

# WP5 OPERATIONALISATION

## through demonstration, piloting and prototyping

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## LIST OF ACRONYMS

AI	Artificial Intelligence	
BAS	Bulgarian Academy of Science	
BD	Birds Directive	
CBNP	Central Balkan National Park	
DDNI	Danube Delta National Institute	
EBOCC	EU Biodiversity Observation Coordination Centre	
EBV	Essential Biodiversity Variables	
ECD	Environmental Crime Directive	
EEA	European Environment Agency	
ESG	Environmental, Social and Governance	
EU	European Union	
EuropaBON	Europa Biodiversity Observation Network project	
HD	Habitats Directive	



HWC	Human-Wildlife Conflict	
IBER-BAS	Institute of Biodiversity and Ecosystem Research at the Bulgarian Academy of Sciences	
KG	Knowledge Graph	
МАМВО	Modern Approaches to the Monitoring of Biodiversity project	
MSFD	Marine Strategy Framework Directive	
Nature FIRST	Forensic Intelligence and Remote Sensing Technologies for nature conservation project	
NGO	Non-Governmental Organisation	
РСР	Pre-commercial procurement	
PPI	Public procurement of innovative solutions	
WFA	Wildlife Forensic Academy	
WFD	Water Framework Directive	
WP	Work Package	
WUR	Wageningen University & Research	
WWF	Worldwide Fund for Nature	



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# **1. Executive summary**

The "Forensic Intelligence and Remote Sensing Technologies for nature conservation" (Nature FIRST) project is a 3-year EU research & innovation project (2022-2025). During the project an innovative tool suite has been developed to monitor biodiversity, to predict human-wildlife conflict (HWC) and to proactively tackle key wildlife crime and environmental challenges. The collection of methods and technologies facilitate: 1. Near real-time monitoring. 2. Early detection of changes and trends. 3. The translation of predictions into timely, actionable interventions. 4. The protection of crime scene evidence in the field, in difficult conditions. 5. Training of rangers and (local) law enforcement in the principles of forensics and comprises the following products/services:

Product / Service	Description
Human-wildlife conflict mapping	A service to understand the extent, location, and patterns of human-wildlife conflicts. This is crucial to develop effective mitigation strategies that promote human-wildlife coexistence.
Bear HWC radar	This tool provides timely information about bear-presence and threats for humans and their assets (e.g. apiaries). The radar is underpinned by a species digital twin model (which can be adapted to other animals / large carnivores).
Habitat and land use mapping model	A product to map Natura 2000 protected habitats at lower cost through automation. Flexible to different habitat classification or land cover, and different resolution products.
Habitat / land use change monitoring	A service offering continuous habitat monitoring through change detection. Calculating conservation status parameters of the habitats in a protected area through remote sensing.
Knowledge Graph for biodiversity	The KG is an Artificial Intelligence (AI)-driven backbone to linking different data and languages, which turns dispersed, inconsistent, and siloed biodiversity data into a usable, connected ecosystem of knowledge—enabling questions that are difficult or impossible to answer with conventional databases.



Product / Service		Description
Wildlife Forensic and Training	Toolkit	A modular forensic toolkit for rangers / first responders to secure the scene of a crime and to protect evidence in difficult situations. Hands-on training for non-experts and experts in handling crime scenes.

The tool suite was developed through a process of co-design and co-creation between technology development partners, business development partners and field site partners involved in conservation research and management, together with their stakeholders, in four countries: Ukraine, Romania, Bulgaria and Spain. Demonstration and testing was done continuously, and we organised field site workshops to obtain valuable feedback from a broader group of stakeholders: experts, management authorities, research organisations, government and conservation agencies. These workshops form the primary source of information for this policy lab deliverable, together with extensive desk research. The findings are enriched by monthly meetings between the technology development partners, business development partners and the field site partners, stakeholder interviews and a small-scale online survey.

Our work is set within the background and context of the European Union (EU) and global legislative framework and we assessed our solutions for their contribution to monitoring and reporting requirements under this legal framework. To assess the long-term sustainability of our results, we consider the nature conservation domain as governmental, non-governmental and institutional markets, which in essence means they are a) driven by regulations and procedures (including rules for public procurement) and b) budget constraints (often project-funding based).

Our exploration of the existence of, opportunities for and barriers to a market for biodiversity monitoring and management underscores that while there is growing demand for practical biodiversity monitoring tools across Europe, the landscape remains fragmented, underfunded, and institutionally complex. Significant challenges persist, including entrenched reliance on legacy systems, inconsistent data standards and databases, lack of traceability and transparency, limited technical capacity at the field level, and highly project-based funding structures. These systemic barriers slow the adoption of innovative tools and create uncertainty around the long-term sustainability of monitoring efforts. Besides, informed decisions are difficult to be made in the absence of sound data from the field, affecting in the long-term the viability of certain species, including of the ones that are sensitive to environmental changes, rare, endemic or highly threatened.



Pressure to improve biodiversity data collection and reporting is increasing due to evolving EU policy frameworks, creating an opening for solutions like those developed by Nature FIRST. Our tools offer meaningful responses to clear pain points — particularly in data harmonisation, real-time monitoring, and compliance facilitation — but uptake will depend on how effectively we can embed them into existing workflows and governance systems. At the same time, the successful implementation of conservation efforts and the emphasis on legal compliance have seen an increase in human-wildlife conflict, a reduction in the acceptance of potentially problematic species and thus willingness to coexist with them, or at least to make sustained efforts in this respect. This has resulted in a corresponding political response which, while not backed by data, sets out to reduce support for biodiversity conservation and nature restoration, at all levels.

The current political climate aside, our findings highlight several critical success factors for market development: offering modular, user-friendly tools that require minimal training; aligning with regulatory frameworks and reporting standards; addressing technical and funding constraints through cost-effective design and open-source strategies; and tailoring value propositions to distinct market segments.

Based on our findings, the contribution Nature FIRST can make and our conclusions, we make the following recommendations.

#### ★ Establish the EBOCC

As our first recommendation we would like to give our express support to the establishment of the EU Biodiversity Observation Coordination Centre (EBOCC) as proposed by the Europa Biodiversity Observation Network (EuropaBON) project. Such a coordination centre should have as its core objectives to overcome the implementation gaps and monitoring deficits identified by EuropaBON and confirmed by our own research findings. We also recommend the use or establishment of national biodiversity monitoring hubs and foster existing networks and communities. Given the fragmentation of governance and stakeholders there is a need to connect overarching EU policy with the operational realities on the ground at local level. We found that, despite the apparently robust legislative framework, implementation is difficult, hindered by persistent gaps and barriers particularly at local and regional level that need addressing. An important barrier is the lack of funding, therefore a major task is to explore how to move from project-based to sustainable funding mechanisms. Another issue is the lack of trust and cooperation among key stakeholders, which the EBOCC could address.

#### ★ Expand, connect and enhance existing initiatives

With regard to EBOCC's re-use of existing networks and communities we make the following specific recommendations:



- Connect the Biodiversa+ partnership and EU CAP Network (now incorporating the EIP-AGRI partnership) to better align conservation and agriculture initiatives and objectives establishing/creating the conditions for coexistence in an early stage. This could include for example joint thematic networks on HWC and exchanging knowledge and innovation information. The project launched under the Farm2Fork strategy, Co-creating Coexistence<sup>1</sup>, can be one of the initiatives to build on.
- Expand the European Commission's initiative<sup>2</sup> to support the European Network of Fact-Checkers to include fact checking and counter false claims made about large carnivores and human wildlife conflicts. Defending nature (and those active to prevent and combat illegal activities) is as much part of our democracy as any other disinformation.
- 3. Use the European Citizen Science Association (ECSA) for active promotion of lessons learnt and good practices across local and regional stakeholders (who are usually at the forefront of conflict as well as a tremendous source of local knowledge and expertise). This can build on best practice projects such as the 'Bear Smart Community' from WWF Romania in Băile Tuşnad<sup>3</sup> and the more4nature<sup>4</sup> project (reversing the trend in environmental degradation through collaboration of citizen science initiatives with authorities).

#### ★ Support market mechanisms in biodiversity monitoring and management

As written above, we consider biodiversity monitoring and management as governmental, non-governmental and institutional markets. Public authorities are driven by regulations and procedures public procurement) and budget constraints. Pooling resources, such as done in the Biodiversa+ partnership for joint research funding, can be applied to market development in the following ways:

1. Develop a preparatory phase for a pre-commercial procurement for biodiversity monitoring (*Pre-PCP*). The purpose is to start the process of bringing public authorities with budget responsibilities (e.g. Ministry of Environment, Forestry or Nature; Executive Agencies) together in a network to jointly determine needs for monitoring and management and to develop Terms of Reference for species monitoring systems, habitat mapping and change monitoring, etc. This phase is needed to make such authorities aware of the role they can play in creating functioning and operational markets (capacity building, networking). The Pre-PCP

<sup>&</sup>lt;sup>4</sup> more4nature.eu



Nature FIRST is a Research and Innovation Action (RIA) from HORIZON-CL6-2021-BIODIV-01-02 Call (grant agreement number: 101060954) that has received  $\in$ 4 538 348.75 EU Contribution

<sup>&</sup>lt;sup>1</sup> The project Co-creating Coexistence, <u>cocoproject.eu</u>, was launched in response to the call

HORIZON–CL6-2023-FARM2FORK: Agro-pastoral/outdoor livestock systems and wildlife management

https://digital-strategy.ec.europa.eu/en/news/commission-launches-eu5-million-call-strengthen-european-fact-checking-network

<sup>&</sup>lt;sup>3</sup> <u>https://test.cdpnews.net/wp-content/uploads/2024/03/27\_4\_Papp-et-al.pdf</u>

should lead to a PCP phase.

- 2. Pre-commercial Procurement (*PCP*) phase<sup>5</sup>. This phase is to publish the joint needs statement and Terms of Reference as a challenge to industry to develop or propose solutions. It shows companies that there is a market demand and stimulates them to invest in research and development (market consultation).
- 3. Public Procurement of Innovation (*PPI*) phase<sup>6</sup>. Once the demand from public authorities for innovative solutions has been demonstrated and the capacity of companies to supply such solutions, a joint or individual public procurement can be launched.

#### ★ Safeguard independent and data-driven decision making and implementation of the Rule of Law & Governance

Ensure that studies used by member states to develop and underpin policy measures are independently contracted, are transparent and accessible by the general public. Support research institutes with protocols for the establishment of databases in support of species management based on genetics and clear evidence of the presence of species<sup>7</sup>. Work closely with Member State authorities, implementing organisations and law enforcement agencies to ensure the national strategies and definitions developed as part of the transposition of the Environmental Crime Directive ensure the protection of flora, fauna, habitats and ecosystems. Liaise with the four relevant networks: European Union Network for the Implementation and Enforcement of Environmental Law (IMPEL<sup>8</sup>), European Network of Prosecutors for the Environment (ENPE<sup>9</sup>), Law Enforcement Agencies (EnviCrimeNet<sup>10</sup>) and the EU Forum of Judges for the Environment (EUFJE<sup>11</sup>), for example on adequate definitions of "negligible" quantity or "substantial" damage.

#### ★ Don't let perfection be the enemy of good

Given the high dependence of EU project-based funding, build mechanisms in research and innovation projects to deliver early results that are practical and operational and can be demonstrated. The purpose and usefulness of innovative tools such as a digital twin

<sup>&</sup>lt;sup>11</sup> https://www.eufje.org/



<sup>5</sup> 

https://research-and-innovation.ec.europa.eu/strategy/support-policy-making/shaping-eu-research-and-in novation-policy/new-european-innovation-agenda/innovation-procurement/pre-commercial-procurement\_ en 6

https://research-and-innovation.ec.europa.eu/strategy/support-policy-making/shaping-eu-research-and-in novation-policy/new-european-innovation-agenda/innovation-procurement/public-procurement-innovative -solutions\_en

<sup>&</sup>lt;sup>7</sup> https://www.kora.ch/en/projects/large-carnivore-monitoring/scalp-categories

<sup>&</sup>lt;sup>8</sup> https://www.impel.eu/en/

<sup>&</sup>lt;sup>9</sup> https://www.environmentalprosecutors.eu/

<sup>&</sup>lt;sup>10</sup> https://www.envicrimenet.eu/

or a real-time conflict incident radar are often difficult to "imagine" by users without a demonstrator or prototype.

#### ★ Specific HWC to HWCoexistence policy development

While perhaps we cannot fully avoid the cyclical nature of politics and with that, shifting policy priorities, we can better anticipate the impact of conservation efforts. Thus allowing us to move from crisis-management mode to predictive and preventive management mode. Deliberate reintroduction of key species, such as the bear in France or the European bison in Romania, should be accompanied by the development of management strategies that include measures to prevent and deal with conflict. The comeback and spreading of species such as the wolf across Europe should be tracked and anticipated, based on the scientific understanding of spatial ecology and animal behaviour studies, allowing the responsible authorities to respond in a timely and appropriate manner. An example is Luxembourg, which started the development of their wolf management plan in 2015. While they do not have a resident wolf population (yet), they have the capacity to respond as soon as the situation requires intervention and timely action.

# 2. Introduction

This deliverable is part of the work developed in WP5 - Operationalisation, which had as its objective to demonstrate and test the methods, maps, routines and models from WP 4 in real-life situations. A second objective was to engage public, management and law enforcement authorities in the process to get an understanding of their needs in developing, implementing and monitoring policies and plans as well as to raise awareness of the impact they have on ecosystem services and biodiversity.

The role of operationalisation in the four field sites and the policy lab was to co-design the results so that they contribute to closing the identified challenges (WP3 - State of Play), are fit-for-purpose in terms of effectiveness (better intelligence through strengthening the evidence-base) and efficiency (more for less). The field sites and policy lab were the next logical step in our work flow towards an integrated monitoring system developed in WP4 - Development of proactive methods and technologies.

This deliverable D16 is one of three deliverables produced as part of WP5, the others being:

- D15 Field site outcomes and recommendations
- D17 Policy brief

Each document is standalone and can be read independently from the others. All three



deliverables are or will be made public.

This deliverable starts with a brief overview of the project, to familiarise the audience with the overall aims and approach of Nature FIRST. This is followed by a description of the scope and approach of the policy lab. The breadth of monitoring of species and habitats and our approach to co-design solutions with the end users necessitated a focus on four specific nature areas in four EU countries and their species-habitation combinations. These are described in section 3.1.

The project overview is followed by a description of the policy lab, including an overview of the policy framework we used to guide our assessment of fit-for-purpose development. This section on the methodology sets the scene for a summary of our findings, which in turn is followed by our conclusions and recommendations.

# **3. Project overview**

The "Forensic Intelligence and Remote Sensing Technologies for nature conservation" (Nature FIRST) project is a 3-year EU research & innovation project. During the project an innovative tool suite has been developed to monitor biodiversity, to predict human-wildlife conflict and to proactively tackle key wildlife crime and environmental challenges. The collection of methods and technologies facilitate: 1. Near real-time monitoring. 2. Early detection of changes and trends. 3. The translation of predictions into timely, actionable interventions. 4. The protection of crime scene evidence in the field, in difficult conditions. 5. Training of rangers and (local) law enforcement in the principles of forensics.

The developed methods and solutions make use of remote sensing technologies (both satellite-based and on-site), ecological digital twins and environmental forensics, which extracts insights from field evidence. This combination has been used to uncover cause-effect relations and prevent human-wildlife conflicts and detect and investigate environmental crimes. By integrating these technologies into a single system for data harmonisation and integration, we shift periodic mapping to real-time monitoring, enabling proactive interventions based on forecast trends. The result is a tool suite comprising:

- human-wildlife conflict mapping and near real-time conflict radar (precursor to the illegal killing of wildlife).
- habitat/land use mapping and change monitoring (detection of illegal activities such as logging, degradation/fragmentation, waste, forest fires).



- knowledge graph (KG) for biodiversity (Al-driven backbone to linking different data and languages).
- wildlife forensic knowledge exchange and portable forensic toolkit (hands-on training and equipment for non-experts and experts in handling crime scenes).

## 3.1 Field Sites

The consortium partners created the above-mentioned tool suite through close collaboration and constant evaluation and testing of interventions and scenarios in real-life situations and with real users. We did this for and with stakeholders in the following field sites, which correspond to protected natural areas in different countries across Europe, covering six biogeographical regions.

**Maramures Transboundary Area (Carpathians) [Romania and Ukraine].** This site is located on the North-Eastern part of Carpathians Mountains, mainly in the Alpine biogeographical region, bordering two countries: Romania and Ukraine. The Carpathian Mountains hosts many of Europe's last great wilderness areas with "exceptional levels of biodiversity, such as high species richness or endemism, or those with unusual ecological or evolutionary phenomena" as well as rich cultural landscapes, including the continent's most extensive tracts of mountain and old-growth forest as well as about half of the European populations of large carnivores like brown bears, wolves and lynxes. As we were implementing Nature FIRST, its relevance to another initiative led by WWF Romania - the 'Bear Smart Community' in Băile Tușnad - became obvious. Băile Tușnad is a small town in Harghita county (Transylvania) that is actively dealing with bear presence and conflict. We added this site as a second pilot at the end of 2023 to test solutions to reduce human-wildlife conflicts. In Ukraine the original pilot sites of Yasinia Forestry and Verkhovyna National Nature Park were expanded to include the Rivne Nature Reserve in Polissya.

**Stara Planina Mountain (Balkan mountains) [Bulgaria]**. This site is part of the Central Balkan National Park with the Balkan buffer, both Natura 2000 sites. The territory of the Stara Planina mountain falls into three climatic zones. The parts with an altitude of over 1000 m fall in the mountain climate area. The weather on the northern slopes of the mountain is a result of the peculiarities of the temperate-continental climate region, and on the southern slopes the transitional-continental climatic region. It has 80 protected species in accordance with the EU Habitats and Birds Directives and Bulgarian regulation and more than 35 habitats of Community Interest.

**Danube Delta** [Romania]. The Danube discharges into the Black Sea in a characteristic delta area, which up until the present day has maintained much of its original natural features. It is part of the Natura 2000 network as SPAs (Special Protected Areas) and



SCIs (Sites of Community Importance). The river shapes its way to the sea by three main branches that form a virtually perfect triangle delta that is composed almost entirely of a virtually untouched wetland area with lots of smaller and larger freshwater bodies interspersed with vast reed beds, woodland and shrubs. Some sandy outcrops of marine origin occur in the easternmost part of the delta. Further south two large former lagoons are situated, lakes Razim and Sinoe, which have been separated from the Black Sea and have since become fresh. Danube Delta and Razim – Sinoe lagunary complex hosts habitat types and populations of different groups of flora and fauna characteristic for Black Sea and Steppic biogeographical regions.

**Ancares-Courel [Spain]**. This is a Special Area of Conservation (SAC) of the Natura 2000 Network. Located in Northwest Spain (Galicia), in the transition of the Atlantic and Mediterranean biogeographical regions, it has a surface area of 102,634 ha. Ancares-Courel is a relatively abrupt area with high and medium mountains. The most dominant habitats are forests and heathlands, but the site has a large variety of ecosystems, including more than 30 habitats of Community Interest. Ancares-Courel hosts relevant populations of different groups of flora and fauna with the presence of large carnivores such as brown bears and wolves.



FIGURE 1: Nature FIRST field sites



Nature FIRST is a Research and Innovation Action (RIA) from HORIZON-CL6-2021-BIODIV-01-02 Call (grant agreement number: 101060954) that has received €4 538 348.75 EU Contribution While we have focused on the specificities of these sites, our methods, technologies for data collection, interpretation and visualisation as well as the tools for detection, prevention and evidence gathering of HWC and illegal activities are replicable to other areas and scalable to other species and land use characteristics.

## 3.2 Work Packages

The Nature FIRST project consists of six Work Packages which together form a logical workflow:

- WP1 Project Coordination
- WP2 Creating Impact
- WP3 State of Play
- WP4 Development of Proactive Methods & Technologies
- WP5 Operationalisation



FIGURE 2: Schematic work plan of the Nature FIRST project



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# 4. Policy lab

### 4.1 Policy background and context

Our work is set within the background and context of the EU and global legislative framework and we assessed our solutions for their contribution to monitoring and reporting requirements under this legal framework. The Birds and Habitats Directives govern the protection of wild fauna and flora, habitats and protected natural areas and set the conservation objectives and biodiversity monitoring of all EU member states.

In addition, we have included in our work the contribution of our tool suite to the EU's Biodiversity Strategy for 2030, the Essential Biodiversity Variables (EBVs) as indicators of the conservation status of species in a protected area and compliance with the Environmental Crimes Directive (notably wildlife crime).

Table 1 lists the main legal instruments for biodiversity conservation and their monitoring obligations and reporting cycles.

Policy instrument	Core monitoring obligations	Reporting cycle	Implications for market demand
Birds Directive (BD) (2009/147/EC)	Monitoring of population size, trends and distribution of wild bird species and habitats, designation of Special Protection Areas (SPA) included in the Natura 2000 network.	6 years	Creates demand for species population data and geospatial tools.

TABLE 1. Core EU and global policy instruments and their associated monitoring obligations, reporting cycles and implications for market demand.



Policy instrument	Core monitoring obligations	Reporting cycle	Implications for market demand
Habitats Directive (HD) (92/43/EEC)	Standardised assessments for 1,000+ species and 233 habitat types, designation of Special Areas of Conservation (SAC) included in the Natura 2000 network.	6 years	Anchors national monitoring programs; requires harmonised data.
Water Framework Directive (WFD) (2000/60/EC)	Monitoring of ecological and chemical status of aquatic ecosystems including rivers, lakes, transitional and coastal waters.	6-years, River Basin Management Plans (RBMPs)	Supports biomonitoring tools and ecosystem quality assessments.
Marine Strategy Framework Directive (MSFD) (2008/56/EC)	Monitoring of biodiversity indicators to track the environmental status of all marine EU waters, including environmental status and biodiversity criteria covering all species groups and broad habitat types.	6 years	Stimulates marine remote sensing and sensor deployment.
Environmental Crime Directive (ECD) (2024/1203/EC)	Monitoring and evaluation strategies to combat environmental crimes.	At least every 3 years	Drives protection of wild flora and fauna, including habitats, from illegal activities and consequently the demand for investigative and forensic tools to allow for prevention and



Policy instrument	Core monitoring obligations	Reporting cycle	Implications for market demand
			intelligence led action <sup>12</sup> .
Convention on International Trade in Endangered Species (CITES)	Monitoring and regulating trade in endangered species of wild fauna and flora to prevent illegal wildlife trade.	Triennial Conference of the Parties; national reporting varies (annually or biennially)	Drives demand for forensic tools, tracking technologies and permit enforcement systems.
Convention on Biological Diversity (CBD)	National Biodiversity Strategy and Action Plans (NBSAPs); global biodiversity indicators (e.g. Aichi Targets, Kunming-Montreal GBF).	National reports every 4 years	Encourages ecosystem-based monitoring solutions and data integration platforms.
UNODC Wildlife and Forest Crime Analytic Toolkit	Assessment of national capacity to prevent, detect and respond to wildlife and forest crime.	Periodic (ad hoc by country)	Creates demand for forensic capacity building, interagency coordination, crime scene investigation training.

These are complemented by strategic frameworks and emerging legislation that elevate the urgency and extent of biodiversity monitoring:

**EU Biodiversity Strategy for 2030**: The EU Biodiversity Strategy for 2030 is a core pillar of the Green Deal, putting forward a plan to protect nature and reverse ecosystem degradation. It aims to establish legally binding nature restoration targets and measures to address the key drivers of biodiversity loss. Its objectives include the establishment of a network legally protecting at least 30% of the EU's land area and 30% of its sea area

<sup>&</sup>lt;sup>12</sup> Articles 13 - 16 require Member States to ensure effective and proportionate investigative tools are available, to protect persons who report environmental criminal offences or assist the investigation, to publish information in the public interest and to take appropriate measures to prevent environmental criminal offences.



and integrating ecological corridors as part of a Trans-European Nature Network. Of importance to the Nature FIRST project is also its goal to establish a nature restoration plan ensuring that habitats and species show no deterioration, and that at least 30% of those in unfavourable conservation status reach favourable status or at least show a positive trend. This objective is aided by the implementation of the BD and HD (European Commission 2020).

**Nature Restoration Law (2024):** As proposed through the Biodiversity Strategy for 2030, this regulation sets legally binding targets to restore degraded ecosystems across the EU. It is an important step towards the EU commitment of reversing biodiversity loss and ensuring ecosystem resilience. Member States are to submit National Restoration Plans to the Commission within two years of the Regulation coming into force (mid 2026), presenting their plans to fulfil the targets. They will also be required to monitor and report on their progress.

**Decision on 8th Environment Action Programme (EAP) (2022/591):** This decision lays out the EU environmental agenda until the end of 2030 as well as a long-term vision for 2050. It aims to "accelerate the green transition to a climate-neutral, sustainable, non-toxic, resource-efficient, renewable energy-based, resilient and competitive circular economy in a just, equitable and inclusive way, and to protect, restore and improve the state of the environment by, inter alia, halting and reversing biodiversity loss" (https://www.fao.org/faolex/results/details/en/c/LEX-FAOC210894/).

Further monitoring obligations are set for groups of species by policies like the Regulation on Invasive Species Act, Common Agricultural Policy, Common Fisheries Policy, and ecosystem services are protected by the EU Pollinators Initiative. Newest policy proposals include the Soil Monitoring Law, the Proposal for Forest Monitoring Regulation, and the Ecosystem Accounting Regulation.

While serving as the legal foundation for the Natura 2000 network, the BD and HD also contribute to the European Red List of Threatened Species compiled by the International Union for Conservation of Nature (IUCN), which assesses species' conservation status. Additionally, global agreements such as the Convention on Biological Diversity (CBD), the Ramsar Convention on Wetlands, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Convention on Migratory Species (CMS), the Bern Convention, and various Regional Seas Conventions play a key role in guiding species and habitat conservation policies adopted at the EU level.

The above outlined instruments shape biodiversity monitoring in the EU to be a compliance-driven and institutional market, wherein tools that enhance data quality, integration, and automation should be in high demand.



## 4.2 Scope and approach of the Policy lab

#### 4.2.1 Scope

To ensure that our solutions are effective for real-life conservation management needs, the scope of our work focused on biodiversity and human-wildlife conflict monitoring in and around protected nature areas described in section 3.1 (field sites). Each field site had a dedicated field partner responsible for local implementation and stakeholder engagement:

- 1. Field site Ancares-Courel, Galicia, Spain. Field partner: 3eData.
- 2. Field site Danube Delta, Romania. Field partner: Danube Delta National Institute (DDNI), supported by the sturgeon team in WWF Romania.
- 3. Field site Maramures Transboundary Area. Field partners: WWF Romania and Ukraine.
- 4. Field site Băile Tușnad, Romania. Field partner: WWF Romania.
- 5. Field site Rivne Nature Reserve, Polissya, Ukraine. Field partner: WWF Ukraine.
- 6. Field site Central Balkan National Park, Stara Planina Mountain, Bulgaria. Field partner: the Institute of Biodiversity and Ecosystem Research at the Bulgarian Academy of Sciences (IBER-BAS).

These sites, home to strictly protected species like bears, wolves and sturgeon, face common challenges such as habitat loss & fragmentation, fires, human-wildlife conflicts, lack of robust data, and poaching. Having a dedicated field partner ensured that our approach (described in section 4.2.2) was bottom-up, addressing real-life challenges (identified in WP3 and described in deliverables D10 and D11) and that our solutions were fit-for-purpose to address operational needs and deliver data-driven evidence to inform policy reporting and development.

#### 4.2.2 Approach

New science and technology can deliver solutions with a significant impact on the development, implementation, monitoring & evaluation of policies<sup>13</sup> to protect and enhance our natural environment. The policy lab aims to test such solutions, developed in the Nature FIRST project, to ensure they meet reliability and trustworthiness ("backed by science") standards and are fit-for-purpose for specific needs (including affordability).

<sup>&</sup>lt;sup>13</sup> We define the policy lifecycle as a continuum of agenda setting (evidence that intervention is needed), policy development (goal to be achieved and instruments to meet set goals), policy implementation (governance, funding, monitoring & evaluation)



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A key element in our project is the involvement of field sites, and the policy lab was run as part of the field site workshops in the partner countries of Romania (2 workshops), Bulgaria (1 workshop) and Spain (1 workshop). These workshops (see Annex 1) brought together government representatives, protected area management and experts, scientists, local authorities, hunters and fishermen, as well as NGOs, to receive their input and feedback on developments.

Throughout the project we held online meetings<sup>14</sup> with our field partners, which led to valuable insights, including limitations and barriers that feed into policy recommendations. Furthermore, we actively participated in and presented at European events to reach EU policy makers and other member states. We compared our findings to those of other projects, such as the "Europa Biodiversity Observation Network: integrating data streams to support policy" (EuropaBON<sup>15</sup>), Biodiversa+ and "Modern Approaches to the Monitoring of Biodiversity (MAMBO<sup>16</sup>) project. The findings from these activities were underpinned by desk research and a small survey carried out by us (43 respondents from 17 countries).

From the outset our aim was to develop cost-effective solutions and test them in a practical and operational environment for both practitioners in the field and public authorities responsible for policy and instrument development, in a way that is scalable, replicable and sustainable as a business proposition. To deliver the impact that is expected of new science and technology, it is necessary to move beyond the initial research and innovation development investment made by national or EU programmes such as Horizon Europe and unlock operational, continuous budgets. We have therefore investigated the existence of, opportunities for and barriers to a market for nature conservation and exploitation towards long-term sustainability. In a biodiversity research environment it is perhaps unusual to consider market development as the domain is dominated by science, NGOs and public authorities and, as described above, driven largely by public policy and legislation. We consider the nature conservation domain as **governmental**, **non-governmental** and **institutional markets**<sup>17</sup>, which in essence means they are a) driven by regulations and procedures (including rules for public procurement) and b) budget constraints (often project-funding based).

The findings from our work are summarised in the following section, followed by our conclusions and recommendations.

https://www.linkedin.com/pulse/marketing-management-ii-institutional-government-markets-agarwal/



<sup>&</sup>lt;sup>14</sup> At the start of the project we held bi-weekly meetings, from November 2023 monthly meetings.

<sup>&</sup>lt;sup>15</sup> www.europabon.org

<sup>&</sup>lt;sup>16</sup> www.mambo-project.eu

<sup>&</sup>lt;sup>17</sup> For a description of government and institutional markets see for example

# **5. Summary of findings**

### 5.1 Governance and stakeholders

The governance structure behind biodiversity monitoring in Europe is highly decentralized and fragmented, creating both entry points and friction for new technologies. The institutional pathways through which EU policy filters down to national and local monitoring actors vary significantly across Member States. This complexity defines the market for biodiversity monitoring tools, and understanding it is essential for tailoring solutions like those developed by Nature FIRST.

At the top level, the European Commission (via the Directorate-General for Environment (DG-ENV) establishes policy goals and reporting obligations. These are monitored by the European Environment Agency (EEA), the body responsible for centralised reporting and the production of EU-wide indicators supported by the Eionet network, which includes national focal points across Member States.

The implementation of these frameworks is delegated to national authorities, often Environmental Ministries or Environmental Protection Agencies (Vihervaara, et al., 2023, interviews, field site workshop takeaways). According to the Biodiversa+ mapping of national organisations across 23 countries (Vihervaara et al., 2023) and our own stakeholder mapping and interviews, these bodies are the dominant steering institutions, but the actual data collection is outsourced to a wide variety of implementing actors: public research institutes, national parks, protected area managers, NGOs, and in some cases citizen science communities. Data collection is often done on hard paper and collected using off-the-shelf tools such as excel spreadsheets, without a standardised format.

The majority (69.6% of 23 countries assessed through Biodiversa+) of national monitoring systems are split by realm, and even within realms, coordination is not always centralized. Countries such as Spain and Poland for example have multiple parallel sub-systems (e.g. air, water, nature, soil etc., in the latter), often tied to different policy or legislative mandates. This separation of responsibilities makes cross-realm and cross-sectoral integration a persistent challenge. Federal countries such as Germany experience additional complexity due to responsibilities split across national and sub-national levels, leading to patchwork data systems with varying standards and limited interoperability.

Most countries' monitoring efforts are tightly linked to EU directives. Assessing current monitoring efforts, the EuropaBON User Needs Assessment has drawn upon a wide



range of stakeholder expert knowledge including a public stakeholder workshop, surveys filled in by national experts, and interviews as well as meetings with experts from EC directorates/agencies (Moersberger et al., 2022). According to their assessment, 62% of monitoring schemes serve European reporting needs, while 58% feed into national reporting. In contrast, only 16% support international obligations, such as those under the Ramsar Convention, Regional Seas Conventions, or the IUCN Red List. Furthermore, 73% of biodiversity monitoring datasets are used primarily for reporting under the Habitats Directive (46%) and Birds Directive (27%), with relatively few supporting broader frameworks like the Common Agricultural Policy, Water Framework Directive, or Marine Strategy Framework Directive (Moersberger et al., 2022).

Most countries depend on project-based funding, typically from EU instruments like LIFE, Interreg or recovery and resilience funds (Vihervaara et al., 2023, interviews, field site workshops). Stable, long-term financing mechanisms are rare, making sustained data collection and institutional development difficult. One example we came across is a national park authority responsible for monitoring 25 species listed under the Birds and Habitats Directives, with a budget of €1,000 per year and 43 field staff (of which 5 experts) covering an area of some 70,000 hectares. Countries such as Italy are using EU recovery funds to initiate major biodiversity investments (e.g., €400M for coordination), while Croatia and Germany are creating national biodiversity coordination centres (Bundesamt für Naturschutz, 2025) to improve interoperability and streamline reporting, but smaller or decentralized states often lack such resources.

In parallel, non-EU countries such as Ukraine are also advancing national biodiversity policy frameworks. The Ministry of Environmental Protection and Natural Resources of Ukraine is currently developing a Biodiversity Conservation Strategy until 2030, which includes provisions for establishing a systematic biodiversity monitoring system (with recommendations provided by WWF-Ukraine based on Nature FIRST project findings).

A shared strength—and vulnerability—is the widespread reliance on volunteer contributions and citizen science (Vihervaara et al., 2023, Field site workshop takeaways). NGOs and local naturalist groups, particularly in countries like Belgium, the Netherlands, Germany and Finland, generate large volumes of data on birds, butterflies, and vascular plants. While cost-effective and community-driven, these efforts often lack formal institutional support, suffer from inconsistent validation, and are at risk due to insecure funding. Some countries (e.g., Finland and Belgium) have developed robust integration mechanisms, but in many others, volunteer-based monitoring remains underutilized or undervalued.

The structure of such national governance results in a biodiversity monitoring value chain involving various stakeholder groups (Figure 3). Informed by our desk research as well as through the case study analyses of our field site workshops, a value chain was created



including exemplary stakeholders.



FIGURE 3. Biodiversity monitoring value chain based on field site case studies and desk research.

### 5.2 Implementation gaps and monitoring deficits

Demand for tools facilitating data harmonisation, integration as well as semi-automated workflows is not only driven by the above-outlined policy context but also by operational realities on the ground in fulfilling the objectives set out by this framework. Despite the robust legislative framework, the findings from our desk research as well as from our field site workshops and interviews point to the reality that implementation is difficult, hard to maintain long-term structured monitoring, hindered by persistent gaps and barriers. As a result, the EU remains off track to meet its biodiversity monitoring and restoration goals by 2030 (EEA 8th EAP Monitoring Report, 2024).

Further, Santana et al. (2023) report that just 25% of EU countries consistently fulfil essential biodiversity monitoring criteria, including data accessibility and long-term sampling. This highlights major deficiencies, especially in genetic data collection. Additionally, significant gaps persist in monitoring species traits (30%), species



populations (48%), and ecosystem structure (58%).

EuropaBON published a proposal for the establishment of an EU Biodiversity Observation Coordination Centre (EBOCC)<sup>18</sup>. In their proposal, EuropaBON (Liquete et al., 2024) details the synthesised perspectives from officials of the European Commission (EC) that recognise the following as top challenges for tracking the implementation of EU legislation and programmes and forming evidence-based policies related to biodiversity:

- Inaccessible and insufficient raw data
- Not harmonised or interoperable measurements and indicators
- Concern about the reporting and financial burden
- Confusing network of knowledge holders
- Lack of an EU IT infrastructure for biodiversity monitoring (Liquete et al., 2024).

To address these gaps in policy implementation, experts of EuropaBON identified several critical needs for improving workflows of EBV reporting in the EU (Lumbierres and Kissling 2023), aligning with Nature FIRST's findings (Deliverables D10, D11, D14):

- 1. Data collection: Identified need in expanding sampling efforts (more sites, broader coverage, higher frequency, more human capacity) and integrating novel technologies (eDNA, remote sensing, digital sensors).
- 2. Data integration & standardisation: Identified need in harmonising biodiversity data across various collection methods, standardising metrics, and improving coordination among national and regional data nodes. Automation of workflows and real-time data processing apps is emphasized for terrestrial monitoring.
- 3. Modelling: Identified need in developing new spatially explicit models, linking EBVs to biodiversity loss drivers, and improving accessibility through open-source tools.

In parallel, countries outside the EU face similar challenges. For example, in Ukraine, the absence of a unified, centralised biodiversity monitoring system hampers the assessment of conservation effectiveness. Fragmented efforts by various institutions using differing methodologies result in incomplete and inconsistent data, limiting the implementation of coordinated biodiversity protection measures.

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https://knowledge4policy.ec.europa.eu/news/proposal-eu-biodiversity-observation-coordination-centre-eb occ\_en



## **5.3 Stakeholder challenges, barriers and needs**

#### 5.3.1 Stakeholder challenges and barriers to change

To identify overarching needs amongst stakeholders along the biodiversity monitoring value chain, EuropaBON's User and Policy Needs Assessment (Moersberger et al. 2022) most highly ranked challenges to biodiversity monitoring relevant to the Nature FIRST project (based on 350+ expert stakeholders from policy, research and practice) were brought in line with their implications for the tool development in Nature FIRST, shown in Figure 4.



FIGURE 4: Stakeholder challenges in the biodiversity monitoring value chain and their implications for technology development

We have contextualised these challenges with our own findings from WP3, the field site workshops, interviews, the monthly meetings with our field partners and our survey.

#### Lack of data integration

As noted in section 5.2, the fundamental issue to be addressed is the inaccessible or lack of raw data, especially in genetic data collection. Significant gaps persist in monitoring species traits (30%), species populations (48%), and ecosystem structure



(58%). EuropaBON found that biodiversity data systems are fragmented across institutions and jurisdictions, lacking harmonisation and interoperability. This obstructs the consolidation of indicators at national and EU levels.

This finding is corroborated through the work in Nature FIRST. The issue of fragmentation was repeatedly mentioned. In some countries, a national database exists but is not interoperable with the tools and methods used at local level in protected areas. Some countries have no national-level integration platform, or its availability is restricted. In these cases data collections remain siloed and in different formats, lacking georeferencing or metadata standards, making integration across sites or tools difficult. Tools developed for specific pilot sites or narrowly defined functions often lack the flexibility to scale or adapt to different ecological, administrative, or cultural contexts, limiting their broader applicability.

#### Insufficient spatial and temporal resolution

Monitoring data is often insufficient in spatial coverage or frequency to track ecological trends or respond to emerging threats from human activities such as hunting, logging and grazing. This impairs early warning systems and adaptive conservation planning.

The need for near real-time or predictive monitoring is particularly acute in the context of human-wildlife conflict (HWC). Nature FIRST focused explicitly on this issue in several field sites with large carnivores. In Romania, for example, the rise in bear-human encounters underscores the urgency of predictive, responsive monitoring tools. Current reporting mechanisms are often delayed, fragmented or inaccessible, limiting local authorities' capacity to act preventively. Lethal interventions are not correlated with damage prevention and identification of true nuisance animals. Similar challenges are observed in Ukraine, where monitoring efforts often lack continuity and spatial coverage due to inconsistent methodologies and institutional fragmentation. Nature FIRST tools like the Human-Bear Conflict Radar aim to bridge this gap by enabling real-time conflict tracking and response, promoting coexistence strategies such as bear-smart communities.

#### Technical and human capacity limitations

A lack of technical capacity was frequently highlighted, particularly in relation to field staff who may not have the necessary training in GIS, remote sensing, or forensic methods. This challenge is compounded in contexts where resources for training and professional development are limited. Infrastructure constraints also emerged as a practical barrier, especially in protected areas with no reliable internet access or cloud infrastructure. In such environments, tools that rely on online platforms or continuous connectivity become difficult or impossible to implement. The processing capacity of old(er) computers is



unable to deal with the increasing volume of data (including video and photo) coupled with new technologies such as Al automated camera trap image analysis (provided by for example Addax.ai or TrapTagger).

Local site managers or conservation staff may not have the legal authority to procure or implement new technologies independently, as decision rights are often centralized at the national level. They also do not have authority to secure or collect evidence from a wildlife crime scene. Stakeholders also cited the high workload of experts as a limiting factor. In Ukraine, biodiversity monitoring is mainly conducted by understaffed institutions or individual researchers, many of whom lack access to modern equipment or training in digital tools. Monitoring professionals are already stretched thin, and the introduction of new tools is often perceived as an added burden unless accompanied by staff support or time relief.

There remains widespread resistance to methodological change, particularly among long-standing practitioners who are more comfortable with traditional field methods. Without clear strategies for integration and continuity, new tools are seen as disruptive rather than supportive, and sometimes even face opposition, despite the trends and efficiency in their use.

#### Funding fragmentation / insufficient financial resources

Consistently, funding comes up as a major constraint. As already mentioned in section 5.2, most countries depend on project-based funding, typically from EU instruments like Horizon Europe (including Biodiversa+), LIFE or recovery and resilience funds. Many organisations lack long-term budgets for biodiversity monitoring, meaning that adoption of new tools is often restricted to the lifespan of EU or national projects. This pattern was consistently observed across all pilot sites. In Romania, the interruption of funding is fragmenting even stakeholder involvement processes, which is detrimental when tackling complex issues such as HWC. In Ukraine, most monitoring activities rely on donor-funded short-term projects, with limited or no stable state funding, which makes long-term biodiversity tracking and infrastructure development extremely difficult. Field actors described how funding delays and procedural hurdles often interrupt ongoing monitoring efforts. As a result, monitoring programmes are designed around short-term funding windows (typically EU projects), with little national budget support. Once funding ends, tools are often shelved, staff are reassigned, and momentum is lost.

The following two figures from the short survey conducted for our research show the dominance in EU project funding for both species and habitat monitoring, followed by funding from national governments, NGOs and academic or research institutions. This confirms the European biodiversity monitoring market to be both a governmental and institutional market.





FIGURE 5: Funding sources of Nature FIRST survey respondents conducting species monitoring.



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FIGURE 6: Funding sources of Nature FIRST survey respondents conducting habitat monitoring.

This instability undermines long-term planning and integration. Unsurprisingly, free to access tools and technologies are therefore preferred (MAMBO, survey, field site workshops, interviews). Free for the user however means that funding of development and operational maintenance has to come from somewhere else. If not EU or national project funding, NGOs often step into the breach using money from donations or projects - again not a guaranteed funding source for a sustainable continuation.

#### Lack of policy coordination

EuropaBON's research found that responsibilities for biodiversity monitoring are often misaligned across scales. Fragmented mandates, conflicting protocols, and a lack of coordination hinder data sharing and coherent implementation. In Nature FIRST, this was also one of the most frequently reported challenges. Institutional inertia was another key issue, with many agencies demonstrating a strong preference for legacy systems. Risk aversion and bureaucratic approval cycles further delay the uptake of new tools, especially in public administrations.

A much encountered challenge is that local actors must negotiate with multiple institutions — inspectorates, ministries, NGOs — to access or report biodiversity data.



Even when data exists (e.g. conflict incidents), inconsistencies in format and access rights limit its utility.

Interviews with stakeholders confirmed that where there are national guidelines, protected area managers are not empowered to modify workflows or adopt new tools unless formally approved. Data ownership and decision-making rights vary between county-level agencies, local municipalities, and site managers.

Nature FIRST partners often struggle to identify the appropriate institutional "owners" for tools like habitat maps or risk models. Even where technical capacity and stakeholder interest exist, tools may be blocked by unclear mandates or uncoordinated procedures. This underscores the importance of policy engagement and long-term embedding strategies for digital solutions.

The issue of political will also surfaced repeatedly, particularly in relation to large carnivores. In several partner interviews, it was noted that conservation is often seen as a cost, caprice or burden — with some regions openly hostile to coexistence strategies. HWC monitoring success often depends on personal relationships and willingness of those in charge (mayor, park director) — an arrangement that may not survive administrative changes. Recent downgrading of the protection status of the wolf, not supported in any way by scientific evidence, shows that the influence of the prevailing political climate affects local to EU and global levels.

To get a more nuanced look at the main barriers, as part of our survey of 43 participants, respondents were asked to rate them on a scale of 1 (does not form a barrier) to 5 (strong barrier). In answering the question which are the main barriers to adopting new tools in the species and habitats monitoring of organisations surveyed, the highest-ranking barriers were identified as: High initial costs or lack of funding for new tools, Lack of time or resources to evaluate and implement new tools, Lack of technical expertise to use advanced tools effectively, Insufficient training or support for staff and volunteers, Compatibility issues with existing systems or workflows, Uncertainty about the effectiveness of new tools, Inadequate collaboration or cooperation between stakeholders, Limited awareness of available tools or technologies. The results are shown in Figure 7. Although being a small sample, the outcome supports the findings from other studies (e.g. MAMBO<sup>19</sup>) as well as our own.

<sup>&</sup>lt;sup>19</sup> https://www.mambo-project.eu/



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FIGURE 7: Weighted averages of our survey respondents' answers to the question: What are the main barriers for your organisation to adopt new tools in the species and habitat monitoring you carry out? Please indicate if and how much these barriers affect your ability to adopt new tools on a scale of 1-5 (does not form a



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barrier-strong barrier)

#### 5.3.2 Stakeholder needs and decision-making

New science and technology can only deliver solutions with a significant impact on the development, implementation, monitoring & evaluation of policies if the tools are cost-effective and fit-for-purpose. Through a process of co-design and co-creation we therefore identified stakeholder needs and decision-making criteria. To determine the existence of and opportunities for a governmental and institutional market, we define these in terms of market segments.

TABLE 2. Key market segments and their associated user profiles as well as monitoring tool needs identified for Nature FIRST products and services.

Market segment	Stakeholder group	Key monitoring tool needs
Protected Area Managers	Park rangers, site administrators	User-friendly tools that facilitate data collection in the field and analysis. Tools for managing, integrating field data, analysing and site reporting to inform decision-making. Cost-efficiency. Citizen-science integration.
National and Regional Environmental Agencies	Ministries, agencies	EU directive compliance. Comprehensive Reporting Systems: tools capable of integrating datasets from multiple sources into national reports aligned with European-level indicators.
	Looking to approve usage of scientifically validated, cost-efficient, and easy to implement tools and methods for in-field use.	
		Identification of data gaps and areas for interventions (e.g., habitat reconstruction and connectivity needs).



Scientific Institutions	Researchers, universities, research consortia	Long-term data continuity to ensure comparability between historical and new datasets when methodologies change. Specialized monitoring techniques: instruments tailorable to specific research purposes. Identification of trends, forecasts and scenarios.
NGOs & Civil Society	Conservation groups, field NGOs	User-friendly tools to facilitate data collection and analysis to improve/maintain conservation status of species and/or habitats. Citizen-science integration. Educational resources: platforms that support awareness raising campaigns or educational initiatives are vital for fostering public understanding of biodiversity issues.

Based on Nature FIRST's pilot field site workshops as well as interviews with our stakeholders the list of primary decision-making criteria of users along the biodiversity value chain was compiled.

TABLE 3. Primary decision-making criteria for adopting new monitoring tools in the field identified through analyses of field site workshops and stakeholder interviews

Decision-making factor	What It means in practice
Data compatibility	New tools must integrate or facilitate integration with existing national or EU-level databases, national reporting formats and help maintain continuity with historical data.
Cost-effectiveness	Preference for tools with low recurring costs and minimal licenses, delivering cost-efficient value for budget-constrained agencies.



User-friendliness	Tools for data collection need to work in offline/field conditions with minimal training required, especially for field rangers and local staff.
Regulatory alignment	Preference for tools that support Birds/Habitats/WFD/MSFD and national reporting formats.
Scientific credibility	Preference for tools validated by research institutions or EU projects.
Support for long-term Monitoring	Tools should facilitate consistent, comparable monitoring over time, enabling trend analysis and restoration tracking.
Digitalization potential	Solutions that replace outdated paper-based or legacy IT systems are viewed favourably, especially by local rangers and park manager staff.
Collaboration Support	Tools that enable cooperation among multiple actors (scientists, NGOs, volunteers, statisticians) are preferred.
Citizen science readiness	Platforms that allow or encourage volunteer contributions to supplement institutional data collection.
Vendor trust and continuity	Concerns about project-based tools that disappear post-funding; continuity, maintenance and transparency of importance.

Having described the governance structure of the market, the legislative implementation gaps and challenges, barriers and needs of those responsible for monitoring and management of protected species and habitats, in the next section we turn to the contribution Nature FIRST's solutions have already made to the field partners and their stakeholders.



# 6. Nature FIRST's contribution

As we described in section 2, the role of the policy lab was to co-design the project's results so that they contribute to closing the identified challenges, are fit-for-purpose in terms of effectiveness (better intelligence through strengthening the evidence-base) and efficiency (more for less). This contributes to Nature FIRST's objective to move the management of biodiversity from reactive to proactive monitoring, through a data-driven approach. Ultimately to reverse the decline in biodiversity, including through human-wildlife conflict and wildlife crime, through prevention rather than restoration.

We have developed, field-tested and demonstrated a catalogue of six products and services in the project to improve the monitoring and management of biodiversity.

Product / Service		Description
Human-wildlife mapping	conflict	A service to understand the extent, location, and patterns of human-wildlife conflicts. This is crucial to develop effective mitigation strategies that promote human-wildlife coexistence. User: This tool is co-developed with and used by the Bulgarian Academy of Sciences (IBER-BAS), Vitosha Nature Park Directorate, WWF Bulgaria. Impact: Preliminary analysis of human-bear conflict data collected through the Cluey Data Collector revealed a dramatic difference in both the frequency and spatial distribution of conflicts between 2023 and 2024. In 2023, a total of 92 conflicts were recorded, with prominent hotspots identified around human settlements. Specifically, conflict concentration was high in proximity to the town of Apriltsi and within Gabrovo city itself. This suggests a strong association between human presence and the likelihood of human-bear interactions leading to conflict.
Bear HWC radar		This tool provides timely information about bear-presence and threats for humans and their assets (e.g. apiaries). The radar is underpinned by a species digital twin model (which can be adapted to other animals / large carnivores). User: public authorities,

TABLE 4. Nature FIRST products and services



conservationists/NGOs, rangers, park managers in areas		
with large carnivores. Impact: By being alerted,		
human-wildlife conflicts can be avoided, fewer people,		
assets and animals wounded or killed. The result is		
greater awareness, less fear and higher acceptance by		
the local community.		

Habitat and land use A product to map Natura 2000 protected habitats at lower cost through automation. Flexible to different habitat classification or land cover, and different resolution products. User: The tool is developed and demonstrated for i.a. the Galician government in Ancares-Courel (Spain). Impact: Improving management of a protected area, key data for preparing management plans and for processing permits and impact assessment studies.

Habitat / land use change A service offering continuous habitat monitoring through detection. Calculating monitoring (including the change conservation status parameters of the habitats in a protected area through detection of illegal activities such as logging, remote sensing. User: Change detection in the region of Băile Tusnad, Romania (WWF degradation Romania). Impact: / Continuous monitoring in protected areas through EP fragmentation, waste, forest fires). products (Sentinel 2), increasing user uptake of the publicly funded Copernicus services and improving compliance with reporting obligations under the EU Habitats Directive. This supports early identification of negative trends, allowing more proactive management responses and ultimately enhancing the effectiveness of conservation planning.

Knowledge Graph The KG turns dispersed, inconsistent, and siloed for biodiversity (Al-driven biodiversity data into a usable, connected ecosystem of backbone to linking knowledge-enabling questions that are difficult or different data and impossible to answer with conventional databases. User: The KG is integrated in the Sensing Clues data collector languages). app (Cluey), habitat mapping, and the bear HWC radar. Impact: More accurate and reliable AI models, the ability to infer ecological interactions, faster discovery of new



		ecological patterns and with greater accuracy, improved Environmental, Social and Governance (ESG) reporting.
Wildlife Forensic and Training	Toolkit	A forensic toolkit for rangers / first responders to secure the scene of a crime and to protect evidence. The Nature FIRST Wildlife Forensic toolkit is a modular toolkit for different habitats and different species of wildlife. User: At the moment the Nature FIRST field sites are involved in the development of the toolkit. It is aimed at law enforcement and rangers investigating wildlife crime. It is in the form of a rucksack to take to difficult to reach areas. Impact: The toolkit is developed by forensic science student teams, creating awareness of wildlife crime as a specialist area of expertise. With the toolkit evidence from wildlife crime scenes can be collected and stored by law enforcement officers / rangers in a secure way for future analysis and - ideally - prosecution. Hands-on training for non-experts and experts in handling crime scenes.

In response to the policy implementation gaps identified in section 5.2, our tool suite addressed the identified needs in the following ways.

#### Data collection:

Nature FIRST products offer scalable and cost-effective biodiversity monitoring solutions, leveraging cutting-edge remote sensing, AI-powered automation, and supporting real-time data acquisition to enhance data collection efficiency (knowledge graph, semi-automated habitat mapping, Cluey Data Collector app).

#### Data integration & standardisation:

Nature FIRST products enable integration and harmonisation of biodiversity datasets through interoperable data infrastructure (e.g. Sensing Clues, Knowledge Graph). Automated data pipelines ensure consistency, reducing manual processing efforts and increasing the accuracy of biodiversity assessments (e.g. Habitat Mapping, Sensing Clues). Al-enhanced monitoring (e.g., Habitat Mapping) matches calls for modernisation through automation and continuous sensing.

#### Federated data modeling:



While governmental authorities require highly standardised aggregated data for nation-wide biodiversity monitoring and policy making, local authorities need flexibility to attune data collection and analysis to their local context and specific management needs. Nature FIRST accommodates both requirements through the Nature FIRST Knowledge Graph and the Sensing Clues platform (see also Deliverable 14).

#### Modelling:

Nature FIRST's semi-automated and spatially explicit predictive modelling tools enhance biodiversity forecasting by integrating multiple data layers (e.g. HWC Radar, Bear Radar, Sensing Clues). Nature FIRST's tools allow policymakers and conservationists to assess biodiversity trends, predict risks, and develop targeted conservation strategies.

Moreover, alignment with Essential Biodiversity Variables (EBVs) and Ecosystem Service Variables (EESVs), as defined by EuropaBON and GEO BON, allows Nature FIRST tools to plug into emerging European data standards and transnational monitoring initiatives.

#### Success stories:

The collaborative efforts of all partners has already led to a series of success stories during the project's lifetime:

- Advancing conservation through technology and collaboration: WWF Ukraine, Sensing Clues and 3edata
- Empowering rangers and transforming conservation through forensic science: Wildlife Forensic Academy, BAS, Staffordshire University
- A collaborative approach to conservation innovation through habitat and land use mapping, change detection, and biodiversity monitoring: 3edata and Sensing Clues
- Real-time risk radar for preventing human-wildlife conflicts and fostering peaceful coexistence: Wageningen University & Research (WUR), Sensing Clues, IBER-BAS, WWF Romania, WWF Ukraine
- Tackle bear conservation challenges with innovation: IBER-BAS, Sensing Clues, WUR
- Redefining human-bear coexistence with advanced data collection tools, risk radars and strategic interventions: WWF Romania, Sensing Clues
- Preserving sturgeon species and mitigating human-wildlife conflicts in the Danube Delta: DDNI, WWF Romania, Sensing Clues, WUR

#### Quote from one of the partners

"It [agent based model] is a fantastic tool, because it is a next step from individual expertise by digitising expertise of the best



knowledge available. It makes a much stronger argument towards public authorities. It's flexible, having more data makes it better; it develops."

## 7. Conclusions and recommendations

### 7.1 Conclusions

Our exploration of the existence of, opportunities for and barriers to a market for biodiversity monitoring and management underscores that while there is growing demand for practical biodiversity monitoring tools across Europe, the landscape remains fragmented, underfunded, and institutionally complex. Significant challenges persist, including entrenched reliance on legacy systems, inconsistent data standards and databases, lack of traceability and transparency, limited technical capacity at the field level, and highly project-based funding structures. These systemic barriers slow the adoption of innovative tools and create uncertainty around the long-term sustainability of monitoring efforts. Besides, informed decisions are difficult to be made in the absence of sound data from the field, affecting in the long-term the viability of certain species, including of the ones that are sensitive to environmental changes, rare, endemic or highly threatened.

Pressure to improve biodiversity data collection and reporting is increasing due to evolving EU policy frameworks, creating an opening for solutions like those developed by Nature FIRST. Our tools offer meaningful responses to clear pain points — particularly in data harmonisation, real-time monitoring, and compliance facilitation — but uptake will depend on how effectively we can embed them into existing workflows and governance systems. At the same time, the successful implementation of conservation efforts and the emphasis on legal compliance have seen an increase in human-wildlife conflict, a reduction in the acceptance of potentially problematic species and thus willingness to coexist with them, or at least to make sustained efforts in this respect. This has resulted in a corresponding political response which, while not backed by data, sets out to reduce support for biodiversity conservation and nature restoration, at all levels.

The current political climate aside, our findings highlight several critical success factors for market development: offering modular, user-friendly tools that require minimal training; aligning with regulatory frameworks and reporting standards; addressing technical and funding constraints through cost-effective design and open-source strategies; and tailoring value propositions to distinct market segments.



## 7.2 Recommendations

Based on our findings, the contribution Nature FIRST can make and our conclusions, we make the following recommendations.

#### ★ Establish the EBOCC

As our first recommendation we would like to give our express support to the establishment of the EU Biodiversity Observation Coordination Centre (EBOCC) as proposed by the Europa Biodiversity Observation Network (EuropaBON) project. Such a coordination centre should have as its core objectives to overcome the implementation gaps and monitoring deficits identified by EuropaBON and confirmed by our own research findings. We also recommend the use or establishment of national biodiversity monitoring hubs and foster existing networks and communities. Given the fragmentation of governance and stakeholders there is a need to connect overarching EU policy with the operational realities on the ground at local level. We found that, despite the apparently robust legislative framework, implementation is difficult, hindered by persistent gaps and barriers particularly at local and regional level that need addressing. An important barrier is the lack of funding, therefore a major task is to explore how to move from project-based to sustainable funding mechanisms. Another issue is the lack of trust and cooperation among key stakeholders, which the EBOCC could address.

#### ★ Expand, connect and enhance existing initiatives

With regard to EBOCC's re-use of existing networks and communities we make the following specific recommendations:

- 4. Connect the Biodiversa+ partnership and EU CAP Network (now incorporating the EIP-AGRI partnership) to better align conservation and agriculture initiatives and objectives establishing/creating the conditions for coexistence in an early stage. This could include for example joint thematic networks on HWC and exchanging knowledge and innovation information. The project launched under the Farm2Fork strategy, Co-creating Coexistence<sup>20</sup>, can be one of the initiatives to build on.
- 5. Expand the European Commission's initiative<sup>21</sup> to support the European Network of Fact-Checkers to include fact checking and counter false claims made about large carnivores and human wildlife conflicts. Defending nature (and those active to prevent and combat illegal activities) is as much part of our democracy as any other disinformation.

https://digital-strategy.ec.europa.eu/en/news/commission-launches-eu5-million-call-strengthen-european-f act-checking-network



 <sup>&</sup>lt;sup>20</sup> The project Co-creating Coexistence, <u>cocoproject.eu</u>, was launched in response to the call
 HORIZON–CL6-2023-FARM2FORK: Agro-pastoral/outdoor livestock systems and wildlife management
 <sup>21</sup>

6. Use the European Citizen Science Association (ECSA) for active promotion of lessons learnt and good practices across local and regional stakeholders (who are usually at the forefront of conflict as well as a tremendous source of local knowledge and expertise). This can build on best practice projects such as the 'Bear Smart Community' from WWF Romania in Băile Tuşnad<sup>22</sup> and the more4nature<sup>23</sup> project (reversing the trend in environmental degradation through collaboration of citizen science initiatives with authorities).

#### ★ Support market mechanisms in biodiversity monitoring and management

As written above, we consider biodiversity monitoring and management as governmental, non-governmental and institutional markets. Public authorities are driven by regulations and procedures public procurement) and budget constraints. Pooling resources, such as done in the Biodiversa+ partnership for joint research funding, can be applied to market development in the following ways:

- 4. Develop a preparatory phase for a pre-commercial procurement for biodiversity monitoring (*Pre-PCP*). The purpose is to start the process of bringing public authorities with budget responsibilities (e.g. Ministry of Environment, Forestry or Nature; Executive Agencies) together in a network to jointly determine needs for monitoring and management and to develop Terms of Reference for species monitoring systems, habitat mapping and change monitoring, etc. This phase is needed to make such authorities aware of the role they can play in creating functioning and operational markets (capacity building, networking). The Pre-PCP should lead to a PCP phase.
- 5. Pre-commercial Procurement (*PCP*) phase<sup>24</sup>. This phase is to publish the joint needs statement and Terms of Reference as a challenge to industry to develop or propose solutions. It shows companies that there is a market demand and stimulates them to invest in research and development (market consultation).
- 6. Public Procurement of Innovation (*PPI*) phase<sup>25</sup>. Once the demand from public authorities for innovative solutions has been demonstrated and the capacity of companies to supply such solutions, a joint or individual public procurement can be launched.

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https://research-and-innovation.ec.europa.eu/strategy/support-policy-making/shaping-eu-research-and-in novation-policy/new-european-innovation-agenda/innovation-procurement/public-procurement-innovative -solutions\_en



<sup>&</sup>lt;sup>22</sup> <u>https://test.cdpnews.net/wp-content/uploads/2024/03/27\_4\_Papp-et-al.pdf</u>

<sup>&</sup>lt;sup>23</sup> more4nature.eu

https://research-and-innovation.ec.europa.eu/strategy/support-policy-making/shaping-eu-research-and-in novation-policy/new-european-innovation-agenda/innovation-procurement/pre-commercial-procurement\_ en 25

#### ★ Safeguard independent and data-driven decision making and implementation of the Rule of Law & Governance

Ensure that studies used by member states to develop and underpin policy measures are independently contracted, are transparent and accessible by the general public. Support research institutes with protocols for the establishment of databases in support of species management based on genetics and clear evidence of the presence of species<sup>26</sup>. Work closely with Member State authorities, implementing organisations and law enforcement agencies to ensure the national strategies and definitions developed as part of the transposition of the Environmental Crime Directive ensure the protection of flora, fauna, habitats and ecosystems. Liaise with the four relevant networks: European Union Network for the Implementation and Enforcement of Environmental Law (IMPEL<sup>27</sup>), European Network of Prosecutors for the Environment (ENPE<sup>28</sup>), Law Enforcement Agencies (EnviCrimeNet<sup>29</sup>) and the EU Forum of Judges for the Environment (EUFJE<sup>30</sup>), for example on adequate definitions of "negligible" quantity or "substantial" damage.

#### ★ Don't let perfection be the enemy of good

Given the high dependence of EU project-based funding, build mechanisms in research and innovation projects to deliver early results that are practical and operational and can be demonstrated. The purpose and usefulness of innovative tools such as a digital twin or a real-time conflict incident radar are often difficult to "imagine" by users without a demonstrator or prototype.

#### ★ Specific HWC to HWCoexistence policy development

While perhaps we cannot fully avoid the cyclical nature of politics and with that, shifting policy priorities, we can better anticipate the impact of conservation efforts. Thus allowing us to move from crisis-management mode to predictive and preventive management mode. Deliberate reintroduction of key species, such as the bear in France or the European bison in Romania, should be accompanied by the development of management strategies that include measures to prevent and deal with conflict. The comeback and spreading of species such as the wolf across Europe should be tracked and anticipated, based on the scientific understanding of spatial ecology and animal behaviour studies, allowing the responsible authorities to respond in a timely and appropriate manner. An example is Luxembourg, which started the development of their wolf management plan in 2015. While they do not have a resident wolf population (yet), they have the capacity to respond as soon as the situation requires intervention and timely action.

<sup>&</sup>lt;sup>30</sup> https://www.eufje.org/



<sup>&</sup>lt;sup>26</sup> https://www.kora.ch/en/projects/large-carnivore-monitoring/scalp-categories

<sup>&</sup>lt;sup>27</sup> https://www.impel.eu/en/

<sup>&</sup>lt;sup>28</sup> https://www.environmentalprosecutors.eu/

<sup>&</sup>lt;sup>29</sup> https://www.envicrimenet.eu/

# Annex 1 Field site workshops

The following field site workshops were organised, contributing to the Policy Lab objectives.

Field site workshop	Purpose of the meeting	Key stakeholders
Danube Delta - national policy (Bucharest, RO), 2 October 2023	<ol> <li>To present Nature FIRST to national public authority representatives</li> <li>To understand Romania's state-of-play regarding monitoring and reporting in compliance with national and EU/international regulations.</li> </ol>	Ministry of Environment, Water and Forest. National Agency for Fishing and Aquaculture. Romanian Border Police.
Danube Delta - local and regional policy (Tulcea, RO), 3-4 October 2023	As above, but focused on local and regional objectives and challenges related to sturgeon monitoring and protection.	Danube Delta Biosphere Reserve Authority. National Environmental Guard. National Administration "Romanian Waters". Romanian Border Policy (regional office).
Stara Planina mountain (Gabrovo, BG), 27-31 May	<ol> <li>To understand the work done by local, regional and national stakeholders to monitor biodiversity and their challenges.</li> <li>To demonstrate the role of digital technologies in support of biodiversity conservation.</li> </ol>	Ministry of Environment and Water. Executive Environmental Protection Agency. Executive Forestry Agency. Central Balkan National Park & Balgarka Nature Park. Regional Inspectorates Environment and Water. WWF Bulgaria. Green Balkans.

TABLE 5. Field site workshops organised as part of Nature FIRST.



Field site workshop	Purpose of the meeting	Key stakeholders
EcoBear conference (Băile Tușnad, RO), 22-25 October 2024 <sup>31</sup>	For this workshop we co-organised the EcoBear conference, taking place for the third time. The event was held under the Citizens, Equality, Rights and Values Programme (CERV) project "Coexisting with bears - Conservation needs Conversation!" (GA-Nr. 101146879). The purpose was to get a broader understanding of human-wildlife conflict with large carnivores (specifically the bear) and to get feedback on our solutions.	128 stakeholders from science, public and management authorities, hunting, media and NGOs attended. Nature FIRST featured prominently in the programme with 8 presentations, 2 poster presentations, 2 keynotes and 1 panel discussion.
Ancares Courel (Lugo, Spain), 28-30 May 2025	Hosted by the Xunta de Galicia in cooperation with Nature FIRST and local partners, the workshop provided a platform for testing new approaches and strengthening collaboration across institutions, researchers, and enforcement agencies. Participants explored practical ways to assess biodiversity, prevent ecological damage, and turn scientific data into defensible evidence for environmental protection.	The more than 60 participants included representatives from the Xunta de Galicia, SEPRONA (the Civil Guard's Nature Protection Service), NGOs, universities, research institutions, and Nature FIRST partners.

<sup>&</sup>lt;sup>31</sup> https://tusnadecobear.ro/conf/ and https://www.facebook.com/TusnadEcoBearFest/

