

Skills 4 eosc

D3.5 Open collection case studies and related material

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Deliverable Abstract

This Deliverable highlights the transformative role of Open Collections in advancing evidence-based policymaking across critical domains: biodiversity, pollution, climate change, and Holocaust and cultural heritage. Case studies illustrate how Open Collections provide essential data for conservation, pollution control, climate change mitigation, and the preservation of historical memory, emphasizing their contribution to societal and environmental challenges. However, achieving their full potential requires addressing common challenges, including fragmented access, insufficient standardization, and the need for ethical frameworks. Common challenges and recommendations are outlined, including securing sustainable funding, promoting Open



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Science skills, and fostering public engagement through citizen science. Policymakers are encouraged to use Open Collections for evidence-based decision-making, supported by FAIR and CARE principles, to ensure responsible and impactful use of these resources. By aligning scientific, historical, and cultural knowledge with policymaking, Open Collections can significantly inform strategies addressing global challenges while promoting inclusivity and societal trust.

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TERMINOLOGY

<i>Terminology/Acronym</i>	<i>Definition</i>
BPR	Biocidal Products Regulation
CARE	Collective Benefit, Authority to Control, Responsibility, and Ethics
ECHA	European Chemicals Agency
EOSC	European Open Science Cloud
ERB	European Raptor Biomonitoring
GLAM	Galleries, Libraries, Archives and Museums
IPCC	Intergovernmental Panel on Climate Change

IPCHEM	Information Platform for Chemical Monitoring
OS	Open Science
REACH	Regulation on the registration, evaluation, authorisation and restriction of chemicals
SDGs	United Nations Sustainable Development Goals

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1 Executive Summary

This deliverable presents a set of case studies to illustrate how Open Collections enable research that provides the evidence needed to define and achieving policy goals in four domains: Biodiversity, Pollution, Climate change, and Holocaust and Cultural Heritage.

The case studies demonstrate the valuable role that Open Collections play in supporting research that serves as evidence for European policy and highlight that more coordination and cooperation to improve the access to the collections and establish the appropriate methods, standards and skills to obtain the information available in these collections is needed to achieve the full potential of these collections for research and policy support. They suggest that this could be achieved through robust and sustainable data infrastructures and research for innovative methods and technologies to use the collections.

The deliverable also includes a description of the Stakeholder Forum ‘Empowering Europe’s Green Deal: Open Science Skills and Taxonomy for Sustainable Innovation’ which took place in Brussels on the 6th of November 2024, jointly organised with the TETTRIs project.¹ The event was aimed at policymakers and policy administrators as an opportunity to demonstrate and discuss how Open Science skills can enhance evidence-based decision-making across different domains. A booklet with the case studies from this deliverable was presented at that event.²

To advance Open Science and Open Collections, it is essential to secure consistent, sustainable funding and policy support at both national and international levels. Promoting public engagement through citizen science initiatives can enhance societal trust and awareness by involving communities in data collection and research, while educational programs should connect the relevance of Open Collections for contemporary societal

¹ This event represented a milestone of this task (MS 3.2), see DoA.

² Gottwald, I., Whyte, A., Linés, C., Evangelinou, B., Vohland, K., & Rainer, H. (2024). Advancing evidence-based policymaking through Open Collections and Open Science Principles. Natural History Museum Vienna. <https://doi.org/10.57827/978-3-903096-78-3>

challenges such as biodiversity loss and climate change. Open Collections can critically inform evidence-based policymaking on issues such as biodiversity, pollution, public health, climate change, and democratic societies. Policymakers should implement ethical frameworks by strengthening FAIR practices, supporting education, training, and community initiatives, and incentivizing progress in Open Science. Expanding accessibility by digitizing and integrating collections into online platforms, standardizing metadata and data formats, and strengthening infrastructures like the European Open Science Cloud (EOSC) will maximize reach and interoperability. Finally, integrating scientific, historical, and cultural knowledge into policymaking will enhance the relevance and impact of decisions.

2 Introduction

Task T3.4, "Open Collections for Policy Goals," has focused on examining how Open Collections (the term Open Collection will be used throughout the Deliverable) contribute to advancing policy objectives, particularly within the European context. This task has involved gathering and analyzing case studies that illustrate the role of accessible, digitized collections in supporting evidence-based policymaking. The results have been shared through the publication of a booklet and a Round Table discussion held in Brussels. This Deliverable summarizes the findings and outcomes of the task, highlighting the key insights and contributions to the field.

2.1 Open Collections for Open Science to Inform Policymaking

Open Collections enhance access to GLAM collections (Galleries, Libraries, Archives, and Museums) through a framework of processes and practices aimed at providing digital representations of these collections, thereby promoting broader engagement. In this context, "open" is guided by FAIR principles (Findable, Accessible, Interoperable, and Reusable)³, making collections broadly accessible and reusable while respecting sensitivities that may restrict some materials, thus balancing openness with necessary limitations (Vohland et al., 2022).

Amid rapid technological shifts and complex global issues, GLAM institutions increasingly need to open up data about their collections and, where feasible, digitized objects within these collections, for research use. Opening up data about collections and digitized objects is essential because it enables wider access to knowledge, fosters inclusivity and collaboration, empowers diverse communities to engage with cultural heritage, and supports informed decision-making to address pressing global challenges such as social

³ FAIR principles. (2022). GO FAIR initiative. <https://www.go-fair.org/fair-principles/>

inequality, climate change, and political unrest (Avdikos et al., 2024). Fundamentally, Open Collections approaches are aimed at enhancing the potential of collections to contribute to Open Science. This is crucial for institutions housing scientific collections (including scholarly collections), as their data can contribute to the evidence needed to address key challenges, such as, among others, biodiversity loss, climate change and fostering peaceful and inclusive societies. Policy measures to develop collections as research infrastructure (facilities that offer resources and services to support research communities in conducting studies and driving innovation within their respective disciplines, European Commission- Research and Innovation, 2024) are making collections more accessible and useful for research, and subsequently for evidence-based policy and impactful decisions.

The capability to mobilise the evidence depends on the development of skills to curate collections, to make Open Collections FAIR and as open as possible to researchers and policymakers.

2.2 Objectives of the Deliverable

The objective of this deliverable is to demonstrate through case studies how Open Collections can directly contribute to achieving policy goals. The case studies presented in the deliverable represent four domains aligned with the United Nations Sustainable Development Goals (SDGs):⁴

- BIODIVERSITY (SDG 14 & 15)
- CLIMATE (SDG 13)
- POLLUTION (SDG 2, 3, 6, 8, 9, 11–15 & 17)⁵
- HOLOCAUST AND CULTURAL HERITAGE (SDG 16)

⁴ THE 17 GOALS | Sustainable Development. (n.d.). United Nations. Department of Economic and Social Affairs. <https://sdgs.un.org/goals>

⁵ The Lancet Commission on Pollution and Health. (n.d.). *Pollution: A Critical Link for Achieving the SDGs*. <https://www.pureearth.org/wp-content/uploads/2021/03/SDGPollutionLinks2018Final.pdf>

This deliverable presents a series of case studies collected by Skills4EOSC Task 3.4 on Open collections for policy goals. The aim of the case studies is three-fold: 1) to illustrate the kinds of impact currently being made by opening collections up, and 2) the critical role of research infrastructures in making this happen, and 3) to offer policymakers insight into the essential connections between the United Nations Sustainable Development Goals (SDGs), Open Science, and Open Collections across various domains. Together, the cases highlight how global policy goals are intrinsically linked to research initiatives that rely on Open Collections to provide evidence for decision-making.

The case studies have been compiled in collaboration with institutions and projects such as i.a. the Distributed System of Scientific Collections (DiSSCo), the Global Biodiversity Information Facility (GBIF), the Vienna Wiesenthal Institute for Holocaust Studies (VWI), the Consortium of European Taxonomic Facilities (CETAF), and the Horizon Europe project “Transforming European Taxonomy through Training, Research, and Innovations” (TETTRIs).

2.3 Importance of Open Science and Collections in Policymaking

By fostering transparency, accessibility, and collaboration, Open and FAIR Science strengthens scientific output while promoting accountability and inclusiveness. These qualities boost public engagement, trust, and the uptake of scientific findings by enabling critical discussions about research methods, data, and outputs – practices fundamental to robust and reliable scientific work. Open Science and Open Collections also provide policymakers with reliable, high-quality data essential for evidence-based decisions on pressing societal and environmental challenges, including biodiversity, climate change, and historical contexts.

The European Commission is committed to advancing Open Science, supporting platforms such as the European Open Science Cloud (EOSC) that

foster cross-disciplinary data and tool sharing.⁶ Open Science is a central pillar of the EU’s research policy and efforts for research and innovation,⁷ aimed at making science more efficient, transparent, and impactful, while responding to societal needs and expectations. The objective is to position Europe at the forefront of global research by facilitating seamless collaboration between researchers across disciplines and engaging society as a whole. Furthermore, the EU’s Open Science policy emphasizes the importance of dismantling barriers to data sharing, access and collaboration, developing incentives for data-intensive science, and promoting knowledge exchange on a massive scale.

Adherence to the FAIR principles and ethical frameworks such as the CARE principles⁸ (Collective Benefit, Authority to Control, Responsibility, and Ethics) ensures that these collections can be widely used for diverse purposes — from research to crafting evidence-based policies. For example, natural history collections are instrumental in research to monitor biodiversity changes over time, enabling policymakers to identify at-risk species, set conservation priorities, and develop robust environmental policies (Johnson et al., 2023). Historical collections also contribute important insights into cultural preservation and social justice fields, such as Holocaust research and human rights advocacy (e.g. the United States Holocaust Memorial Museum⁹).

Open Science seeks to make research accessible to all, benefiting both scientists and society, while fostering collaboration and information sharing. This approach is in line with UNESCO’s Open Science Recommendation, which advocates for open, equitable, and inclusive scientific practices on a global scale.¹⁰ UNESCO’s Recommendation outlines shared values and principles for implementing Open Science, emphasizing transparency, inclusiveness,

⁶ <https://eosc.eu/>

⁷ <https://op.europa.eu/en/publication-detail/-/publication/0dc27be9-de75-11e9-9c4e-01aa75ed71a1/language-en>

⁸ CARE Principles. (2023). Global Indigenous Data Alliance. <https://www.gida-global.org/care>

⁹ <https://www.ushmm.org/collections/the-museums-collections/about>

¹⁰ UNESCO Recommendation on Open Science. (2021). UNESCO. <https://doi.org/10.54677/mnmh8546>

and equity in access to knowledge, and the diversity of scientific practices and outputs. It also encourages policymakers to create supportive environments for Open Science by investing in infrastructure, training, and international cooperation to close knowledge gaps. It promotes principles of transparency, scrutiny, and reproducibility to ensure that science not only reaches broader audiences but also has a tangible, positive impact on society.

The following sections describe how Open Science and Collections align to support policymakers in several critical ways.

2.3.1 Supporting International Collaboration

Open Science infrastructures, such as the European Open Science Cloud (EOSC), support cross-border research collaboration by promoting data sharing between researchers globally. The open exchange of knowledge allows for coordinated international responses to pressing global challenges such as biodiversity loss, climate change (Committee on Biological Collections, 2020), and the fostering of inclusive and peaceful societies (Urata et al., 2022). Furthermore, the Horizon Europe framework actively supports Open Science by mandating that research outputs – such as publications, data, and software – are made openly accessible.¹¹

As part of the Stakeholder Forum held on November 6 (see Appendix 2 and Section 2.3.4), collaboration was established with another Horizon Europe project, TETTRIs¹². Building on the synergies identified between the two projects – focusing on open science skills for taxonomy and sustainable development – a joint Stakeholder Forum was convened. This forum brought together representatives from the European Commission, policymakers, researchers, research infrastructures, industry, and the education sector.

¹¹ https://rea.ec.europa.eu/open-science_en

¹² tettris.eu

2.3.2 Raising Awareness and Advocacy

GLAM institutions increasingly use Open Collections to raise awareness about critical challenges (Johnson et al., 2023). By leveraging their scientific resources, such institutions may play a pivotal role in stimulating engagement and advocating for evidence-based policy changes. Open Science practices, such as public engagement and Citizen Science initiatives (e.g. Train4EU+ approach to Citizen Science from the European University Alliance¹³), further encourage active participation from members of society, thereby aiming to strengthen public trust in science.

For example, the Natural History Museum in London has responded to declarations of a 'climate emergency' by launching new exhibits and programs to educate the public and policymakers about critical environmental issues. Their strategy¹⁴ couples a new science and digitisation centre to protect past collections with public engagement to 'make an impact far beyond our physical limits', including via a digital channel on climate change.¹⁵

2.3.3 Supporting Sustainable Development

Through both historical and current data on ecosystems, species distribution, and disease spread, Open Collections offer policymakers critical insights for developing long-term, sustainable policies. For example, natural history collections help monitor biodiversity trends, while public health data informs policy decisions regarding disease prevention and climate resilience (Johnson et al., 2023). Making collections open involves applying Open Science practices to data from the collections, to ensure they are FAIR and open to the research community. The case studies in this report illustrate steps taken that are already helping to ensure that policymakers have timely access to

¹³ <https://4euplus.eu/4EU-12.html?newsID=19212>

¹⁴ <https://www.naturalmuseums.org.uk/news/planetary-emergency-nhm-places-climate-centre-its-strategy-2031/>

¹⁵ <https://www.nhm.ac.uk/discover/climate-change.html>

the most up-to-date information needed for addressing complex societal challenges, for example in the following ways:

- **Providing Long-Term Data on Global Changes:** The case studies described in section 4 of this report emphasise that collections hold unique data for understanding global change (Kharouba et al. 2020). Collections can provide long-term records of biodiversity and human culture that span before the acceleration of climate change and other recent human impacts. This historical data can inform policies aimed at, for example, addressing the drivers of biodiversity loss, or mitigating climate change and pollution.
- **Tracking the Spread of Infectious Diseases:** Museum specimens have been used to track the spread of infectious diseases, such as the chytrid fungus that is a major cause of amphibian decline (Fisher and Garner, 2020). By analysing historical specimens, researchers can better understand how diseases have spread over time, which can inform policy decisions to mitigate their impacts.
- **Informing Conservation Priorities:** Collections allow researchers to identify rare, threatened, and endangered plant species (Lughadha et al, 2019). This information is crucial for guiding conservation policies and prioritising protection efforts. Collections of living plants and seed banks also help conserve the genetic diversity of plant species. Such genetic material can be used for research, restoration, and in reintroduction programs.
- **Informing Habitat Restoration Efforts:** Natural history museum specimens can provide valuable data to inform habitat restoration efforts. This is especially relevant for forest restoration efforts, which mitigate the loss of canopy species to invasive insects (Panzavolta et al, 2021).

2.3.4 Example Stakeholder Forum: Fostering the role of Open Science and Open Collections in policymaking

In light of the goal of this Task, it is crucial to facilitate direct engagement with policymakers. This ensures that the key messages reach the primary target group and are incorporated into the political and scientific discourse and decision-making process. For this purpose, a stakeholder forum entitled ‘Empowering Europe's Green Deal: Open Science Skills and Taxonomy for Sustainable Innovation’¹⁶ was held on 6 November 2024 at the Vienna House in Brussels.¹⁷ The event was jointly organised by two Horizon Europe Projects, TETTRIs and Skills4EOSC and provided a platform for policymakers and stakeholders from various domains to explore the role of Open Science skills in advancing evidence-based policymaking and sustainable development. Focusing on the relevance of taxonomy, the event highlighted how Open Science, aligned with the FAIR (Findable, Accessible, Interoperable, Reusable) principles, can support biodiversity conservation, strengthen taxonomic capacity, and contribute to the goals of the EU Green Deal. Through panel discussions and interactive audience engagement sessions, the forum underscored how Open Science practices and taxonomic expertise can drive biodiversity conservation and scientific progress. As mentioned above, the booklet ‘Advancing evidence-based policymaking through Open Collections and Open Science Principles’¹⁸ produced for the event provided a general overview of the topic alongside selected case studies.

Participants appreciated the opportunity to network across the different domains and the wide range of topics selected for the discussions. The joint efforts of the two Horizon Europe projects and the participation of

¹⁶ For further information on this event, see Appendix 2.

¹⁷ We would like to greatly thank the colleagues at the Vienna House for their support with the organisation and coordination of the event.

¹⁸ Gottwald, I., Whyte, A., Linés, C., Evangelinou, B., Vohland, K., & Rainer, H. (2024). *Advancing evidence-based policymaking through Open Collections and Open Science Principles*. Natural History Museum Vienna. <https://doi.org/10.57827/978-3-903096-78-3>. The printed version was available at the event.

representatives from Directorates-General of the European Commission on the panels, were also regarded as highly beneficial. Above that, it is also crucial to maintain an ongoing dialogue with diverse target groups and stakeholders, while engaging with multiple audiences to gather a wide range of perspectives, including opposing viewpoints.

Key messages from the event:

- Integrating Taxonomy and Open Science: The integration of taxonomy with Open Science is essential for addressing biodiversity and climate challenges. Emphasizing FAIR principles, cross-disciplinary collaboration, and improved training for Europe’s taxonomic community can enhance data usability, transparency, and innovation.
- Transforming Research Practices with Open Science: Open Science fosters collaboration but requires embedding relevant skills in education.
- Strengthening Policy-Science Alignment: Greater collaboration between scientists, projects, and policymakers is essential.
- Open Data and Biodiversity Indicators: Limited trust, funding, and national capabilities hinder the widespread availability of open biodiversity data. Collaborative frameworks and stepwise approaches are needed to improve data-sharing mechanisms and indicator systems.
- Enhancing Biodiversity Monitoring: Biodiversity monitoring in Europe relies heavily on citizen science due to limited professional investment. The integration of Open Science practices and research infrastructures, such as DiSSCo, is critical to supporting biodiversity data collection, sharing, and policy development.
- Bridging the Science-Policy Gap: Addressing the gap between scientific research and policymaking is essential for impactful biodiversity strategies. Researchers need targeted Open Science and science communication training to effectively communicate with policymakers, ensuring that scientific insights translate into actionable policies.

3 Methodology

Case studies for the deliverable were identified through desk research and expert consultation, starting from identifying relevant European policy goals and investigating in which cases the research that supports or could support them is based on collection data. Sources consulted include research papers, news articles and organisations websites.

The scope was initially focused on case studies on environmental themes, aiming to describe how research based on open natural history collections contributes to policy goals. The scope was later expanded to include a case study from the Cultural Heritage domain, to allow contributions to social goals to be highlighted.

After identifying a set of case studies, people from the relevant organisations or initiatives were contacted to discuss the case studies in more detail or request additional information. In one of the cases, the pollution case study, we were not successful in establishing contact with the team responsible for the collection aspects of the project and the information included in the case study is based only on their project outputs and publications, which include research papers and policy briefs.

4 Case Studies on Open Collections

The four case studies outlined in this section illustrate the diverse applications of Open Collections in supporting evidence-based policymaking across critical domains (for detailed elaboration on the case studies, see “Appendix 1 Extended case studies”). In biodiversity, natural history collections provide data essential for tracking species distributions and assessing ecosystem health, enabling policymakers to prioritize conservation efforts and mitigate biodiversity loss. The pollution case study demonstrates how open collections can support policy goals aimed at reducing or eliminating chemical contamination. In the climate change domain, the case study demonstrates the role of digital natural history collections hosted in data infrastructures in providing historic records that serve as a reference to track ecological changes and inform climate change mitigation measures. Finally, the Holocaust and cultural heritage case study highlights the importance of Open Collections in preserving historical memory and fostering social justice, as these collections provide crucial resources for educational and policy initiatives that promote inclusivity and peace. Together, these case studies underscore the transformative role of Open Collections in shaping policy across environmental, public health, and social domains, affirming the need for ongoing digitization, ethical considerations, and cross-sectoral collaboration.

4.1 Case Study 1: Biodiversity Domain

4.1.1 Objective

This case study emphasizes the crucial function of natural history collections in preserving biodiversity, aligning with SDGs 14 and 15, the 2030 Biodiversity Strategy, and the biodiversity objectives outlined in the EU Green Deal. It illustrates how Open Collections and Open Science principles in biodiversity

facilitate evidence-based decision-making by improving access to taxonomic information and reference materials.

4.1.2 Policy Context

Safeguarding and restoring biodiversity are critical to achieving global sustainability goals, as reflected in SDGs 14 (Life Below Water) and 15 (Life on Land). Achieving these objectives requires reliable, accessible data on species diversity and ecosystem dynamics. Open Collections provide policymakers with critical tools, including digitized taxonomic records, reference specimens, and genetic data, to inform evidence-based decisions. These resources are particularly valuable in addressing urgent issues such as species loss, invasive species management, and ecosystem degradation. Achieving sustainability goals outlined in initiatives like the EU's Green Deal and 2030 Biodiversity Strategy depends on high-quality, up-to-date data. However, challenges remain, including the need for robust digital infrastructures, cross-border collaboration mechanisms, and strategies to address gaps in taxonomic expertise. Addressing these challenges is essential to ensure policymakers have the tools and resources necessary to mitigate environmental and economic risks while advancing sustainability goals.

4.1.3 Research Context

Taxonomy, the science of identifying, naming, and classifying organisms, forms the foundation of biodiversity conservation (CBD, 2010). Accurate species identification is essential for biodiversity monitoring and understanding the impacts of human activities on ecosystems (Sandall et al., 2023). By enabling precise species identification, Open Collections support research by making taxonomic records, reference collections, and genetic data more accessible, ensuring that research outputs are based on reliable data (Vohland et al., 2022).

In addition to species identification, taxonomic knowledge aids in understanding population dynamics and assessing human impacts on ecosystems. The decline of species underscores the importance of Open Access to taxonomic data, enabling researchers and policymakers to create informed strategies for the protection and restoration of species (Johnson et al., 2023; Sandall et al., 2023).

However, the taxonomic field faces challenges due to a decreasing workforce, which affects its capacity to support global research efforts (Engel et al., 2021). Addressing these challenges requires strategic investments in research infrastructure, including the development of new tools for taxonomy, enhancing access to reference collections, and creating clear career pathways for future taxonomists. These actions will ensure that taxonomy continues to be a critical pillar of biodiversity research and conservation, providing a solid scientific foundation for addressing the current biodiversity and climate crises.

Moreover, the involvement of citizen scientists, expands the scope of research and increases public engagement with biodiversity issues. Citizen science contributes to monitoring efforts and raises awareness of biodiversity conservation, supporting the achievement of global research and conservation targets.

4.1.4 Policy Recommendations

- **Enhanced Access to Taxonomic Data:** Prioritizing the digitization of natural history collections and ensuring Open Access to taxonomic metadata to improve species identification, thereby supporting informed decision-making in biodiversity conservation.
- **Expanded Taxonomic Capacity:** Addressing the shortage of taxonomic expertise by investing in Open Science training programs, promoting innovative citizen science tools, and facilitating knowledge transfer across sectors to build a skilled pool of experts capable of advancing biodiversity monitoring and conservation efforts.

- **Sustainable Funding for Biodiversity Research:** Supporting Open Collections through digitization efforts and tackling interoperability issues to foster sustainable funding mechanisms for taxonomic research critical to biodiversity monitoring and related policy goals.
- **Promotion of Open Science Principles:** Aligning data policies with FAIR (Findable, Accessible, Interoperable, Reusable) and CARE (Collective Benefit, Authority to Control, Responsibility, Ethics) principles, particularly for data from indigenous communities, to enhance data usability and maintain high standards of consistency and quality at the international level.

4.2 Case study 2: Pollution

4.2.1 Objective

The aim of this case study is to explore how Open Collections can provide evidence to support policy goals to address pollution from chemicals and micro-plastics.

4.2.2 Policy context

The EU Action plan “Towards Zero Pollution for Air, Water and Soil”¹⁹ adopted in 2021 restates the vision to achieve a zero pollution by 2050, as well as the need and support for better and more integrated monitoring already outlined in the Green Deal communication, and defines actions to advance towards those goals.

EU’s chemicals strategy for sustainability towards a toxic free environment²⁰ adopted in 2020, which also calls for research and (bio-)monitoring chemicals-related risks prevention and innovation in chemical risk assessment and regulatory science.

¹⁹ [COM/2021/400 final](#)

²⁰ [COM/2020/667 final](#)

4.2.3 Research context

Two initiatives to advance biomonitoring in Europe run in the period 2017–2022:

- LIFE APEX, which focused on demonstrating a new approach to chemical monitoring based on data from apex predators and their prey. The project also aimed to raise awareness among regulators on the value of Environmental Specimen Bank, Natural History Museum collections and other research collections, as well as facilitating better and more effective use of chemical monitoring data from the rich and valuable samples available in those collections.
- European Raptor Biomonitoring Facility (ERBFacility), which focused on establishing the basis for raptor biomonitoring in support of EU regulation, based on specimens and samples from environmental specimen banks, natural history museums and other collections. The project developed the ERBFacility, constituted by a European Raptor Biomonitoring Scheme, a distributed European Raptor Specimen Bank and a European Raptor Sampling Programme.

Together, the two projects delivered a proof of concept for analysis and sampling across Europe.

4.2.4 Policy Recommendations

Environmental Specimen Bank, Natural History Museum collections and other research collections are well placed to supply the regular biomonitoring data from apex predators required for the levels defined by the EU policy, since they are allowed to store samples of protected species, have the capacity to store and analyse the samples and regularly receive fresh samples from specimens found dead (Movalli et al., 2022). Many of these collections are being digitised, which facilitates the selection of specimens for contaminant monitoring (Ramello et al., 2022).

LIFE APEX project demonstrated how this information can be used to address specific European regulatory needs. However, it also highlighted that this resource is currently underused and its use is often limited to project initiatives and recommended that the shift to more consistent monitoring could be facilitated by a centralised European data infrastructure to store and access chemical monitoring data and by guidance to standardise the different steps of the process to ensure high data quality (Treu et al., 2022).

4.3 Case study 3: Climate change

4.3.1 Objectives

The aim of this case study is to demonstrate the essential role of digital infrastructures that support Natural History Collections in offering scientists a ‘time-machine’ for ecological changes to be tracked over the industrial period, informing climate change mitigation measures.

4.3.2 Policy context

Open Collections expand the evidence-base for the EU’s climate action initiatives, which include bringing into law the Green Deal targets of becoming climate-neutral by 2050 and 55% less emissions by 2030 (compared to 1990). These targets align with the commitments made by the EU and its member states on signing the 2015 Paris Agreement.²¹

4.3.3 Research Context

Through digital transformation, natural history collections are contributing to research evidence of historic climate impacts. Evidence for this is provided by GBIF, the Global Biodiversity Information Facility, which is now routinely used by Museums and Herbaria to publish and index data from their

²¹ Climate change: what the EU is doing: <https://www.consilium.europa.eu/en/policies/climate-change/>

collections. These datasets are cited in research literature that is, in turn, cited in high-level policy documents. This includes published outputs of the Intergovernmental Panel on Climate Change (IPCC), a United Nations body formed by the world’s leading climate scientists and tasked with regularly assessing the science related to climate change to inform policymakers. Relevant documents include IPCC reports that inform EU policy, for example the 2018 ‘Special Report on Global Warming of 1.5 C’, and the Sixth Assessment Report (AR6), published in stages from 2021–2023.

IPCC assessments have been a key source of information for the implementation of the Paris Agreement. They set out the implications of climate change and potential future risks, as well as suggestions for adaptation and mitigation options.

Taking the AR6 Report as an example, analysis by GBIF Secretariat shows that AR6 cited a total of 166 papers that made use of GBIF-mediated data. Of these papers, 43 cited DOIs used by GBIF to link the citation to the contributing datasets and publishers. 38 of these papers cited occurrence downloads sourced to one of six major natural history collections in Europe. These represent a small but significant contribution by these six institutions to the IPCC’s analysis.

This case study further shows how natural history collections are contributing to research on the three main climate change trends the AR6 Report points to: **shifts in species range**, changes in **timing of lifecycle events**, and **changes in ecosystem** structure in response to higher temperatures.

4.3.4 Policy Recommendations

Leverage collections-based research to inform environmental policy measures: institutions and research funders should recognise the vital role that collections-based research can play in informing climate change mitigation measures. They can for example provide insights on temporal

patterns in plant–pollinator interactions (Rakosy et al., 2023). These interactions have implications for human food security, e.g. where changes concern the lifecycles of crops, through their interaction with pollinators such as bees and moths (Vasiliev & Greenwood, 2021)

Raising Awareness and Advocacy: Natural history museums and botanic gardens should take a proactive stance in using their collections and expertise to raise awareness about climate change and to advocate for policy action. Long-term collections “are particularly useful in communication to raise citizen awareness about the urgency to mitigate climate change and to foster public engagement in citizen science, in education to further sensitize the coming generations, and in politics to promote sustainable environmental decisions” (Vitasse et. al., 2022).

Further investment in digitisation and enhancement of Open Collections: natural history specimens, digitised and made FAIR, will support the continued research needed to inform policy. The role of infrastructure in enabling digitisation and aggregation of records is crucial for European collections to further impact on global change research and policymaking. The EU has invested in infrastructure established so far in DiSSCo, BiCIKL, and SYNTHESYS+ (Groom et al., 2023). It is not alone in making such investments. US efforts are currently focused on implementing a National Action Plan for Natural History Collections, which is envisaged to create and oversee a US specimen collection and environmental sampling plan, with the ambitious aim of “solving society’s grand challenge questions” around climate change and related issues (Nelson et al., 2023). This highlights the importance of continued European contributions to international initiatives, and support for digitising and enhancing natural history collections.

4.4 Case Study 4: The relevance of Open Science in Holocaust Studies for promoting peace, justice and strong institutions

4.4.1 Objective

This case study illustrates how Open Collections, exemplified by the Vienna Wiesenthal Institute for Holocaust Studies (VWI), enhance access to Holocaust-related resources and support evidence-based policymaking. By applying Open Science principles like digitization and international collaboration, these collections advance academic research and influence policies on human rights, education, and memory culture, highlighting their role in shaping effective policy development.

4.4.2 Policy Context

The study of the Holocaust is fundamentally connected to the promotion of peace, justice, and strong institutions, in line with the United Nations' Sustainable Development Goal 16 (SDG 16), underscoring the importance of fostering inclusive societies, ensuring access to justice, and building effective, accountable institutions.

4.4.3 Research Context

Holocaust studies, focusing on the systematic genocide during World War II, rely on primary sources such as testimonies, archival documents, and artefacts. The Vienna Wiesenthal Institute for Holocaust Studies (VWI) serves as a key institution in advancing Holocaust research, particularly within the framework of the European Holocaust Research Infrastructure (EHRI). As a national coordinator for EHRI-AT, VWI integrates research into the broader European network, enhancing contributions to Holocaust studies. The institute focuses on researching antisemitism, racism, nationalism, and the

Holocaust, applying methodologies to explore questions around Holocaust memory and its comparison with other genocides. This research connects historical analysis with contemporary issues, contributing to discussions on human rights, reparative justice, and cultural memory.

VWI is also committed to Open Science practices, notably through its extensive digitization efforts. Significant archival collections, including materials from the Archive of the Jewish Community of Vienna and the estate of Simon Wiesenthal, are preserved and made globally accessible. These resources are integrated into platforms such as EHRI, Europeana, Kulturpool, and the Austrian Library Network, promoting cross-border collaboration and broader access to Holocaust-related materials. Additionally, VWI's fellowship program fosters innovative and interdisciplinary research by supporting international scholarly exchange. Through publications like the Open Access journal S:I.M.O.N., VWI ensures that its research contributes to academic discourse and policy development, establishing itself as a significant contributor to Holocaust studies.

4.4.4 Policy Recommendations

The integration of Open Science principles at the Vienna Wiesenthal Institute for Holocaust Studies (VWI) has led to key outcomes for both academic research and policymaking:

- **Support ongoing efforts for enhanced accessibility and openness:** Policymakers should actively support digitization and Open Science initiatives like those of VWI, which have significantly improved the availability of Holocaust-related materials. These efforts enable academic research and provide a foundation for evidence-based policymaking in areas such as human rights, education, and justice.
- **Build on Research and Open Collections for Policy Formulation:** VWI's collections and research offer valuable empirical evidence that can inform policies on historical education, collective memory, and human rights. Policymakers are encouraged to utilize these resources to support

democratic legislation and initiatives aimed at fostering societal understanding and inclusivity.

- **Promote Sustainable International Collaboration:** Supporting VWI's role in European research networks, such as the European Holocaust Research Infrastructure (EHRI), will strengthen international cooperation. This collaboration enhances Holocaust studies and contributes to the development of policies focused on peace, justice, and reconciliation.

5 Impact of Open Collections on Policy Goals

5.1 Enhancing Accessibility and Transparency

Open Collections enhance accessibility and transparency by making historical and scientific archives widely available online. This digital access allows researchers, policymakers, and the public to engage with these resources, fostering inclusivity, trust, and informed dialogue in research and decision-making.

Open Science principles enable stakeholders to review research data and methodologies, thereby enhancing the credibility of results. Such transparency not only aids researchers but also supports policymakers by providing them with reliable information necessary for informed decision-making.

Importantly, the European Open Science Cloud (EOSC), which serves as a central hub for sharing resources and facilitating collaboration among researchers, encourages the adherence to the FAIR principles – Findable, Accessible, Interoperable, and Reusable – ensuring that the data and collections are not only available but also usable across various disciplines and sectors. Such an environment nurtures cross-disciplinary and cross-border collaboration, strengthening collective responses to urgent global issues. To maximize the widespread benefits of the EOSC, policymakers should prioritize the enhancement of FAIR practices in GLAM institutions. This can be achieved by e.g. funding initiatives aimed at raising awareness, providing education and training, and supporting community-specific efforts. Additionally, the development and continuous monitoring of robust policies for FAIR data and research objects in the collections context is essential. Finally, fostering a culture of Open Science requires the recognition and reward of advancements in implementing Open Science practices (EOSC Executive Board, 2020).

For example, referring to Case Study 4 (Holocaust Studies and Cultural Heritage), the VWI's digitization and Open Access initiatives have greatly

expanded access to Holocaust-related resources, fostering academic research and evidence-based policymaking in human rights, education, and justice. By digitizing their collections, VWI ensures their preservation and global accessibility for researchers, educators, and the public. Integration into platforms like EHRI²², Europeana²³, Kulturpool²⁴, and Austrian Library Network²⁵ further promotes cross-border collaboration, exemplifying VWI's commitment to transparency, accessibility, and the democratization of historical knowledge.

5.2 Supporting Evidence-Based Policymaking

Open Collections support evidence-based policymaking by providing access to digitized records and resources, enabling a more informed understanding of issues such as environmental conservation and justice.

For example, through digital transformation, natural history collections are providing essential evidence regarding historical climate impacts on species distribution, lifecycles, and ecosystem structures, enabling policymakers to identify at-risk species and formulate conservation strategies. Similarly, historical archives related to human rights issues provide valuable context for contemporary social justice initiatives. These resources not only inform legislative frameworks but also enhance the capacity of governments to respond effectively to societal needs.

Using Open Collections data within policy development fosters collaborative input from a range of stakeholders, such as researchers, government agencies, and NGOs. By engaging with diverse perspectives, policymakers can develop more comprehensive and effective solutions to complex societal and environmental challenges. The integration of Open Science practices

²² <https://www.ehri-project.eu/>

²³ <https://www.europeana.eu/>

²⁴ <https://kulturpool.at/>

²⁵ <https://www.obvsg.at/en/>

further ensures that policymakers receive timely information essential for rapid decision-making.

Institutions that use Open Collections to inform policy can also be key players in raising awareness on critical issues. By disseminating findings and engaging the public through outreach programs, these institutions help to foster a better understanding of the challenges at hand and advocate for necessary policy changes.

5.3 Fostering Public Engagement and Education

Encouraging Open Science and Open Collections is vital for enhancing public engagement, educational outreach, and participatory research. By making collections openly accessible, institutions promote community involvement and stimulate interest in a wide range of topics, from historical events to scientific advancements. This accessibility provides opportunities for individuals from diverse backgrounds to explore and learn from these resources, advancing public understanding and knowledge.

Educational initiatives leveraging Open Collections can bridge the gap between academic research and public comprehension. Through workshops, exhibitions, and online resources, institutions can highlight the importance of historical and scientific insights, equipping the public to engage in meaningful discussions and contribute to broader societal discourse. Incorporating citizen science within Open Science frameworks further invites public participation in research processes, enriching data collection while fostering a sense of ownership and responsibility among participants.

To achieve these goals, policies should prioritize digitizing and sharing collections, developing educational programs that utilize open resources, and ensuring inclusive access for underrepresented communities. Additionally, fostering citizen science initiatives and creating mechanisms for public input in research and policy dialogues can strengthen societal capacity to address complex challenges. These efforts align with the broader aim of

democratizing knowledge, empowering public contributions, and enhancing collective problem-solving.

For example, the Vienna Wiesenthal Institute for Holocaust Studies (Case Study 4) emphasises public outreach through lectures, exhibitions, and educational projects to deepen understanding of Holocaust studies, racism, and antisemitism while offering valuable Open Access resources for educators and students. Notable platforms include the online exhibition Wiesenthal in Linz, showcasing key archival "Linz documents", and the Database of Hungarian Forced Labour in Vienna, which sheds light on forced labor history and preserves related artifacts. Additionally, the Austrian Heritage Archive provides interviews with Austrian Jewish emigrants, complementing recorded lectures and events on VWI's YouTube channel, all reinforcing its mission of accessible, enduring educational engagement.

5.4 Promoting Cultural Heritage and Preservation

Digital data and research methods are revolutionising the relevance of museum collections as cultural heritage resources, expanding their accessibility and analytical potential in a number of ways including the following:

- **Digitisation and Data Accessibility:** Digital technologies have enabled large-scale digitization efforts of museum specimens and objects. However according to one survey only 16% of objects in museums currently have digitally discoverable records, indicating a need to expand efforts in this direction (Johnson et al., 2023). Industrial scale digitisation methods are accelerating this process. Conveyor belt and similar methods for large-scale digitisation can process thousands of items per day, rapidly increasing the availability of digitised objects (Sweeney et al., 2018).
- **Enhanced Data Integration and Analysis:** Digital technologies allow for the integration of diverse data types. Semantic technologies help apply taxonomic standards to collection descriptions and make these more

machine-readable, interlinking collections to make these more readily interpretable for research and societal benefit, e.g. where genomic data is used to augment Natural History Collections, linking it to physical specimens (Hedrick et al., 2020).

- **Machine Learning and Artificial Intelligence:** These technologies are transforming how collection data can be accessed and analysed. AI can help process and analyse large datasets derived from digitized collections, uncovering relationships that might be difficult for humans to detect. Machine learning algorithms can be applied to digitized specimens for automated identification, measurement, and pattern recognition (Meineke et al., 2020).
- **Environmental DNA and Genomics:** Digital technologies are enabling new sources of biological data to augment natural history collections. Environmental DNA techniques, combined with digital databases of museum specimens, allow researchers to detect and identify species from trace amounts of genetic material in environmental samples. Only 0.2% of biological collections currently have accessible genomic records, indicating significant potential for growth in this area (Johnson et al., 2023).
- **Digital Twinning and 3D Visualisation:** These technologies are creating new ways to interact with and study museum specimens, allow researchers to examine detailed 3D models from anywhere in the world. Augmented reality can overlay digital information onto physical specimens, enhancing morphological analysis (Lecarpentier et al., 2024).

6 Challenges and Recommendations

6.1 Common Challenges in Open Collections

The case studies demonstrate the valuable role that open collections play in supporting research that serves as evidence for European policy. However, the case studies based on natural science collections indicate that there still much to do to achieve the full potential of using these collections for research. They also express a need for more coordination and cooperation to improve the access to the collections and establish the appropriate methods, standards and skills to obtain the information available in these collections. They suggest that this could be achieved through robust and sustainable data infrastructures and research for innovative methods and technologies to use the collections.

For example, Holocaust research faces significant challenges due to the fragmentation of sources and expertise across numerous institutions, underscoring the need for greater integration and collaboration as outlined in case study 4. The sensitive nature of Holocaust-related data requires careful handling to balance accessibility with ethical considerations. Expanding Open Science practices and investing in effective science communication strategies are essential to support informed discourse, particularly in addressing contemporary issues like political polarization, antisemitism and conflicts. These efforts not only advance scholarly inquiry but also contribute to strengthening democratic societies by fostering historical understanding and dialogue.

6.2 Recommendations for Policymakers

Recommendations outlined under this section are informed by the case studies presented in this work (particularly recommendations 2–5) as well as broader observations during the course of this task.

1. Secure Funding and Policy Support: Ensure consistent funding for Open Collections initiatives at institutional, national, and international levels, focused on adopting Open Science practices to data derived from collections.
2. Enhance skills in digitization, data curation, digital archiving, and taxonomy to build expertise and career pathways as exemplified in the Skills4EOSC Minimum Viable Skillset for Digital Collections Curators.²⁶
3. Promote Public Engagement and Citizen Science:
 - Involve communities in data collection and research to enhance societal trust and awareness in science.
 - Develop educational initiatives to connect Open Collections with contemporary societal challenges and increase public understanding.
4. Utilize Open Collections for policymaking based on evidence-based insights on critical issues like biodiversity, pollution and public health, climate change, and peaceful democratic societies.
5. Implement Ethical Frameworks: To maximize the impact of the European Open Science Cloud (EOSC), policymakers should strengthen FAIR practices by funding education, training, and community initiatives, enforcing robust FAIR policies, and incentivizing progress in open science.
 - Apply CARE principles alongside FAIR standards to ensure responsible and inclusive use of sensitive datasets.
 - Address ethical considerations for collections related to indigenous communities or sensitive historical events.
6. Expand Accessibility and Integration:
 - Digitize and integrate collections into accessible online platforms to maximize reach and impact.
 - Standardize metadata and data formats across institutions for improved interoperability and usability.

²⁶ D2.1 Catalogue of Open Science Career Profiles - Minimum Viable Skillsets - Version 2 (to appear, 2025).

- Strengthen digital infrastructures like the European Open Science Cloud (EOSC) to foster collaboration.
7. Support the integration of scientific, historical, and cultural knowledge into policy decisions.

7 Conclusion and Future Directions

The case studies presented in this document illustrate the potential of Open Collections in shaping evidence-based policymaking across diverse sectors, including biodiversity conservation, pollution control, climate change mitigation, and cultural heritage preservation. By integrating practices that facilitate Open Science, such as digitization, accessibility, and international collaboration, Open Collections enable the provision of high-quality, reliable data spanning centuries of human experience and observations of the natural world. In doing so, they offer significant support to policymakers in addressing complex global challenges.

In the biodiversity domain, Open Collections facilitate the identification, monitoring, and conservation of species, contributing to the achievement of global sustainability goals like SDGs 14 and 15. The digitization of natural history collections provides critical tools for tracking species distributions, mitigating biodiversity loss, and informing ecosystem management strategies. However, challenges remain in enhancing taxonomic expertise and overcoming infrastructure limitations, necessitating increased investment in both technology and capacity building. To ensure that policymakers have access to the data necessary for informed decision-making, it is crucial to support the expansion of digital infrastructures and the promotion of Open Science practices.

Open Collections can also play a role in supporting policy goals to address pollution. In particular, initiatives like LIFE APEX and the European Raptor Biomonitoring Facility successfully delivered a proof of concept for improved biomonitoring of chemicals across Europe based on data from samples available at Environmental Specimen Banks, Natural History Museums and other research collections. These collections hold the potential to support environmental regulations by offering long-term, reliable data on pollutants including micro-plastics and chemicals, but their full potential is yet to be unlocked. A centralized European data infrastructure and standardized

methodologies would further enhance the usability of this data, facilitating consistent monitoring and informed policy implementation.

The climate change case study highlights how digital natural history collections provide valuable historical records, helping scientists track ecological changes over time. By correlating species distribution and ecosystem changes with shifts in temperature and other climatic variables, Open Collections are contributing essential evidence to inform the EU's climate action goals and the IPCC's climate assessments. The integration of digital records into global research networks enhances the scope and impact of these data, providing policymakers with robust evidence for climate mitigation and adaptation strategies. To expand these efforts, increased investment in digitization, data interoperability, and cross-border collaboration is essential.

Finally, the Holocaust and cultural heritage case study underscores the importance of Open Collections in fostering social justice, inclusivity, and peace. Open Science initiatives, such as those led by the Vienna Wiesenthal Institute for Holocaust Studies, improve access to critical historical materials, enabling evidence-based policymaking in areas like human rights and education. Continued investment in digitization and international collaboration will help ensure that these resources remain accessible and continue to influence policies promoting peace and justice.

The future vision for Open Collections in Europe is centered on developing an integrated and accessible ecosystem that extends beyond the digitalization of data. This vision emphasizes the importance of making collections available according to FAIR standards to a wide range of users, including researchers, policymakers, educators, and the general public. Such accessibility is expected to facilitate advances in scientific research, in areas including biodiversity, climate change, and environmental and social justice. It will also enrich education by providing data for teaching and fostering public involvement in research. Moreover, aligning Open Collections with the United Nations' Sustainable Development Goals (SDGs) will enhance their role in addressing global challenges, while promoting sustainable

development. It is anticipated that collaboration among governments, research institutions, and the broader global community will continue to strengthen the impact of Open Collections. By integrating these collections into broader scientific and policy frameworks, there is potential to foster innovation and support evidence-based decision-making. Ultimately, Open Collections are positioned to play a key role in advancing policy innovation and contributing to the achievement of sustainability goals.

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No	Description/Link
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R33	Sweeney, P.W., Starly, B., Morris, P.J., Xu, Y., Jones, A., Radhakrishnan, S., Grassa, C.J. & Davis, C.C. (2018). Large-scale digitization of herbarium specimens: Development and usage of an automated, high-throughput conveyor system. <i>Taxon</i> 67 (1) 165-178. https://doi.org/10.12705/671.10
R34	Treu, G., Slobodnik, J., Alygizakis, N., Badry, A., Bunke, D., Cincinelli, A., Claßen, D., Dekker, R. W. R. J., Göckener, G., Gkotsis, G., Hanke, G., Duke, G., Jartun, M., Movalli, P., Nika, M-C, Rüdell, H., Tarazona, J. V., Thomaidis, N. S., Tornero, V., Vorkamp, K., Walker, L. A., Koschorreck, J. & Dulio, V. (2022). Using environmental monitoring data from apex predators for chemicals management: towards better use of monitoring data from apex predators in support of prioritisation and risk assessment of chemicals in Europe, <i>Environmental Sciences Europe</i> , 34, 82. https://doi.org/10.1186/s12302-022-00665-5
R35	UNESCO Recommendation on Open Science (2021). UNESCO. https://doi.org/10.54677/mnmh8546
R36	Urata, S., Kuroda, K., & Tonegawa, Y. (2022). Sustainable Development Disciplines for Humanity. In Sustainable development goals series. https://doi.org/10.1007/978-981-19-4859-6

R37	Vasiliev, D., & Greenwood, S. (2021). The role of climate change in pollinator decline across the Northern Hemisphere is underestimated. <i>Science of the Total Environment</i> , 775, 145788. https://doi.org/10.1016/j.scitotenv.2021.145788
R38	Vitasse, Y., Baumgarten, F., Zohner, C. M., Rutishauser, T., Pietragalla, B., Gehrig, R., ... & Sparks, T. H. (2022). The great acceleration of plant phenological shifts. <i>Nature Climate Change</i> , 12(4), 300–302. https://doi.org/10.1038/s41558-022-01283-y
R39	Vohland, K., Eichert, S., Fiedler, S., Kapun, M., Kroh, A., Mehu-Blantar, I., Ott, I., Rainer, H., Schwentner, M. & Zimmermann, E. (2022). Open Science in Museums - Strategy of the Naturhistorisches Museum Wien (NHMW): The benefits of openness. Version 1.0 (2022-04-27) Naturhistorisches Museum Wien. https://doi.org/10.5281/zenodo.6505108
R40	VWI (2024). VWI im FOKUS 2024/2025. Newsletter. https://www.vwi.ac.at/images/Publikationen/Newsletter/Newsletter_2024/VWI Newsletter-2024.pdf
R41	VWI (n.d.). Documentation. https://vwi.ac.at/index.php/en/documentation
R42	VWI (n.d.) Research. https://vwi.ac.at/index.php/en/research
R43	Wiesenthal in Linz (n.d.). https://wiesenthal-in-linz.vwi.ac.at/

Appendix I. Extended case studies

Case study 2: Pollution

Objective

The aim of this case study is to explore how open collections can provide evidence to support policy goals to address pollution from chemicals and micro-plastics.

Policy context

In 2019, the European Commission presented the European Green Deal²⁷, as part of its strategy to implement the United Nation's 2030 Agenda and the SDGs. The European Green Deal aims at tackling climate and environmental challenges through a new growth model based on a clean and circular economy, as well as protecting nature and citizens from environment-related risks.

One of the commitments it sets is the zero pollution ambition for a toxic-free environment, which is addressed in the EU Action plan "Towards Zero Pollution for Air, Water and Soil"²⁸ adopted in 2021. This plan restates the vision to achieve a zero pollution by 2050, as well as the need and support for better and more integrated monitoring already outlined in the Green Deal communication, and defines actions to advance towards those goals.

Another Green Deal key deliverable to address the zero pollution ambition is the EU's chemicals strategy for sustainability towards a toxic free environment²⁹ adopted in 2020, which pledges to "continue to foster research and (bio-)monitoring to understand and prevent chemicals-related

²⁷ [COM\(2019\) 640](#)

²⁸ [COM/2021/400 final](#)

²⁹ [COM/2020/667 final](#)

risks and drive innovation in chemical risk assessment and regulatory science through its future framework programme for research and innovation”.

Research context

Examples of biomonitoring projects

Biomonitoring is the measurement of levels of chemicals in biological samples from for example body fluids (such as blood or urine), tissues, or faeces, with the aim to assess the exposure to pollutants.

Apex predators: LIFE APEX

LIFE APEX³⁰ was a LIFE demonstrator project (LIFE17 ENV/SK/000355) to show a new approach to chemical monitoring based on data from apex predators and their prey, which allows screening thousands of chemicals per sample and prioritising those which are frequently occurring. The project run during the period 2018–2022.

In addition to promoting the advantages of new methods to monitor data from apex predators, the project also aimed to raise awareness among regulators on the value of Environmental Specimen Bank, Natural History Museum collections and other research collections, as well as facilitating better and more effective use of chemical monitoring data from the rich and valuable samples available in those collections.

Raptors: European Raptor Biomonitoring Facility

The European Raptor Biomonitoring Facility (ERBFacility) was a COST Action (CA16224)³¹ that run from October 2017 to April 2022. Its objective was to establish the basis for raptor biomonitoring in support of EU regulation, to

³⁰ <https://lifeapex.eu/>, Final report: https://lifeapex.eu/wp-content/uploads/2023/05/FINAL-REPORT_LIFE-APEX_110523_FOR-EC-1.pdf

³¹ <https://www.cost.eu/actions/CA16224/>

ultimately contribute to achieve a non-toxic environment and reduce the toll of chemicals on human and wildlife health. The biomonitoring was based on specimens and samples from environmental specimen banks, natural history museums and other collections. In particular, the initiative aimed at using raptors as a sentinel species to explore the following questions:

- What are the environmental risks of specific chemicals?
- Are EU chemicals regulations effective in reducing environmental exposure to contaminants?
- Are there emerging contaminant problems requiring remedial action?

The project developed the ERB Facility, constituted by a European Raptor Biomonitoring Scheme, a distributed European Raptor Specimen Bank and a European Raptor Sampling Programme. It also delivered a proof of concept for analysis and sampling across Europe together with the LIFE APEX project.

Impact

Building on information from specimens and samples from environmental specimen banks, natural history museums and other collections, LIFE APEX project addressed specific needs of regulators for applications related to the Regulation on the registration, evaluation, authorisation and restriction of chemicals (REACH) and the Biocidal Products Regulation (BPR). LIFE APEX project team cooperated with the European Commission on the update of some lists of contaminants of the Marine Strategy Framework Directive (MSFD), sharing data with the Information Platform for Chemical Monitoring (IPCHEM)³², and with the European Chemicals Agency (ECHA).

Environmental Specimen Bank, Natural History Museum collections and other research collections are well placed to supply the regular biomonitoring data from apex predators required for the level defined by the EU policy, since they are allowed to store samples of protected species, have the capacity to store and analyse the samples and regularly receive fresh samples from specimens found dead (Movalli et al., 2022). Based on

³² <https://ipchem.jrc.ec.europa.eu/>

survey data collected as part of EBRFacility COST Action, Ramello et al. (2022) estimate that collections in Europe collectively receive over 5,000 raptor carcasses a year, with NHM being the main recipients in most countries, and that European collections probably hold over 10,000 raptor carcasses, which constitute a valuable resource to monitor current and legacy contaminants in support of zero pollution policy goals. The study also found out that these collections are being digitised (around half of the respondent organisations have digitised records of the carcasses and processed tissue samples) which facilitates the selection of specimens for contaminant monitoring.

However, this resource is currently underused and its use often limited to project initiatives. The shift to more consistent monitoring would be facilitated by a centralised European data infrastructure to store and access chemical monitoring data and guidance to standardise the different steps of the process to ensure high data quality (Treu et al, 2022).

Case Study 3: Climate Change

Objectives

The aim of this case study is to demonstrate the essential role of digital infrastructures that support Natural History Collections in offering scientists a ‘time-machine’ for ecological changes to be tracked over the industrial period, informing climate change mitigation measures.

Policy context

Open Collections expand the evidence-base for the EU’s climate action initiatives, which include bringing into law the Green Deal targets of becoming climate-neutral by 2050 and 55% less emissions by 2030 (compared to 1990). These targets align with the commitments made by the EU and its member states on signing the 2015 Paris Agreement.³³

Research Context

Through digital transformation, natural history collections are contributing to research evidence of historic climate impacts. Evidence for this is provided by GBIF, the Global Biodiversity Information Facility, which is now routinely used by Museums and Herbaria to publish and index data from their collections. These datasets are cited in research literature that is, in turn, cited in high-level policy documents published by the IPCC. These include IPCC reports that inform EU policy, for example the 2018 ‘Special Report on Global Warming of 1.5°C’, and the Sixth Assessment Report (AR6), published in stages from 2021–2023.

³³ Climate change: what the EU is doing: <https://www.consilium.europa.eu/en/policies/climate-change/>

The Intergovernmental Panel on Climate Change

The Intergovernmental Panel on Climate Change (IPCC) is a United Nations body formed by the world's leading climate scientists and tasked with regularly assessing the science related to climate change to inform policymakers. Their assessments include the implications of climate change and potential future risks, as well as suggestions for adaptation and mitigation options.

The IPCC reports have been a key source of information for the implementation of the Paris Agreement, by exposing the ways in which crossing the 1.5°C threshold in global average temperature increase risks unleashing severe climate change impacts.

The EU is one of the top funders of research cited by the IPCC. According to the Commission's analysis one reference out of six is linked to a project funded under FP7 or H2020. Aligning with the IPCC report findings, the EU has reinforced its commitment to climate neutrality by 2050. It has also increased its focus on nature-based solutions and adaptation measures to mitigate climate impacts.³⁴

Traditionally one of the barriers to analysing the impact on the IPCC's work of collections datasets published by GBIF has been that research reports have referenced data only indirectly through literature. Movement towards Open Science has more recently led to datasets becoming more recognised as scientific outputs in their own right, allowing links to be traced between research literature cited in IPCC reports and datasets published by GBIF that underpin that literature. GBIF now provides tools to track citations of the data it aggregates from its providers.

Based on GBIF's citation tracking, the journal *Science* reports that SR15 "used over 385 million species occurrence records... from 5432 data providers,

³⁴ European Commission (n.d.) https://research-and-innovation.ec.europa.eu/research-area/environment/climate-change-science/intergovernmental-panel-climate-change-ipcc_en

mostly natural history museums, to show species movement in response to climate change".³⁵

A more recent case is the AR6 Report. Analysis by GBIF Secretariat shows that AR6 cited a total of 166 papers that made use of GBIF-mediated data. Of these papers, 43 cited DOIs used by GBIF to link the citation to the contributing datasets and publishers. 38 of these papers cited occurrence downloads sourced to one of six major natural history collections in Europe. These represent a small but significant contribution by these six institutions to the IPCC's analysis.

This case study further shows how natural history collections are contributing to research on the three main climate change trends the AR6 Report points to: **shifts in species range**, changes in **timing of lifecycle events**, and **changes in ecosystem** structure in response to higher temperatures.

Species range

Natural History Collections (NHCs) enable scientists to map the geographic (spatial and altitudinal) distributions of species across decades and in some cases centuries, correlating these with temperature changes over the duration. By analysing where and when specimens have been collected, researchers can identify shifts that may be driven by climate change. Insects and other organisms at the base of food chains, which typically have relatively short lifespans, are moving north to cooler latitudes. In the UK for example, analysis over 20 years found southern species of plants have expanded their range northwards, while northern species have retreated from their southern limits. Over a similar period, moth distributions shifted northwards at a rate of 5km per year on average. Affected species include other pollinators with a vital role in food production. For example, using long-term data for 66 bumble bee species across North America and Europe, a

³⁵ Johnson, K. R., Owens, I. F., & Global Collection Group. (2023). A global approach for natural history museum collections. *Science*, 379(6638), 1192–1194.
<https://www.science.org/doi/abs/10.1126/science.adf6434>

recent study tested whether climate change altered likelihoods of bumble bee species' extinction or colonization. Increasing frequency of hotter temperatures predicts species' local extinction risk, chances of colonizing a new area, and changing species richness.

Timing of lifecycle events

Collections allow researchers to track changes in the timing of plant flowering, fruiting, and leaf production over time. Studies on this theme show for example that many plant species are now flowering and leafing out earlier in the year compared to historical records. Herbarium and museum records are also proving valuable to track changes in when bird eggs hatch, and when animals breed. Research evidence from NHCs shows, for example, that over 200 years grasses in Denmark have been flowering earlier in response to warmer spring temperatures, while over 143 years bird species in the US Midwest have begun laying eggs 10 days earlier.

Ecosystem structure

Museum and herbarium collections offer insights into changes in ecosystem structures, such as food webs. These are formed through interaction between an ecosystem's living members, or between them and its non-living parts, such as sunlight, temperature, or key elements like nitrogen and phosphorus. Preserved specimens can reveal predator-prey relationships, host-parasite associations, and other ecological interactions. Changes in these relationships over time can be inferred by examining specimens from different periods.

Cause and effect relationships on this theme are relatively difficult to study due to complex interactions between changes in climate, land use, and pollution. The availability of historic records helps disentangle these, showing for example that increasing spring temperatures affect not only when tree leaves form but how the resulting shade impacts on wildflowers beneath forest canopies.

Policy Recommendations

Informing environmental policy measures:

Research on this theme is especially important to inform climate change mitigation measures where there are potential impacts on human food security, e.g. where changes concern the lifecycles of crops and their interaction with pollinators such as bees and moths. As well as providing evidence of anthropogenic (man-made) change, research on this theme also informs conservation efforts and policies to protect threatened and endangered species.

Raising Awareness and Advocacy

Institutions such as the Natural History Museum in London have taken a proactive stance in using their collections and expertise to raise awareness about climate change and to advocate for policy action. The museum has responded to declarations of a 'climate emergency' by launching new exhibits and programs to educate the public and policymakers about these critical environmental issues.³⁶

Further investment in digitisation and enhancement of Open Collections

Natural history specimens, digitised and made FAIR, will support the continued research needed to inform policy. The role of infrastructure in enabling digitisation and aggregation of records is crucial for European collections to further impact on global change research and policymaking. European policymakers need to monitor and assess global efforts towards unlocking the value that biological collections offer. Echoing recommendations of a US National Academy of Science review (NAS, 2021), a recent *Science* report observed that

³⁶ Natural History Museum (n.d.) 'Climate Change': <https://www.nhm.ac.uk/discover/climate-change.html>

“...despite their enormous potential value to society, the information embedded in the collections housed in these museums is largely inaccessible. Fortunately, advances in digital, isotopic, imaging, and genomic technologies, as well as machine learning and artificial intelligence, are transforming and amplifying how natural history collections can be accessed and used.”(Johnson et al., 2023).

US efforts are currently focused on implementing a National Action Plan for Natural History Collections, which is envisaged to create and oversee a US specimen collection and environmental sampling plan, with the ambitious aim of “solving society’s grand challenge questions” around climate change and related issues (Nelson et al., 2023). This highlights the importance of European contribution to international initiatives towards policy coordination and investment in museums and botanic garden collections, building on the infrastructure established so far in DiSSCo, BiCIKL, and SYNTHESIS+ (Groom et al., 2023).

Case Study 4: The relevance of Open Science in Holocaust Studies for promoting peace, justice and strong institutions

On the example of the Vienna Wiesenthal Institute for Holocaust Studies (VWI)

Objective

This case study aims to illustrate how Open Collections, along the example of the **Vienna Wiesenthal Institute for Holocaust Studies (VWI)**, improve access to resources related to the Holocaust while promoting evidence-based policymaking. Through the implementation of Open Science principles, such as digitization and international collaboration, these collections not only enhance academic research but also influence policies concerning human rights, education, and memory culture. This relationship underscores the importance of Open Collections in shaping effective policy development.

Background

The study of the Holocaust is fundamentally connected to the promotion of peace, justice, and strong institutions, in line with the United Nations' **Sustainable Development Goal 16** (SDG 16), underscoring the importance of fostering inclusive societies, ensuring access to justice, and building effective, accountable institutions at all levels. Holocaust studies, a critical area within the humanities and social sciences, focus on understanding the systematic genocide perpetrated during World War II. This field relies on extensive examination of primary sources, including testimonies, archival documents, and artefacts.

Key institutions, including the **European Holocaust Research Infrastructure** (EHRI), the **EHRI Austrian Consortium** (EHRI-AT), and the **Vienna Wiesenthal Institute for Holocaust Studies** (VWI), play essential

roles in the preservation and accessibility of Holocaust-related resources and will be outlined under this section.

EHRI functions as a pan-European research network dedicated to the transnational study, commemoration, and education regarding the Holocaust. Its primary objective is to address the challenges posed by the fragmentation of Holocaust sources and expertise across numerous institutions. By connecting various resources, institutions, and individuals, EHRI facilitates collaborative research and enhances access to Holocaust documentation. The EHRI Portal provides comprehensive online access to information about Holocaust-related sources, regardless of their location. Additionally, the Conny Kristel Fellowship allows researchers to engage with the collections of the world's leading Holocaust archives, promoting international scholarly collaboration. EHRI also undertakes extensive networking and training initiatives that bring together researchers, archivists, educators and other stakeholders and foster innovative digital tools to advance Holocaust research. While EHRI's focus is primarily on scientific inquiry, it also contributes to addressing broader social and political issues. The resurgence of antisemitism, xenophobia, and aggressive nationalism in Europe underscores the critical need for Holocaust research as a foundation for promoting open and inclusive societies.

EHRI operates within the framework of the **European Strategy Forum on Research Infrastructures (ESFRI)**, a strategic initiative designed to enhance the scientific integration of Europe and broaden its international outreach. ESFRI aims to support a coherent and strategically informed approach to policymaking related to research infrastructures, facilitating multilateral initiatives for optimal usage and development. This framework allows for competitive access to high-quality research infrastructures, bolstering the activities of European scientists and attracting top researchers globally. As an ESFRI project, EHRI exemplifies the collaborative spirit necessary to confront the historical challenges posed by the Holocaust while contributing to contemporary social discourse.

Moreover, EHRI is structured as a **European Research Infrastructure Consortium (ERIC)**, providing a specific legal framework that enables the establishment and operation of research infrastructures with a shared European interest. This arrangement allows EHRI to function as a recognized legal entity across EU countries, facilitating flexible adaptations to meet the unique needs of Holocaust research. By fostering cooperation among its members, EHRI exemplifies the principles of transparency, non-discrimination, and competition essential for effective research collaboration, further enhancing its role as a cornerstone of Holocaust studies in Europe.

The **Austrian component, EHRI-AT**, connects leading research institutions in Austria, enhancing their contributions to Holocaust studies within the broader EHRI network. The **Vienna Wiesenthal Institute for Holocaust Studies (VWI)** plays a central role in coordinating national activities within the European Holocaust Research Infrastructure (EHRI), effectively linking these efforts to the broader European framework. The VWI focuses on the study of antisemitism, racism, nationalism, and the Holocaust, including its antecedents and consequences. Its research agenda employs innovative methodologies to explore critical questions, such as the distinctive characteristics of Holocaust memory and comparisons with other genocides, allowing for engagement with both historical and contemporary implications. VWI complements EHRI's objectives by curating extensive collections, including access to Holocaust-related archival materials from the Archive of the Jewish Community of Vienna (IKG) and the estate of Simon Wiesenthal, while supporting scholars through fellowship programs that foster academic exchange and innovation. A key aspect of VWI's mission is its commitment to Open Science practices, enhancing the accessibility and utility of Holocaust research. By promoting resource access and transparency, VWI aligns with Open Science principles, facilitating cross-border collaboration and data sharing among researchers.

Together, EHRI, EHRI-AT, and VWI exemplify the values of Open Science, emphasizing educational outreach and collaborative research efforts. Their

initiatives significantly contribute to Holocaust studies and support the development of a more informed and engaged society, further advancing the goals of SDG 16.

Advancing Open Science in Holocaust Research

- 1. Enhancing Open Science Practices in Holocaust Research:** One of VWI's primary goals is to improve accessibility to its archival materials through comprehensive digitization efforts. This includes significant collections, such as those from the Archive of the Jewish Community of Vienna and the estate of Simon Wiesenthal. By converting these documents into digital formats, VWI not only preserves them for future generations but also ensures that they are widely available for researchers, educators, and the general public. This initiative embodies the principles of Open Science, allowing for a more democratic engagement with historical knowledge and fostering a deeper understanding of the complexities surrounding Holocaust studies.
- 2. Facilitating Evidence-Based Policymaking:** VWI aims to provide crucial insights for policymakers through its extensive research and digitized collections. The institute's well-documented historical evidence serves as a valuable resource for developing policies in human rights, education, and cultural memory. Moreover, its research influences discussions around reparative justice and collective memory, ensuring that the lessons of the Holocaust inform contemporary policy formulation and social dialogue.
- 3. Fostering Public Engagement and Awareness:** VWI is committed to enhancing public understanding of Holocaust history and its relevance today. By making its research and resources more accessible, the institute aims to engage a broader audience in discussions about historical memory and its implications for societal development. This objective emphasizes the importance of public discourse in recognizing the impact of past atrocities and reinforces the role of education in

promoting awareness and sensitivity to issues of discrimination and injustice.

4. **Encouraging Collaborative Research Across Borders:** VWI actively seeks to promote interdisciplinary and transnational collaboration within Holocaust research. By participating in networks such as the European Holocaust Research Infrastructure (EHRI), VWI facilitates partnerships that allow for the integration of diverse methodologies and perspectives. This collaborative approach enhances the quality and scope of Holocaust studies while ensuring that insights gained are relevant to an international audience. Through these efforts, VWI contributes to a shared understanding of the Holocaust.

Impact

The Vienna Wiesenthal Institute for Holocaust Studies (VWI) employs a multifaceted strategy to advance its mission of expanding accessibility, transparency, and collaborative potential within Holocaust research through Open Science practices. The following strategies, focusing on digitization, research enhancement, public engagement, and capacity building, exemplify the institute's commitment to fostering impactful and inclusive Holocaust research.

- **Digitization and Integration of Archival Collections:** To promote accessibility and preservation of Holocaust-related resources, VWI has initiated comprehensive digitization efforts covering its extensive archival and library collections. This includes critical historical materials, such as documents from the Archive of the Jewish Community of Vienna and from Simon Wiesenthal's estate. By digitizing these collections, VWI makes them available to a global audience, integrating their metadata into platforms like the European Holocaust Research Infrastructure (EHRI), Europeana, Kulturpool, and the Austrian Library Network (OBV). This integration facilitates cross-

border research and supports scholars in accessing essential primary resources, thus enhancing the utility and reach of VWI's collections.

- **Strengthening Research Through Fellowship Programs:** Central to VWI's scholarly contribution is its fellowship program, which fosters innovative Holocaust research by supporting both emerging and established scholars. This program encourages interdisciplinary and international research exchanges, allowing for the development of new methodologies and research questions within Holocaust studies. Through publishing in Open Access journals, such as S:I.M.O.N., the institute ensures that its research outputs contribute to broader academic and public policy discussions on antisemitism, racism, and collective memory. These fellowships allow for continuous evolution within Holocaust research, fostering dialogue and innovation among scholars worldwide.
- **Expanding Public and Educational Outreach:** In alignment with its mission to engage diverse audiences, VWI prioritizes public outreach through lectures, exhibitions, and educational projects. These initiatives aim to broaden public understanding of Holocaust studies, racism, and antisemitism, while providing valuable resources for educators and students. To support accessible learning, VWI makes extensive use of Open Access resources and online content, ensuring ongoing availability for educational use. Notably, VWI offers several Open Access platforms designed to enhance historical engagement. For example, the online exhibition "Wiesenthal in Linz" presents a foundational set of documents, known as the "Linz documents," which anchor the archival collection of the Jewish Documentation Centre (JDC). This collection, like many postwar Jewish records, is widely scattered. Another significant Open Access resource is the Database of "Hungarian Forced Labour in Vienna", which focuses on the history of Hungarian forced laborers in Vienna. This presentation aims not only to bring this little-known story to light but also to make visible the existing objects, memories, and documents tied to it. By doing so, it

contributes to the gradual reintroduction of forced labor in Vienna into public memory. Additionally, the “Austrian Heritage Archive” (AHA) provides a valuable open access collection of audio and video interviews with Austrian Jewish emigrants who fled to the United States or Palestine/Israel during or shortly after the Nazi era. These Open Access resources, alongside recorded lectures and events available on VWI’s YouTube channel, exemplify VWI’s commitment to broad, enduring educational outreach.

- **Advanced Library and Archive Management:** The VWI’s documentation is structured in two distinct sections: the library and the archive. The library is part of the Austrian Library Network (OBV) and provides access to existing Open Access publications, including the VWI’s own Open Access journal, S:I.M.O.N. S:I.M.O.N. operates under the Creative Commons Licence CC-BY-SA (Attribution-Non Commercial-No Derivatives). This allows for the reproduction of all articles, free of charge, for non-commercial use, and with appropriate citation information. These resources are searchable through the network’s search engine, enhancing accessibility. The archive, on the other hand, operates with its own archival information system, in which collections are catalogued and, where available, digitally documented. This system will soon offer web access for external users, independent of the Austrian Library Network.

Through these targeted strategies, VWI demonstrates a proactive commitment to Open Science, enhancing the accessibility, utility, and influence of Holocaust research. The institute’s approach provides a model for integrating public engagement, transparency, and scholarly innovation within historical research.

Policy Recommendations

The integration of Open Science principles at the Vienna Wiesenthal Institute for Holocaust Studies (VWI) has produced several significant outcomes relevant to academic researchers and policymakers alike:

- **Support expanded accessibility and openness:** Policymakers should prioritize support for digitization and Open Access initiatives like those undertaken by VWI, which have increased the availability of Holocaust-related materials. These efforts facilitate academic inquiry and provide essential resources for evidence-based policymaking in areas such as human rights, education, and justice, encouraging more informed decision-making and public discourse.
- **Utilize research for policy formulation:** VWI's comprehensive collections and research findings offer valuable empirical evidence to guide the development of policies on historical education, collective memory, and human rights. Policymakers are encouraged to build on these insights to craft legislation and initiatives that reinforce democratic principles and promote historical awareness.
- **Encourage cross-border collaboration:** Policymakers should support initiatives like VWI's engagement in European research frameworks like the European Holocaust Research Infrastructure (EHRI), which underscores the importance of international cooperation in Holocaust studies. These partnerships strengthen research efforts, secure sustainable funding, and enhance the capacity of Holocaust studies to contribute to policies promoting peace, justice, and reconciliation.

Through these initiatives, the Vienna Wiesenthal Institute for Holocaust Studies not only advances the field of Holocaust research but also reinforces the significance of Open Science in promoting peace, justice, and strong institutions in alignment with Sustainable Development Goal 16 (SDG 16). By ensuring widespread access to its collections and engaging diverse stakeholders with insights, VWI demonstrates how Open Collections can

effectively influence policy objectives and contribute to the development of a more equitable and inclusive society.

Appendix II. Stakeholder Forum Brussels

Short Summary

The stakeholder forum was originally planned as a roundtable for parliamentarians and political administration within Task 3.4. During the preparation phase, the task team decided to collaborate with another Horizon Europe project, TETTRIs (Transforming European Taxonomy through Training, Research, and Innovations), which also aimed to organize a stakeholder event for policymakers in Brussels, in order to enrich the event and highlight the potential of Open Collections for policymaking by merging the main themes of both projects: Open Science and Biological Taxonomy. TETTRIs, led by CETAF (Consortium of European Taxonomy Facilities), focuses on strengthening taxonomic research to effectively address general biodiversity issues. TETTRIs aims to optimise the use of collections in research and integrate them into policy-making, identifying key impact areas for taxonomists, discussing environmental legislation initiatives, and fostering interdisciplinary collaboration. By promoting knowledge sharing, capacity building and stakeholder dialogue, TETTRIs provides reliable resources to have evidence-based grounds for policy-making.

Together, TETTRIs and Skills4EOSC highlighted the crucial role of scientific collections, taxonomic research and Open Science competencies for achieving biodiversity-related goals at the Stakeholder Forum. By integrating Open Science practices and the rich data extracted from these collections, the two projects aim to create new opportunities for innovation and impact, particularly in monitoring biodiversity and scientific progress.

Invitations for the event were extended to 40 stakeholders from diverse sectors, including political administration (e.g., the European Commission's Directorates-General for Environment and Research and Innovation), citizen science, research infrastructures, funding organizations, scientific collections, education, industry, and the private sector.

The forum was structured as a moderated discussion with two panel sessions, each featuring six panellists offering distinct perspectives. At the end of each session, the audience participated actively, fostering an interactive exchange of ideas across multiple domains. This format allowed for key aspects to be highlighted from various perspectives, reflecting the practical experiences of participants.

The first session, titled "Interdisciplinary Taxonomic Capacity Needs in a Multi-Faceted Approach", focused on how Open Science skills and taxonomic research can meet the interdisciplinary needs for scientific, environmental, educational, economic, and political collaboration. The session emphasized the potential and relevance of integrating taxonomy with Open Science to address biodiversity and climate challenges. Data gaps, the decline in taxonomic expertise, and uneven data availability were discussed, alongside the importance of embedding and strengthening Open Science skills through projects like Skills4EOSC. The session also highlighted the need for new economic models that integrate social and environmental indicators as well as the need for strengthening the alignment between policy and science.

The second session, "What is the Impact Envisioned by Ensuring Trained Experts?" addressed how ensuring trained experts in Open Science and taxonomy can drive European biodiversity goals and foster cross-sector collaboration. The panel explored the role of Open Collections and taxonomic research in advancing global biodiversity frameworks, particularly the Global Biodiversity Framework (GBF), and how these tools can influence policy-making. The projects Skills4EOSC and TETTRIs were highlighted for preparing early-career researchers to contribute to Open Science and Open Collections, and the potential of emerging professionals in supporting global biodiversity initiatives and European policies like the EU Green Deal.

Research infrastructures, such as DiSSCo, were recognized as essential for advancing taxonomic research and ensuring transparency in biodiversity monitoring. The panel discussed how taxonomic data and Open Science competencies can be better integrated into European research infrastructures to support interdisciplinary research and inform policy

decisions. Citizen science’s increasing influence was explored, with a focus on how Open Science tools can empower citizen scientists in taxonomy and biodiversity monitoring, especially in the context of the EU Green Deal. Industry collaboration was also discussed, with an emphasis on using taxonomic knowledge and Open Science data to enhance sustainability measures.

The session highlighted the significant shortage of taxonomists and biodiversity researchers, emphasizing the need for international collaboration, capacity-building programs, and data-sharing initiatives to bridge this gap. Biodiversity monitoring in Europe depends heavily on citizen science, requiring harmonized methodologies and skilled professionals which are facing a decline. Training the next generation of taxonomists through initiatives like TETTRIs is crucial to addressing gaps in expertise. Opportunities for citizen science and industry collaboration were also noted, alongside concerns about balancing openness with the risks of cyberattacks and managing sensitive data. Finally, the growing role of AI in biodiversity research was acknowledged, with a call for region-specific training and the importance of human expertise in research. Addressing the science-policy gap was identified as essential for translating scientific insights into actionable policies.

Program of the event

Moderators: Michael Magee (TETTRIs), Betty Evangelinou (Skills4EOSC)

08:30–09:15	Registration and Welcome Coffee
09:15–09:45	Opening & Impulse sessions <ul style="list-style-type: none"> • Welcome: Michaela Kauer (Vienna House) • Introduction from the organiser: Katrin Vohland (NHMW) • Introducing CETAF and TETTRIs project: Ana Casino (CETAF) • Introducing Skills4EOSC project: Sara Di Giorgio (GARR)

09:45–11:00	<p>Session 1 – Interdisciplinary taxonomic capacity needs in a multi-faceted approach</p> <ul style="list-style-type: none"> • Scientific dimension: Colombe Warin (DG Research and Innovation) • Environmental dimension: Frank Vassen (DG Environment, European Commission, Nature Protection Unit) • Educational dimension: Milena Dobрева (University of Strathclyde/RDA Working Group) • Economic dimension: Lydia Korinek (ZOE- Inst for Future Economies) • Political dimension: Bernhard Zlanabitnig (EEB) • Collections as research infrastructures: Dimitris Koureas (DiSSCo, Leiden, Netherlands)
11:00-11:30	Coffee Break
11:30-13:30	<p>Session 2 – What is the impact envisioned by ensuring trained experts</p> <ul style="list-style-type: none"> • Global Perspective: Pierre Huybrechts (CEBioS/GTI NFP) • Immersion in the biodiversity strategy in Europe: Andreas Gumbert (DG Environment) • Integration of our results (Taxonomic work + Skills4EOSC) into research infrastructure: (Open science collections): Patricia Mergen (Botanical Garden Meise) • Raise awareness and engagement with citizen scientists: Enrico Balli (ECSA) • Synergies with industry: Rena de Mey (Wienerberger) • Future dimension: Amelie Höcherl (SMNS/ZSM)
13:30-13:40	Closing remarks: Ana Casino, Sara Di Giorgio & Katrin Vohland
13:40	<p>Goodbye aperitif</p> <p>Afterwards: Booth providing the opportunity for hands-on experience with species identification, exchange with taxonomists and biodiversity data gathering initiatives</p>

Further Links referring to the event

- <https://www.skills4eosc.eu/news/skills4eosc-and-tettris-join-forces-to-empower-open-science-skills-for-europes-green-deal>
- <https://tettris.eu/2024/11/18/taxonomy-and-open-science-skills-for-empowering-europes-green-deal/>