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Grant Proposal

OneSTOP: OneBiosecurity systems and technology for people, places and pathways

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Abstract

The overarching objective of OneSTOP is to pioneer an innovative and joined-up approach to biosecurity for terrestrial invasive alien species, strengthening the interconnections between animal, plant, human and environmental health. OneSTOP aims to harness current technologies and citizen science, while overcoming challenges posed by dispersed and fragmentary processes, policies, and knowledge, to deliver methods for identification, early detection and surveillance of invasive alien species. OneSTOP aims to achieve transformative results to minimise the introduction, establishment and spread of invasive alien species by integrating cutting-edge detection methods, underpinned by prioritisation and robust models, alongside stakeholder engagement to inform harmonised policies and facilitate knowledge exchange. The outcomes will be relevant for invasive alien species policy, noting the importance of enhancing collaboration and coordination across local, national, and regional scales, recognising that geographic boundaries do not confine the impact of these species. By adopting a holistic and interconnected approach, OneSTOP seeks to establish a strategy to achieve rapid and transformative progress in detecting, eradicating and controlling invasive alien animals and plants, ultimately contributing to a more secure and resilient environment. Throughout, OneSTOP is based upon the strategic actions recommended for integrated governance of biological invasions in the recently published IPBES Thematic assessment report on invasive alien species and their control (IPBES 2023).

Keywords

citizen science, data integration, early warning systems, environmental protection, invasive species impact, living labs, pathway prioritisation, rapid response, sentinel gardens, species detection, species prioritisation, surveillance of environment in order to alert.

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1. Excellence

1.1 Objectives and ambition

1.1.1 OneSTOP Motivation and Strategic Vision

The overarching objective of OneSTOP is to pioneer an innovative and joined-up approach to biosecurity for terrestrial (AreaA) invasive alien species (IAS), by applying cutting-edge technologies and strengthening the interconnections between animal, plant, human and environmental health.

OneSTOP aims to achieve transformative results to minimise the introduction, establishment, spread and impact of IAS by integrating cutting-edge detection methods, underpinned by risk prioritisation and robust scenario modelling, alongside stakeholder engagement to inform harmonised policies and facilitate knowledge exchange. Throughout, consideration will be given to enhancing collaboration and coordination across local, national, and regional scales, recognising that geographic boundaries do not confine the impact of IAS. By adopting this holistic approach, OneSTOP seeks to establish a strategy to achieve rapid and transformative progress in detecting, eradicating and controlling IAS (animals and plants), ultimately contributing to a more secure and resilient environment. Throughout, OneSTOP is based upon the strategic actions recommended for integrated governance of biological invasions in the recently published Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) Thematic assessment report on IAS and their control, hereafter referred to as the IPBES IAS Assessment (Roy et al. 2024).

OneSTOP is built on four pillars: **detection**, **prioritisation**, **dissemination** and **socio-political action Fig. 1**. Each pillar of OneSTOP contributes to the overarching aim to maximise the benefits from synergies and harmonise approaches across various sectors within the terrestrial realm to reduce the threat of IAS. By integrating advanced detection methods with dissemination and prioritisation tools, we will deliver a comprehensive approach to addressing terrestrial IAS in Europe and beyond. The goal is to ensure these innovative methods are accessible and effective with far-reaching benefits for people and nature including informed decision-making across the human, animal, plant and environmental health sectors.

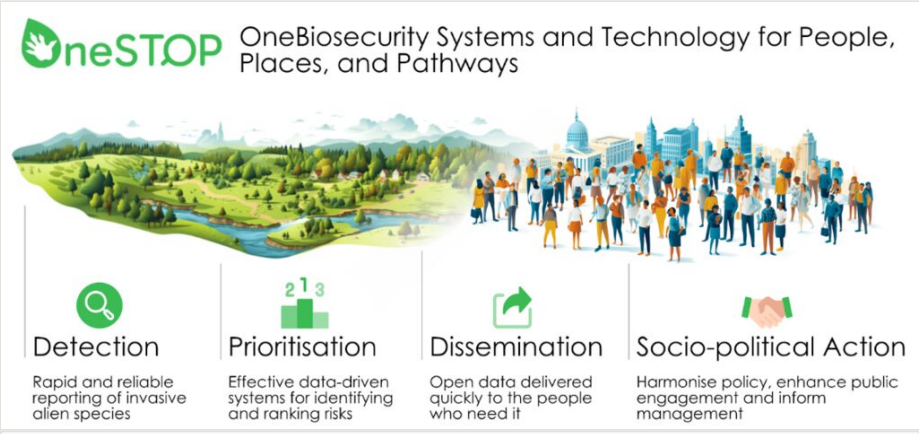

Figure 1. doi

A conceptual figure illustrating the four pillars of OneSTOP, where the rapid mobilisation of data enables prioritisation of action, informs all stakeholders, and facilitates coordinated responses.

1.1.2.1 Innovation Area 1: Detection

Objective: Prototype four novel methods for detection of IAS in terrestrial ecosystems

Existing approaches to detection and surveillance of IAS are predominantly ad hoc and reactive, often leading to delays that impede effective and timely management. The speed at which data are mobilised for decision-making is crucial but often falls short, highlighting the need for more agile and integrated workflows.

There are many emerging technologies for the detection and monitoring of wildlife that could be exploited for IAS but most are not yet at sufficiently high technical readiness levels for widespread deployment. OneSTOP will focus on the most promising: Air-DNA, iEcology, computer vision, and use of citizen science in gardens as sentinel sites for biological invasions. Each of these methods offers unique advantages, transforming how we monitor and respond to IAS. OneSTOP will also demonstrate how disparate detection methods can be plugged into a holistic data dissemination strategy enabling rapid reach to relevant stakeholders with timely, accessible and relevant information. This will allow Europe to substantially increase its capacity to prevent the introduction of IAS, and where this is not possible, ensure early warning and rapid response to reduce establishment, spread and ultimately impacts.

Air-DNA is an advanced technique that identifies the taxonomic composition of traces of DNA in air samples. It has considerable potential as a fast and accurate means of identifying the introduction and spread of IAS. Recent studies show that terrestrial animals, plants, fungi, and bacteria leave DNA traces in the air, in bioaerosols (Lynggaard et al. 2022, Thuillet et al. 2024). The use of these bioaerosols, especially through DNA metabarcoding, could revolutionise the detection of IAS by providing efficient and cost-effective means to assess a breadth of taxonomic groups. While aquatic ecosystems have long benefited from water as a source of environmental DNA (eDNA), air can serve a parallel role on land, as a source of DNA from various species, including those invasive to the ecosystem. It faces challenges such as optimising bioaerosol sampling, false positives, refining DNA extraction techniques, and mitigating detection biases and contamination risks. The potential of using air as a large-scale, monitoring tool is immense. We anticipate moving from proofs of concept (Technical Readiness Level 3) to demonstration of use in relevant environments (Technical Readiness Level 6).

iEcology, an emerging field in ecological research, utilises diverse digital data sources (including social media, online databases, and image repositories) to explore ecological patterns. IAS, closely tied to human activities such as trade, travel and urbanisation, are often mentioned online, making them visible on various platforms (Pernat et al. 2024, Jarić et al. 2020). Through access to real-time global data, iEcology holds promise for studying IAS. Its scalability allows for early warning of IAS, while its extensive geographical and temporal coverage enables tracking of spread. Moreover, iEcology analysis of online trends provides insights into societal factors influencing IAS management. Our goal is to advance iEcology by developing repeatable workflows,

employing advanced data analysis techniques, and integrating additional digital sources (Technical Readiness Level 4 to 6).

Computer vision involves the automated identification and monitoring of IAS through image analysis to support their management and control. OneSTOP will repurpose well-established car-mounted camera technology, currently used for applications such as Google Street View, to enhance its capabilities for effectively imaging IAS. OneSTOP will adapt the use of light traps with standardised screens for imaging, previously tested in extreme environment research studies, for practical deployment by field practitioners under real-world conditions, specifically targeting nocturnal insect detection (Technical Readiness Level 5 to 7).

Computer vision algorithms, leveraging Machine Learning (ML), are capable of automatically detecting animals and plants, with established applications such as wildlife monitoring through fixed-positioned camera traps for mammals and birds, as well as methods for identifying individual tree crowns from aerial images. These tools have already been used in detecting invasive alien plants, exemplified by the use of Google Street View images and custom-designed cameras for roadside verge plant monitoring. In OneSTOP, we will advance these technologies to enable continental-scale detection of invasive alien plants, mammals, and insects using vehicle-mounted cameras and light traps (Technical Readiness Level 6 to 8).

Sentinel gardens are private gardens used as early detection and monitoring sites for IAS. While botanical gardens have been acknowledged as important sentinel sites for the early detection and monitoring of pests and pathogens (Wondafrash et al. 2021), this approach has not been widely applied in private gardens with the involvement of citizen scientists. Gardens, particularly private ones in urban areas, are recognised as primary entry points for many IAS. The location of these private gardens makes them ideal for early detection and monitoring of IAS using citizen science. Citizen science initiatives raise public awareness of IAS and contribute information from areas otherwise difficult for researchers to access. Engaging gardeners in citizen science to report these species has been shown to be effective in delivering this critical information and reducing lags in detection times (Dehnen-Schmutz and Conroy 2018). Coventry University has been running a garden-focused citizen science project since 2019. Having demonstrated it in a relevant environment (Technical Readiness Level 6) we will complete and qualify the system to include all taxa from gardens in all European countries (Technical Readiness Level 8).

KPIs: Number of IAS detected on social media, validated and published (>200); Number of computer vision deployments (10) and number of organisations deploying them (5); Number of Air-DNA deployments (30) and number of organisations deploying them (10); Number of citizen scientists participating and number of gardens surveyed (>1000); Number of reports of emerging IAS reported from gardens (>1000).

The dissemination of information from all these technological approaches to relevant stakeholders will be critical to their successful use as IAS detection and monitoring tools

as described in 1.1.2.3 **Innovation Area 3: Dissemination**. Furthermore, it is important that the methods are acceptable and accessible to stakeholders as outlined in 1.1.2.4 **Innovation Area 4: Socio-political action**.

The OneSTOP detection pillar aligns with strategic actions of the IPBES IAS Assessment to "Support, fund and mobilise resources for innovation, research and environmentally sound technology". Success will be measured by the number and quality of detections of IAS, but also by the cost effectiveness of those detections.

1.1.2.2 Innovation Area 2: Prioritisation

Objective: Implement a data-driven prioritisation system for managing IAS, incorporating automated workflows, model projections, and multi-criteria analysis to effectively identify, rank, and address the risks

We will implement automated workflows that transform dynamically generated raw data (including from citizen science) into comprehensive IAS prioritisation underpinned by modelled projections of IAS distributions under current and potential future conditions and pathway prioritisation, complemented by data-driven horizon scanning. Our focus is to identify and rank terrestrial IAS, assessing their potential to arrive, establish, spread and impact biodiversity (particularly threatened Red List species) and ecosystems while also incorporating the feasibility of management to ensure targeted and effective resource allocation. In doing so, we aim to address gaps and uncertainties in existing data and knowledge and to use data science decision tools, co-designed with stakeholders to ensure their acceptability, to deliver bespoke IAS information to the regional decision-makers responsible for delivering action on IAS. We will in part be building on the automated data and modelling workflows created in the Biodiversity Digital Twin project (BioDT, see Table 3) for dynamically projecting the potential distributions of IAS under current and future scenarios. OneSTOP will further refine this digital twin making it much more accessible for the IAS community (Technical Readiness Level 7).

Our advanced approach to prioritising action against IAS includes structured assessment methods and multi-criteria analysis (Booy et al. 2020). This analysis will consider various factors that influence management decisions, such as the impacts of cross-border e-commerce on the spread of IAS. By prioritising planning and prevention, we seek to mitigate the risks associated with the introduction, establishment, and spread of IAS.

A key aspect of our strategy is to consider the impact of IAS on priority (terrestrial) species such as the species included on the IUCN Red List of Threatened Species (hereafter called Red List species), aligning with the EU Biodiversity Strategy for 2030's target 12 of a 50% reduction in the number of Red List species threatened by IAS. To facilitate effective communication, we will co-develop tailored dissemination materials, overcome language barriers, and provide specific advice and technical guidance on managing IAS. Our overarching goal is to contribute to the global conservation strategy, placing a strong emphasis on risk analysis and risk communication as central pillars of our

comprehensive approach. By using a joined-up data-driven approach to prioritisation we support strategic actions of the IPBES IAS Assessment to “Enhance coordination and collaboration across international and regional mechanisms” and to “Develop and adopt effective and achievable national implementation strategies”.

Table 1.

The call documentation asked applicants to "set out a credible pathway resulting in the strategic plan having the following impact: "*Biodiversity is back on a path to recovery, and ecosystems and their services are preserved and sustainably restored on land, inland water and at sea through improved knowledge and innovation*". One or more of six impacts should be addressed. OneSTOP specifically addresses these three impacts.

Expected Impact 1. “*Direct drivers of biodiversity decline will be understood and addressed–land and sea use change, natural resource use and exploitation, climate change, pollution, invasive alien species–aswell as indirect drivers–demographic, socio-economic, technological, etc.*” OneSTOP directly addresses IAS, a major driver of biodiversity decline. It does so at different scales by addressing the species, the pathways and the places related to the impacts of IAS. OneSTOP will contribute directly to the key commitments of the EU Nature Restoration Plan under the Biodiversity Strategy for 2030, and the improved implementation of the EU Regulation1143/2014 on IAS.
Expected impact 2. “*Protected areas and their networks will be planned, managed and expanded and the status of species and habitats will be improved based on up-to-date knowledge and solutions.*” OneSTOP will directly address the status of Red List species with regard to the impact of IAS. It will also address specific protected areas associated with the Living Labs as case studies for the prevention and management of IAS in such areas.
Expected impact 5. “*Biodiversity research and support policies and processes will be interconnected at EU and global levels,making use of advanced digital technologie sandsocietal engagementwhereappropriate.*” OneSTOP will use global infrastructures (EASIN, GBIF, GRIIS, IUCN) funded by Europe to disseminate and link research to policy. OpenScience,and FAIR data principles will underpin advanced repeatable workflows for the publication, analysis, and dissemination of data and models. The OneSTOP project will use GBIF as a central hub for the mobilisation and aggregation of detection data and species lists. The OneSTOP consortium has strong connections with GBIF secretariat and national nodes which facilitates collaboration.

Table 2.

OneSTOP’s Key Exploitable Results

Key Exploitable Result	Target users	Exploitation route
Policy recommendations tackling environmental and economic policies (Tasks 6.3, 6.4 and 1.2)	Policy and decision makers	Policy briefs co-developed with relevant stakeholders and disseminated through various channels as agreed with the stakeholders
Molecular and digital sensors for detection and classification of IAS (Tasks 2.1 and 2.2)	Monitoring, biosecurity & scientific communities	SME to commercially exploit IAS validated high volume air samplers using existing international sales channels.
A workflow to collect IAS data from media platforms (Task 2.3)	Monitoring, biosecurity & scientific communities	Released as Open Source software, results distributed through Living Labs and the website
Citizen science sentinel scheme for IAS (Task 2.4)	Citizen scientists and their associated organisations	Implementation in existing citizen science platforms, published to GBIF for Open FAIR distribution, including to EASIN.

Key Exploitable Result	Target users	Exploitation route
Living Labs for IAS network (Task 3.4)	Local and regional stakeholders	Living Labs stakeholder network will consider sustainable approaches to ensure the Living Labs will remain active beyond the project lifetime and expand the network to other regions and countries.
Automated species distribution modelling workflows (Task 5.1 and 5.2)	Monitoring, biosecurity & scientific communities	Released as Open Source software, results distributed through Living Labs and Task 5.6.
Large Language Model (LLM) - assisted EICAT assessments (Task 4.4)	Scientific and policy communities	The tools developed for using LLMs within the EICAT assessment process will be made open and well-described in an associated publication. We will disseminate their application through the EICAT Unit and Authority
Open and real-time IAS detections available on GBIF (Task 4.1)	Scientific community, local and regional stakeholders	Incorporated into EASIN and Work Package 5 workflows through GBIF, disseminated to stakeholders through OneSTOP Alert.
A European species list of IAS (GRIIS Europe) (Task 4.2)	Scientific community, local and regional stakeholders	Published on GBIF and GRIIS website
European Alert system for new detections of IAS in Europe (Task 4.3)	Scientific and biosecurity communities, local and regional stakeholders	Released as Open Source software, results distributed through Living Labs and the website
Policy briefs on integrated governance (Task 6.4)	Policy and decision makers	Disseminated through various channels in Task 1.2

Table 3.

OneSTOP's links with international, European, and national projects and initiatives.

Alien-CSI: A networking action to address the challenge of managing IAS introductions, emphasising the role of citizen science, enabled by digital technology, in enhancing data collection and public engagement on the issue.
AlienScenarios: A Biodiversa+ research project that developed models and scenarios for biological invasions for the 21st century, and conceptual research on iEcology.
B^3: Addressing the urgent need for rapid, reliable, and repeatable biodiversity monitoring in response to global crises like climate change and natural resource exploitation. It highlights the importance of leveraging large data volumes, advanced modelling techniques, and computing tools for timely policy-relevant syntheses.
Biodiversity Information Standards (TDWG) is a not-for-profit organisation that promotes international collaboration and the sharing of biodiversity information by developing data exchange standards and facilitating discussions on biodiversity information management.
BioDT: will offer sophisticated models for simulation and prediction of global biodiversity dynamics through practical use cases, including threats from IAS. Utilising the LUMI Supercomputer, BioDT integrates FAIR data with digital infrastructure, predictive modelling, and AI to provide evidence-based approaches for biodiversity conservation and restoration.
COBRAS: A New Zealand-based Centre of Excellence implementing data synthesis to develop innovative research to support interdisciplinarity through the concept of One Biosecurity. It will provide a Southern Hemisphere perspective on IAS management and research approaches.

DECIDE: Enhancing biodiversity models for better decision-making by prioritising recorder motivations, the project plans to map 1,000 species with high precision, leveraging data from Recorders. It will direct Recorders on optimal times and locations for data collection in their areas, employing 'adaptive sampling' to refine species distribution maps effectively.
Easy-RIDER: A network of researchers across Europe and North America working together to develop automated camera systems for monitoring insects. The network brings together hardware and software engineers, computer scientists, entomologists and statisticians, to develop end-to-end workflows.
EuropaBON: OneStop will liaise with the Biodiversity Monitoring Coordination Centre conceived by EuropaBON with the aim to coordinate monitoring activities across Europe.
GBIF: This key international data infrastructure, funded by governments globally provides open access to data on life forms worldwide. Based in Copenhagen, it serves as an EOSC (European Open Science Cloud) data provider, facilitating the sharing of biodiversity data through established standards like Darwin Core.
InsectAI: Supporting insect monitoring and conservation at the national and continental scale using computer vision methods. The COST Action brings together researchers and stakeholders in image-based insect AI technologies to direct and drive the research agenda, build research capacity across Europe, and support innovation and application. The Action will organise workshops, conferences, short-term scientific missions, hackathons, design-sprints. It will amplify the impact from OneSTOP.
INVASIVESNET: The International Association for Open Knowledge and Open Data on Invasive Species aims to enhance the understanding and management of IAS worldwide by establishing a comprehensive network for effective knowledge exchange to address the growing ecological, social, cultural, and economic impacts of IAS.
LIFE RIPARIAS: The Belgian RIPARIAS alert system for IAS and the 2023 Ebbe Nielsen-winning GBIF Alert system. OneSTOP will elaborate further on this initiative and build an alert system for IAS in Europe.
MAMBO: Developing, testing, and implementing tools for monitoring the conservation status and ecological needs of under-studied species and habitats. The project emphasises stakeholder engagement, technology integration with existing infrastructures, and the co-design of new monitoring tools and standards. It aims to improve data collection and analysis through a virtual lab, assess the effectiveness of these tools across Europe, and co-design future monitoring schemes. Ultimately, MAMBO strives for enhanced management of protected sites and species by leveraging novel technologies for more efficient and cost-effective monitoring.
TrIAS: OneSTOP will build on this Belgian initiative, which created an open, data-driven framework to dynamically track, identify, and assess the risk of IAS, thereby informing policy. With a vision rooted in open science and data, it employs international standards to ensure interoperability and sustainability, making it adaptable to evolving policy needs.

KPI: Number of IAS with modelled distributions under current and future conditions (>100). Number of external experts contributing to horizon scanning (>20). Number of countries processed through the horizon scanning workflow (>5). Number of regional decision-makers involved in the co-design of decision tools (>25).

1.1.2.3 Innovation Area 3: Dissemination

Objective: Ensure IAS data and software are Open, FAIR and disseminated expeditiously to the people who need them

Rapid dissemination of updated information on detection and prioritisation of IAS is vital for stakeholders responsible for management actions, resource allocation and strategy planning. Ensuring this information is available in both human and computer-readable formats, tailored to specific user languages and needs, is essential for building an effective and responsive information network, a core objective of our project. Acknowledging the challenges in integrating diverse data formats from new detection

methods, our project will streamline open (meta)data flows using domain-relevant standards and will publish these data in widely used open data repositories. This effort ensures compliance with FAIR principles (Findable, Accessible, Interoperable, Reusable) and overcomes harmonisation difficulties. Building on the work of Reyserhove et al. (2020), our project will automate data flows to the Global Biodiversity Information Facility (GBIF) and Global Register of Introduced and Invasive Species (GRIIS)(Pagad et al. 2022) using the Darwin Core standard and Ecological Metadata Language (EML). This initiative will enhance data utility for biodiversity monitoring and IAS management and will align our data with various European initiatives such as EOSC or EASIN, while optimising the publication process of quality-assured detection data through GBIF's robust infrastructure. The IUCN SSC Invasive Species Specialist Group (ISSG) has an international network for managing checklists, with the Belgian TrIAS project (see Table 3) demonstrating national-level maintenance (Technical Readiness Level 6) through semi-automated workflows. We will expand this and establish sustainable procedures for its use (Technical Readiness Level 8).

Due to the large amount of raw data on species observations, it's hard for experts and national authorities to track new species introductions and manage IAS accordingly. OneSTOP will introduce an alert system, 'OneSTOP Alert', to inform stakeholders of potential new IAS using data from GBIF and GRIIS checklists. Users can customise this system's alerts to their specific needs. This early alert system will not replace existing initiatives but will support them by including more species and cover a larger geographic area, by reaching a broader audience and by speeding up the notification process (1.2.2.3.3). An experimental proof of concept by partner EV-INBO won the GBIF Ebbe Nielsen Challenge in 2023 (Technical Readiness Level 3) and we will expand its scope and capabilities to Technical Readiness Level 7.

All software developed will be Open Source with a permissive licence, enabling adaptation of our workflows for local or national use. OneSTOP will provide educational innovation in the form of interactive Shiny apps to explain the science behind Species' Distribution Models, IAS prioritisation and management interventions. These interactive apps will be trialled in our Living Labs (1.1.2.4), with co-design of outputs and supporting resources, and will themselves provide data for Culturomics research (1.2.2.1.2).

OneSTOP will partner with diverse stakeholders to share knowledge and data for informed decision-making. Collaborating with the Joint Research Centre on the European Alien Species Information Network (EASIN), it aims for broad dissemination across Europe, in line with Subsidiary Body on Scientific, Technical, and Technological Advice (SBSTTA) and IPBES IAS Assessment recommendations.

KPIs: Number of species occurrences published to GBIF (>1000); Number of days from IAS observation to publication (<14); Hits and engagements on dedicated Shiny app webpages (>1000); Number of people registered on the OneSTOP Alert System (>200).

1.1.2.4 Innovation Area 4: Socio-political action

Objective: Address IAS by understanding societal influences, innovative co-creation methodologies in living labs, culturomics for socioeconomic insights, and the active participation of citizen scientists, aiming to harmonise policy goals, enhance public engagement, and inform effective management strategies.

Recognising that biological invasions are, in large part, phenomena created by people through our trade, economy, and desires, we will consider broader societal influences, and how these interplay with the process of IAS transport, introduction, impacts, and potential for management. This pillar includes examining national, European, and international policies across different sectors to identify where policies have synergistic or conflicting outcomes related to IAS and to suggest potential solutions to harmonise policy goals.

In OneSTOP we will use living labs as an innovative methodology across the work packages for co-creation, product testing, and understanding both national and local socio-economic landscapes. These living labs are user-centred, open-innovation environments, operating within specific geographic areas. They are designed to integrate user communities into the research and innovation process, enabling active contribution to the development and exploration of innovative ideas and technologies. This approach provides a more immersive and interactive setting compared to traditional research methods, enhancing user engagement in the co-creation process. OneSTOP will establish a network of living labs across Europe, each demonstrating innovative detection and monitoring techniques for IAS. Living labs will offer the necessary real-world settings for testing and implementing our methodologies and ensure engagement with local stakeholders and the public. The living lab network will be crucial in providing actionable feedback to researchers, facilitating public involvement, and stimulating ethical discussions on IAS management. The network will initially comprise five countries. Feedback from participants and end users will inform the development of best practice guidance to inform extension to other countries.

Culturomics is a novel approach in understanding the socioeconomic factors driving IAS through internet-based data (Technical Readiness Level 3). This technique involves analysing cultural and social data from digital platforms, like social media, news, and forums, to gauge human perceptions, attitudes, and behaviours towards ecological phenomena, particularly IAS. By tracking how often and in what context these species are mentioned online, culturomics provides insights into public awareness and sentiment. This method also identifies human activities contributing to the spread of IAS, such as gardening, pet trade, or travel, and assists in shaping public awareness campaigns. Furthermore, culturomics informs decision-makers including policymakers by revealing public opinions and societal impacts of IAS, aiding in the creation of more effective and socially acceptable management strategies.

Our approach is to go deeper into the analysis of digital content to not only understand public perception but also to predict and influence behaviour regarding IAS (Technical

Readiness Level 6). By leveraging advanced data analytics and ML algorithms, we will analyse trends and patterns in digital discourse more comprehensively. This will enable us to anticipate public reaction to IAS and preemptively address concerns or misconceptions. Additionally, we plan to integrate these insights with ecological data to create more nuanced and holistic strategies for IAS management. This integration will inform more targeted and effective public awareness campaigns and policy decisions, ensuring ecological interventions align with societal values and expectations, thereby enhancing their efficacy and adoption.

KPI: Five of living labs operating; >500 mentions of IAS in social media and online platforms are detected; 30 stakeholder interviews; >750 public surveys completed.

1.2 Methodology

1.2.1 Concept

OneSTOP's methodology builds on the concept of One Biosecurity and especially the emerging need to bring together environmental DNA, novel surveillance technology, machine learning models, and social sciences to deliver advances in managing IAS (Hulme 2020). Enhancing biodiversity conservation, especially regarding invasive species, can significantly benefit from a stronger, mutually beneficial relationship among conservationists, policy-makers, researchers, and citizen scientists, centred around shared objectives and understanding (Fig. 2). While acknowledging there is no one-size-fits-all solution, given the variability of political and social contexts, leveraging information technology can swiftly transform data into valuable information, aligning the interests of citizens with policy objectives. Strengthening the connection between data collection, knowledge generation, and policymaking will highlight the importance of supporting citizen science to policy-makers. Similar to how weather forecasting integrates data from various sources for different stakeholders, the future of biodiversity data mobilisation promises to support all those in need of information about our biological environment.

1.2.2 OneSTOP Methodology

OneSTOP will last 42 months to accommodate three seasons for technology testing and citizen science campaigns.

1.2.2.1 Detection

1.2.2.1.1 Air-DNA

Platform Kinetics will develop and configure high volume air samplers capable of capturing air-borne particulates from the air over a wide range of aerodynamic diameters. The collected material will range from whole spores through to insect fragments and other cellular material, from which eDNA can be extracted. The aim is to deploy samplers in three of the five living labs to collect fungal spores and pollen through the spring/

autumn 2026 and 2027. The spring/autumn 2025 season will be centred in the UK to allow modifications and improvements to be made to the sampling and analysis pipeline within the host country. The samplers will allow

a) scheduled samples to be collected,

b) adaptive and dynamic sampling based on external events, conditions and triggers with

c) multiple samples being collected, extracted and preserved.

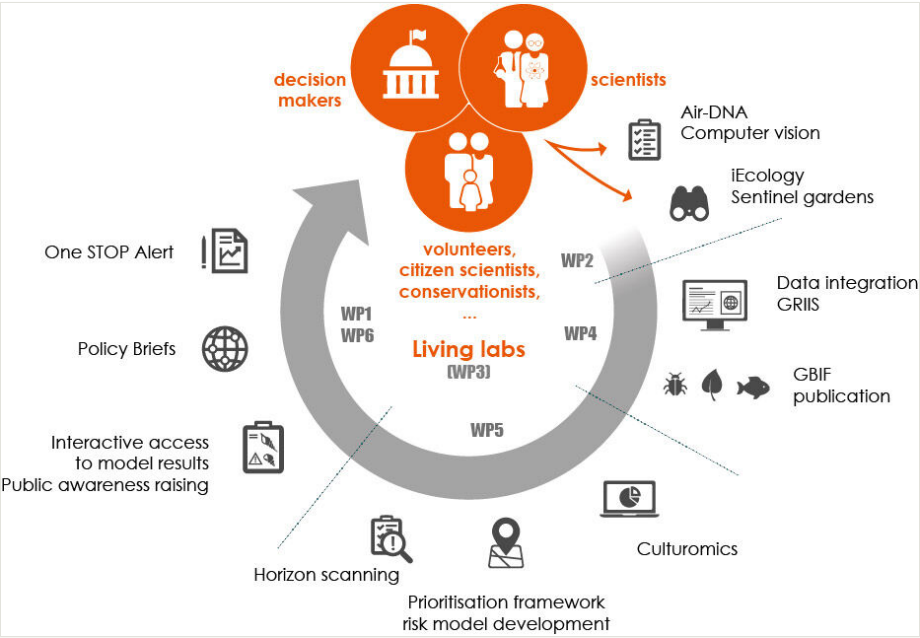

Figure 2. doi

Many individuals and organisations are involved in the detection, control, and management of invasive species. OneSTOP seeks to build upon, support, and inspire this community through both technical and social innovations. By promoting data sharing and providing open-access tools, the initiative enables the community to amplify the impact of their efforts, work more efficiently, and stay motivated (Groom et al. 2019).

The samplers are able to record and monitor temporal and spatial parameters aggregated with external/third party data sources. The collected samples will be ready for application of eDNA workflows to identify target IAS using quantitative PCR and communities of organisms using both short-read Illumina and long-read Oxford Nanopore metabarcoding of fungal, plant and invertebrate eDNA.

1.2.2.1.2 iEcology

We will leverage Application Programming Interfaces (APIs) to access and aggregate diverse digital content, encompassing text, images, and videos from European users

across multiple social media platforms such as YouTube and TikTok, online forums like Reddit, as well as data from Wikipedia Page Views and Google Trends. Advanced algorithms and machine learning tools will be employed to streamline the analysis of these extensive digital sources efficiently. This approach allows for the creation of repeatable workflows for the detection of priority species such as those listed on the Union List of Concern and identified through horizon scanning in Work Package 5, and can grow to be part of early warning systems for IAS. Google trends, for example, shows high predictive accuracy in forecasting events in public health and finance supporting its potential utility in the context of IAS detection (Petropoulos et al. 2022). Our methodology includes constructing a time series of Wikipedia and Google searches for specific terms related to target IAS in Europe, intending to forecast historical or current incursions of species such as *Vespa velutina* and *Solenopsis invicta*. For instance, our time series analysis will utilize data from Wikipedia page views and Google Trends, quantifying monthly search volumes on a 0 to 100 scale from 2004 onwards, adaptable to European country and subregional levels. Throughout prototype development, we will evaluate search volumes for various IAS across Europe, pinpointing drivers of search intensity such as species traits and socioeconomic indicators. Additionally, we will investigate temporal correlations and potential lag effects in search patterns to assess the feasibility of predicting known IAS incursions using this data.

1.2.2.1.3 Computer Vision

Plants will be monitored with a novel custom-built machine vision camera system mounted on vehicles and capable of recording high resolution images without motion blur at vehicle driving speeds up to 110 km/h (CamAlien) (Dyrmann et al. 2021). The system can be mounted on a car, train or boat to record vegetation continuously alongside the vehicle. Images from the system will be processed using an advanced deep learning pipeline to recognize multiple plant species in an image currently being developed in the MAMBO project in collaboration with PlantNet. To further expand the training data, the camera system allows a co-driver to tag image sequences during recording when species of concern are observed. In this way, the speed at which additional training data can be gathered is rapidly increased. In OneSTOP, training data will be used to retrain plant identification models to make the recording fully automatic and remove the need for botanical experts during the recording. We will also expand the use of this camera system to road kills, many of which are IAS. Promising results from preliminary tests using the same camera system for monitoring leads us to believe that the system holds the potential for early detection of the spread of mammals along road networks through roadkill monitoring. We will use the expertise in the living labs to collect images of rare invasive alien plant species using our vehicle-mounted cameras. This will help to build training datasets for these species, and create tools that can be tested, and generate significant impact, in the living labs. These methods rely on training data of the species of concern to function effectively. Additional data will be created by expert review of a subset of the images collected with the system. Nocturnal insects will be monitored with the AMI system, which has been developed by AU and UKCEH, and deployed in over 20 countries. The system uses lights designed specifically to attract nocturnal

insects. Insects arriving at the light land on a white board and are automatically photographed. Images are downloaded from the systems and analysed using detection and classification algorithms developed by AU and collaborators. Preliminary results suggest that the analysis pipeline can be adapted to detect IAS insects attracted to light, but it remains to be tested if the system can be used efficiently for detection at introduction sites. Raw data will be collected during 2024 from deployments at urban (30 systems) and natural sites (50 systems) across the EU. In addition, UKCEH leads a network of 20 systems in the UK and 40 across the tropics. These existing datasets will be used to evaluate the accuracy of classification models focused on detection of IAS.

1.2.2.1.4 Citizen science

For many taxa, particularly obvious ones such as birds and vascular plants, monitoring of IAS is dependent on data collected by volunteers, often so called citizen scientists. In research circles, there is a significant focus on the reliability of data collected in this way, with numerous studies addressing these concerns. However, there is an increasing call for more attention to be paid to the 'citizen' aspect of citizen science. OneSTOP will harness the power of citizen science to pioneer early detection and monitoring of IAS (Pocock et al. 2024). This approach not only fosters innovation in environmental management but also capitalises on the inherent benefits of increased engagement and awareness among participating citizens (Phillips et al. 2021). Our emphasis will be on engaging gardeners and their gardens as ‘sentinel’ sites. This recognizes that gardens are pivotal in the introduction of IAS: both from cultivated plants establishing themselves in new environments, but also through weeds, diseases and invertebrates being dispersed inadvertently through the movement of plants and soil. Therefore gardeners are pivotal in both early detection and action to reduce IAS establishment. We will stimulate the use of established and (inter)nationally used citizen science platforms and apps that support open data publication, such as iNaturalist, Observado.org, or iRecord (UK), or IAS specific apps such as that of EASIN. In Belgium we will employ MijnTuinlab, a specific web platform for garden-related citizen science initiatives in Flanders, Belgium.

Our approach will be to target promotion of recording specific groups of species that cause greatest threat or are greatest risk. The use of such apps will be actively promoted through a variety of dissemination approaches (e.g. social media, public lectures, project newsletter) throughout the project as well as in dedicated activities in the OneSTOP living labs network. For ornamental plants, which are often outside the scope of general citizen science recording schemes, we will launch a dedicated citizen science initiative engaging gardeners to report ornamental plants that are spreading in their gardens. All results from these activities will then be used in OneSTOP horizon scanning and prioritisation assessments.

1.2.2.2 Prioritisation of IAS and pathways

Species distribution models (SDMs) are frequently used to project potential distributions and invasion risks under climate or land use changes (Klonner et al. 2019, Pouteau et al. 2021). Yet, building on SDMs for accurately predicting the invasion risks of recently

introduced species remains challenging due to the violation of the equilibrium assumption of SDMs or poor model transferability into non-analogous environments (Capinha et al. 2018, Guisan et al. 2013, Václavík and Meentemeyer 2009).

1.2.2.2.1 Automated modelling workflows

To enable automatic updates of SDMs, we will develop data streams for each dynamic input data source (e.g. GBIF), which will download, process, store and serve data for modelling. Data streaming workflows will build on the work on IAS in the BioDT and B3 projects (see Table 3), both of which will provide repeatable workflows and dynamic data products for SDMs. We will initially, in Task 5.1, collate SDMs for IAS in Europe, where these exist, and augment with SDMs for priority species lacking SDMs. The construction of SDMs will inform the construction of automated pipelines in Task 5.2.

1.2.2.2.2 Ecological modelling

We will develop an innovative modelling framework that combines two complementary computational approaches to project species distributions: integrated SDMs (iSDM (Fletcher et al. 2019)) and joint SDMs (jSDM (Wilkinson et al. 2021)). iSDMs enable the integration of heterogeneous input information, including species presence-only records (typically used in SDMs), systematic survey data, checklists and expert knowledge, resulting in more accurate distribution projections for individual species compared to traditional approaches when high-quality data are limited. In contrast, jSDMs rely more on the data quality but allow simultaneous modelling of multiple species, accounting for species correlations due to species interactions and missing covariates and thus better predicting the distributions of co-occurring species. Both approaches are also highly flexible in terms of including additional information about species biology, dispersal barriers and phylogenies (Tikhonov et al. 2020). Consequently, the framework can utilise the wealth of data mobilised in OneSTOP (Work Package 2 & 4), achieving robust projections of IAS distributions.

Using this modelling pipeline, we will be able to assess how already present IAS, or potential future invaders (identified in Task 4.2 & 5.3) might spread in Europe under different climate and land-use scenarios within the 21st century (Naimi et al. 2022). For projecting the potential future distributions and impacts of IAS, we will use four recently developed scenarios until 2050 representing different combinations of socio-economic developments (Shared Socioeconomic Pathways, SSP (O'Neill et al. 2014) and pathways of atmospheric greenhouse gas concentrations (Representative Concentration Pathways, RCP). From the least extreme to the most extreme, the scenarios rank as follows: SSP126, SSP245, SSP370, and SSP585. For each scenario, we will obtain quantitative projections for climate (Karger et al. 2017, Lucas et al. 2013) and land use (Hoffmann et al. 2023), and use them as input data for projections of future potential IAS distributions.

The modelling platform will include a data cleaning and preparation protocol following the established data standards in OneSTOP. This will guarantee that models can be

updated once new data becomes available or new models can be easily run when new priority species are identified.

1.2.2.2.3 Data driven horizon scanning

Horizon scanning is a systematic process for reviewing data and publications to identify IAS that are likely to invade or emerge in the short to medium term in specific countries or regions (Roy et al. 2014). Based upon the framework of Matthews et al. (2017) we will develop a repeatable, multi-criteria analysis workflow that compiles and ranks species for this purpose, with the results evaluated and refined through co-creation with experts in the consortium, using the Living Labs methodology. Our initial step involves starting with national GRIIS checklists and the European compilation of checklists (Work Package 4) to rapidly generate a list of IAS in Europe that are not present in the target country of the workflow, supplemented by species from non-European countries that are widespread IAS but not yet established in European countries.

Once the preliminary list is formed, we match these species with additional data, including known pathways of introduction, impacts on biodiversity, economies, and human health, manageability, and specific traits such as plant life form, mode of dispersal, and host. Species are then categorised into different risk levels (high, medium, low) using a scoring system agreed upon by experts in the consortium and at the living labs. The methodology includes screening high-risk species based on their absence, limited presence, or controlled presence in the target country, considering factors like climate match, habitat requirements, and reproductive potential. We also classify the recorded impact types of potential IAS per introduction pathway and species group and rank these impact types by frequency to prioritise species groups and pathways for management interventions. This approach integrates systematic data collection, expert consultation, risk harmonisation, and frequent reviews. It is designed to effectively prioritise and manage IAS, recognising the dynamic nature of biological invasions and the necessity for periodic updates in response to global changes and new findings.

1.2.2.2.4 Priorities to reduce the impact of IAS on European Red List species

Reducing pressure from IAS on species considered threatened by the IUCN Red List (IUCN 2023) is a priority globally (followingTarget 6 of the Global Biodiversity Framework; CBD 2022) and at the European scale (following the EU Biodiversity Strategy for 2030). Currently, nearly 3000 terrestrial species are threatened in Europe of which more than 670 are threatened specifically by IAS, as acknowledged in the EU Biodiversity Strategy for 2030. In OneSTOP we will evaluate the impact of IAS on threatened native species currently and under future land-use and climate change scenarios, and hence determine the priority actions required to reduce the impact of IAS on Red List species by 50%.

First, we will identify the set of European Red List species that are currently documented as threatened by IAS. We will then determine their current realised and potential distribution in Europe. Current distributions will be obtained using convex hull and alpha hull approaches based on available occurrence records from GBIF that will subsequently

be refined for each species' habitat affiliation based on CORINE land cover data for Europe (Feranec et al. 2016). We will then combine these with the projections of IAS in Europe for different climate change and land-use scenarios based on the modelling workflow built in Task 5.1 & 5.2. IAS will be selected on their documented presence across the CORINE land cover classes to identify those IAS projected to co-occur with the European Red List species in their current distribution and potential distribution. Finally, we will generate spatio-temporal prioritisation maps for IAS to direct management actions and policies to reach a 50% reduction in the number of Red List species threatened from IAS by 2030. For that, we will develop maps between the Red List species and IAS distributions currently, potential current and under future climate and land-use change scenarios. Current co-occurrence patterns provide a baseline for the level of threat of European Red List species by present IAS, drawing on the environmental matching hypothesis (Ricciardi et al. 2013) and following the potential impact assessment of IAS by Pérez et al. (2022). Red List species distributions enable us to identify priority sites for native species reintroductions and target sites for early detection of IAS introduction and establishment and also provide a baseline for comparison with the future scenarios identifying areas with a high probability of invasion in the future. It further enables us to assess current protected area placement and their importance for safeguarding European Red List species. The final output from Task 5.4 will be the development of a (semi-)automated workflow to easily reproduce and update these prioritisation maps following changes in data availability or the occurrence of new IAS in Europe.

1.2.2.2.5 Prioritisation Framework

The integrated prioritisation framework for IAS in the EU will adopt a data cube approach, aligned with the principles of B3 (see Table 3) and the occurrences cubes described in Oldoni et al. (2020). The design of the proposed approach will consider flexibility and scalability. Particularly, species occurrence will be integrated with three critical dimensions: spatial (where), temporal (when), and impact (what/how). The spatial dimension will account for geographical species distribution, the temporal dimension considers the timing of occurrences, and the impact dimension assesses the nature and severity of the impacts.

These dimensions serve as the foundation for constructing data cubes, each based on the characteristics of specific IAS. Its adaptability allows for the incorporation of specific goals, such as enhancing public awareness, supporting effective management, or informing policy briefs.

Throughout the methodological process, testing of pilot cubes for selected species will be conducted by experts and stakeholders in the living labs to validate the practicality and efficiency of the framework, promoting a collaborative environment for refining the prioritisation model and ensuring its applicability in real-world scenarios. The final integration and validation will involve collaboration with experts from the OneSTOP team and stakeholders in living labs workshops, ensuring the reliability and relevance of the prioritisation model.

This innovative approach not only enhances the effectiveness of IAS prioritisation but also aligns with contemporary data management methodologies, emphasising the need for structured and interconnected data representation in complex ecological assessments.

1.2.2.2.6 Integrating IAS information for regional-decision makers

In order for the information developed for the prioritisation to be effective, it needs to be delivered to those who make decisions for action for IAS. Automated communication tools to provide early warning at the country level will be developed elsewhere in the project (Work Package 4), but Work Package 5 will draw on the richness of the information developed during the prioritisation and develop a tool (Task 5.6) to deliver bespoke information to regional decision-makers, e.g. via an interactive, map-based web app. This will build on the learnings from the recent DECIDE project (web app: https://decide.ceh.ac.uk/, and bespoke automated emails) in which multiple data sources were brought together to inform wildlife recorders about accessible places where records were most needed, based on SDM predictions and their uncertainty. It is anticipated that this tool will provide the regional decision-makers with real-time, on demand information on IAS priorities for any user-defined region, based on IAS presence, predicted presence, projected future presence and impacts (Tasks 5.1 to 5.5). Critically, in OneSTOP this will be developed through co-design with regional decision-making stakeholders (engaged through the living labs), to meet their needs for IAS information to prioritise actions to reduce IAS establishment and impact. Co-design will be through a cycle of rapid prototyping and feedback to ensure efficient and effective co-design, as undertaken in DECIDE, and delivery will draw on the team's experience of visual data analytics, web app development, and LLM to create user-centred outputs.

1.2.2.3 Dissemination of data and information

1.2.2.3.1 Data publishing

OneSTOP will develop a seamless, swift, Open Source workflow that spans from the initial detection of a species in the field to its open FAIR publication. Such a system has been successfully trialled in Belgium but has not been implemented at a European scale. In this way, data will be made FAIR and Open to alert relevant stakeholders rapidly. Primary data products will be made findable by publishing them in domain-specific or generic open data repositories (ENA, Zenodo, etc.) and wherever possible, by adhering to specific (meta)data standards (EML, MIxS, INSDC, camtrapDP, etc.). The workflow will automatically map detection data to the Darwin Core standard and harmonise metadata which allows the publication to GBIF. By leveraging the strengths of the Darwin Core standard and the GBIF platform, we anticipate a significant contribution of the detection data to the early warning system and prioritisation of IAS management. A key focus of the OneSTOP project is the sustainability and adoption of these automated workflows post-project. To achieve this, we plan to conduct training sessions and provide comprehensive technical documentation. Every step of the workflow will be meticulously documented to ensure the provenance of both the source data and the methodologies used. Our

approach is centred on being comprehensive, transparent, and upholding high standards of data quality. Below we describe the feasibility of publishing detection data from our technical innovations tasks (Work Package 2).

Air-DNA Data: The workflow will take raw reads (Task 2.2) and capture sequence metadata using the MIxS standard (Minimum Information about any Sequence). These primary data products will be published to the European Nucleotide Archive (ENA). The raw reads will be further processed to filter out irrelevant data and identify the genetic sequences of the detected species. The result of this processing is a set of Amplicon Sequence Variants (ASV) or Operational Taxonomic Units (OTU), presented in a ASV/ OTU table. These tables are enriched with detailed metadata, including the location, time of detection. These data will be transformed to Darwin Core and published to GBIF. Simultaneously, we will ensure that our data adheres to International Nucleotide Sequence Database Collaboration (INSDC) standards. Processing of these data is in a pilot phase at both ENA and GBIF. OneSTOP will contribute to the further development of these pipelines, and to the international standards organisations developing the standards underpinning the interoperability of these data. In this way, OneSTOP will leverage newly developed capabilities of both the ENA and GBIF. We will conduct pilot runs to ensure the data are published correctly and are easily retrievable.

iEcology Data: These data are highly heterogeneous and come with inherent uncertainties related to species identification, geographical location, and time of observation. Our methodology will include rigorous steps to minimise these uncertainties and communicate them. Where available we will extract information about the media, such as the date and location of the record. Where possible we will publish iEcology data on GBIF so that they can contribute to the pool of all observation data and feed into other systems. Given the nature of our data sources, there is a potential for encountering sensitive data and for the system to be gamed either maliciously or accidentally. We will therefore, remove any personal information before publication and incorporate checks of the veracity of the data before publication.

Computer vision data: We will develop workflows and databases to take the raw images and associated metadata, organise it in databases and store them at the Electronic Research Data Archive at Aarhus University (erda.au.dk). This facility can store the terabytes of data we plan to collect and connects seamlessly with high performance computing resources and allows for user defined access rights. Harvard Dataverse will be used to publish final datasets with Digital Object Identifiers (DOI). Camera deployment information (coordinates, sampling duration, camera alignment and ecological covariates) and AI-derived observations will be further processed, aligned with the Darwin Core standard and published to GBIF. Where possible, we will align our data with the camera trap data packaging standard (camtrap DP) using the camtrapR R package (Bubnicki et al. 2023).

Citizen science data: The (inter)nationally used citizen science applications such as iNaturalist.org, observation.org and iRecord publish their data to GBIF on a regular basis and contribute to the majority of citizen science IAS occurrences. To integrate as much

data as possible, we will make efforts to include data from other citizen science platforms or applications.

1.2.2.3.2 Publishing pipelines for updating GRIIS lists and GRIIS Europe

Our methodology encompasses the development of an open-source protocol for creating and updating national GRIIS checklists and GRIIS Europe. This protocol will be documented openly on GitHub, allowing for transparent collaboration and understanding of the process. The publication pipeline starts with the careful collection and verification of data on IAS, incorporating rigorous quality control to ensure accuracy, completeness, and consistency, as described by Reyserhove et al. (2020).

For each GRIIS checklist, a mapping scheme will standardise the original data model to the Darwin Core standard. This includes documenting each dataset with metadata to maintain provenance and packaging it as a Darwin Core Archive. The (re)publication of datasets to GBIF will utilise the Integrated Publishing Toolkit, with updates facilitated through an automated publication workflow.

The retrieval of all GRIIS checklist data will be conducted through the GBIF species API, leveraging the GBIF backbone taxonomy for unified classification. This approach is critical for creating a unified checklist for Europe (GRIIS Europe) and ensuring all relevant data are accessible through a single, repeatable protocol, thus making the species names linked to the GBIF backbone taxonomy.

To support the long-term adoption and evolution of these publication pipelines, we will provide training webinars and guidelines, offering a scalable and adaptable model for other countries. This will ensure that the GRIIS checklists are not only updated and published effectively but also become a living document, continually evolving with new insights and data.

1.2.2.3.3 Early warning system for IAS in Europe

To ensure the effectiveness of early detection and rapid eradication, OneSTOP will aggregate observations of IAS in Europe to produce a generic, European Alert (early warning) system for new detections of IAS in Europe which complements the EASIN Notification System (Notsys). Such an alert system has been successfully piloted in Belgium and acts as an important tool in the management of IAS in Belgium (https://alert.riparias.be/). However, a tool to monitor and provide timely notifications about the occurrence of IAS across Europe is still lacking. We will aggregate occurrences of IAS in Europe from a myriad of sources published to GBIF, including data from detections and using the GRIIS Europe species list as a taxonomic filter. This aggregation step will include the Air-DNA, computer vision data, iEcology and citizen science data published in the OneSTOP project. To set up such a system, we will use a participatory approach, with all relevant stakeholders to technically define the desired system.

1.2.2.3.4 Optimising communication and awareness raising

The management of IAS greatly benefits from engaging the public through effective awareness-raising and information transfer. However, a challenge frequently encountered is the technical complexity and jargon-laden style of such information, which can impede readability and comprehension. This issue of readability in scientific research, particularly in studies on biological invasions, has been highlighted by Hulme & McLaren-Swift (Hulme and Mclaren-Swift 2022). Yet, the assessment of readability in formal documents produced by governmental and non-governmental organisations remains largely unexplored. To address this, government departments must tailor their documents to their audience, ensuring readability and understanding.

Our approach includes assessing the availability and accessibility of information on species listed in the EU Directive across Europe. We plan to apply language-independent readability metrics to evaluate if the information is appropriately pitched for diverse European audiences and to analyse how readability varies across countries for the same IAS set. This will be compared against data from the OECD Programme for the International Assessment of Adult Competencies (PIAAC), which measures adult literacy proficiency in a standardised way.

Recognising that short words and sentences alone do not guarantee clear communication, we aim to identify key communication characteristics that enhance clarity and aid public understanding. The outcome will be the development of pan-European guidelines for preparing information with high readability and impact. Furthermore, we will deliver educational information through interactive Shiny apps (e.g. simuland.exeter.ac.uk), which simplify scientific concepts through interactive play and citizen science. These apps "gamify" scientific concepts to make them more accessible to target groups (Table 4). OneSTOP aims to disseminate SDMs and IAS prioritisation through simple, visual, and interactive models, explaining the science behind policies. These interactive models not only show decision-making processes but also emphasise the role of uncertainty and gather user inputs for citizen science objectives. Thus also contributing 1.2.2.3.4 Citizen Science.

Table 4.

OneSTOP target groups.

Target group	Representatives	Description
Governmental and regulatory bodies (GR)	Competent authorities, environmental agencies and biodiversity monitoring bodies, government departments dealing with agriculture, forestry, wildlife, and natural resources, transport and border control agencies, public health authorities. Particularly those responsible authorities for managing Red List species	The Governmental and Regulatory Bodies serves as a bridge between scientific research, policy formulation, and the practical implementation of strategies to combat IAS. This group comprises local, national, and international policymakers, Member States Competent Authorities, Rail and Road authorities, border control agencies, public health authorities, environmental agencies, and regulatory authorities tasked with developing and enforcing biosecurity laws and guidelines. They translate scientific insights into actionable policies, setting regulatory standards, and ensuring compliance with biosecurity measures.

Target group	Representatives	Description
Industry and private sector (IP)	The Agricultural European Innovation Partnership (EIP-AGRI); Pest control organisations	The industrial and private sector are essential for translating scientific insights and technological innovations into practical, scalable solutions for managing terrestrial IAS. This group includes companies specialising in environmental monitoring technologies, biosecurity solutions, and data analytics platforms, as well as sectors directly impacted by IAS, such as agriculture, transportation, and tourism.
Environmental and conservation groups (EC)	EPPO; IUCN; Protected areas; Natuurpunt; Botanical Society of Britain and Ireland; World Wildlife Fund; Particularly those responsible for managing Red List species	Championing biodiversity preservation and ecosystem protection against the threats posed by IAS. This cohort includes NGOs, conservation agencies, biodiversity research centres, and grassroots environmental advocacy groups. Their expertise and dedication are crucial for advancing conservation strategies, habitat restoration efforts, and public awareness campaigns focused on the impacts of IAS. These groups work on the front lines of conservation, employing scientific research, community engagement, and policy advocacy.
Research and Technology groups (RT)	Biodiversity Information Standards (TDWG); Research Data Alliance; GBIF; GeoBON; INVASIVESNET; Biodiversa+	Professionals, from academic researchers in environmental sciences to innovators in technology and data analysis, focused on combating terrestrial IAS. This diverse group leverages advancements in fields such as eDNA analysis, computer vision, and AI to enhance IAS detection and monitoring.
Society and the general public (SP)	Private gardeners; Royal Horticultural Society	Encompassing environmentally conscious individuals, gardeners, educators, and the wider public, all motivated to contribute to IAS monitoring and management. Through citizen science projects, educational outreach, schools, colleges, and universities and policy advocacy, this diverse community is instrumental in raising awareness, facilitating early detection, and fostering sustainable behaviours.

The rise of Large Language Models (LLMs) presents a significant opportunity in this domain. LLMs, initially designed for predicting text responses, are now capable of extracting relevant information from large texts, summarising documents, and even producing outputs in various formats including data and images. In our project, we will utilise Retrieval Augmented Generation (RAG), which combines LLMs with specific datasets (like IAS distribution maps and species descriptions) to avoid the generation of inaccurate information. This approach will leverage data produced in this project, particularly from work packages 4 and 5, to provide reliable, scale-appropriate information to users through an advanced LLM implementation.

1.2.2.4 Socio-political action: Integration of social sciences and humanities into OneSTOP

The social sciences and humanities (partners CU, GF) are vital to ensure a holistic approach to managing terrestrial IAS. This multidisciplinary inclusion acknowledges that the challenges posed by IAS are not solely ecological or technological in nature but are deeply intertwined with human behaviours, values, and societal structures. By incorporating social sciences, we can better understand the socio-economic drivers, public perceptions, and community attitudes that influence the introduction and spread of IAS (Work Package 6). This understanding is crucial for developing effective communication strategies, policy-making, and fostering behavioural change that aligns with biosecurity goals (Task 1.4). Humanities, on the other hand, provide critical insights

into ethical considerations, cultural values, and historical contexts that shape human interactions with the environment. These perspectives are essential for designing interventions that are not only scientifically sound but also socially acceptable and ethically responsible. Together, social sciences and humanities enrich our methodology, ensuring that our strategies for detection, prioritisation, dissemination, and socio-political action are grounded in a comprehensive understanding of the human dimensions of biosecurity (Living Labs, Work Package 3). This integration is pivotal for the success of OneSTOP, as it enhances stakeholder engagement, facilitates informed decision-making, and ensures that our solutions are sustainable, equitable, and resonate with diverse communities.

1.2.2.4.1 Stakeholder consultation and engagement

Stakeholder engagement through surveys plays a crucial role in understanding public awareness and attitudes toward IAS and its management types among a wider public. Building on the results of a global survey of IAS lead by IBOT-CAS (in preparation) on the general awareness, knowledge, perceptions and attitudes of the public towards IAS and their management across the world and culturomics (Task 6.1), we aim to expand these results by conducting public surveys across five European countries of the living labs. These surveys will have a broad socio-demographic coverage thanks to survey companies, allowing for a comprehensive understanding and comparability of public perceptions. The surveys will focus on exploring public awareness and attitudes towards IAS, the social acceptance of IAS management options, and different framings of IAS that can increase awareness and support for management actions. Involving a diverse range of participants through representative surveys will provide valuable insights into overall public opinion and their acceptance of IAS management strategies, while also raising awareness.

The findings from the surveys will inform the development of interview questions to explore policy actors' perceptions and support of IAS within Task 6.3. These interviews will also test the various acceptance of the incorporation of IAS into policy using methods such as framing and choice experiments during the interviews. This will aid to decide for instance whether negative framing receives more attention for action (e.g. triggering loss aversion through highlighting risks and economic losses) or positive framing (e.g. saving costs, lives protected) triggers more support. We will also test which aspects (e.g. health, conservation, costs and other social or economic elements) are worth emphasising more when interacting with policy actors.

The results will help understand how various stakeholder groups (general public, practitioners, academics, policy-makers) perceive IAS, what management options they find preferable and with what messages policy can integrate more extensively IAS. We will also understand how different framing of IAS can be used to enable effective integration of IAS management into practice and policy. Overall, we will also explore how engagement and communication strategies can be compiled to aid the effective implementation of IAS policies and management.

1.2.2.4.2 Conservation Culturomics

While iEcology studies ecological patterns and processes based on digital data generated for other purposes (e.g. users posting in social media, online forums or e-commerce websites), Conservation Culturomics uses this same digital data to study human interactions with nature (Jarić et al. 2021). Therefore, we will use the same digital sources mentioned before (1.2.2.1.2 iEcology) to gauge societal awareness, attitudes and perceptions towards IAS. We will construct a time series of sentiments of posts published in social media and online forums mentioning target IAS in Europe. Additionally, we will monitor e-commerce websites (including eBay and Amazon) to construct time series including which alien species are sold in Europe. This approach will allow for the creation of repeatable workflows that, in this case, will allow us to monitor people's interactions with biological invasions.

1.2.2.4.3 Integrated governance

Borrowed from systems thinking which deals with the *wicked* problems, causal loop diagram analysis will be used to look at the relations between different policy instruments with a focus on Europe (Shackleton et al. 2018). A bibliometric analysis using the OpenAlex open-access bibliographic database will be used to quantify integration of research into biosecurity by linking invasion research to funding mechanisms. Integrated governance is important to achieve sustainable management of biological invasions (McGeoch et al. 2024). However, there are many cases of perverse and contradicting policies which prevent effective management. Through the living labs and other stakeholders, we will identify species which require integrated governance and of which the impacts have been well-studied and assessed in an Environmental Impact Classification for Alien Taxa (EICAT) assessment (Hawkins et al. 2015). Furthermore, using a culturomics approach from previous tasks (Task 6.1) and stakeholder engagement (Task 6.3) we will look for good examples of integrated governance. Based on these "seeds of a good anthropocene" we will develop policy briefs for aiding governments to achieve Target 6 of the Kunming-Montreal Global Biodiversity Framework (hereafter called the Global Biodiversity Framework) using a positive message approach.

1.2.2.4.4 Living Labs

To test and demonstrate the innovative detection and monitoring approaches OneSTOP will establish a network of five living labs representing different climatic and socio-economic conditions in Europe. The living lab approach has been successfully used in many areas of environmental science and policy development, but the OneSTOP living lab network would be, to our knowledge, the first within the context of IAS. The living labs will provide not only the relevant operational real-world environment for demonstrating our novel methodologies, but also ensure that this happens with the involvement of local stakeholders and the public. The experience in the uptake and usability of tools within the living labs through this participatory approach will provide actionable feedback to researchers to reach technical readiness level 6 to 7 by the end of the project. Furthermore, the pilot studies and outcomes of the living labs will feed into broader public

communication, fuel societal discussions on ethical aspects of IAS management, and explore future scenarios and policy contexts.

The rationale for the number, location and distribution of the living labs takes into account a range of socio-ecological and socio-political factors. Conforming to an approximate NUTs II geographic scale, collectively the five living labs (Brussels (Belgium), Constanța (Romania), Coventry (UK), Porto (Portugal), Uusimaa (Finland)) contain a number of potentially high-risk settings for introduction and establishment of IAS. These include marine ports (Uusimaa, Porto, Constanța), large scale retail distribution hubs (Coventry), and botanic gardens (Brussels, Uusimaa), and a range of transportation infrastructure (roads – all; rail – all; canals – Coventry, Brussels; inland port - Brussels). Their geographic scale ensures that all the living labs contain a mixture of urban and rural environments, and at a more local scale, a mixture of private gardens, local authority managed green space, commercial gardening centres, and gardeners. They also include protected conservation areas (e.g. Gerês Xurês Transboundary Biosphere Reserve / Peneda-Gerês National Park (Portugal), Sipoonkorpi and Nuuksio National Parks (Finland), Cheile Dobrogei and Canaraua Fetei (Romania)). Furthermore, the distribution of the living labs across the north (Uusimaa), south (Porto), east (Constanța) and west (Brussels, Coventry) of Europe ensures that the IAS innovations can be piloted in a range of climatic, socio-cultural and political settings.

The selection of living lab locations has also been informed by the desire of the OneSTOP consortium to maximise the opportunities for promoting stakeholder engagement throughout the lifetime of the project and to adopt a co-creative, transdisciplinary approach to the piloting of the individual IAS innovations. Accordingly, each living lab overlaps with the physical location of a consortium partner, including two partners (CU, LUKE) with substantive previous experience of running and participating in European living labs (REWAISE; AE4EU, OPERANDUM, JustFood, AlfaWetlands).

Each living lab will be governed by a core learning community of about eight stakeholders - a Living Lab Learning Community. The recruitment of members to each Community will be guided by a quintuple helix approach to stakeholder selection with the aim of securing a diversity of members, including by sector, as well as experience, gender and, ideally, also other intersectional dimensions. In accepting the invitation to join a Community individual members will be asked to commit to attending a minimum of five in person meetings across the duration of the project. We will motivate their participation by providing hands-on experience with cutting edge detection and prioritisation technologies, but we have also budgeted to pay for their local travel expenses and catering for these single day events.

Each Community will co-define (in collaboration with the local consortium partner) the aims and scope of the living lab, taking into account both the IAS characteristics and needs of that living lab setting and of the work programme of the OneSTOP project. The Community will provide coordination, guidance and expert input into the running of the respective living lab, including as a means of ensuring that an open and transparent approach is adopted to the pilot testing of the IAS technologies. We will aim to introduce

all key innovations within the living labs i.e. Computer vision (Task 2.1); Air-DNA (Task 2.2); Garden Sentinels (Task 2.4); OneSTOP Alert (Task 4.3); Communications (Tasks 1.4 and 5.6); Data driven horizon scanning (Task 5.3), but the agenda will remain open for the Community to lead dictated discussions on other topics. Living labs will facilitate the exchange of knowledge, enabling countries to learn from each other, especially about IAS that are present in one country but have not yet been introduced to another.

1.2.2.5 Compliance with the Do No Significant Harm Principle in OneSTOP

OneSTOP is committed to adhering to the Do No Significant Harm principle, as specified in the EU Taxonomy Regulation (Regulation (EU) No 2020/852). Particularly aligning with the objective of "*protection and restoration of biodiversity and ecosystems*" OneSTOP will ensure that its activities and the technologies it is developing contribute positively to this goal while avoiding significant harm to the four other environmental objectives delineated by the Regulation. OneSTOP will conduct a comprehensive assessment throughout the project's life cycle to identify any actual and potential adverse environmental impacts. This evaluation will cover all stages of the project activities, ensuring an all-encompassing analysis. In the event of identifying adverse impacts, OneSTOP will implement strategies to either prevent or mitigate these effects. This approach aims to minimise the environmental footprint of the project activities and aligns them with sustainable and environmentally friendly practices. OneSTOP will track the performance against the identified impacts and the effectiveness of mitigation strategies. Regular communication of these results will be maintained, ensuring transparency and accountability in our commitment to the Do No Significant Harm principle. Through these dedicated efforts, OneSTOP will not only uphold its commitment to the Principle but also actively contribute to the overarching environmental objectives of the EU. We wish our approach to serve as an exemplary model for embedding environmental responsibility into project development, ensuring that our activities support biodiversity and ecosystem health while upholding the highest standards of environmental stewardship.

1.2.2.6 Gender Dimension

The mainstreaming and broadening of Gender Dimension in Horizon Europe is a significant opportunity for us to address sex bias in biodiversity data, knowledge on biodiversity, the collection of biodiversity data and the management of IAS (Schiebinger 2021). Sex has particular relevance to invasion biology, because it relates to how likely species are to establish and to whether individuals are able to reproduce sexually and therefore create propagules that can disperse. For example, we may create separate SDMs for male and female organisms where that might be relevant or how the implementation of technical solutions will influence gender norms. We are conscious that implementation of policies and management techniques can affect women and men differently.

OneSTOP acknowledges the varying gender distribution across different social media channels. For example, X, the social media channel predominantly used in academia,

has a higher male user base of 63% (Statista 2024). In light of this, our objective is to ensure equality in the number of followers, and if any disparities exist, we will specifically target female researchers, practitioners, and politicians. Additionally, we will explore alternative social media platforms that exhibit a more balanced gender distribution. OneSTOP is also committed to gender balance in its consortium and activities and this is elaborated in section 3.2 below.

1.2.2.7 Research data management

1.2.2.7.1. Open Science and Data Management Plan

OneSTOP is committed to adhering to an Open Science Data Management Plan, which will be developed at the start of the project and regularly updated. This plan underscores our dedication to early and open sharing of research outputs. To enhance the Findability, Accessibility, Interoperability, and Reusability (FAIR) of our project results, outputs will be published in a single citable collection in the open-access Research Ideas and Innovation (RIO) journal, and/or uploaded to repositories such as Zenodo, GBIF or GitHub All public tools will also be available on the OneSTOP website. Scientific publications will be published under a Creative Commons Attribution licence (CC-By) in Gold open access journals. Datasets of species observations and checklists will be made available under a Creative Commons Zero waiver (CC0). Other datasets will also be made available either in the public domain or with an attribution licence depending on the nature of the material and the wishes of the owners. Data will be made available as rapidly as possible, no embargo is foreseen. Datasets and publications will be identified by digital object identifiers.

1.2.2.7.2 Software Development and Open Data Workflows

OneSTOP will implement repeatable Open Data workflows, transforming primary data into clear, informative, and reproducible models of species distribution. This approach, which aligns with the studies by Groom et al. (Groom et al. 2019) and Reyserhove et al. (Reyserhove et al. 2020), will ensure that all primary data, aggregated data products, summaries, indicators, and software comply with the FAIR Data Principles. Our Open Data – Open Source approach will allow these workflows to be scrutinised and repurposed by the community, fostering an evolving and continuous process. OneSTOP will provide a seamless data-driven workflow to meet regional and global information demands, anticipate biological invasions, and inform policy. By utilising internationally recognised biodiversity standards, we ensure the interoperability, repeatability, and sustainability of our processes, as well as the trustworthiness, reliability, and transparency of our outputs. Furthermore, OneSTOP will leverage European investments in science infrastructure, such as the European Open Science Cloud, GBIF, EASIN, and Copernicus data, thereby enhancing the overall effectiveness and impact of our work. Software code will be managed and versioned in an open code repository and will be programmed in open source languages. Bugs and feature requests will be tracked using an issue tracker linked to numbered versions.

Types of data/research outputs include IAS observation from Air-DNA, Computer vision, iEcology and citizen science that will be published to GBIF in datasets identified by DOIs and described with EML metadata. National checklist data will be published to GBIF and through that to other databases, including GRIIS, GloNAF; DAMA; GAVIA; First Records Database. Open source software produced during the project will be managed on GitHub, releases will be archived to Zenodo to provide versioning and a DOI so they are uniquely referenceable. Other data, such as EICAT Impact data, presence of the species in e-commerce platforms such as eBay or Amazon, data from social media, data from social media and questionnaires will be archived on Zenodo. Where necessary data will be anonymised before archiving to comply with GDPR regulation. Full metadata will be provided, including methods used to generate it and provenance.

Implementation

Objectives

- O1.1: Promote the project through a recognisable project branding and website.
- O1.2: Plan for Exploitation, Dissemination and COMmunication (PEDCOM) to ensure the impact and long-term legacy of the project's results; Establish collaboration and synergies with key biosecurity networks.
- O1.3: Maximise OneSTOP's outreach to relevant stakeholders of the quadruple helix model and local actors.
- O1.4: Raise awareness of priority IAS with multiple stakeholders to reduce introductions and spread.
- O2.1: Develop eDNA, computer vision, and iEcology methods to a point where they are ready for deployment for detection of IAS.
- O2.2: Quantify the efficacy of these technological solutions including their detectability for a range of IAS, and their ability to make accurate predictions.
- O2.3: Demonstrate how private gardens can act as sentinels for emerging IAS
- O3.1: Map local/regional actors; identify and recruit a core learning community of about 8 per living lab.
- O3.2: Establish two-way channels for sharing updates, findings, and knowledge with stakeholders.
- O3.3: Test technologies and alerts in real landscapes and in co-development with stakeholders.
- O3.4: Equip stakeholders with the necessary skills and knowledge to maintain the use of living labs beyond the duration of the project for collaborative IAS management.
- O4.1: Set up automated workflows to radically improve the lag time between IAS detection and dissemination of that information to the stakeholders who need to know.
- O4.2: Automate the (re)publishing procedure for national GRIIS checklists and generate GRIIS Europe.
- O4.3: Provide timely notifications about the occurrence of IAS across Europe.

- O4.4: Improve the harmonisation of impact data using international standards.
- O5.1: Produce maps of current and future potential distribution of relevant IAS.
- O5.2: Create workflows for real-time IAS data use in distribution modelling and future projections.
- O5.3: Use dynamic data flows to horizon scan for emerging species threats.
- O5.4: Estimate current and potential future impacts of IAS on Red List species to prioritise management.
- O5.5: Equip stakeholders with a pathway to guide the allocation of resources in managing IAS.
- O5.6: Communicate the results from our analysis of prioritisation to decision makers.
- O6.1: Develop data driven workflows using social media to track public attitudes towards IAS.
- O6.2: Assess public views on IAS and how they impact on our prioritisation and management.
- O6.3: Use insights from Work Packages 1 to 5 to optimise policy approaches under EU Regulation 1143/2014 on IAS.
- O6.4: Empower stakeholders with integrated governance solutions to achieve Target 6 of the Global Biodiversity Framework.
- O7.1: Ensure efficient use of the project's resources and deliverables of high quality.
- O7.2: Ensure smooth communications between the coordinator and consortium members. Also provide an effective interface with the Commission's administrative authorities.
- O7.3: Provide a platform for internal communication and document management.
- O7.4: Identify risks, identify potential problems early, resolve conflicts and implement mitigating actions.
- O7.5: Ensure conformation to the highest ethical standards and relevant legislation.
- O7.6: Organise and follow-up meetings of the Executive and External Advisory Boards.
- O7.7: Establish and maintain coordination and synergies with other relevant international, European, and national projects and initiatives.

Work plan

Work Package 1

Task 1.1: Visual identity of the project, website, and promotional materials (Objective 1.1) [Lead: PENSOFT - Partners: MBG] [Months 1-4] At the start of the project we will create a visual identity for OneSTOP, building on the already developed project logo. This will include a marketing pack that includes an introductory presentation, brochure, poster and presentation templates, project infographic, roll up banner, stickers. From the start we will raise awareness with potential users and other stakeholders (Task 1.4) and be

supported by multilingual promotional materials, interactive online visualisations, IAS information packs for communication and dissemination activities until the end of the project. One of the most prominent platforms for project presentation and engagement with the OneSTOP community, will be the project website. This will be a tailored user-friendly, project-branded platform of online communication tools and routes allowing easy access to general information about the project with the following characteristics: visually appealing, UX and UI-optimised design, project description (concept and relevant background research documents), as well as latest content (project-produced scientific outputs and awareness raising initiatives, recent news and activities). The PEDCOM (Month 6) and its updates (Month 20 and Month 38) will be developed jointly by PENSOFT, MBG, UKCEH, and Platform Kinetics, with UKCEH and Platform Kinetics specifically contributing to the project's exploitation plans. The results of Task 1.1 will be reported in Deliverable 1.1.

Task 1.2: Dissemination, Communication & Exploitation (Objective 1.2) [Lead: PENSOFT - Partners: All] [Months 1-42] In the initial stage of the project, a Plan for Exploitation, Dissemination and COMmunication (PEDCOM) will be developed. This plan streamlines and guides all outreach efforts of work package 1 to maximise impact, including the process of information exchange within the consortium. The plan will contain information on:

1. key dissemination actors (based on the stakeholder mapping in Task 6.3);
2. target audiences and respective key messages;
3. multi modal mix of communication & dissemination channels (e.g. social media accounts on and LinkedIn or comparable alternatives, policy briefs, awareness raising campaigns deriving from Task 1.4);
4. bilateral communication approaches (e.g. trainings, events; synergies with other projects and initiatives (also see task 7.6));
5. Key Performance Indicators (KPIs) for each action (Month 6);
6. Intellectual Property Management Strategy.

To guarantee the success of the outreach and dissemination strategy, appropriate monitoring tools will be established. The PEDCOM will be updated in month 20 and month 38 of the project, also adding Key Exploitable Results (KERs) and the most suitable means of exploitation, based on a questionnaire filled out by all partners. This task will collaborate with task 6.4. The results of Task 1.2 will be reported in Deliverable 1.2, with updates in Deliverables 1.3 and 1.4.

Task 1.3: Data and knowledge management plan (Objective 1.3) [Lead: PENSOFT - Partners: All] [Months 1-40] OneSTOP will develop a Data Management Plan (DMP) within the first six months of the project and keep it up-to-date for its full duration. It will be solidified by a final version of the DMP in the last months of the project. The DMP safeguards adherence to the FAIR data management criteria, in accordance with the EU's Open Science Practices. In particular, the DMP will describe what data types, licences and formats will be used within the project. To add value to the DMP, an additional one-pager with Data Management Guidelines will be produced and shared

with partners, in order to acquaint them with the recommendations valid for the project and serve as a guiding tool when generating, collecting or using research data. The results of Task 1.3 will be reported in Deliverable 1.5, and updated in Deliverables 1.6 and 1.7.

Task 1.4: Raising awareness of key species and pathways (Objective 1.4) [Lead: UoE - Partners: MBG, UKCEH, CIBIO, Cyl, PENSOFT, GF, UOC, LUKE] [Months 12-40] Increasing awareness of multiple stakeholders, including the public, about the threat of IAS is important to underpin action. There are existing resources available in many languages, including EASIN Beware of the Aliens campaign materials, and these will be promoted, for example through the living labs (Work Package 3), and included within the PEDCOM (Task 1.2). We will develop additional exemplary communication materials, including specifically for raising public awareness, to define IAS and their impacts (Task 4.4) while also supporting implementation of citizen science initiatives including through Task 2.4. GRIIS lists (Task 4.2) will be described and promoted through the living labs with participating stakeholders informing the optimal route to maximise uptake and impact. Interactive online visualisations will explain the importance of IAS management, including priority IAS and pathways, to multiple audiences, and will simultaneously source citizen science data for culturomics (Task 6.1) and promote action including practical ways to contribute effectively to biosecurity and the Alert (early warning) system (Task 4.3). Work with stakeholders in the living labs to define the scope, and evaluate the outputs, of these information communication tools to further enhance societal awareness of the connection between IAS, animal and plant biodiversity and human health and well-being (Work Package 6). The results of Task 1.4 will be reported in Deliverable 1.8.

Work Package 2

Task 2.1: Development of camera hardware systems and ML workflows for the rapid detection, and classification of invasive alien plants, insects and mammal species (Objectives 2.1 & 2.2) [Lead: AU - Partners: MBG, UKCEH] [Months 1-36] Two promising and already pilot tested systems will be further refined to advance their technical readiness level, deployed, and iterated, through the life of this project. First, vehicle-mounted cameras for detection of invasive alien plants will be deployed on cars, trains and boats to demonstrate the automation of detection of IAS spreading along transport infrastructures. Second, the same hardware will be adapted to monitor roadkills, of which invasive alien mammals make up a substantial part. Third, we will use automated insect camera traps fitted with UV light to monitor invasive alien insect species attracted to light. Each of the taxa-specific solutions will be advanced to a stage, where a complete workflow is available to process raw data and receive detections of key IAS with associated identification uncertainty. For plants and insects, image databases and classification platforms are emerging, but not specifically related to IAS. For mammal roadkills this is not the case. We will expand, curate and publish expert reviewed image databases for all three taxonomic groups. We will develop near real time data pipelines to ensure that IAS sightings from these systems flow into the data systems where they are required. (2.4) To support this task two CamAlien high-speed camera systems and three

cameras for automated monitoring of insects will be purchased. The results of Task 2.1 will be reported in Deliverable 2.1.

Task 2.2: Development and optimisation of air-based sampling methods for the detection of invasive fungal and plant species based on DNA (Objectives 2.1 & 2.2) [Lead: UKCEH - Partners: LUKE, PK] [Months 1-30] Here, we will focus on deploying air-based DNA samplers on risk sites identified in the living labs, such as gardens, nurseries and transport hubs. The devices will be able to capture fungal spores, pollen and insect fragments, allowing us to detect the presence of a wide variety of alien organisms. The methodology will be used by the living labs, allowing for effective exchange of information and hands-on experience with stakeholders and practitioners as well as promoting the further uptake of the methods by these parties. As the devices will be able to capture DNA samples from a wide variety of species present in the area, the list of target species will not be restricted in advance, but our experience in developing the equipment, and with practitioners will inform best practice in their deployment and their effectiveness with different target organisms. The results of Task 2.2 will be reported in Deliverable 2.2.

Task 2.3: iEcology (Objectives 2.1 & 2.2) [Lead: MBG - Partners: CIBIO, IBOT-CAS, LU] [Months 1-15] Develop advanced informatics workflows to harness data from a variety of media platforms, including Wikipedia, Google Trends, Flickr, Reddit and Mastodon. We will collect and analyse information on species that are newly emerging and generating discussion in the digital realm. Evaluation will be conducted on species with a well-documented, rapid expansion in recent years, such as the Asian hornet (*Vespa velutina*), parrot species (Psittaciformes) and Impatiens species. We will explore whether data from social media platforms can effectively signal their initial presence in new regions. These workflows will be adaptable, designed to accommodate a range of species, languages, and geographical contexts. They will be calibrated to optimise detection accuracy, carefully managing the balance between false positives and false negatives. With Wikipedia logs and Google Trends data, we will construct a comprehensive time series analysis tracking online engagement and searches pertaining to these specific invasive species. The results of Task 2.3 will be reported in Deliverable 2.3.

Task 2.4: Citizen science: Private gardens as sentinels of invasion (Objectives 2.3) [Lead: CU - Partners: MBG, UKCEH, EV-INBO, IBOT-CAS, UOC] [Months 6-38] OneSTOP will establish and evaluate a citizen science garden sentinel scheme for IAS. This will be co-designed with the living labs and focussed on the living lab countries to evaluate their success. For plants, gardeners will be asked to report ornamental plants that are invasive in their gardens. The scheme will be implemented in existing citizen science platforms depending on the local situation in each partner country (i.e. Waarnemingen, iNaturalist Network sites, iRecord, MijnTuinlab.be). For invertebrates, we will also organise targeted ‘garden bioblitz’ events using these same citizen science platforms encouraging participants to submit records from their gardens. We plan that each event will be combined with communication on specific invertebrate groups, such as ants, to demonstrate its potential as a sentinel scheme. Participation in both activities will be promoted through the living labs, however, the projects will be on multilingual pan-

European citizen science portals open for submission across Europe. All records will be published on GBIF so they are made available for inclusion in EASIN, and the alert system. We will undertake an evaluation of the cost-benefit of this targeted approach to inform how we efficiently support further investment in citizen science. Subcontractors will be used in Belgium to support dissemination of this task to people with gardens. The results of Task 2.4 will be reported in Deliverable 2.4.

Work Package 3

Task 3.1: Establishment Living Labs and core Living Lab Learning Communities (Objectives 3.1 & 3.2) [Lead: CU - Partners: MBG, AU, CIBIO, EV-INBO, IBOT-CAS, PK, PENSOFT, GF, UOC, LUKE] [Months 3-10] Task 3.1 will support the establishment of the living labs and their associated living lab Learning Communities. To begin with, each lead lab consortium partner will identify and map the local and regional actors already actively engaged with the management and prevention of IAS within the Lab. In addition to drawing on their existing knowledge of who these actors are, the mapping of local stakeholders will be further informed by a snowballing technique: stakeholders already known to the local consortium partner will be approached and invited to suggest other relevant stakeholder organisations. In follow-on, a core learning community of about eight stakeholders will be recruited to form the Learning Communities which sits at the heart of each Lab and remains active for the duration of the project. During this phase, living labs will also identify key sampling sites and target species for the activities in Task 3.2 in collaboration with work Package 2 task leads. The results of Task 3.1 will be reported in Deliverable 3.1.

Task 3.2: Stakeholder experimentation through Living Labs (Objectives 3.2 & 3.3) [Lead: LUKE - Partners: MBG, CIBIO, CU, EV-INBO, GF, UOC] [Months 9-33] We will be pilot testing IAS technologies from work package 2 (Tasks 2.1, 2.2 & 2.4). Work package 2 camera vision technologies will be tested in all living labs at least once with car mounted cameras, and on trains and boats in selected Labs. Air-DNA sampling units will be employed in all living labs over the two experimental sampling seasons. Activities of the sentinel garden citizen science monitoring tasks will be conducted over two years in each of the Labs by organising at least one annual gardeners' engagement event to report ornamental plants (Plant Alert) and one targeted annual bioblitz event for invertebrates in addition to the distribution of promotional materials developed in Task 1.1 & 1.4. These in-person events will be complemented by at least one online event to enable wider participation. Feedback from participants will be collected and communicated to the respective task leaders in Work Package 2. The results of Task 3.2 will be reported in Deliverable 3.2.

Task 3.3: Multi-stakeholder scenario workshop series through Living Labs (Objective 3.3) [Lead: CIBIO - Partners: MBG, CU, EV-INBO, UOC, LUKE] [Months 27-36]Each living lab will run a scenario workshop with stakeholders testing the response capabilities to potential alerts coming in from the European Alert System developed in Task 4.3 and the bespoke information provided by Task 5.6 and Task 1.4. Stakeholders will develop local

management workflow models to be activated should alerts relevant to their area be received. Scenarios will be Lab specific and take into account results from predictions of species current and future distributions (Task 5.1), horizon scanning (Task 5.3) and prioritisation framework (Task 5.5). The results of Task 3.3 will be reported in Deliverable 3.3.

Task 3.4: Living Lab Evaluation and Optimisation (Objective 3.4) [Lead: CU - Partners: MBG, CIBIO, EV-INBO, GF, UOC, LUKE] [Months 34-40] We will support the evaluation and optimization of the living labs as a model for supporting the prevention and management of IAS both during and beyond the OneSTOP project. This task will incorporate the critical reflection of each living lab Learning Community, as well as the local consortium partner, with regards to the establishment and running of an IAS living lab. The purpose will be to support the sharing of the main learning points to enable take-up by other countries/city-regions beyond the lifetime of this project. This will be supported by meetings in the local living labs as well as in a collective reflection across living labs. The results of Task 3.4 will be reported in Deliverable 3.4.

Work Package 4

Task 4.1: Publication pipelines of detection data from Tasks 2.1 to 2.4 to GBIF and EASIN (Objective 4.1) [Lead: EV-INBO - Partners: AU, UKCEH, IBOT-CAS] [Months 6-24] To create automated workflows that take raw output data from computer vision, Air-DNA, citizen science and iEcology and publish these data to GBIF. In case data publication to GBIF is not suitable, data will be published to open data repositories (e.g. Zenodo). Raw data products will be published to domain-specific or generic repositories. For each source, we will create a mapping schema to standardise the original data model to the Darwin Core standard. The published occurrence data will minimally include the species name, date, location, any uncertainties related to the observation and source information for each record. Each dataset will be documented carefully with metadata to maintain provenance and will be packaged as a Darwin Core Archive and registered with a DOI. We will use the GBIF Integrated Publishing Toolkit (IPT) to publish each source. Republication will be done automatically on a regular basis. Each publication pipeline will be meticulously documented, ensuring reproduction even beyond the project's lifespan. Partners will be trained to autonomously maintain and implement the workflow. The results of Task 4.1 will be reported in Deliverable 4.1.

Task 4.2: Generate new and updated national GRIIS checklists and GRIIS Europe (Objective 4.2) [Lead: EV-INBO - Partners: MBG, CIBIO, CyI, UOC] [Months 4-22] To enhance and deploy automated workflows for the publication and updating of GRIIS checklists in Cyprus, Belgium, Portugal and Romania. In the project's first year, a datathon will be organised to foster collaboration and facilitate learning among stakeholders, including GuardIAS. This collaborative effort will involve collecting and verifying updated data on terrestrial IAS, and possibly aquatic organisms as identified by the procedures. Our collaboration extends to our sister project GuardIAS for specialised consultation on aquatic species. A key feature of our initiative is the drafting of a

memorandum of cooperation for each country involved. These documents will detail the collaborative processes, roles, and responsibilities essential for the sustainability of national GRIIS lists. Additionally, the project will engage stakeholders through datathons and training webinars, providing guidelines and a template workflow for data publication that other countries can adapt to their specific needs. The creation and updating of the GRIIS Europe checklist are central to our mission. This involves the aggregation of individual checklists into a unified European list, facilitated by the automatic matching of scientific names to the GBIF Backbone Taxonomy. This checklist will be versioned and published on GBIF, making it easily accessible and referenceable. It will also include a complete list of national contact points to encourage contributions to future updates. We will also work with EASIN to ensure that they have access to update species information for their portal. The results of Task 4.2 will be reported in Deliverable 4.2.

Task 4.3: Alert system to disseminate detection events of new IAS (Objective 4.3) [Lead: MBG - Partners: EV-INBO] [Months 6-38] We will develop and implement a European alert system for new detections of IAS in Europe. This tool will monitor and provide timely notifications about the occurrence of IAS across Europe. We will use a participatory approach, by sitting together with relevant stakeholders to technically define the desired system. Sub-actions of this task include:

1. aggregate occurrence data from IAS in Europe, including those data published in Task 4.1 and using the GRIIS Europe checklist published in Task 4.2 as a species filter,
2. set up an infrastructure that can broadcast those observations in real time (e.g. RSS/API),
3. to set up a system that listens to those feeds and aggregates them,
4. to make a user-friendly interface to display that information and
5. to set up a taxonomically and geographically configurable email notification mechanism, enabling users to receive immediate updates on new observations of IAS.

In this way, European decision makers, research and field managers can be made rapidly aware of new occurrences of IAS. The results of Task 4.3 will be reported in Deliverables 4.3 and 4.5.

Task 4.4: Use of large language models to increase the efficiency of writing, integrating and updating Environmental Impact Classification for Alien Taxa (EICAT) assessments (Objective 4.4) [Lead: UKCEH - Partners: CU, EV-INBO, IBOT-CAS, LU, SU, UOC] [Months 8-24] EICAT is the IUCN standard for categorising alien taxa according to the magnitude of their impacts. The Global Invasive Species Database (GISD) hosts all the assessments available to date, which includes more than 300 species. The goal to assess IAS is slowed by the time it takes to collate literature, extract information and summarise across sources. LLMs, such as ChatGPT, perform well at finding relevant information, summarising large amounts of text, and are now readily accessible and scalable. We will apply LLM methods to the EICAT assessment process including finding literature, screening relevant literature, extracting key information and

summarising across data sources. We will use a subset of the 300 previous EICAT assessments, and experienced EICAT assessors in the team, to assess the potential for LLMs to support scaling up the EICAT process through each step of the process, and will quantitatively assess the cost-benefit of using LLM to support these activities. Furthermore, the task aims to improve the data flow from primary impact data to integration into EICAT assessments using the IUCN Standard. The results of Task 4.4 will be reported in Deliverable 4.4.

Work Package 5

Task 5.1: Distribution models for European IAS (Objective 5.1) [Lead: CIBIO - Partner UKCEH, UNIVIE, UFZ] [Months 3-17] Work Package 4 will provide standardised lists on existing and emerging terrestrial IAS. From this, a list of species will be selected for potential distribution modelling, considering their known distributions and impacts. Potential distribution models will be calibrated using species occurrence data available from relevant sources (e.g. GBIF; Work Package 4) and a comprehensive set of environmental predictors (e.g. climate, land-use/cover). These models will be used to predict species' potential distributions under currently observed conditions and to project how these distributions will change under scenarios of future climatic conditions and land use patterns. Complementary to this, pathway-related variables (e.g. road network, rivers density, proximity to ports) will be compiled and combined to produce spatial estimates of potential propagule pressure across the continent. This allows for identifying regions where species are more likely to be introduced. Performance of predictions and their uncertainty will be assessed species-wise, considering aspects of modelling algorithms and data comprehensiveness. The predictions obtained will be used downstream to inform Task 5.2, 5.3, 5.4, 5.5 and 5.6. The results of Task 5.1 will be reported in Deliverable 5.1.

Task 5.2: Automated workflows for species distribution modelling under environmental change scenarios (Objective 5.2) [Lead: UFZ - Partners: UKCEH, CIBIO, UNIVIE] [Months 9-39] To identify species likely to establish, spread and impose threats on native ecosystems in Europe, we will develop workflows to dynamically model potential current and future species distributions of a range of terrestrial IAS of Union and regional concern. The workflows will enable regular automatic updates of the models and their respective predictions to make use of newly available data, including those generated in Tasks 2.1 to 2.4, and will build on the work currently performed in the projects BioDT and B3 (see Table 3). We will review cutting-edge advances in modelling (such as Bayesian joint SDMs and integrated SDMs) and will develop these within our workflows where they are practicable and likely to support effective data integration and better model outputs (e.g. better propagation of model uncertainty for prioritisation and impact assessments). We will project the potential future distributions and impacts of IAS to 2050 under four recently developed scenarios of socio-economic development (Shared Socioeconomic Pathways) and climate change (Representative Concentration Pathways). The results of Task 5.2 will be reported in Deliverable 5.2.

Task 5.3: Data driven horizon scanning for potential new threatening species (Objective 5.3) [Lead: MBG - Partners: EV-INBO, IBOT-CAS, LU, SU] [Months 4-28]A repeatable multi-criteria analysis workflow that can be run regularly or on demand that combines observation data from GBIF, checklist data from GRIIS (Task 4.2), impact information from the EICAT on GISD (Task 4.4), GLOBI and elsewhere, and the model outputs from Task 5.1 to generate a prioritised list of species that pose a threat of becoming invasive for a country, have the most impact. The results will be validated by experts in the consortium and with members of the living labs. The workflow will be fully documented with the software open for anyone to clone to rerun or fork for their own purposes. The workflow will be piloted on living labs countries (Work Package 3). The results of Task 5.3 will be reported in Deliverable 5.3.

Task 5.4: Reducing the impact of IAS on Red List species (Objective 5.4) [Lead: UNIVIE - Partners: SU, UOC] [Months 9-39] In order to reduce the impact of IAS on native Red List species we need to predict the current and future (under future land-use and climate change scenarios from Task 5.2) likely impact by developing spatio-temporal prioritisation maps for IAS management actions to deliver a 50% reduction in the number of EU Redist species threatened from IAS by 2030. There will be close interactions with other tasks of OneSTOP, obtaining information from Task 5.1 (use of current and future distribution of IAS with known threats to Red List species), Task 5.2 (identification of potential new IAS with known impacts on native species elsewhere for inclusion in prioritisation maps) and providing information to Task 1.2 & 6.3 (communication of priority sites for IAS management; information to develop policy briefs), Task 1.4 (communication of which IAS has documented impacts on European Red List species to the wider public). The results of Task 5.4 will be reported in Deliverable 5.4.

Task 5.5: Framework for prioritisation of invasive alien species in the European Union (Objective 5.5) [Lead: CIBIO - Partners: SU, UNIVIE, UFZ] [Months 6-30] To develop a framework to prioritise IAS in the EU. The framework will consider a three dimensional space, where the dimensions are: spatial (where), temporal (when) and impact (what/how). First, data obtained from Task 5.1 (i.e. current and future species distributions), Task 5.3 (i.e. horizon scanning results) and Task 5.4 (i.e. current and future spatial impact on Red List species) will be assessed for fitness of use (to ensure feasibility and quality of the framework). For each species, a cube will be developed by aggregating the spatial, temporal and impact dimensions. Then, pilot cubes will be tested for selected species. Finally, pilot cubes will be integrated into the prioritisation framework and validated by experts (OneSTOP team members) and stakeholders through living labs workshops (Task 3.3). Outcomes will support the communication and public awareness of priority species and pathways (Task 1.4), communication of information to support effective management (Task 5.6) and provide additional information and recommendations for policy briefs (Task 6.4). The results of Task 5.5 will be reported in Deliverable 5.5.

Task 5.6: Automating communication of information to support effective management (Objective 5.6) [Lead: UKCEH - Partner: UoE, UFZ] [Months 18-40] We will develop automated tools for retrieving data and information, and tailoring their

presentation for policymakers and practitioners (Task 5.1 to 5.4). We will develop automated methods for summarising the relevant data into reports that are personalised (e.g. taxonomic and geographic scope), accessible and actionable. We anticipate that these tools will be applied to two principal use cases:

1. we will support monitoring activity by providing tailored guidance on taxonomic and spatial priorities for policy makers, and
2. we will deliver IAS information packs for local land managers, outlining local priorities, risks, and management options, using locally relevant information and data sources.

We will use our experience in adaptive sampling (DECIDE), LLM development and data analytics to deliver on our ambitions. Stakeholders will work with us to co-design the delivery of monitoring priorities and information packs through subscription email services and personalised web pages. Stakeholders in the living labs will define the scope, and evaluate the outputs, of our information communication tools, with dissemination and promotion through Task 1.4 highlighting relevance in the context of priority species and pathways. The results of Task 5.6 will be reported in Deliverable 5.6.

Work Package 6

Task 6.1: Advanced Culturomics: Deciphering public perceptions and behaviours towards IAS via digital Social Media (Objectives 6.1 & 6.2) [Lead: IBOT-CAS - Partners: MBG, CIBIO, CU] [Months 1-18] While Task 2.3 is dedicated to extracting data regarding the occurrence and traits of IAS from social media and other digital sources, Task 6.1 will use these same data sources to discern human interest, and perceptions towards IAS. Internet salience will be used as a proxy of human interest with sentiment analysis tools applied to understand public perceptions towards IAS, and reveal potential challenges or opportunities for policy and awareness campaigns. IAS from the Union List of Concern will be prioritised. The results will inform Task 6.2 and together will be used as a basis for communication and engagement activities in Work Packages 1 and 3. The results of Task 6.1 will be reported in Deliverable 6.1.

Task 6.2: Societal perception, understanding and attitudes towards IAS & management thereof (Objective 6.2) [Lead: GF - Partners: MBG, UKCEH, CU] [Months 3-24] Building on the outcomes of Task 6.1, public surveys with broad socio-demographic coverage will be undertaken across the five Living Lab countries (Work Package 3) to further explore public awareness and attitudes towards IAS, including acceptance of IAS management options. We will further explore the effect of different framing options (positive versus negative) on triggering actions on IAS management by the relevant stakeholders. This task will develop questions for the interviews conducted in Task 6.3 using choice experiments. Our findings on people's attitudes towards IAS will help shape our key messages (Task 1.2) to be used, among others, in raising IAS awareness (Task 1.4), in citizen science engagement and the living labs (Work Package 3). Some of the subcontracting budget will be used to run a survey on public perceptions. The results of Task 6.2 will be reported in Deliverable 6.2.

Task 6.3: Blueprint for improved implementation of EU Regulation 1143/2014 on IAS (Objective 6.3) [Lead: UOC - Partners: MBG, UKCEH, LU, UNIVIE, GF, UFZ] [Months 12-38] The blueprint, designed to refine the implementation of the IAS Regulation at the Member State and European levels, will integrate OneSTOP results derived from Work Packages 1 to 6. Beyond making recommendations, this task will engage stakeholders with relevant research outputs by conducting interviews with governmental and regulatory bodies, as well as environmental and conservation groups (see Stakeholder Table 4) at local, national, and international levels. Additionally, a stakeholder workshop will be conducted with organisations supporting the Regulation, such as IUCN, EASIN, and national regulatory authorities to examine how the reporting and implementation of the IAS regulation can be improved. The blueprint will include Member States' needs in relation to the implementation of the IAS Regulation as well as tailored recommendations for using OneSTOP's tools in implementing the regulation. In addition, the blueprint will identify best practices from outside Europe (South Africa and New Zealand) and provide recommendations for guiding implementation of the EU Regulation. The results of Task 6.3 will be reported in Deliverable 6.3.

Task 6.4: Case study analysis to enhance integrated governance to Achieve Target 6 of the Global Biodiversity Framework (Objective 6.4) [Lead: SU - Partners: MBG, CIBIO, EV-INBO] [Months 12-41] This task will focus on the integrated governance for management and policy implementation needed to achieve Target 6 of the Global Biodiversity Framework. Firstly, we will use case studies of IAS which require coordinated efforts across diverse sectors such as trade, environment, agriculture, forestry, horticulture, and health to manage impacts. Causal loop diagrams will be used as a tool to visualise the complex interactions, mechanisms and consequences of policies from different sectors, and to dynamically interact with stakeholders in the living labs (Task 3.2) as an instrument to capture sector-specific knowledge. Secondly, the integration of research into biosecurity will be assessed by quantifying the engagement of Member States with research on biological invasions by studying the links between published research, policy frameworks and funding calls. Finally, engaging stakeholders through a policy forum will provide an opportunity to refine policy briefs from OneSTOP activities, such as the living labs, alongside recommendations from the IPBES Assessments and SBSTTA under the Convention on Biological Diversity. This Forum will be organised in parallel with an international event, such as the World Biodiversity Forum. This will enable us to reach a broad range of stakeholders, but we will also invite a representative of each Member State. EASIN is the key European node in this context and will be an important partner in this forum. The project's established outreach channels for communication and dissemination in Task 1.2 will support the stakeholder engagement in Task https://www.globalbioticinteractions.org/6.4 and the policy recommendations will be distributed by Task 1.2 through established platforms for reaching policymakers such as the Horizon Results Platform. Some of the subcontracting budget will be used for a consultant on legislative matters pertaining to Tasks 6.3 and 6.4. The results of Task 6.4 will be reported in Deliverable 6.4.

Work Package 7

Task 7.1: Overall project coordination, management, and administration (Objectives 7.1, 7.2 & 7.3) [Lead: MBG - Partners: All] [Months 1-42] To develop and implement management processes to ensure an efficient and successful project execution. The tasks include: Production of progress reports. Preparation of external reports for the European Commission, such as intermediate and a final report. This includes monitoring technical and financial activities, as well as providing audit reports if necessary. Organization of consortium meetings to facilitate collaboration and communication among partners. Distribution of the EC's financial contribution and coordination of costs, ensuring proper control and oversight. Communication with the Commission, including the submission of deliverables as required. Ensuring effective communication between partners and facilitating the exchange of information. Preparation and maintenance of a communication and collaborative environment for consortium members, including mailing lists, a project repository (Teamwork), internal wikis, and reporting tools. Coordination of activities related to the Advisory Board. Moderating potential difficulties and conflicts, proposing solutions and corrective actions. Ensuring efficient use of resources and reducing waste. Progress reports will be provided to the project officer every 6 months (at months 6, 12, 24, 30 and 36) describing the main achievements of each WP/tasks, the challenges, and participation/organisation of events. A phone call with the EC will be organised after the reception of the report. The results of Task 7.1 will be partially reported in Deliverable 7.1, but this task is a continuous process throughout the project.

Task 7.2: Risk management (Objective 7.4) [Lead: MBG] [Months 1-42] The Coordinator, along with the Project Management Team, will closely oversee contingencies that could impact the expected progress in terms of time and quality. They will forecast, detect, and assess potential risks. Risks or issues that require closer scrutiny, as well as pre-identified risks, will be reported to the Executive Board. The regular meetings of the Board will include a review of risk management, and it will determine any necessary follow-up actions. These actions will subsequently be reported to the General Assembly (GA), which serves as an annual forum for broader discussions and course corrections in case important risks require amendments to project tasks and activities. The Management will also provide a helpdesk to address day-to-day queries from partners regarding contractual and financial issues related to the project. The results of Task 7.2 will be reported in Deliverable 7.2, with updates in Deliverable 7.3. and the risk register will be a standing agenda item at executive meetings.

Task 7.3: Quality control (Objectives 7.1 & 7.5) [Lead: MBG] [Months 1-42] Quality control will be ensured through peer review of deliverables by at least two reviewers who are not part of the task. Task leaders responsible for the delivery of the deliverables will need to prepare a draft at least four weeks before the delivery deadline and report it to the Coordinator. The management team will appoint a reviewer and ensure that the draft is reviewed, and feedback is provided to the task leader before the final submission of the deliverables. This quality control mechanism will be applied to all deliverables including

reports, software, articles, etc. The results of Task 7.3 will be continuously worked on during the project.

Task 7.4: GDPR, Gender Balance, and Ethical Issues Management (Objective 7.5) [Lead: MBG - Partner: CU] [Months 1-42] Responsible for the development and oversight of procedures and protocols to address ethical considerations throughout the project's duration. We will establish a comprehensive framework for ethical compliance, aligning our practices with the European Code of Conduct for Research Integrity and Data Protection legislation. This framework will encompass various ethical requirements that OneSTOP must adhere to, including guidelines for participant identification/recruitment, templates for informed consent, and ethical considerations for involvement in project activities (such as demos, online surveys, workshops, etc.). This task will oversee other work packages to ensure GDPR and privacy compliant processes. We will also monitor gender balance throughout the project, striving to maintain balance among project participants. For those partners involved in working with people, such as those organising living labs, specific ethics training will be given. The results of Task 7.4 will be reported in Deliverable 7.7.

Task 7.5: Operation of the Executive Board, General Assembly, and Advisory Board meetings (Objectives 7.1, 7.2, 7.5, & 7.6] [Lead: MBG] [Months 1-42] The coordinator will set up and chair monthly Executive Board meetings that will review progress, disseminate news within the partnership and plan future work. The Executive Board will be the ultimate decision making body of the project, but will consult with other stakeholders, notably the Advisory Board, Ombudsperson, Ethic Advisor and the Equality, Diversity and Inclusion Champion. The Annual General Assembly will bring all project partners together. The agenda will cover all relevant tasks of the project; it will review deliverables delivered, report progress and plan future work. The Assembly will also be a time to review events and their timing and ensure colocation if that improves efficiency. The Advisory Board members will be invited to the Annual General Assembly and will have access to all meetings of the partners. They will provide advice throughout the project, but also links to other important linked projects, organisations and infrastructures (see Table 3). Representatives of GBIF and the IUCN have already agreed to join the Board. The results of Task 7.5 will be reported in Deliverable 7.4, with updates in Deliverable 7.5 and 7.6.

Task 7.6: Coordination and Synergies with other relevant international, European, and national projects and initiatives (Objective 7.7) This task involves identifying and engaging with other projects or initiatives that have complementary objectives, activities, or outcomes. The coordination will include regular communication, information sharing, and collaborative planning to leverage synergies and foster a cohesive approach towards achieving common goals. Together with Work Package 1, particularly tasks 1.2, we will conduct a comprehensive review of ongoing and completed EU-funded projects and initiatives that align with the project's objectives. Initiate contact with the coordinators and key stakeholders of the identified projects. Exchange information on methodologies, tools, and results with other projects. Organise joint workshops, webinars, or conferences to share best practices and lessons learned. Identify opportunities for joint activities, such

as co-organized events, joint publications, or collaborative research initiatives. Particularly with our sister project GuardIAS we will develop and implement joint action plans to address common challenges and leverage shared opportunities. We will report on the outcomes of collaborative efforts in periodic project reports and deliverables.

2. Impact

2.1 Expected impacts

OneSTOP has been co-developed by the partners to directly address three of the expected impacts of the 2023-2024 Cluster 6 work programme (Table 1).

2.1.1 OneSTOP's unique contribution to the outcomes specified in this topic

Work Program Outcome 1. "*The establishment of alien species accidentally introduced in the EU environment is minimised and where possible they are eradicated.*"

OneSTOP will enhance the management of IAS in Europe by improving detection of IAS and reducing the time between detection and management action. OneSTOP will develop workflows to ensure efficient dissemination of information to relevant stakeholders. Dissemination approaches will be, where appropriate, co-developed with stakeholders (for example through the living labs) ensuring amplification of key outputs across the project (Work Package 1 and 6). The project will use techniques for rapid detection of IAS, particularly for those that are difficult to detect with traditional methods and are often only recognised after causing adverse impacts. OneSTOP will increase the spatial coverage of biodiversity monitoring and thus address potential gaps in detection. Detection events will be assessed based on several factors, such as the potential impact of the IAS, compliance with European legislation, potential for management including the social acceptability of management actions. This prioritisation is intended to anticipate potential threats and inform on existing ones to relevant authorities and stakeholders, focusing resources and efforts on high-risk introduction events for timely and effective management.

Specific target groups: Member States competent authorities; Pest control organisations; Environmental agencies; biodiversity monitoring bodies; Transportation network operators and managers; Also see target groups on Table 4, particularly groups GR, IP and EC.

Scale: All 27 Member States of the EU have a Competent Authority responsible for overseeing the national implementation of the EU Regulation 1143/2014 on IAS. Depending on the species, they work with a large number of different organisations to prevent introduction, establishment and spread.

Significance: Supporting implementation of the EU Regulation; Achieving Kumming/ Montreal Target 6

Work Program Outcome 2. "*Early warning systems to inform relevant stakeholders of the introduction of invasive alien species, building upon EASIN.*"

Stakeholders will be aware of emerging threats outside Europe, and biosecurity measures will be adapted accordingly to prevent those threats. OneSTOP will optimise data flows to minimise key bottlenecks in the rapid management and eradication of IAS, focusing on increasing awareness of emerging threats, rapid detection at points of entry, and in pathways of secondary spread. This will include rapid dissemination of information on IAS including detection and impacts). Up-to-date and regularly updated GRIIS checklists will ensure that IAS occurrences and taxonomy are consolidated and rapidly disseminated nationally and internationally. IAS occurrences (including data from citizen science, collections, research, and more) will be aggregated and shared through GBIF. Opportunistic and systematically collected observations from the general public and professionals will be rapidly identified as alien species using GRIIS checklists. OneSTOP alert system will align with EASIN. Detection data will be disseminated through automated workflows and FAIR Open Data to inform relevant (identified through the living labs) stakeholders rapidly. This detection data will also be fed back into horizon scanning workflows to improve their accuracy and responsiveness. Environmental policy decisions will be informed by reliable models of future change in biological invasions, ensuring that stakeholders are informed of the best global biosecurity practices. All of which is enriched by a framework for prioritising IAS (Task 5.1 & 5.5), boosts early warning systems with insights on potential distributions, dynamics, and impacts, improving horizon scanning accuracy. Practitioners with previous experience of the IAS will exchange knowledge with practitioners in countries where the IAS is novel.

Specific target groups: Transport and border control agencies. Environmental consultants and private sector companies that offer environmental assessment, biosecurity solutions, and ecological consulting services. Public health authorities in the case of IAS can pose risks to human health; International environmental organisations, such as the European Environment Agency, the Convention on Biological Diversity, European Topic Centre Biodiversity and Ecosystems and the IUCN. Also see all target groups in Table 4.

Scale: Potentially large scale due to the enormous numbers of IAS (12-17,000) (Roy et al. 2024), the large number of stakeholders and the wide range of impacts on a number of sectors.

Significance: All Member States struggle with limited resources to implement early warning and rapid response. OneSTOP offers low-cost, standardised, configurable early warning, aligning with EASIN. It will reduce the time to disseminate new observations of potential IAS from months to days.

Work Program Outcome 3. "*The introduction of invasive alien species is effectively prevented and established ones are systematically managed.*"

OneSTOP will pilot a range of innovative detection methods, eDNA, computer vision, sentinel gardens and iEcology, to proactively identify priority IAS at key entry points and dispersal hubs across Europe. This approach will significantly enhance capability to intercept and prevent the introduction of new IAS. To address the challenge of established IAS, novel computer vision tools will be developed and tested to detect and assess the spread of IAS, along transport corridors, which are key for secondary spread. Through the living labs we will co-design approaches to ensure the acceptability and enhance the impact of methods and tools for those who have responsibility to prevent and manage IAS. The current public awareness, interest, and perceptions of IAS will be evaluated using culturomics. This approach, involving a repeatable workflow, will not only monitor existing trends but also identify emerging issues related to IAS, thus contributing to their effective management. Understanding the drivers behind the introduction and spread of IAS is a crucial aspect of OneSTOP's strategy. The insights gained from IAS, spatial and pathway prioritisation will be disseminated to relevant stakeholders, ensuring informed and coordinated action. Furthermore, the project aims to align and integrate biosecurity measures within all sectors of environmental policy, including the EU Forest Strategy, the Zero Pollution Action Plan for air, water, and soil, the Climate Adaptation Strategy, and the EU Soil Strategy. By identifying conflicting policies that are identified in species focused case studies in sectors such as farming, transport, leisure, and forestry, OneSTOP seeks to identify improvements to policy implementation that supports the prevention of IAS introduction and the systematic management of those already established. Furthermore, it will aid governments in achieving Target 6 of the Global Biodiversity Framework by presenting them with policy briefs outlining good examples of, and recommendations on, integrated governance.

Specific target groups: Environmental agencies and conservation bodies, General public and community groups

Transportation and trade sectors, Research institutions and technology companies, Policymakers and legislative bodies, Agricultural and forestry sectors, Local environmental management agencies, International environmental organisations

Scale: Every Member State has to manage the species listed on the Union List of Concern, and other impactful species, and address the spread of IAS at ports of entry and along transport corridors.

Significance: Few countries met the Aichi 2020 Target 9 on IAS, and transformative change is required to achieve target 6 of the Global Biodiversity Framework.

Work Program Outcome 4. "*Public awareness, literacy and engagement, on invasive alien species monitoring and management are supported and improved.*"

OneSTOP will collaborate with local, national, continental, and international organisations to heighten awareness of IAS across various sectors, including health, relevant industries, conservation groups, citizen scientists, and the wider public. Building on existing campaigns (such as EASIN Beware of the Aliens), OneSTOP will co-develop

public awareness resources (including interactive web-apps) and communication plans tailored to educate and inform different stakeholders, thus enhancing their ability to contribute actively to biosecurity. OneSTOP will focus on elevating the general public's understanding of the risks associated with IAS and the ways these risks can be minimised to inform behavioural change. The living labs will enable co-development and testing of approaches. A key goal is to make information on IAS readily accessible, using straightforward and interpretable language, ensuring the public knows where to find this information and how they can play a role in improving biosecurity. Special attention will be given to educating gardeners about good biosecurity practices, acknowledging their crucial role in preventing the spread of IAS. Monitoring and evaluation of this approach will inform good practice for other awareness-raising campaigns.

Through the use of culturomics, the project will monitor and assess public awareness and perceptions of IAS and management by analysing social media posts. Public surveys with broad socio-economic coverage will further advance understanding of societal perceptions and attitudes towards IAS and their management. OneSTOP will employ citizen science, actively involving the general public in data collection from private gardens and using the information in species prioritisation. Moreover, OneSTOP will use living labs, engaging people in both data collection and discussions about the outcomes and practical applications of the research including co-design of awareness raising materials. This inclusive approach aims to foster greater stakeholder engagement, awareness, and literacy in monitoring and managing IAS including priority species and pathways, and dissemination of recommendations for policy briefs (Task 5.5).

Specific target groups: Gardeners. Local governance actors (e.g. Municipal councils), Schools/universities, Plant dealers, Pet shops, Tourism agencies. Also see target groups in Table 4, particularly SP.

Scale: Depending on the European country between 30%-80% have a garden or other kind of outdoor space.

Significance: The active involvement of people in conservation across Europe is of significant importance. First, it reflects a growing public awareness and commitment to environmental protection and sustainability, highlighting a collective effort to address critical issues such as biodiversity loss and habitat degradation. Second, the participation of individuals in conservation activities, whether as professionals, volunteers, or members of organisations, plays a crucial role in implementing effective environmental policies and conservation strategies.

Outcome 5. "*Pressure on species on the Red List threatened by invasive alien species is reduced, contributing to the following key commitment of the EU biodiversity strategy for 2030 "a 50% reduction in the number of Red List species threatened by invasive alien species*"

OneSTOP includes spatio-temporal modelling of IAS distributions under various climate change and socio-economic change scenarios (Task 5.1, 5.2, 5.4), which aids in

identifying and mitigating the impacts of IAS on biodiversity. OneSTOP will identify IAS that potentially pose risks to Red List species (Task 5.4). OneSTOP will prioritise IAS, and vulnerable sites, taking into account factors including conservation potential (Task 5.4), and societal acceptability (Task 6.1 & 6.2). Data publication workflows will ensure that data on the occurrence and impact of IAS are accurate, accessible, up-to-date, and rapidly published in accessible formats (Work Package 1). As part of this proactive approach, responsible authorities for managing Red List species will be promptly notified of new risks through OneSTOP Alert and OneSTOP communication features, facilitating timely intervention. We will also endeavour to include those responsible for the management of red list species in our living labs.

Specific target groups: Environmental regulatory bodies, Conservation organisations and NGOs, National and regional government agencies, Biodiversity monitoring and management groups, Land and wildlife managers, Policy makers and legislators, International environmental agencies and organisations.

Scale: This is expected to have a widespread impact across Europe, benefiting hundreds of Red List species and thousands of populations of these species. Furthermore, by leading the way and aligning with the Global Biodiversity Framework target there is potential to reduce IAS impacts on endangered species globally.

Significance: Our project baseline includes the current IUCN Red List species status, IAS distributions, and impacts, using studies and models to understand IAS effects on biodiversity and their potential spread affecting Red List species. The IUCN Red List encompasses plants protected by policies like the Habitats Directive and CITES, guiding OneSTOP to identify and protect sites from IAS threats.

2.1.2 Wider impacts, in the longer term

OneSTOP's comprehensive approach to enhancing the detection and management of IAS in Europe is poised to create lasting impacts on biodiversity and ecosystem health. By advancing innovative techniques such as Air-DNA, computer vision, and iEcology, OneSTOP will provide approaches to significantly shorten the time between the detection of IAS and implementation of management actions, improving the likely success of interventions and contributing substantially to progress towards Target 6 of the Global Biodiversity Framework. By working with an enterprise selling detection equipment (PK), and with field practitioners, OneSTOP will open the biosecurity market to these detection methods in a form that can be scaled up and become part of routine biosecurity monitoring. The project's commitment to rapidly disseminating detection data and engaging with diverse stakeholder groups (including general public, gardeners, and policy-makers) in co-developing communication approaches, will foster a heightened awareness and understanding of the threat of IAS and management strategies across the EU.

OneSTOP will address the need for congruent policies across different sectors, informing environmental, agricultural, transport, health and leisure policies to collectively support

IAS management. By prioritising Red List species and vulnerable sites, the project contributes to the EU's goal of reducing the number of Red List species threatened by IAS. In the long term, this will lead to more effective biosecurity practices, reduced spread of IAS, and ultimately more robust and resilient European ecosystems. The project's influence extends beyond immediate biosecurity measures, fostering a sustainable culture of informed and proactive environmental stewardship across Europe.

By creating reusable workflows for the prioritisation of IAS, across diverse locations and pathways, OneSTOP will contribute to the protection and preservation of native species and ecosystems across the EU, again with lasting benefits for ecosystem resilience and building resilience against climate-related environmental challenges. Reducing the threat of IAS will have benefits for people as well as nature, noting, as an example, the interconnections between ecosystem health and human health. Effective early detection and appropriate management of IAS will reduce the need for chemical pesticides and other control measures that may be environmentally damaging, leading to a reduction in unintended consequences including pollution. Furthermore, implementation of the approaches outlined in OneSTOP will bring economic benefits, reducing the costs of early warning and also reducing the need for deployment of expensive management options. Improved data availability and detectability will advance the scientific understanding of IAS dynamics and management informing action and leading to long-term progress in reducing the threat of IAS. By using repeatable modelling workflows, including digital twins and realistic scenarios, we can better predict the future spread of IAS and their impacts, while also simulating the effects of different policy decisions. From a policy perspective, outcomes from OneSTOP will ultimately underpin high resolution (aspiring to real-time) monitoring, rapid information dissemination, and improved national reporting and contributing to processes for assessing IAS for inclusion on the Union List of Concern. Overall, One STOP will lead to a step change in biosecurity across the EU while engaging diverse audiences in biodiversity conservation and specifically mitigating the threat of IAS.

2.1.3 Barriers or obstacles for reaching the impact

The ambition of OneSTOP is to overcome barriers that prevent early detection, rapid response and informed management of IAS in Europe.

Technological Challenges, OneSTOP will develop efficient and cost-effective detection and monitoring technologies, genetic identification and taxonomic verification methods, data management and integration strategies, robust risk assessment and predictive modelling techniques, and the design of decision support systems.

Market Readiness, OneSTOP will assess the readiness of the market to adopt our innovations by addressing barriers such as cost, scalability, regulatory compliance, and intellectual property issues.

Policy and Regulation, EU Regulation 1143/2014 on IAS gives a framework under which to conduct the project, but integrating biosecurity requires considering policy integration

across sectors, including policy on trade, physical infrastructure and environmental legislation. OneSTOP will identify such barriers and propose strategies for policy engagement and regulatory compliance (Work Package 6). Particularly looking for inconsistent or inadequate regulations, limited enforcement capacity, and a lack of harmonisation across different jurisdictions.

Social Acceptance and Adoption, OneSTOP will consider the social, cultural, and behavioural aspects that could affect the (risk) perceptions, level of acceptance and adoption of the project outcomes while addressing any potential resistance, public perception, or user acceptance barriers.

Sustainability and Long-Term Impact, OneSTOP will consider potential barriers related to resource availability, economic viability, and environmental impact, and propose strategies for ensuring the continued impact and integration of results beyond the funding period.

Ecological Complexity, can pose challenges for understanding the spread and impact of IAS and developing effective management strategies. OneSTOP will consider the ecological complexities associated with IAS interactions, including potential indirect effects and cascading impacts.

Early Detection and Rapid Response, OneSTOP will develop much-needed standardised protocols, and will address difficulties with taxonomic stability and distinguishing species from one another.

Integrated Management Approaches, IAS management often requires integrated approaches that combine various methods such as prevention, eradication, control, and restoration. OneSTOP will assess the barriers to implementing integrated management strategies, such as coordination among stakeholders, lack of knowledge about effective control methods.

Global Collaboration, acknowledging IAS are a global issue that requires international collaboration and cooperation, OneSTOP will address barriers to global collaboration including limited data sharing, differing regulatory frameworks, and challenges in aligning management across and between different countries, time zones and regions.

Socioeconomic Impacts, IAS have socioeconomic impacts, including damage to agriculture, infrastructure, and human health. OneSTOP will address the difficulties associated with assessing, comparing and quantifying socioeconomic impacts, challenges in valuing ecosystem services, and difficulties in integrating socioeconomic considerations into management strategies.

2.2 Measures to maximise impact

2.2.1 Dissemination, exploitation and communication

Strategic communication, dissemination, and exploitation (CDE) activities constitute a crucial stepping stone in OneSTOP's journey towards impact. These activities will be encapsulated in a Plan for Exploitation, Dissemination and COMmunication (PEDCOM) at Month 6, subject to regular updates at month 20 and month 38. This iterative process aims to enhance granularity, incorporate stakeholder feedback, and optimise planned actions through a performance co-evaluation with stakeholders. The skeletal framework of PEDCOM encompasses:

Stakeholder groups and subgroups: based on a stakeholder mapping: Ensuring targeted dissemination to groups set to derive maximum benefit and exploitation. These include Governmental and regulatory bodies (GR), Industry and private sector (IP), Environmental and conservation groups (EC), Research and Technology groups (RT), Society and the general public (SP) (Table 4).

Research outputs and Key Exploitable Results (KERs): Action planning tailored to each result, as outlined in Table 2.

Key messages and relevant output for each group: Crafting a tailored outreach approach for major stakeholder groups.

Multi-modal mix of tools and channels: ensuring the forenamed outcomes effectively reach identified project stakeholders.

Implementation plan: A clear mapping of the connection between the aforementioned elements, providing details on project CDE tools, target stakeholder groups, timing of use, and Key Performance Indicators (KPIs) for effectiveness measurement (see Tables 4, 5 for preliminary mapping).

Table 5.
OneSTOP's CDE activities, scope and KPIs. See target group descriptions in Table 4.

Activity type	Target groups	Tool/Channel	Key Performance Indicators
C	All	OneSTOP website	No. of visits >15,000/project duration; Average session duration >120s; Returning visitors >30%; Distribution: EU & beyond
C, D	All	Social media networks (X, LinkedIn, YouTube)	No. of posts >2/week; No. of retweets/reposts (X/ LinkedIn) >2/week; No. of followers/subscribers & “likes” >+100/year; No. of impressions on X >100 000/project duration

Activity type	Target groups	Tool/Channel	Key Performance Indicators
C	All	Promotional materials (brochures, posters & roll-ups)	No. of materials>5; No. of copies>500/promo material
C	SP	Popular media publications (magazines, press releases)	No. of press releases>5/project duration; No. ofdownloads/visits > 1500/press release
D	All	Infographics	No. of infographics>5/project duration
D	RT, GR	Factsheets	No. of factsheets>5/project duration
C	All	Newsletters	No. of subscribers +50/year; No. of opens >50%
D, E	RT, GR	Presentations at scientificconferences, and workshops	No. of conferences > 3/year
D	RT	Scientific publications	No. of publications> 10/project duration; 5/after the project
D	RT	Tutorial videos on the project's solutions and model usage	No. of videos>5/project duration; No. of views>150/video
D, E	All	Living Labs	No. of Living Labs 5; Meets < 5/lab; Outreach of Living Labs' members > 2,000 people/country
D	EC	Training packs for local land managers	No. of training packs = 1; 50 copies distributed/ downloaded
D	GR	Policy briefs	No. of briefs >3; ≥200 copies distributed/downloaded
D	GR	Policy webinars/workshops	No. of webinars > 6
C	All	Partners' existing websites, social media, newsletters	No. of engagements; at least 4 partner channels (websites, social media etc.)/year
D	IP	Practice abstracts in EIP-Agri	No. of abstracts >10
C	All	Joint press release with other projects, incl. aquatic IAS	No. of joint press releases>3/project duration
E	RT	Training	1 PhD trained

This implementation plan unfolds across three stages:

1. **Foundations (Month 1 to 18)**: Focuses on raising awareness, establishing project identity, setting up key CDE channels, consolidating OneSTOP's community, and initiating outreach.

2. **Active and Targeted Dissemination (Month 19 to 36)**: Builds on impact evaluation from the previous stage, encompassing active dissemination, outreach, and collaborative activities with other initiatives.

3. **Legacy and Exploitation Paths (Months 37 to 48+)**: Concentrates on maximising the exploitation paths of the project's most significant results nearing its end, and establishes the plan for OneSTOP's legacy.

2.2.2 European Alien Species Information Network (EASIN)

OneSTOP aligns with EASIN's objectives of safeguarding the EU's biodiversity by managing and preventing the introduction and spread of IAS. Leveraging advanced biosecurity technologies, our project can provide more comprehensive, accurate, and up-to-date data, contributing to the depth and quality of information available on EASIN. By contributing to EASIN, we can strengthen the EU's capacity to detect and respond to new threats from IAS in a timely manner, thus minimising ecological and economic impacts. OneSTOP emphasises collaboration and information sharing, principles that are fundamental to EASIN's success. Our participation with EASIN will foster stronger links between Member States, facilitating the sharing of best practices and enhancing the collective effort to manage IAS across the EU. OneSTOP's advanced tools and methodologies will support Member States in complying with EU regulations, such as EU Regulation 1143/2014 on IAS. The integration of OneSTOP into EASIN represents a strategic enhancement to the EU's efforts in managing IAS. EASIN is managed by the Joint Research Centre (JRC) of the European Commission. We will approach the JRC during the grant agreement preparation regarding the means of collaboration on EASIN. This might be achieved through the JRC becoming a formal partner in the project, or the project becoming an Alien Species Data Partner to EASIN - European Alien Species Information Network.

The main contribution from the JRC will be

1. to ensure the uptake of OneSTOP results with relevance to IAS policy implementation, particularly Tasks 4.1 and 4.3;
2. contribute with data such as the EASIN Catalogue species and georeferenced records as needed (e.g., Work Package 5);
3. to contribute to stakeholder engagement and dissemination, by availing of EASIN network, tools, website, and social media (Work Package 1 and 3), and
4. contribute to design the blueprint for improve implementation of the EU Regulation 1143/ 2014 (Task 6.3) and to task 6.4 Forum.

2.2.3 GBIF, ISSG & Biodiversa+

The OneSTOP project will use GBIF as a central hub for the mobilisation and aggregation of detection data and species lists. The OneSTOP consortium has strong connections with GBIF secretariat and national nodes, which facilitates collaboration. Furthermore, our outputs may also be suitable for the Knowledge Centre for Biodiversity. OneSTOP requires close collaboration with the ISSG, the primary host of GRIIS checklists on their IPT installation. We have included a budget under services to pay for this. Furthermore, we will collaborate with Biodiversa+, particularly their work package two titled *Promote and support transnational biodiversity monitoring* where they have a sub-task on IAS.

2.2.4 Communication Strategy

As the broadest of the CDE activities, communication activities in OneSTOP will commence from the project's inception and extend beyond its lifetime. The overarching goal is to contribute to the positive societal impact of the project, specifically enhancing Europe's capacity to conserve and restore ecosystems and safeguard biodiversity. OneSTOP's communication strategy involves employing a range of materials, formats, and channels tailored to the distinct needs of each target group (refer to Table 5). Numerous promotional materials, including a presentation introducing the project, one-page accessible overview, poster, rollup banner, attractive social media posts and other resources will be developed at month 3. These materials, written in accessible language, will raise awareness and provide partners with visually impactful resources for distribution within their networks, Living Labs, presentation at events, meetings, or sharing on social media. Engaging communication formats, such as video series, will be utilised to enhance societal awareness of the connection between IAS, animal and plant biodiversity and human health and well-being. Additionally, the project will create and circulate a bi-annual electronic newsletter. This will keep stakeholders informed about the latest developments and achievements of the project, while also extending the reach of OneSTOP's key messages beyond the project's duration. OneSTOP will actively engage with known contacts in various large media outlets, newsrooms, and message platforms, including partners' newsletters and blogs, EurekAlert!, AlphaGalileo, etc. The project will adopt a bi-directional communication approach (see below), encouraging partners to utilise both personal and institutional social media channels. Moreover, partners will make contact and explore potential knowledge exchange opportunities with organisations, networks, and projects, such as EuropaBON, BioAgora, RESPIN, CO-OP4CBD, B^3, Biodiversity Genomics Europe, INVASIVESNET, TDWG, ISSG, European and Mediterranean Plant Protection Organization (EPPO), Knowledge Centre for Biodiversity, GBIF, GEO BON, IUCN, IPBES, EASIN (also see Table 3). The potential for collaboration among these projects will contribute to the amplification of messages, particularly when the leaders of outreach activities share common roles in different projects (e.g. PENSOFT).

2.2.5 Dissemination Strategy

Regular updates will be shared via OneSTOP's website, serving as a central dissemination tool for storing project outputs, including deliverables, publications, access to events, policy briefs, promotional materials, etc. Existing relevant resources (e.g. Beware of the Aliens) will be promoted alongside materials developed to raise awareness of the activities and outputs of OneSTOP amongst diverse stakeholder groups including the public. OneSTOP's dissemination activities will rapidly maximise the accessibility of outputs to all stakeholders including those identified as users of the findings, thereby contributing to the project's scientific and economic/technological impact. Tailoring various uni- and bi-directional channels to the needs of stakeholder groups, including through the Living Labs, OneSTOP seeks to elicit expertise, knowledge, and perceptions of a diverse range of stakeholders as part of the project's

outreach, synergies building, and engagement activities. **Uni-Directional channels**: OneSTOP's social media channels (Bluesky and LinkedIn) will be operational from the project's kick-off, engaging relevant stakeholders and disseminating results promptly to maximise uptake. The project supports open science principles for publications, data, and tools, aiming for entirely gold open access journals such as NeoBiota, Biodiversity Data Journal, Database, Diversity and Distributions & People and Nature. Tutorial videos on the project's solutions and model usage will benefit the scientific community by providing an accessible approach to communicating complex concepts. We will open a project collection in an open-access journal to ensure broader reach, long-term accessibility, and access to less traditional research outputs. **Bi-Directional channels**: OneSTOP employs bi-directional dissemination methods to ensure the uptake of results, such as including Large Language Models (Work Package 4) and automated approaches to retrieving and summarising data and information (Work Package 1 and 5). OneSTOP will leverage the networking potential of consortium members, engage in joint activities, through key roles in ongoing and completed European projects and initiatives (Table 3). Project partners will establish new connections by presenting OneSTOP and its results at selected relevant events on local, national, and international scales. In addition, the project will provide training, including information packs for local land managers, outlining local priorities, risks, and management options (Task 5.6 & 1.4).

2.2.6. Collaboration with the Aquatic IAS Project (Area B) [GuardIAS]

While OneSTOP focuses solely on terrestrial IAS, we recognise the interconnection of ecosystems. Some IAS, such as mosquitoes, have both aquatic and terrestrial life stages, and water bodies are integral to the habitat mosaic of many terrestrial species. For this reason we will work closely with the project dedicated to aquatic IAS within this call (Area B). This collaboration will ensure that data, knowledge and strategies are shared where relevant, and that we do not create disciplinary boundaries that prevent the integrated approach to IAS that we aim for.

2.2.7. Cluster Activities

In addition to working with GuardIAS we will have many other opportunities for working with other Cluster 6 and other European projects. Many of these projects have links from members of the OneSTOP consortium, such as B–Cubed, MAMBO, Biodiversity Meets Data, the COST Actions Alien-CSI and InsectAI and BioDiversa+ projects, such as META PLANTCODE. We will look for joint cluster activities, invite related Cluster 6 projects to our events and training, and look for opportunities for cross project publications. These activities will support the strategic goals of the OneSTOP project, fostering collaboration, innovation, and public engagement in the fight against invasive alien species.

2.2.8 Exploitation Strategy

Policy Recommendations: The project team has extensive experience in science-policy communication. OneSTOP will issue concise policy briefs distributed in relation to relevant events (e.g. Neobiota, Biodiversity Information Standards, International Conference on Ecology and Management of Alien Plant Invasions (EMAPI, COP) while leveraging existing stakeholder networks from other Horizon Europe projects (see Table 3) and information platforms like the Horizon Results Platform and EASIN to maximise the potential for uptake of policy recommendations.

Direct Exploitation Routes: For the direct exploitation of OneSTOP's outputs, webinars involving key policy actors will be organised to, as an example, promote knowledge on detection and prioritisation and co-develop approaches to embed these within relevant activities such as the EASIN notification system (Work Package 6). Additionally, the project aims not only to exploit and build on results from other relevant European-funded projects but also to contribute to understanding gaps and informing research needs for potential future European research projects.

2.2.9. Intellectual Property Management Strategy

OneSTOP will develop a comprehensive Intellectual Property Management Strategy, ensuring the responsible, ethical and strategic handling of intellectual property associated with OneSTOP results generated throughout the project's lifespan. This strategy will focus on the thorough identification and documentation of all forms of intellectual property, including potential intellectual property protection tools such as patents, copyrights, trademarks, and unique methodologies. We will clearly define intellectual property ownership, taking into account the diverse contributions from various partners, such as academic institutions and private companies. Details of this will be incorporated into our Consortium Agreement from the beginning of the project (Task 1.2 & 1.3).

Legal protection will be a cornerstone of our strategy. We will secure appropriate legal protections for identifiable intellectual property, adhering to relevant national and international laws. Measures, including Non-Disclosure Agreements, will be implemented to safeguard confidential information and trade secrets. For the utilisation and commercialisation of intellectual property, we will establish licensing agreements dictating fair usage by project partners and third parties. A commercialisation strategy will be outlined to identify potential markets and partners for the intellectual property generated.

Regarding knowledge dissemination, we will institute a publication policy that balances intellectual property rights with the promotion of open access to our research findings. In the event of disputes arising from intellectual property, we will have a clear dispute resolution mechanism in place, in alignment with the intellectual property rights regulations of the Consortium Agreement. This mechanism will ensure conflicts among partners are resolved effectively and equitably. We will conduct regular audits for

compliance with the intellectual property management strategy and adapt the strategy as necessary in response to changes in the project's scope, partnerships, and legal frameworks.

3. Quality and efficiency of the implementation

3.1 Work plan and resources

3.1.1 Project structure

OneSTOP is structured around seven work packages, each contributing uniquely to the project's objectives (Fig. 3). Work Package 3 plays an integral role in this structure, acting as a facilitator for collaboration, co-creation and communication among the different work packages. It uses Living Labs methodology to engage stakeholders, ensuring their active participation and co-creation in the project.

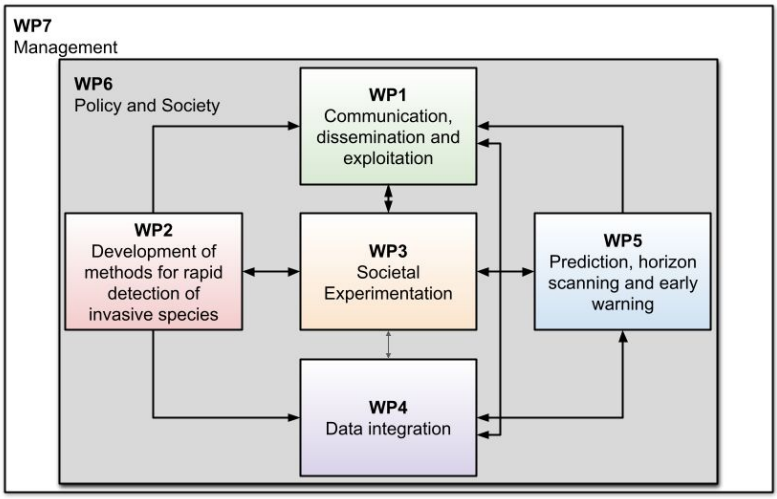

Figure 3. doi

Relationships between work packages. The diagram shows the interactions among the project's work packages. Work Package 1 handles communication and dissemination. Work Package 2 develops rapid detection methods for invasive species. Work Package 3 tests solutions in society. Work Package 4 integrates data. Work Package 5 focuses on prediction and early warning. WP6 links to policy and societal needs. WP7 provides overall project management. Arrows indicate information flow and interdependencies.

Work Package 1 aims to maximise OneSTOP's impact by devising and implementing communication, dissemination, and exploitation strategies for the project's transformative results and generated knowledge. This includes communicating the project's results to a wide range of target groups and the wider public. OneSTOP will base its outreach on tailored and multifaceted methods to effectively reach its stakeholder groups and

enhance synergies with existing biosecurity actors. The specific objectives are to ensure broad and impactful dissemination of project outcomes.

Work Package 2 is focused on raising the readiness level of a suite of technologies with high potential for the detection and reporting of IAS. This includes tasks aimed at improving the technical readiness of novel detection methods for IAS. Concurrently, Work Packages 4 and 5 are dedicated to data science innovations. Work Package 4 ensures that data and information related to these technologies are disseminated rapidly and openly. Meanwhile, Work Package 5 contributes by providing information in the form of models under future scenarios, enhancing the overall approach to managing IAS through these technological advancements.

Work Package 6 takes the project results, current policy and examines them in the context of societal attitudes, European Green Deal, EU IAS legislation and 2030 targets, and other European and global goals. Work Package 7 will coordinate and oversee the entire project, ensuring that all activities align with the outlined objectives and timelines. This includes effective resource allocation, risk management, communication between various project teams and stakeholders across sectors including environmental but also health where appropriate, and regular monitoring and reporting to maintain the project's integrity and achieve its goals efficiently.

3.2 Capacity of participants and consortium as a whole

The OneSTOP consortium includes experts spanning diverse and complementary disciplines ensuring a comprehensive approach underpinned by exceptional expertise that spans cutting-edge detection methods and modelling to stakeholder engagement and policy harmonisation. Each consortium member will contribute their unique expertise to collectively tackle the complex challenges of managing terrestrial IAS. The work packages provide a logical but integrated framework for the project team to collaborate and deliver the innovative approaches to maximise impact.

From the inception of OneSTOP, the consortium has been committed to gender balance, with women making up 57% of the leadership team and 45% of overall participation. As OneSTOP proceeds, the project team will strive for equitable representation through all recruitment across the consortium and also within the Living Labs Communities and other engagement activities. OneSTOP benefits from partners spanning four countries from Eastern Europe, two each from Northern and Southern Europe, and five from Western Europe, ensuring representation across the continent. The consortium also has broad taxonomic expertise, including vascular plants (CIBIO, CU, MBG, UOC, UNIVIE), vertebrates, insects (CIBIO, EV-INBO), Coleoptera (UKCEH), Diptera (CyI), Hymenoptera (CyI), Odonata (UOC)) and Fungi (LUKE), and many partners have been engaged in developing risk assessments of IAS in their areas of expertise.

The OneSTOP consortium is designed to encapsulate the entire value chain in addressing the challenge of IAS, from researchers at universities (AU, CU, LU, UOC, SU, UNIVIE, UoE, CIBIO) and research institutes (UKCEH, CyI, IBOT-CAS, EV-INBO, MBG,

UFZ, LUKE) to practical application (GF), communication (PENSOFT, UoE), policy implementation (EV-INBO), and commercial solutions (PK). Researchers within the consortium are pivotal in bridging the gap between academic research and real-world application with consortium members having extensive expertise in informing policy application and the practical implementation of direct management of IAS, ensuring that theoretical advancements are translated into actionable strategies. Previous studies undertaken by members of the consortium encompass developing management practices, engaging with science-policy platforms, and progressing national and international standards for IAS management. OneSTOP has three SME partners, PK specialises in the commercial aspect of the value chain, focusing on the development, manufacture, and sale of cutting-edge detection equipment, while PENSOFT provides excellent science communication and GF expertise in biodiversity and nature-based solutions from the perspective of social transition and transformation. PK are experts in air sampling devices and will work in partnership with CEH, and with the Living Labs to refine the method. The majority of their work will be conducted under task 2.2. They will be deploying air filtering systems in a number of different locations and conducting experiments to determine the optimum strategies for detecting invasive species and the nature of the species that are detected. This will include looking at the volumes of air sampled, the location of sampling and the length of time sampling. While the physical equipment and molecular techniques exist for this work we know little of how they can be deployed effectively for alien species detection.

Members of the consortium are connected with competent authorities of their countries (EV-INBO, LUKE, MBG) and will ensure the flow of information and collaboration between researchers, policymakers, and practitioners. Furthermore, tasks within Work Package 6 have been developed to extend dissemination to relevant decision-makers across the EU and beyond. The consortium has considerable experience in science-policy engagement including through leading roles in the IPBES IAS assessment and subsequent promotion of the Summary for Policymakers including to the G7. Additionally, dissemination activities will include direct engagement with other relevant stakeholders such as national road and rail authorities (AU), who are critical in implementing management practices and mitigating the spread of IAS through transportation networks. The project team have maximised the impact of previous research to industrial partners through projects such as the EC-funded Beware of the Aliens campaign (UKCEH, EV-INBO, MBG). Indeed, the consortium has considerable strength in dissemination of research findings, driven by a blend of expertise in science communication, stakeholder engagement, technology, and extensive experience in reaching diverse audiences globally. This collective strength positions the consortium to effectively communicate at local, national, and international levels. As examples, UKCEH have led many EC-funded studies and disseminated the results through peer-reviewed publications, blogs, presentations and executive summaries alongside communication materials to raise awareness of the threat of IAS. PENSOFT's track record in developing cutting-edge Open Science publishing tools will amplify the consortium's ability to deliver findings effectively to the scientific community. UoE has extensive experience in ensuring the relevance of research outputs, including conservation ecology, to diverse stakeholder groups with an

emphasis on increasing accessibility of complex concepts through both in person approaches and on-line applications.

The technical expertise of the consortium is world-leading. AU and UKCEH provide expertise in computer vision of plants and insects respectively through projects such as MAMBO, AMBER and InsectAI. MBG has experience of building image training datasets and image segmentation. LUKE and UKCEH have developed and implemented various eDNA monitoring methods, which include field sampling strategies, laboratory methodologies, and bioinformatics pipelines for diverse eDNA approaches. This expertise is further augmented by their proficiency in next-generation sequencing of eDNA. Complementing these strengths, PK is a leader in air sampling devices and the design, manufacture, sales, and supply of scientific instrumentation, enhancing the consortium's comprehensive approach to environmental monitoring and conservation efforts.

AU are experts in using artificial intelligence with high speed cameras for wildlife monitoring. They will be conducting numerous jobs in relation to this work, indeed they conduct the majority of work in Task 2.1, except for work on data standards conducted by MBG and some work on insect traps conducted by CEH. The work of AU includes further refining two pilot-tested systems to advance their technical readiness level. Deploying vehicle-mounted cameras on cars, trains, and boats for the detection of invasive alien plants along transport infrastructures. Adapting vehicle-mounted cameras to monitor roadkills, particularly focusing on invasive alien mammals. Using automated insect camera traps fitted with UV light to monitor invasive alien insect species.

The consortium is well-equipped to address the socioeconomic implications of IAS management. Drawing from a wealth of expertise in social sciences (CU, GF, IBOT-CAS), applied ecology (UoE, UKCEH), policy briefs (CIBIO, CU, GF, MBG, UKCEH), ethics (CU), biosecurity (LU) and public engagement (MBG, UKCEH, CyI, EV-INBO, UoE), the consortium can foster holistic solutions that resonate with diverse stakeholders and promote ethical, sustainable outcomes. By engaging social scientists, informaticians and ecologists the consortium maximises the potential for inclusive, ethical, and sustainable solutions (CU, GF).

Several partners have contributed to the publication of GRIIS checklist, particularly contributing taxonomic and identification skills in the areas of expertise and for their country (CyI, EV-INBO, IBOT-CAS, MBG, UKCEH, UOC, UNIVIE). In the case of EV-INBO and MBG the partners have created automated workflows that generate particularly rich GRIIS checklists from expert validated taxonomic lists in Belgium. There are also several partners with expertise in IAS risk assessment for particular taxonomic groups (EV-INBO, UOC, SU), and partners who have developed novel methods and procedures for risk assessment, including the use of species interaction networks (MBG, SU).

AU and EV-INBO are partners in Biodiversa+, working on a sub-pilot on IAS, under Biodiversa's work package for promoting and supporting transnational biodiversity monitoring. UNIVIE has led a Biodiversa+ funded project, AlienScenarios. For several

years MBG has worked closely with GBIF, contributing to their task groups on alien species information and mobilisation and use of biodiversity data for research and policy on human diseases, and has also been board member on Biodiversity Information Standards and leader of their interest group on Invasive Organism Information.

The partners embrace Open Science, fostering transparency, collaboration, and accessibility across all stages of research. With a strong commitment to making research outputs openly available, the consortium exemplifies the principles of Open Science. EV-INBO hosts the Open Science Lab for Biodiversity with a focus on open data publication and Open Source research software development. EV-INBO and MBG have considerable experience with biodiversity standards development with the Biodiversity Information Standards organisation, particularly in relation to Darwin Core and Camtrap DP and are well-engaged in the Flemish Open Science Board, EOSC and the Research Data Alliance (RDA).

The consortium has extensive experience in developing and delivering successful citizen science, demonstrated by several of the consortium partners being involved in the Alien-CSI networking action (see Table 3), driven by a collective commitment to engaging the public as valuable contributors to detection and monitoring of IAS. Leveraging expertise in training (UOC), outreach (CU, EV-INBO), technology (AU), and community engagement (MBG, UKCEH), the consortium empowers citizens to actively participate in data collection, monitoring, and the decision-making processes. The UKCEH, CU, MBG, UoE, LUKE and EV-INBO have considerable experience in co-designing and leading citizen science projects, working with citizen science organisations and analysing data collected by the general public. CU and LUKE have experience in establishing and running living lab projects, for example CU is running a Coventry living lab for urban agroecology and is a member of the European Network of Living Labs. IBOT-CAS has been involved in the development of the novel fields of invasion iEcology and Conservation Culturomics, and MBG has developed automatic workflows for meta-analysis from digital literature.

SU has significant expertise in engaging with policy at both national and international levels, notably through its contributions to the IUCN EICAT and SEICAT standards (Bacher et al. 2017, Hawkins et al. 2015). Moreover, UKCEH led the recent IPBES IAS Assessment (Roy et al. 2024), demonstrating expertise in the science-policy interface. Additionally, various partners, including CIBIO, CU, CyI, LU, MBG, UOC, and UNIVIE, have played key roles as coordinating lead authors, lead authors, or fellows of this assessment, further underlining our collaborative strength in providing evidence to inform policy decisions on IAS. All partners involved in the IPBES IAS Assessment have been engaged in promoting the Summary for Policymakers including through the development of factsheets, web platform, media and many talks and webinars. CIBIO and GF are involved in the emerging EU Science Service for Biodiversity and MBG coordinates the B3 project, which is helping to conceptualise the Green Deal Data Space, by creating policy relevant information on biodiversity at a national, continental and global level.

The consortium has extensive experience in establishing and handling large ecological databases (UNIVIE, UKCEH, UoE, CIBIO), modelling potential distributions of IAS (CIBIO, MBG, UFZ, UKCEH, UNIVIE), handling citizen science data (UKCEH, EV-INBO), developing and applying scenarios (CIBIO, UFZ, UNIVIE), and building automated workflows for modelling of IAS dynamics (MBG), including digital twins (UFZ). UoE provides expertise in building innovative online tools for the communication of complex information to a wide range of stakeholders.

Incorporating New Zealand (LU) and South Africa (SU) into OneSTOP will provide insights and enrich the initiative with detailed understanding of advanced biosecurity strategies. Both nations, known for their unique biodiversity and successful management of IAS, offer valuable lessons in control, biosecurity policies, and technological innovations. This global partnership not only fosters the exchange of research and best practices but also strengthens the global response to IAS through shared experiences and technological advancements. Members of the consortium (UKCEH, MBG) have co-led two successful COST Actions on alien species, TD1209 (2012-2017) and CA17122 (2017-2022), which have demonstrated the value of cross-border, international collaborations including increasing the impact of research through dissemination and outreach.

The OneSTOP project will be coordinated by MBG that has many years' experience leading national and European projects with large and complex consortia, examples of projects where they play or played leading roles include B^3, ICEDIG, Synthesys+, TETTRIs, TrIAS and Alien CSI. MBG will ensure that dissemination strategies are aligned with project objectives. MBG and UKCEH will co-lead the delivery of OneSTOP. UKCEH has led many national and international projects on IAS including EC-funded research on risk assessments, horizon scanning, communication and stakeholder engagement. MBG and UKCEH alongside WP leaders, task leaders and the wider consortium collectively bring a unique partnership that combines exceptional technical expertise with innovative approaches to extensive experience in dissemination and outreach to maximise the impact of the project outcomes.

NNIT (SME) is a provider of custom software development services, particularly for organisations involved in science, nature, and conservation. The company has developed software for various projects, including the Open Science Lab for Biodiversity, the Belgian Biodiversity Platform, LifeWatch, Vespa-Watch, TrIAS, and LIFE-RIPARIAS. These projects have frequently involved workflows and software related to the monitoring and analysis of biodiversity data.

4. Ethics Self-assessment

We are committed to upholding the highest standards of ethical conduct throughout our project, in line with all relevant legal and ethical requirements of the European Union, its member states, and associated countries. This commitment includes adherence to the European Code of Conduct for Research Integrity, ensuring our practices reflect

principles of reliability, honesty, respect, and accountability. Recognising the evolving nature of ethical practice, we will regularly review and refine our approach, ensuring continual improvement and strict adherence to the highest ethical standards. Our self-assessment has identified four critical areas of ethical concern: the involvement of human participants, collaboration with non-EU countries (including a middle-income country), research on data concerning endangered fauna, flora, and protected areas, and the utilisation of artificial intelligence, specifically computer vision.

Involvement of Humans in the Project

The involvement of humans '*as volunteers for social or human research*' is a necessary and integral dimension of OneSTOP. In order to better understand societal levels of awareness, attitudes and behaviour towards the prevention of IAS and also, in turn, to work closely with a set of key stakeholders in pilot testing the techniques developed through the project, they will be engaged with using a number of different social science research methods. This will include the use of questionnaires, Living Labs, workshops, interviews, and citizen science initiatives. We also aim to analyse human attitudes towards invasive species using social media and other online platforms. Research participants will include: government officials at various administrative levels; third sector environmental organisations; local business representatives, and civil society.

Personal data collection will be limited to organisational necessities, adhering strictly to GDPR guidelines, and will exclude sensitive data categories. Informed consent will be secured for all human participants. Children and individuals unable to provide consent will participate only under parental or legal supervision, for instance, in activities like bioblitzes in local parks or botanic gardens. Data anonymization where possible will be a priority to mitigate data protection risks. We are committed to inclusivity, and although specific participation of indigenous peoples and local communities (IPLC) is not foreseen, it is not excluded. Should a specific focus on ILPC be necessary, we will adhere to the CARE Principles for Indigenous Data Governance, emphasising collective benefit, authority to control, responsibility, and ethics.

Participation of Non-EU Countries

The UK, New Zealand, and South Africa are integral partners, bringing valuable insights into invasive species management, policy and research. These collaborations aim for equal partnership and intellectual property sharing. South Africa, in particular, offers extensive knowledge in biological invasions, contributing significantly to invasive species risk assessment. Ethical considerations for including a middle-income country are acknowledged, ensuring that South Africa helps to co-create, and benefits equitably, from project outcomes. Full representation in executive and advisory boards, and stakeholder consultations, is planned. The project will respect local laws, ethical standards, and cultural norms.

Research on Fauna, Flora, and Protected Areas

Our research focuses on delivering insights through “big data” analytics without direct hands-on interaction with endangered species or protected areas. While analysing publicly available data, we recognise the risks of misinterpretation or misuse. We commit to respecting biodiversity and ensuring our activities do not adversely affect endangered species or their habitats by not publishing sensitive records of the location of threatened species.

Use of Artificial Intelligence

OneSTOP explores computer vision technology for IAS detection, and large language models for information synthesis. Our commitment to ethical AI involves ensuring transparency, eliminating bias, and minimising environmental impacts. The AI's role is to augment human decision-making in invasive species management, with safeguards against misidentification of non-target entities, including people or native species. We will follow the evolving European regulatory framework proposal on artificial intelligence, evaluating risks and adapting to best practice and regulations as they are developed. Care will be taken to have technology and procedures in place to recognise and remove any pictures of people captured by our cameras. Our use of large language models will use retrieval augmented generation, to ensure that generated text is grounded in primary data sources, and so reduce the risk of false statements. None of our AI applications involve automated decision making. We are aware of the EU guidelines on ethics in AI.

OneSTOP explores computer vision technology for invasive species detection, aiming to enhance biodiversity conservation efforts. Our commitment to ethical AI involves ensuring transparency, eliminating bias, and minimising environmental impacts. The AI's role is to augment human decision-making in invasive species management, with safeguards against misidentification of non-target entities, including people or native species. We will follow the evolving European regulatory framework proposal on artificial intelligence, evaluating risks regularly and adapting to best practice and regulations as they are developed. Special care will be taken to have technology and procedures in place to recognise and remove any pictures of humans captured by our wildlife cameras. None of our AI applications will involve automated decision making systems. We are aware of the EU guidelines on ethics in artificial intelligence and recognise that this is an evolving field with guidelines and legislation emerging frequently.

Compliance with ethical principles and relevant legislation

Throughout the project, to ensure the full adherence to ethical standards and to effectively navigate any emerging ethical challenges throughout the project, the OneSTOP management structure will incorporate an Ethics Committee as a subordinate entity of the Executive Board. Comprising three members with considerable ethical expertise which (collectively) spans both social and natural sciences, namely Alex Franklin (CU), Agnes Zolyomi (GF), and Quentin Groom (MBG). Their role will involve

ensuring compliance with established ethical regulations and providing guidance on necessary updates as deemed appropriate by the Executive Board. The Ethics Committee will produce a comprehensive ethics report, reviewing our informed consent processes, participation procedures, and personal data processing methods. Their analysis will encompass both issues identified in our self-assessment and potential ethical concerns that may have initially been overlooked. Additionally, we will engage with data protection officers and ethics approval boards, or their equivalents, at all partner institutions to ensure they are fully informed about the project's activities and are involved in upholding our ethical standards and data protection practices. We will also ensure communication channels, including an anonymous one, whereby external stakeholders can raise issues of ethics with OneSTOP.

The Ethics Committee will be responsible for compiling a OneSTOP Participant Information Sheet for use in all partner activities involving human participants. This document will provide a concise written overview of the project's objectives, methodologies employed, use of results, relevance to the respondent, together with any implications of participation. The document will be translated into all languages connected with primary data collection and used in accompaniment with a participation consent form. Our data management plan will detail all processes from data collection to storage, guaranteeing transparency and compliance at every stage. All Personal Data collected will be securely stored within the European Union, in accordance with EU and national data protection regulations. We are committed to maintaining the highest standards of privacy and security for all personal information. Any data transferred outside of the EU will be fully anonymised beforehand, ensuring that it cannot be traced back to any individual. This approach safeguards the integrity and confidentiality of personal data and enables international collaboration and data sharing that fully respects EU data protection standards.

We are dedicated to respecting the dignity and autonomy of individuals, ensuring fair distribution of benefits and burdens, and upholding the rights and interests of participants. External participation in our project will be entirely voluntary, and we are acutely aware of risks related to data privacy, cultural insensitivity, and potential ecological impacts.

In Non-EU Countries, South Africa, the UK, and NZ, we will abide by local laws and ethical standards, and address cultural or social considerations relevant to conducting research in these areas. We recognise South Africa's economic status and its implications for fair benefit-sharing. No material subject to the Nagoya Protocol will be transferred during the project from South Africa, but we are mindful of the Protocol and will comply with Access and Benefit Sharing regulations within Europe.

We are aware of international regulations such as CITES though it is not envisaged that we will be working directly with material of listed species. We will only be working with data on species listed by the IUCN as Near Threatened, Vulnerable, Endangered or Critically Endangered. In these cases we will follow national rules on working with these data, and beyond that consult locally on the risks of disseminating such data, particularly

on species that might be at risk of exploitation. We will also follow the Invasive Alien Species Regulation (Regulation (EU) 1143/2014) and obligations that require us to notify national authorities. We will also support national reporting requirements by making our data FAIR and open. For analysis purposes, Air-DNA filters containing biological material will be transferred from Living Labs countries (Belgium, Finland, Portugal, Romania, UK) to partners in Finland and the UK. Before shipping these samples will be treated to ensure living material (e.g. spores) is inert. In addition, all biosecurity regulations will be followed including obtaining phytosanitary certificates where necessary.

Potential risks and mitigation strategies will be reviewed regularly at Executive Board meetings. Ethics training will be provided by CU early in the project and ethics will be a standing agenda item in project meetings, with the coordinator and ethics advisor updating the partnership on any new ethical issues, developments, or changes in legislation.

Budget

A total budget of €6,277,964.38, with a maximum grant of €5,999,990.00.

Timeline

1st January 2025 - 30th June 2028

Conflicts of interest

The authors have declared that no competing interests exist.

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