**Implementation Plan for the CEOS Biodiversity Virtual Constellation**

**Draft for discussion at the CEOS SIT Technical Workshop**

**September 9th - 11th, 2025**

**Darmstadt, Germany**

**Biodiversity Study Team Co-leads:**

**Gary Geller[[1]](#footnote-1), NASA**

**Shaun Levick, CSIRO**

**Marc Paganini, ESA**

**Version 1.1**

**21 August 2025**

This document provides additional detail on the activities that are outlined in the

Biodiversity Virtual Constellation’s Terms of Reference. Eventually, it will be the basis for the Implementation Plan that will be a component of a B-VC full proposal. It follows the format indicated in the [CEOS Virtual Constellation Process Paper](https://ceos.org/document_management/Publications/Governing_Docs/Virtual-Constellations_Process%20Paper_rev1-2019.pdf).

**Introduction**

This Implementation Plan provides an overview of the activities the Biodiversity Virtual Constellation (B-VC) will focus on, following the guidance provided in the [CEOS Virtual Constellation Process Paper](https://ceos.org/document_management/Publications/Governing_Docs/Virtual-Constellations_Process%20Paper_rev1-2019.pdf). The Requirements and Specifications section explains that the B-VC is a domain-based virtual constellation focused on the needs of the biodiversity community that were identified in the [Biodiversity Study Team](https://ceos.org/document_management/Biodiversity_Study_Team/TORs_CEOS%20Biodiversity%20Study%20Team%20V1.0_2025%20Feb%2012.docx)’s stakeholder assessment. The B-VC activities that will address those findings are then discussed and timeframes for their development are presented. A short section explaining how the B-VC will assess its level of success is followed by an overview of the role of other CEOS entities and how the B-VC will coordinate with them. Lastly is a section on Funding that summarizes how the B-VC will be resourced.

The overarching objective of the B-VC is to increase utilization of space-based Earth observation (EO) for understanding, monitoring and conserving biodiversity to support the needs of the biodiversity and conservation user communities. Activities include identifying needed EO data products and tools and facilitating their development; enhancing EO utilization through outreach, engagement, and capacity building; and facilitating development of demonstration systems that utilize EO and that act as testing grounds for new products and capabilities as well as an engagement mechanism.

**Definitions**. To ensure that all readers have a common understanding of the terminology used in this document, definitions of some key terminology are provided.

|  |  |
| --- | --- |
| Biodiversity | In the strict sense this refers to the variety of living organisms at all levels of organization including genes, species, and ecosystems. However, it is commonly used much more broadly to include all of the living natural world and its processes, roughly synonymous with “nature”. This broader meaning is used here and other BST and B-VC documents unless otherwise indicated. |
| Ecosystem | A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit. |
| Indicator | A measure reflecting the status of a target of interest (e.g., an ecosystem or species). |

**Requirements and Specifications**

The B-VC is a domain-based virtual constellation driven by biodiversity community requirements. Following its mandate, the Biodiversity Study Team completed a stakeholder assessment that identified specific user needs for utilizing space-based EO for biodiversity understanding, monitoring, and conservation. The user organizations contacted are listed in Appendix 1. Because of the high degree of overlap across organizations these needs were consolidated into a focused list (App. 2) that was shared with CEOS Agencies and entities for review and comment. This assessment, consistent with the findings in the Ecosystem Extent Task Team’s [White Paper](https://ceos.org/document_management/Publications/Publications-and-Key-Documents/Cross-Cutting/EETT%20White%20Paper%20V1.1%202023-12-04.pdf), made clear that the value of space-based EO is not yet fully exploited by the biodiversity community. Two top-level areas were identified where user needs were not well-met:

* **Availability of fit-for-purpose products.** Most agencies do not process beyond Level 2, yet the data products users need, such as those for Essential Biodiversity Variables (EBVs) and for biodiversity indicators, are usually Level 4.
* **Addressing limited user technical capacity.** While EO familiarity and expertise varies across the biodiversity user community, technical capacity generally limits EO utilization; most users cannot, for example, process a Level 2 product to derive the higher level product they need.

At the product level, users identified three product categories where their needs are currently not well-met but that align well with existing and, particularly, forthcoming CEOS Agencies’ satellite missions: ecosystem extent, ecosystem condition, and species distribution. These products depend on measurement of several complementary ecosystem characteristics[[2]](#footnote-2) – physical structure, taxonomic composition, and functional processes – that newly launched and forthcoming missions[[3]](#footnote-3) are expected to make widely available, globally, from space, for the first time. This will enable a step-change in the quality, frequency, and value of these and other biodiversity products.

The overlap in the needs of key stakeholders enables the work of the B-VC to address the requirements of a much wider range of organizations. However, to best leverage existing Agency activities the B-VC plans to initially focus on several organizations, including the CBD, Ramsar, and UN SEEA. These activities provide ongoing user engagement and an environment that, via feedback loops, enables incremental development that is particularly responsive to user needs and constraints.

**Activities**

Based on the information provided by users and discussed in the previous section the B-VC plans to initially focus on the six priority areas listed below. These areas capture what can reasonably be expected in the first years of a new CEOS Biodiversity entity. This list should be understood as dynamic; the B-VC will adjust its activities based on a variety of factors including resource availability, updates in user needs and priorities, data availability, and what is learned as the activities move forward.

1. **Identify and facilitate filling gaps in priority data products.** These gaps include indicators such as those identified by various international conventions. Addressing the gaps identified by the BST is a multi-step process:
   * Prioritize needed products based on the balance between value to users and cost of implementation
   * Develop the plan and methods to fill gaps
   * Implement the product gap-filling plan (incremental, with partners)
   * Assess data quality and suitability
   * **Outcome**: Increased availability of needed products and utilization of space-based EO
2. **Identify and facilitate enhancement of data utilization tools.** The stakeholder assessment was clear that users need enhanced data access and analysis tools. Steps include:
   * Assess current tools and identify and prioritize enhancements
   * Develop plan and methods for enhancements, including use of the Open Data Cube
   * Implement tool enhancements (incremental, with partners)
   * **Outcome**: More/better tools and increased utilization of space-based EO
3. **Demonstrator development[[4]](#footnote-4).** Demonstrators such as those developed as an Ecosystem Extent Task Team (EETT) activity have a new role in the B-VC. Demonstrators provide a framework within which to develop and test new products and capabilities, including those mentioned above, and for user engagement. Plans include:

* Continue development of the three EETT demonstrators (Hudson Bay—ECCC; Costa Rica—CNES; Great Western Woodlands—CSIRO)
* Seek new demonstrator activities and use them as a framework for other B-VC activities
* **Outcome:** Functioning demonstrators that enable real-world development and testing of new capabilities, and new pathways for user engagement

1. **Capacity building.** Work with WGCapD to prioritize and enhance capacity building.
   * **Outcome:** Increased ability to utilize space-based EO data for understanding and monitoring biodiversity
2. **Biodiversity community engagement.** Increasing utilization of EO requires closer and ongoing ties with the biodiversity community.Approach:
   * Develop informational webinars, brochures, and perform other outreach activities such as conferences (BIOSPACE25 is a good example).
   * **Outcome**: A stronger communication channel leading to improved understanding of user needs and increased utilization of space-based EO
3. **Coordinate with GEO BON and its Global Biodiversity Observing System (GBiOS) concept[[5]](#footnote-5).** GEO BON’s global monitoring concept requires coordination with CEOS Agency space-based observations, products, and capabilities. Approach:
   * Identify GBiOS needs, gaps, challenges, and areas for coordination (jointly with GEO BON)
   * Guide concept development to enhance EO utilization (jointly with GEO BON)
   * **Outcome**: Embedding of space-based EO in GBiOS for global biodiversity monitoring

**Schedule**

The proposed schedule for the B-VC activities follows, recognizing that the detail and timeframe may evolve over time in accordance with CEOS Agency priorities and stakeholder needs:

| **Activity Topic** | **Milestones** | **Timeframe** |
| --- | --- | --- |
| Data product gaps | Prioritize needed products to fill product gaps | Year 1 |
| Develop plan and methods to fill gaps | Years 1-3 |
| Implement product gap-filling plan (incremental, with partners) | Years 2-5+ |
| Data utilization tools | Assess current tools and identify and prioritize enhancements | Years 1-3 |
| Develop plan and methods for enhancements | Years 2-4 |
| Implement tool enhancements (incremental, with partners) | Years 2-5+ |
| Demonstrator development | Continue development of the three Ecosystem Extent Task Team demonstrators (Hudson Bay—ECCC; Costa Rica—CNES; Great Western Woodlands—CSIRO) and seek new demonstrator options | Years 1, 2-5 |
| Capacity building | Work with WGCapD to prioritize and enhance capacity building | Continuous |
| Stakeholder engagement | Outreach and engagement via informational webinars, brochures, and other means | Continuous |
| Space arm of GBiOS | Identify needs, gaps, and challenges (jointly with GEO BON) | Years 2-3 |
| Integrate space-based EO into the GBiOS concept and architecture (jointly with GEO BON) | Years 3-7+ |

**Accreditation and Recognition Metrics**

The B-VC’s success over time will ultimately be measured by the increase in incorporation of space-based EO into the activities of the biodiversity community, by the utilization of the products and tools the B-VC focuses on, and by the overall value of the B-VC’s activities to the biodiversity user community. As mentioned above, the B-VC will adjust its activities in response to changing conditions and interim results. Additionally, as part of its engagement activities the B-VC will help connect users to the new products or tools developed and promote and facilitate their utilization. This will not only increase the impact of the new products or tools but ensure that the sponsors and developers are properly recognized.

**Working with CEOS WGs, VCs and Other Entities**

Consistent with CEOS’s [Mission Statement](C://Users/ggeller/Downloads/Reviewed%20Strategic%20Document%202024_clean%20version.pdf) and B-VC’s Objective 3 (see the B-VC ToR), the B-VC will coordinate, work with, and as appropriate, utilize the expertise in other CEOS entities, including those below. The B-VC is also available to support the activities of other VCs and WGs where needed.

* WGCapD. User capacity is often limited and enhancing it will require active coordination with WGCapD.
* WGCV. New biodiversity data products (e.g. EBVs) will combine different types of sensors and inter-sensor calibration will be important.
* WGDisasters. Natural disasters such as river or coastal flooding often have an ecosystem component; forecasts for, and mitigation of, some of these hazards is possible and coordination will likely be mutually beneficial.
* WGISS. Many of the challenges that biodiversity users have are related to CEOS Agency information systems that generate and provide access to data products. WGISS can provide guidance to the B-VC on standards, interoperability issues, and other areas.
* COAST-VC. The coastal environment is a particularly important area for biodiversity and collaboration with the COAST-VC will be needed.
* LSI-VC: The Forests and Biomass subgroup will be of particular importance; the LSI-VC’s work on CEOS-ARD and the AFOLU Roadmap are also highly relevant to the B-VC.
* SST-VC. Sea surface temperature is a controlling factor for a variety of biological activities, including species distribution and algal blooms.
* SEO. The SEO’s CEOS Analytics Lab will be particularly useful for experimenting with new products or methods.

**Funding**

Three categories of support will provide the necessary resources to enable the B-VC’s activities and to meet its objectives:

**B-VC team members.** As Biodiversity Study Team membership (App. 3) shows, there is significant interest in Biodiversity across CEOS. Member time and associated resources will be supported by their sponsor Agencies in a manner similar to that for the BST. As indicated in the Activities section above, the B-VC and its members largely focus on planning and facilitating biodiversity-relevant activities to increase utilization of space-based EO. Support from other CEOS entities, as summarized in the previous section, is also expected to enable achievement of the B-VC objectives.

In addition to CEOS Agency involvement, members of the research and applied biodiversity communities such as those at universities, institutes, and other organizations, will be invited to participate in the B-VC and to support its activities. In-kind participation is expected where there is alignment with an activity such as development of a product (product development is a common activity at universities, often by a graduate student under the guidance of their professor).

**Agency Research and Development Programs.** Some of the B-VC’s planned activities, such as algorithm and product development and the “demonstrators”, align with Agency research and development programs that already support these types of activities, often by soliciting proposals. Universities, institutes, and NGOs have focused on EO utilization for biodiversity for many years, as exemplified by the many proposals that space agencies have funded. The exceptionally high interest in ESA’s BioSpace25 conference (February 2025; many attendees had to be turned away as capacity was exceeded) is an example of the level of interest in this topic. It is noted that each of the three Ecosystem Extent Task Team Demonstrators was funded by a CEOS member Agency. Demonstrators such as those have components that support all of the B-VC’s planned activities and are a valuable tool for users seeking to enhance their use of space-based EO to meet their needs.

**External Support.** Another source of support for B-VC activities is proposals submitted to non-CEOS Agency organizations by B-VC external partners. For example, a national science agency or an agency within an Environment Ministry may solicit proposals for work relevant to the B-VC’s activities, such as development of a product or tool for which a biodiversity expert at a university then submits a proposal. An important role of the B-VC is to continue engagement with such external partners so they are aware of, and encouraged, to engage with potential B-VC activities.

**Appendix 1: User Organizations Contacted**

|  |  |
| --- | --- |
| [**Ecosystem Extent**](https://geobon.org/ebvs/what-are-ebvs/) | An Essential Biodiversity Variable that is not tied to a single organization, but a universally needed product across the biodiversity community that underpins numerous applications |
| [**GEO BON**](https://geobon.org/) | GEO Biodiversity Observation Network |
| [**IOC/UNESCO**](https://www.ioc.unesco.org/en) | Intergovernmental Oceanographic Commission of UNESCO |
| [**IPBES**](https://www.ipbes.net/) | Inter-governmental Platform on Biodiversity and Ecosystem Service (analogous to IPCC) |
| [**Ramsar Convention on Wetlands**](file:///C:\Users\cmcmaho1\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\CPT5309X\ramsar.org) | International treaty on Wetlands (signed in 1971 in Ramsar, Iran) |
| [**TNFD**](https://tnfd.global/) | Taskforce on Nature-related Financial Disclosures (other “nature finance” organizations were also considered) |
| [**UNCBD**](https://www.cbd.int/) | UN Convention on Biological Diversity |
| [**UNCCD**](https://www.unccd.int/) | UN Convention to Combat Desertification |
| [**UNSEEA**](https://seea.un.org/) | UN System of Environmental-Economic Accounting |

**Appendix 2: Identified User Needs**

This table summarizes the results of the Biodiversity Study Team’s stakeholder assessment and provides the list of user needs that guide the Biodiversity Virtual Constellation’s activities. Additionally, Agencies, Working Groups and Virtual Constellations provided feedback to indicate which needs they may be able to contribute to; this will be used to help coordinate the B-VC’s activities with those of other entities.

|  |  |  |
| --- | --- | --- |
| **General Need Category** | **Example Conservation Applications** | **Example Products or Tools Needed with Direct Relevance to EO** |
| Species Distribution | ● Invasive species detection  ● Endangered species management  ● Extinction risk assessment | Environmental data |
| Mapping/visualization tools |
| Multi-sensor products (e.g., optical + SAR + lidar) that characterize ecosystem structure, composition, function |
| Ecosystem Extent | ● Managing ecosystems & protected areas  ● Monitoring & assessing  ● Planning ecosystem restoration | Ecosystem extent maps |
| EO-based tools for mapping ecosystem types |
| EO-based methods for monitoring changes |
| Time series & change maps |
| Distinguishing natural from plantation ecosystems |
| Multi-sensor products (e.g., optical + SAR + lidar) that characterize ecosystem structure, composition, function |
| Ecosystem Condition | ● Monitoring health & function of ecosystems  ● Monitoring ecosystem degradation & restoration  ● Identifying eutrophication | Ecosystem condition metrics |
| Time series & change maps |
| Trend maps & figures |
| Multi-sensor products (e.g., optical + SAR + lidar) that characterize ecosystem structure, composition, function |
| Increased user capacity, data access, & usability | All | Data access tools to simplify finding/accessing data |
| Data utilization tools to simplify analysis, particularly for SAR & hyperspectral data |
| Guidance on data to use for particular applications |
| Ecosystem Services | ● Monitoring food, lumber, carbon sequestration, hydrological buffering, natural beauty, etc. | Data & products that characterize ecosystem functions & products that are useful to humans |
| Various | ● Ecosystem conservation (all aspects) | Vegetation indices, productivity, biomass |
| Change detection & mapping |
| Identification/mapping threats to biodiversity (e.g., climate change, LULCC, roads, invasive non-native species) |
| Ecosystem connectivity | ● Animal movement planning  ● Ecosystem condition assessment | Ecosystem extent & condition maps |
| Combines Ecosystem Extent & Ecosystem Condition |
| Species extinction risk | ● Conservation planning | Identification of threats (e.g., climate change, LULCC, roads, invasive non-native species) |
| Change in species distribution |
| Ecosystem degradation and restoration | ● Degradation & restoration assessment  ● Restoration planning and reporting | Frequent plant productivity time series (10m or less, since 2000) |
| Land cover change (10m or less, annual) |
| Plant cover, soil carbon, & soil moisture for dry, sparsely vegetated areas |
| EO standards for land degradation assessment |

**Appendix 3:**

**Agency Support for the Biodiversity Study Team**

Biodiversity Study Team membership was supported by the following agencies:

* CNES
* CSA
* CSIRO (co-lead)
* EC
* ECCC
* ESA (co-lead)
* ISRO
* JAXA
* NASA (co-lead)
* NOAA
* UKSA
* USGS

1. Jet Propulsion Laboratory, California Institute of Technology [↑](#footnote-ref-1)
2. Distinguishing and mapping ecosystems, assessing ecosystem condition, and mapping species habitats and distribution all require these three complementary measurements. [↑](#footnote-ref-2)
3. Forthcoming missions will provide L-band SAR, lidar, thermal, hyperspectral, and enhanced multi-spectral data. Radar and lidar provide information on ecosystem physical structure while optical data, particularly hyperspectral, can be used to create data products that characterize an ecosystem’s taxonomic composition and functional processes. [↑](#footnote-ref-3)
4. Demonstrators enable real world application of many activities, act as laboratories to improve products and tools, and provide a basis for additional activities such as cal/val sites or supersites. [↑](#footnote-ref-4)
5. GBiOS: GEO BON’s concept for a global biodiversity observing system; it would combine in situ, space-based EO, models, and expertise to facilitate biodiversity monitoring for societal benefit [↑](#footnote-ref-5)