species distribution in Europe and it looks at the viability of tree species under climate change. C3S also provides training for users to engage and use their data for modelling and research.

Bio-envelope methodology: Downscaled bioclimatic indicators for selected regions from 1979 to 2018 derived from reanalysis ([20])

Contributions to the use cases

C3S undertakes the Evaluation Quality Controls (EQCs), where all C3S products are given quality/fitness-for-purpose instructions to provide confidence and documentation to all products in the climate data store. Moreover, C3S EO data, e.g., long-term climate data records, aim to be stable and can be used to support the assessments of climate. Even though such record may not be specifically relevant for biodiversity, data stream can still be useful for the characterisation of climate studies, and for the long-term climate assessments and policy developments. This may be relevant in the context of the Use Case advanced by DG CLIMA.

Contributions to Research & Development

The ability to monitor the nexus between biodiversity and carbon sinks would be very useful for future monitoring; to achieve this, an inter-service use and access to WEkEO and the EU Copernicus DIAS services would facilitate the incorporation of various datasets and data streams from various Copernicus services and platforms into value added services for the biodiversity sector. It could be relevant to explore how DestinE could be included into these activities for modelling and understanding reliance of biodiversity and biodiversity restoration activities.

5.1.5 Marc PAGANINI, European Space Agency (ESA)

ESA ([21]) is engaged in biodiversity activities and agreements to enable the uptake of EO data in support of the implementation of international conventions, providing support to achieve and report on progress, in partnership with an international network of actors including the Group on Earth Observation (GEO) ([22]) and the Committee on Earth Observation Satellite (CEOS) ([23]).

There is a need of policy uptake for EO in Biodiversity related and Multilateral Environmental Agreements including:

- Convention on Biological Diversity (CBD) ([24])
- Ramsar Convention on Wetlands ([25])
- 2030 Agenda & Sustainable Development Goals (SDGs) ([26]): SDGs have many indicators related to biodiversity and ecosystems, and the outcomes of the Biodiversity Deep Dive would be

[18] https://cds.climate.copernicus.eu/about-c3s
[19] https://forest-forward.com/
[20] https://cds.climate.copernicus.eu/cdsapp#!/dataset/sis-biodiversity-era5-regional?tab=overview
[21] https://www.esa.int/
[22] https://www.earthobservations.org/index.php
[23] https://ceos.org/
[24] https://www.cbd.int/
[25] https://www.ramsar.org/

beneficial for the achievement of international goals and could provide added value to SDGs related studies

- UN SEEA Ecosystem Accounting ([27]) is the UN System on Ecosystem accounting, a new statistical standard regulating the production of statistical accounts on ecosystem extents and services also including 5 ecosystems accounts, namely (1) ecosystem extent, (2) ecosystem condition, (3,4) ecosystem services, (5) monetary ecosystem asset. This system is seen as a monitoring framework underpinning the development of standards in international agreements and it is important in the context of the proposed EU legal module on ecosystem accounting
- UN Convention to Combat Desertification (UNCCD) ([28]) has the strategic objectives to improve ecosystems and it is pivotal to understand how to check ecosystems' status and conditions, thus, monitoring strategies need to be further analysed to ensure the most efficient and transparent assessment
- UN Framework Convention on Climate Change (UNFCCC) ([29]) is pivotal in the context of natural ecosystems for climate adaptation and mitigation to connect ecosystem services and the Climate Pact resulted from the UN Climate Change Conference COP26 (Glasgow, 2021)

ESA EOP – EC RTD Earth System Science Initiative ([30]) is a joint initiative by ESA and EC to advance the use of EO, to enhance Earth System science exchanges, and to accelerate the fundamental knowledge of the processes of different scientific domains, including biodiversity. The Initiative aims at setting up joint research programmes to complement expertise, institutions and funding, in order to serve a common goal. The Flagship Action on Biodiversity and Vulnerable Ecosystems ([31]) was launched in 2021 and pilots on Freshwater Ecosystems ([32]), Coastal Ecosystems ([33]), and Terrestrial Ecosystems ([34]) were developed to:

- Analyse the major knowledge gaps and science questions on biodiversity and vulnerable ecosystems
- Assess how the present and upcoming EO system can help addressing these scientific challenges in biodiversity knowledge
- Demonstrate the adequacy of Earth System Science approaches with Earth System pilots for biodiversity that could capitalise on the availability of multiple satellite observations, and assimilate these observations into potential biodiversity modelling
- Develop a Science Agenda and a Scientific Roadmap for the EC-ESA Biodiversity Flagship Action

These projects will serve the scope of enhancing biodiversity policy uptake of EO.

Contributions to the use cases

In the context of the proposed EU legislation on ecosystem accounts (amendment to Regulation (EU) No 691/211 on European environmental-economic accounts), the ecosystem extent account is different from land cover mapping exercises: it records the total area of each ecosystem (by ecosystem type) and its changes over the accounting time period. The recent IUCN Global Ecosystem Typology ([35]) may be used to better classify ecosystems as it consists in "a conceptually robust, scalable, spatially explicit approach for generalizations and predictions about functions, biota, risks and management remedies across the entire biosphere" (Keith, et al., 2022). A first step towards the mapping of these global ecosystem typologies is to study ecosystem suitability to obtain an underlying knowledge of ecosystems and their conditions. In order to do this, a harmonised approach which could include modern digital technologies (i.e., machine learning and deep learning) may be exploited and complemented with ground/in-situ data about different ecosystem types.

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[26] https://sdgs.un.org/goals
[27] https://seea.un.org/ecosystem-accounting
[28] https://www.unccd.int/
[29] https://unfccc.int/
[30] https://eo4society.esa.int/communities/scientists/ec-esa-joint-initiative-on-earth-system-science/
[31] https://eo4society.esa.int/tag/biodiversity-flagship/
[32] http://biomondo.info/
[33] https://bicome.info/
[34] https://www.eo4diversity.info/
[35] https://global-ecosystems.org/

Focus on DG ENV Use case on wetlands: The mapping of the many types of wetland ecosystems requires complex multi-sensor approaches. Hyperspectral missions would allow to discriminate different types of wetland habitats. Currently, L-Bands SARs are useful to study forested wetlands, while C-Bands do not allow to observe below canopy cover. It is important to understand the different types of wetlands ecosystems and their ecological properties: each type requires a different mapping method, and it is not possible to map peatlands, mangroves, seagrass or saltmarshes using the same methodology. It could be useful to rely on new technologies, machine learning, deep learning algorithms and AI complemented with field studies. CEOS has placed ecosystem extent as its top priority, and GEO-Wetlands Initiative is contributing to create a wetland inventory.

Contributions to Research & Development

Further research on biodiversity modelling regarding the integration of EO and ecosystem resilience assessments in relation to Climate Change would be useful to visualise potential future scenarios. Progress on the modelling aspect needs to be further developed in collaboration with larger networks of actors. Among other initiatives, the Digital twin Earth (a component of Destination Earth) would include biodiversity-related aspects. Developments on ecosystem accounting aim to support the upcoming Regulation on the new environmental economic accounts modules ([36]), and the MS to provide these accounts. Research is focused on uncertainties and how these accounts are used within the policies. Activities will also be focusing on ecosystem degradation and restoration to support the Nature Restoration Law targets. Ecosystem conditions will need to be further studied, especially considering the different ecosystem types: Indicators on ecosystem conditions need to be specific and/or adjusted to each ecosystem. Information on ecosystem presence and conditions is fundamental to implement restoration activities. Finally, a potential area of research would be to find the appropriate ECVs' scale of application for biodiversity observations and assessments.

5.1.6 Hayley EVERS-KING, European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT)

EUMETSAT ([37]) has two main mandates under its mission as an international organisation: (1) the provision of weather and climate information to MS, and (2) international projects and activities within the Copernicus Programme. EUMETSAT has a broad thematic data range available that links directly or indirectly to biodiversity, e.g., biodiversity interactions with weather, natural disasters, volcanoes eruptions, wildfires, and droughts which all provide information on the importance of biodiversity. Data is provided through several data services, particularly cloud processing services (e.g., WEkEO) and provide users support and trainings for capacity building through Jupyter Notebooks and YouTube-based tutorials. Data towards biodiversity – a snapshot of case studies:

- Climate trends: how data can be relevant to understand the impact of marine heatwaves on marine sensitive species, such as corals and other species having thermal-tolerance issues
- Ecological niches: consideration of different environmental variables such as temperature, chlorophyll, and sediments that can impact different marine species
- Ecosystem services: it is possible to provide information on ecosystem services which are intimately linked to biodiversity (e.g., links to fisheries, aquaculture, …)
- Plankton biodiversity can be monitored, including large algal species which interact with ecosystem functions and services (e.g., impacts of algal blooms on fishery resources issues)
- Habitat extent/disruption: habitat status is monitored such as sea ice presence and extent using optical imagery and satellites
- Phenology
- Environmental baselines
- Extreme weather: extreme weather events such as storms may negatively affect marine sediment distributions which can be disruptive for marine ecosystems in those areas
- Climate Mitigation and ecological restoration: observing the impacts of waves on different coastal ecosystems could contribute to assess coastal resilience

[36] COM/2022/329 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52022PC0329
[37] https://www.eumetsat.int/

Contributions to the use cases

Focus on DG MARE use cases: Monitoring is important to support coastal protection and restoration and to value biodiversity and resilient ecosystems. Information on coastal ecosystems changes over time would provide evidence to understand where to implement restoration projects and whether ongoing restoration activities are successful.

In the context of monitoring and understanding the implementation and outlook of MPAs:

- Further research on methods to include data on trade-offs would be useful to look at economic valuations of different marine-related activities against the decision of hosting MPAs
- EO can provide useful insights in the field of marine-related activities to identify where renewable energy or aquaculture sites could be suitable. This would bring together the operational oceanography side with the MPAs biodiversity aspects.
- Trend analysis may be useful to understand MPAs future suitability under different climate scenarios and how to act to make them more resilient in the future.

Contributions to Research & Development

Geostationary and Hyperspectral data from different missions may not be directly designed for ocean observations but might become useful in the future. Additionally, there is a growing need of traceability with precise quality and reference measurement approaches for satellite observations. However, this would require further research to stream this process through the value chain towards the end products that could then be used and connected to seas and oceans data useful for policies.

5.2 Contributions from European R&D Projects

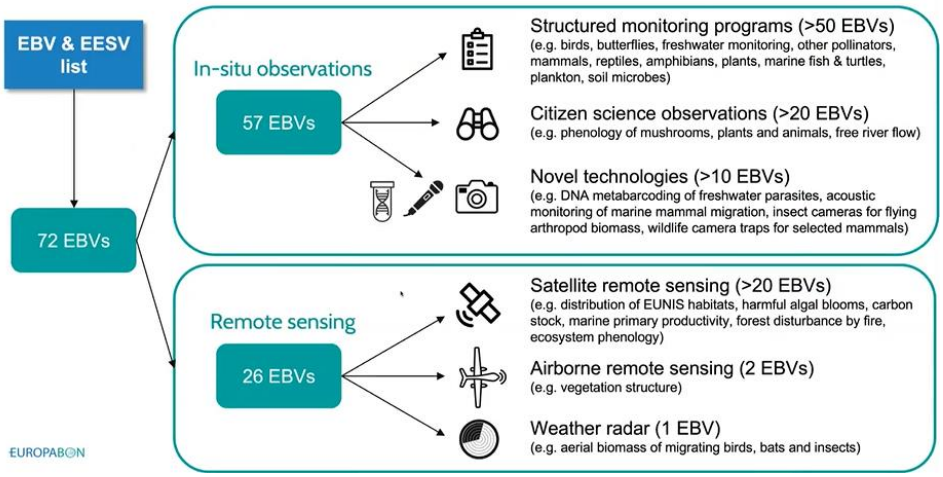
Moderator: Jean DUSART, DG RTD

This panel session was dedicated to the research and innovation projects in Europe under the Horizon Europe and Horizon 2020 framework.

5.2.1 Néstor FERNANDEZ, EuropaBON

EuropaBON ([38]) is a Horizon 2020 project aiming to improve how biodiversity data is used in Europe to report on specific policies (e.g., Nature Directives, Nature Restoration Law). EuropaBON is large network of >1000 members. Currently, EU Member States (MS) do not apply a harmonised methodology to report on EU biodiversity status and change: making it difficult for MS to report systematically. For this reason, Essential Biodiversity Variables (EBVs) aim at integrating multiple data streams and biodiversity observation (in-situ and EO) in open platforms from all MS and to produce improved monitoring products across the different EBVs. There are two different ways to integrate in-situ and EO data: (1) modelling: understanding biodiversity data in relation to stressors, ECVs or other predictors that could be derived from RS: data model fusion to produce biodiversity change variables across space, time and biological entities, (2) direct monitoring of some of the EBVs components, namely those addressing ecosystem functions and structure. EBVs Data Cubes would be produced and downstreamed to elaborate biodiversity indicators on change and across different scaled and they would provide analysis ready information about states of biodiversity across space and time. Currently, there are 72 EBVs with specification of data workflows and 6 EBVs classes monitored across realms and include changes at the species level or at the ecosystem levels (i.e., aggregated signals from changes in biodiversity for multiple species).

Figure 5. Direct monitoring and pressure-state models EBVs workflows.



Source: EuropaBON

EuropaBON is developing new EBVs data products that would address:

- Birds Directive (i.e., species populations: spatially explicit distribution and abundance for 50 farmland birds)
- Habitats Directive (i.e., contribution to better ecosystem structure, and EUNIS habitats distributions over time)
- Water Framework Directive (species distribution of aquatic macrophytes in lakes)

[38] https://europabon.org/

- Transversal policy areas such as soil restoration (i.e., community composition microbial biomass; ecosystem function: potential soil restoration) and bioeconomy (I.e., species traits: mushrooms fructification phenology; community composition: community abundance of birds)

Horizon 2020 and e-shape projects are supporting data interoperability processes including EBVs Cube and GEOBON EBV portal. ([39])

Contributions to the use cases

Currently, EuropaBON can provide the workflow of 72 EBVs including aspects regarding critical RS products to monitor specific variables, however, it is crucial to be able to facilitate data flow of in-situ data and to integrate these data with RS products.

Contributions to the improvements of Copernicus Services

There are two potential areas to expand: (1) technical part – what is the path to develop better products that can be used for policies: namely, the development of technical aspects such as high resolution, temporal resolution, and spectral resolution, which include technologies which are not extensively used in biodiversity yet but could provide information (e.g., Radar and LiDAR data). (2) Gap to be filled – the accessibility of such technologies to policymakers, high level of products that are ready to use to assess biodiversity change. This matter is linked to the culture of the distribution of data, and how to correctly assess users' needs, starting from what is already available.

Despite the consistent amount of data coming from MS which needs to be considered when developing the EBVs workflow, a lack of infrastructure still causes information accessibility issues.

5.2.2 Boris HINOJO, Nature First

The Horizon Project Nature First ([40]) started in September 2022 aims at monitoring biodiversity, protecting nature and tackling different issues associated with biodiversity monitoring such as the costs required for field assessments. It provides support to managers and decision-makers for the reporting under the Habitat and Birds Directives, it provides support to plan monitoring of areas, interventions, or restoration activities in different sites, including Protected Areas (PAs), throughout the year, and it provides information on the human-wildlife conflicts. Nature First provides different data sources (different frequencies, resolutions, taxonomies ecosystems and habitats), and it proposes a continuous near real time monitoring for ecosystems and human-ecological processes and their interactions to better understand the reality. The project proposed to use RS and in-situ data for mapping protected areas and ecosystems and their changes in order to assess the conservation status of protected areas. The data would be used to attempt to model ecosystems and ecosystem changes through an "ecological digital twin" and to support informed decision-making for protected areas, and pilot field studies are located in Spain, Romania, Bulgaria and Ukraine.

Nature First could benefit from the use of EBVs to support site managers in providing them with specific variables that could tackle key features of an ecosystem/area. This type of information would then support site managers in reporting and prioritising interventions and needs for restoration activities and monitoring key areas.

Contributions to the Use Cases

The creation of a base map of ecosystems, and habitats of community interest (Protected Areas), which will be produced within the Nature First project can provide valuable information for the EU Biodiversity Strategy 2030, and they can provide inputs for the use cases on *Monitoring key habitats for biodiversity with a focus on wetlands* (DG ENV), and on *Biodiversity monitoring in agriculture landscape* (DG AGRI). The project is proposing to map the ecosystem of these habitats through semi-automatic ecosystem mapping using unit-classification of sites, and AI technologies for ground-control points (in-situ data) among others. This information would be needed to support the reporting on the Nature Directives as well as to support the provision of permits at the cadastral level (i.e., requiring HR information on the ecosystem). The project has implementing partnerships in Africa to monitor protected sites which could potentially contribute to the biodiversity monitoring in Key Landscapes for Conservation (NaturAfrica).

([39]) https://portal.geobon.org/home
([40]) https://www.linkedin.com/company/naturefirst-info/

Contribution to the improvements of Copernicus services

Very high spatial resolution (VHR) imagery can provide valuable inputs for the classification of ecosystems and habitat mapping. One possible strategy would be to obtain VHR imagery twice per year while monitoring the ecosystem changes using the already available Sentinel data.

5.2.3 Petteri VIHERVAARA, Biodiversa+

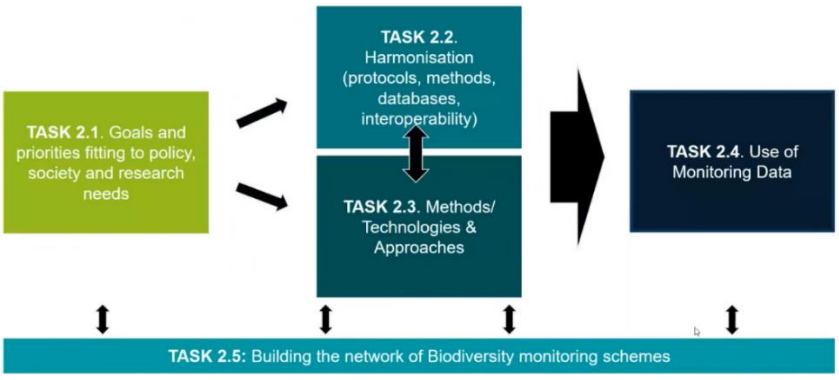
Biodiversa+ ([41]) aims at developing a harmonised biodiversity monitoring scheme for Europe in which EO is essential. The network is formed by the collaboration of 37 countries and has a network of 74 partners; it brings together European researchers, several Environmental Ministries, and Environmental Protection Agencies which take part in national and international agreements on different environmental matters. Currently, the project is expected to run until 2028 with a co-funded budget of >800 million € and 1/3 of the Biodiversa+ budget is focused on biodiversity monitoring initiatives. In addition, funds are allocated by the partners and the EU. Biodiversa+ has several operational objectives:

- Promote and support R&I programs and projects across the ERA
- Promote and support transnational biodiversity monitoring
- Promote and support Nature based Solutions (NbSs) and valuation of biodiversity in private sectors
- Better connect R&I programmes and projects to policies
- Internationalisation of European R&I related to biodiversity topics

The overarching aim is to promote and support transnational biodiversity monitoring and harmonise biodiversity monitoring schemes across Europe, as well as to understand better status and trends to inform EU Biodiversity Strategy 2030 Indicators. For this purpose, Biodiversa+ is bringing together national and sub-national actors (e.g., EEA, KCBD, EuropaBON, IUCN, Copernicus Programme) to operationalise the network of partners and provide bottom-up data streams towards this European biodiversity monitoring scheme.

The monitoring scheme is built on a set of priorities in which EO and in-situ observations play pivotal roles. These priority areas include terrestrial and marine protected areas (incl. Nature 2000 sites), habitats, offshore marine biodiversity and/or marine mega-fauna, invasive alien species, soil biodiversity, pollinators, butterflies and other insects, wildlife diseases and biodiversity facets linked to health issues. The whole path from the priority settings (incl. goals and indicators), develops practices, methods, protocols, and databases with the support of recent technologies in RS and AI, as well as novel methods to assess biodiversity such as the eDNA metabarcoding. Efforts and funds are allocated to be able to design an integrated and collaborative approach in Europe for the future.

Figure 6. Main working areas and links between Biodiversa+ tasks.



Source: Biodiversa+

[41] https://www.biodiversa.eu/

Contributions to the Use Cases

The Biodiversa+ network provides a state of the art of the current national biodiversity centres and hubs for interoperability which is necessary for national and subnational experts for the reporting under the EU Biodiversity Strategy 2030, Nature Directives and Restoration Law implementation needs. The network brings together different expertise which are relevant for comprehensive assessments of biodiversity. Given the importance of in situ data for such assessments, potential collaboration to support the development of national (in situ) data sets could be beneficial for both EO and Biodiversity communities and could inform biodiversity monitoring methods at national and international scales.

Contribution to the improvements of Copernicus services

Currently, EO and RS are very useful tools for biodiversity if coupled with in-situ studies, particularly when there is a need to assess EBVs that cannot be comprehensively assessed only with RS. Land Cover products would need further accuracy and HR to better assess biodiversity indicators and variables, as well as frequency of observations and temporal resolution for establishing long-term biodiversity monitoring schemes. For these long-term assessments, it is fundamental that the services are proving long-term support, ensuring the availability of data even in the case of future changes in the technologies.

5.2.4 Momme BUTENSCHÖN, FutureMARES

FutureMares ([42]) is a Horizon 2020 R&I action project started in September 2020 aiming to address how Climate Change and Anthropogenic pressures impact marine biodiversity and ecosystem services. The workflow focuses on three Nature based Solutions (NbSs) case studies, namely on (1) effective restoration (i.e., habitat restoration such as seagrasses, kelp forests), (2) effective conservation (MPAs network, MPAs suitability and potential improvements), (3) Nature-inclusive harvesting (fisheries and aquaculture). The partnership includes several actors in Europe (i.e., Norwegian Coasts, NE Atlantic, Baltic Sea, Bay of Biscay, NW Mediterranean, Eastern Mediterranean) and overseas (i.e., Belize and the Humboldt area - Chile). The overarching goal is to provide socially and economically viable actions, strategies and NbSs for Climate Change adaptation and mitigation to safeguard future biodiversity, and ecosystem functions, maximising natural capital and its delivery of services from marine and transitional ecosystems.

- Understand the links between ecological functions and ecosystem services
- Deliver projections of future climate change hotspots and refugia
- Explore climate change impacts in fields and mesocosm experiments
- Project climate change effects on marine species and biodiversity
- Conduct novel socio-ecological vulnerability assessments
- Perform economic analyses of different nature-based solutions
- Test implementation strategies including bio-economic analysis
- Co-create research activities with decision- and policymakers
- Communicate and engage with a broad range of stakeholders within the focus regions

In this context, further EO support within the project would be needed to map the results and outcomes. The delivery of habitat suitability information and species ecological modelling are key aspects contributing to provide valuable information on key marine species and the whole food web. Socio-ecological vulnerability assessments of the services complemented with economic analysis to understand costs and benefits is entailed within the project for different NbSs. Thus, the project looks at the evolution of biodiversity trends under different climate change scenarios and other pressures to provide pathways to viable actions on NbSs that allow for adaptation and mitigation on the impacts on biodiversity and ecosystem functions and maximise services within the marine system.

[42] https://www.futuremares.eu/

Contributions to the Use Cases

Through Climate Change assessments, ecological modelling and the assessment of related ecosystem services, the outcomes of the project will provide habitat maps and hotspots of climate change. Importantly, considering future scenarios, there may be areas where new opportunities and services will arise, e.g., new or extended services may become available in new areas. The availability of EO data to support and inform the extent of marine habitats in this context would be greatly beneficial (also in connection with DG MARE use case) to validate the project monitoring approach and to complement existing climate and ecological assessments.

Contribution to the improvements of Copernicus services

FutureMares uses Copernicus data, in particular CMEMS reanalysis products, to drive the downscaling at HR and to inform the coarse resolution climate model data in the downscaling algorithm. EO data is also used to inform ecological modelling about climate conditions. One of the modelling components on seagrass meadows and kelp forests addresses the Blue Carbon assessments and it identified that there is insufficient data available to better inform current habitat maps. The validation process remains an issue particularly regarding concrete information on specific NbSs on coastal remote areas. The long-term data availability is necessary to determine trends for tracking Climate Change impacts and consistent long-term monitoring is key to understand global changes and to obtain consistent assessments throughout time.

5.2.5 Elnaz NEINAVAZ, E-shape: EuroGEOSS Showcases: Application powered by Europe

The e-Shape ([43]) project is a Horizon 2020 R&I action program: it includes 7 showcases, 37 pilots, and 54 partners. Focus on Showcase 4 – myECOSYSTEM: The aim is to integrate in-situ data with EO information to generate different Biodiversity Variables for protected sites in Europe. HR EO data is used for each site considered during the project (if the assessment will be scaled up to EU-level, coarser resolution may be used). The project aims at to co-designing services to link different portals, such as GEOBON and Eurosense, to improve accessibility for users and other communities, in particular for the biodiversity-user community. The objectives are to:

- demonstrate the mobilization and valorisation of long-term ecosystem and biodiversity in situ data
- provide access to spatially continuous and EO value added products which are relevant for users
- provide access to model derived data such as the Essential Biodiversity Variables
- access through one-stop-shop

The final users are environmental assessment agencies, EU and national conservation agencies, the research communities, protected areas/sites and platform coordinators. Within my-ECOSYSTEM showcase, there are three pilots which are linked with each other to achieve the development of EBVs products with high accuracy and HR and that they are available to the public. Within the larger myECOSYSTEM e-shape project, there are 3 pilots, namely, (4.1) mySPACE, (4.2) mySITE, and (4.3) myVARIABLE. They have different objectives but all these showcases are linked and designed to support each other to develop EBVs products with high accuracy and high resolution, and to ensure their availability to the users.

Contribution on the improvements of Copernicus services

The availability of time intervals to retrieve information depend on the needed parameters. For instance, for habitat modelling there is a need to retrieve parameters every 1-2 years, while for others needs such as EBVs there is a need to retrieve data on a monthly basis. The use of EO data to obtain high prediction accuracy would require ground data information which are currently mostly project-based. In relation to this, two concerns may be raised. (1) The validation process of products generated with EO data, presents issues due to the unavailability/inaccessibility of in-situ data and data providers (such as research institutes) are not always willing to share data. (2) The infrastructure available to download HR real-time data presents restrictions and does not favour the research process (for instance, data downloaded may be available for 48 hours only).

[43] https://e-shape.eu/

5.3 Contributions from EU Member States & Industry

Moderator: Richard GILMORE, DG DEFIS & KCEO

The aim of this session was to bring together stakeholders to improve the visibility of parallel uptake activities at the downstream sector of the private sector and at the national level, in particular in relations to the FPCUP, the Copernicus Academy and the Copernicus Relays, as well as the value-added products advanced by the downstream sector which could be of interest for policy support and useful to examine whether there are potential synergies to exploit for this parallel uptake strands.

5.3.1 Andrea TARAMELLI – ISPRA ([44]); Copernicus User Forum, Copernicus User Committee and Framework Partnership Agreement for the Copernicus User Uptake (FPCUP)

National User Forum for the uptake of Copernicus activities at national level has several working tables, and, among these, one of them is fully dedicated to uptake activities within the environmental domain, including biodiversity. The work is related to legislations to be implemented at national level within the EU Framework Directives. For instance, Italy is building evidence on how Copernicus can support in the implementation of the Birds Directive at the national level. This type methodology has also been used for other pieces of legislations such as the Maritime Spatial planning. Under the FPCUP framework there have been a series of interventions and trainings including uptake events focused on biodiversity within the last two years. In this context, Italy has proposed two kind of actions: (1) to organise info-days on what Copernicus can do, (2) to link and support policy implementation through the National Collaboration Programme with EEs (e.g., Italy has already started collaborating with ECMWF and EEA). To ensure uptake, in particular for policy implementation, it is essential to discuss with the downstream users, namely the people that are dealing with policy implementation at national level. The Copernicus Academy and Relay Network are very valuable to inform and train users at national level.

Suggested priority Use Cases linked to the Biodiversity Deep Dive

The user requirement analysis is organised in three steps: (1) user requirements collection, (2) requirements analysis and prioritization, (3) operational services development. Coastal areas studies are of high priority in Italy (including land and offshore assessments). The analysis of coastal areas-related Directives led to the extrapolation of specific parameters for implementation, and to the identification of coastal users (national and regional actors) to perform an assessment of existing products and to conduct gap analyses. These implementations are linked to the Maritime Spatial Planning (MSP) ([45]), the EU Marine Strategy Framework (MSFD) ([46]), and the relative implications for biodiversity and ecosystems. The parameters were grouped into a set of typologies, i.e., use of anthropogenic infrastructure, pollutants flows, hydro-meteorological assessments, geomorphological assessment, physical parameters, land cover, bio-geo-chemical parameters. Moreover, monitoring and reporting criteria were defined to support national and regional actors. Italy, together with other MS, advanced the need to have parameters to measure for several Directives in coastal areas in support of policy implementation at the national level as well as need of a Coastal Thematic Hub at EU level (recently advanced by Mercator Ocean).

In relations to the user needs analysis, studies on the identification of existing Copernicus products for coastal management (Geraldini, et al., 2021) and forestry sectors were carried out at the national level for Italy. It emerged that there is the need of a system allowing to study forest cover and cover change in relation CO_2 assessment. Moreover, there is a need for a strong interaction with national institutional services and expert knowledge, in-situ data for validation, and a definition of threshold values for Copernicus core services and downstream application. In the framework of FPCUP, the parameter analysis ([47]) was relevant during the cross-boundary discussions with other MS on European Coastal Services, and in the context of the MED7 Initiative (MS: Portugal, Spain, France, Italy, Malta, Greece, Cyprus).

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[44] Istituto Superiore per la Protezione e la Ricerca Ambientale: https://www.isprambiente.gov.it/it
[45] Directive 2014/89/EU
[46] Directive 2008/56/EC
[47] https://land.copernicus.eu/user-corner/technical-library/roadmap-for-coastal-zone-monitoring-activities

Contributions to the products proposed by Copernicus Services (interest, space for development, additional improvements for biodiversity-relevant indicators and services)

Italy set up funding activities for the new IRIDE Constellation and downstream applications. The Copernicus products would need to be tailored for the national user communities of MS (i.e., customisation at national/regional levels). The Italian national land-use and land-use change (LULUC) service will be implemented with the use of funding allocated for ecosystem services and biodiversity to support the advancement of several studies on these topics, and to develop a number of biodiversity parameters that are not currently addressed within the Copernicus services.

5.3.2 Pierre-Yves VION – Geoformation and EO for Territories and the Environment AgroParisTech

TETIS([48]) is focused on research on GIS and Remote Sensing on topics including agriculture, biodiversity, forests, water and health. The Institute is part of the Copernicus Academy since the launch of FPCUP which focuses on EO capacity building, and it aims at connecting universities, research institutions and business schools, private and non-profit organisations within the Copernicus Participating Countries and beyond. The online modules include agriculture (published), biodiversity (under development) and forest (under development). Masters' students, engineers, and PhD students, and professionals including engineering offices, public administration and companies are enrolled in the Programme to develop profiles as GIS/RS and thematic specialists. The biodiversity module includes the uses of RS for biodiversity and ecological continuity monitoring, the mapping on natural habitats, biodiversity indices and the recognition of plant species for which there is a necessity to integrate in-situ data.

Suggested priority Use Cases linked to the Biodiversity Deep Dive

Green and blue continuity to monitor the EU Biodiversity Strategy. Operational tools are needed to monitor and report targets. Regarding the Use Case advanced by DG CLIMA in relation to the forests' health, there is capacity to monitor forests in relation to climate change and the assessment of the diseases and pests' impacts assessments.

Contributions to the products proposed by Copernicus Services (interest, space for development, additional improvements for biodiversity-relevant indicators and services)

Copernicus products for biodiversity are not extensively used, and researchers tend to develop new algorithms and methods to use the products.

5.3.3 Emmanuel PAJOT, European Association of Remote Sensing Companies – EARSC

EARSC ([49]) is a network of 136 European Companies specialised in EO and it aims to be an enabler of European capabilities: all the actions intend to support the uptake of the development of EO and the various services for the use of EO data. EARSC promotes events to inform and train users on thematic areas and it is involved in different Commission funded projects such as e-shape, European flagship initiatives, and EO4GEO ([50]). Moreover, EARSC coordinates FIRE ([51]), the industry-led Forum for Innovation and Research in European Earth Observation aiming to identify gaps to support the EO uptake into the market under thematic areas as agriculture and maritime areas. EARSC also aims at creating new services to bridge the gaps between users and service providers with a co-design approach. Other important actions are related to the policy uptake, such as the Green Deal Working Group aiming to identify how the downstream EO sector can support the EU Green Deal targets. The work also focuses on policy needs and legislation anticipation in various thematic areas, including for instance deforestation and forest monitoring, soil health proposal, and the Nature Restoration Law.

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(48) https://www.umr-tetis.fr/index.php/fr/
(49) https://earsc.org/
(50) http://www.eo4geo.eu/
(51) https://fire-forum.eu/

Suggested priority Use Cases linked to the Biodiversity Deep Dive

EARSC has addressed some of the issues ([52]) included in the Use Cases: a potential follow-up in the context of the KCEO Deep Dive on Biodiversity may be to develop a booklet of services specific to the different Use Cases. This could contribute to the understanding of what is available on the market and what are the current available capabilities.

Contributions to the products proposed by Copernicus Services (interest, space for development, additional improvements for biodiversity-relevant indicators and services)

Among the most relevant topics, land-related, security and emergency services are generally the most used by companies and private entities. The integration of higher resolution and access to all different Sensors (optical, infrared, SAR, hyperspectral) would be needed to support the demand side.

5.3.4 Michal POLANSKY - WaterMe (TreeCount&Care)

The WaterMe Project ([53]) is the Co-Winner of the 2021 Cassini Hackathon on digitizing green spaces that developed an innovative tool (smartphone-based app) to optimise the watering of trees in urban settings. The project aims to contribute to the sustainable maintenance of urban green spaces and to complement governmental measures engaging citizens in watering urban trees, particularly in emergency circumstances, e.g., during droughts. In this context, the app would inform the citizens when the trees would need to be watered. This project contributes to saving trees and optimising the use of water, while also educating citizens on environmental issues in their cities. Research potentials:

- To estimate the health of trees: provide latest data (satellite, sensors) and historical data for phenophases detection for long term/seasonal impacts (NDVI and Optical data)
- To estimate environmental conditions: based on average and low-resolution satellite data (SSM soil moisture and land surface temperature)
- In situ sensor data for real time monitoring
- Tree watering need modelling to understand the impacts on different species under changing conditions and create a Digital Twin for each urban tree
- Tree detection: based on aerial/sentinel data; initial tree database and detection of missing/dry trees; experts and citizen science
- Citizen engagement with adaptation and climate change mitigation actions
- Citizen education and citizen science

This project is connected to the Use Case on Urban Green spaces (DG ENV).

Suggested priority Use Cases linked to the Biodiversity Deep Dive

In the future, more applications related to environmental services and evaluation are expected to be implemented. Currently, in Czech Republic, forest monitoring and precision agriculture are relevant topics. Such issues would require further services and products, as well as improved data availability.

Contributions to the products proposed by Copernicus Services (interest, space for development, additional improvements for biodiversity-relevant indicators and services)

The app is based on research institutes' information on drought and trees' health and it capitalises on the integration of EO and in-situ data, as well as on citizen science contributions. Citizens' inputs would be used with EO data for calibration to inform data and to develop better information in cities. This would contribute to better assess local conditions in complex interacting urban settings. Moreover, it would be useful to understand the reflectiveness of the energy produced in urban contexts (e.g., roofs): even though this area of

[52] https://earsc-portal.eu/display/EOwiki/EO+in+Action
[53] https://zalejme.cz/

research might not be strictly related to biodiversity, it could match the need for better urban-related evaluation of ecosystem services.

5.3.5 Chiara SOLIMINI - European Union Agency for the Space Programme – EUSPA

EUSPA ([54]) has implemented an integrated approach for downstream activities based on three pillars:

1. Market and user knowledge, including: EO GNSS Market report; User consultation Platform, a dedicated workshop to engage with downstream users and communities as EO providers, industry, commercial entities, NGOs – it is a key opportunity to identify gaps within specific markets, gather feedback, user needs and requirements and identify priorities for future Research programmes (Note: in 2023, there will be a dedicated UCP on biodiversity and environmental market segments).
2. Demand support: a common market segments approach for all EU space downstream and extended key account with main players of the value chain such as corporates that are contributing to open the market and create demand.
3. Offer creation: supporting development of innovative, made in EU products through different tools such as the Cassini Hackathons, myEUspace competition, a dedicated procurement for the implementation of demonstrators and end to end solutions, and Horizon Europe.

Currently, there are a number of projects and initiatives related to biodiversity and environmental issues, namely:

— Cassini Maritime Prize ([55]) (included in the work programme in cooperation with the EU Commission) for the best data-driven marine or maritime digital application. Solutions for the detection, monitoring and the removal of micro plastics, plastic litter as well as of larger items in rivers, shores and coastal zones, to support the prevention of ocean pollution. The project must include Copernicus/Galileo data in combination with AI, high performing computing and big data processing and management

The following solutions were included in the framework of myEUspace competition:

— SustCoast ([56]) (within myEUspace framework): Digital platform for monitoring the transparent and shallow coastal waters: designed for large scale coastal monitoring of coastal waters in high resolution satellite imagery such as Sentinel 2 data. It enables greater spatial and temporal coverage of the monitoring area for water quality monitoring including rising eutrophication levels, degradation of biodiversity, and harmful algal blooms.

— Related to SustCoast, the Reef Support ([57]) project (within myEUspace framework): aquaculture data management online platform that puts together data from Copernicus, drones and under water cameras and generates environmental reports and predictive models for the maintenance of the reefs.

Additionally, the WaterMe app related to the speaker Michal Polansky was part of myEUspace competition environmental challenge portfolio.

EUSPA Horizon Europe projects related to EGNSS & Copernicus applications fostering the European Green Deal include:

— 100K TREEs ([58]) Decision Toolbox for cities to improve air quality, biodiversity, human wellbeing and reduce climate risks by planting more trees in our cities. Galileo and Copernicus supporting EU's biodiversity strategy for 2030, improving urban planning and life in European cities, where 75% of the population lives

— SWIFTT ([59]): Satellites for Wilderness Inspection and Forest Threat Tracking Protect forest health and production with an early warning system of forest threats, using space data and Artificial Intelligence

— BIRDWATCH ([60]) - A Copernicus-based service for the improvement of habitat suitability of farmland birds via satellite-enabled monitoring, evaluation and optimisation of CAP greening measures leveraging EU Space data to protect agricultural biodiversity

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(54) https://www.euspa.europa.eu/
(55) https://www.euspa.europa.eu/opportunities/horizon-europe/horizon-europe-prizes
(56) https://seacras.com/en/
(57) https://www.reef.support/
(58) https://www.euspa.europa.eu/decision-toolbox-cities-improve-air-quality-biodiversity-human-wellbeing-and-reduce-climate-risks
(59) https://www.euspa.europa.eu/satellites-wilderness-inspection-and-forest-threat-tracking

Suggested priority Use Cases linked to the Biodiversity Deep Dive

EUSPA also deals with Galileo applications and there are synergies with Copernicus in regard to faunal and habitat monitoring with Galileo for animal tracking of endangered species. Synergies Copernicus/GNSS for forest monitoring and inventories. The use of Drones could be beneficial to access more remote areas or protected areas to gather further information. In addition, the solutions that will be developed in the framework of the EUSPA HE projects are relevant to the following use cases:

- 100K TREEs: DG ENV – Monitoring of urban green spaces
- SWIFT: DG CLIMA – Regular assessment and monitoring of EU forests health conditions
- BIRDWATCH: DG AGRI – Biodiversity monitoring in agriculture landscape

Contributions to the products proposed by Copernicus Services (interest, space for development, additional improvements for biodiversity-relevant indicators and services)

Copernicus services and data are at the backbone of downstream solutions. Combined approaches such as data fusion techniques may be applied (i.e., for cloud cover) and further investigated to better respond to users' needs, such as the necessity to obtain HR and VHR data, and the availability of data of frequently revisited sites.

(60) https://www.euspa.europa.eu/birdwatch-copernicus-based-service-improvement-habitat-suitability-farmland-birds-satellite-enabled

6 Conclusions

The workshop aimed at engaging a broad community of stakeholders in the KCEO Biodiversity Deep Dive to obtain inputs and feedback in order to further develop the Deep Dive's Use Cases. The Use Cases have been initially identified without any technology-drive, and all the EO links and relations have been identified along the initial development phases of the study. The presentation of the Deep Dive methodology and the outlook of the specific Use Cases under development provided the basis to open the discussion with the stakeholder community.

During the panel sessions, it emerged that different communities of stakeholders are interested in, or are already dealing with the topics under study in the Biodiversity Deep Dive. Products and services seem to be fit for purpose at EU level. However, further improvements are needed to tailor these products at thematic and national and/or regional levels. Some of the Copernicus Services have already developed evolution plans in terms of biodiversity-related products, and there are already cross-service mechanisms such as the upcoming Thematic Hubs (e.g., Coastal areas and Biodiversity Thematic Hubs). There is a need for integration of satellite based EO with in-situ data as well as an improvement in the biodiversity-related modelling applications. These improvements may (a) have implications for the Copernicus programme's infrastructure development, (b) need to be further integrated into the EO value chain, and (c) be further developed within other opportunities outside Copernicus, such as Destination Earth.

Moreover, the outcomes of the workshop suggest that further integration of EO and in-situ data would be beneficial for calibration and validation, and for ground observation used in parameterising algorithms. A number of recurrent thematic areas have been mentioned and discussed in the panel discussion sessions such as coastal areas, forest monitoring and health, wetlands. These topics could have implications for additional products and services and they would need to be first addressed by research and innovation processes.

Other issues raised during the discussions included habitat mapping, classification methods, critical issues on the resolution of the products available for classification, long-term sustainability of data, and finally viable methods to downscale ECVs to higher resolution for biodiversity-related assessments.

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List of abbreviations and definitions

CAP	Common Agricultural Policy
CBD	Convention on Biological Diversity
CLC	CORINE Land Cover
CLMS	Copernicus Land Monitoring Service
CMEMS	Copernicus Marine Environment Monitoring Service
C3S	Copernicus Climate Change Service
DG	Directorate General
DG AGRI	Directorate General for Agriculture and Rural Development
DG CLIMA	Directorate General for Climate Action
DG CONNECT	Directorate General for Communications Network, Content and Technology
DG DEFIS	Directorate General for Defence Industry and Space
DG ENV	Directorate General for Environment
DG EUROSTAT	Directorate General for European Statistics
DG INTPA	Directorate General for International Partnerships
DG MARE	Directorate General for Marine Affairs and Fisheries
DG REGIO	Directorate General for Regional and Urban Policy
DG RTD	Directorate General for Research and Innovation
DTO	Digital Twin Ocean
EC	European Commission
ECB	Essential Biodiversity Variable
ECV	Essential Climate Variable
EE	Entrusted Entity
EEA	European Environment Agency
EFH	Essential Fish Habitat
EGNSS	European Global Navigation Satellite System
EO	Earth Observation
ESA	European Space Agency
EU	European Union
EUBDS	European Union Biodiversity Strategy 2030
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
GBF	Global Biodiversity Framework
GKSSB	Global Knowledge Support Service for Biodiversity
GNSS	Global Navigation Satellite System
HE	Horizon Europe
HR	High-Resolution
HSM	Hot Spot Monitoring
IUCN	International Union for Conservation of Nature
JRC	Joint Research Centre

KCBD	Knowledge Centre for Biodiversity
KCEO	Knowledge Centre on Earth Observation
KLC	Key Landscape for Conservation
LAI	Leaf Area Index
MPA	Marine Protected Area
MS	Member State
N2K	Natura 2000
NBS	Nature based Solution
NDVI	Normalized Difference Vegetation Index
NGO	Non-Governmental Organization
PA	Protected Area
RS	Remote Sensing
SDGs	Sustainable Development Goals
SEEA	System of Environmental-Economic Accounting
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
UNCCD	United Nations Convention to Combat Desertification
UNEP	United Nations Environment Programme
VHR	Very High Resolution
VME	Vulnerable Marine Environment

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