biodiversa+
European Biodiversity Partnership

EUROPEAN PARTNERSHIP

Biodiversa+ survey towards a roadmap on biodiversity monitoring novel technologies and approaches

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What is Biodiversa+

Biodiversa+ is the new European co-funded biodiversity partnership supporting excellent research on biodiversity with an impact for policy and society. It was jointly developed by BiodivERsA and the European Commission (DG Research & Innovation and DG Environment) and was officially launched on 1 October 2021.

Biodiversa+ is part of the European Biodiversity Strategy for 2030 that aims to put Europe's biodiversity on a path to recovery by 2030.

The Partnership aims to connect science, policy and practise for transformative change. It currently gathers 80 research programmers and funders and environmental policy actors from 40 European and associated countries to work on 5 main objectives:

1. Plan and support research and innovation on biodiversity through a shared strategy, annual joint calls for research projects and capacity building activities
2. Set up a network of harmonised schemes to improve monitoring of biodiversity and ecosystem services across Europe
3. Contribute to high-end knowledge for deploying Nature-based Solutions and valuation of biodiversity in the private sector
4. Ensure efficient science-based support for policy-making and implementation in Europe
5. Strengthen the relevance and impact of pan-European research on biodiversity in a global context

More information at: https://www.biodiversa.eu/

Table of acronyms

Biodiversa+	European Biodiversity Partnership
EBV	Essential Biodiversity Variables
EC	European Commission
EuropaBON	Europa Biodiversity Observation Network
UAVs	Unmanned Aerial Vehicles

Executive Summary

The goal of this report was to understand the state of deployment of five novel technologies for biodiversity monitoring, and to assess their use across partners of Biodiversa+. In order to achieve these goals, we designed a specific survey for five preselected novel technologies, *i.e.*, bioacoustics, camera traps, eDNA/genomics, Unmanned Aerial Vehicles/drones, and sensor networks, in which we asked respondents about the state of deployment of the technologies they use, their target taxa of study and the targeted Essential Biodiversity Variables (EBVs) with these methodologies. We also consulted participants in the Biodiversa+ network about the challenges and constraints they face in deploying these technologies. Overall, our survey showed very different states of deployment between the five selected novel techniques and between the targeted taxa. We observed a high variability in technology readiness, with some taxa (*i.e.*, algae, amphibians/reptiles, aquatic invertebrates, birds, fish, mammals, plants or terrestrial invertebrates) and environments still in their first stages of deployment, or even only reporting the intention to employ these novel technologies, but not having been able to do so yet. In addition, we found that, currently, technologies aimed at species and community level are more developed than those aiming to monitor ecosystem features.

To further advance in the development and actual implementation and use of novel methodologies, we suggest the need for scalable analytical pipelines and the implementation of capacity- building webinars and workshops aimed at promoting agreement and standards to facilitate the generation and exchange of data. This would enhance collaboration and transfer of knowledge between biodiversity monitoring entities who are at different stages of deployment of these technologies. This would also help with future challenges emerging from the use of these technologies, rapidly increasing amounts of data being collected and a lack of methodological and data standardisation. This is essential to achieve the larger goal, harmonisation of this rapidly growing source of biodiversity monitoring data across Europe.

1. Introduction

One of the main objectives of Biodiversa+, the European Biodiversity Partnership, is to promote and support transnational biodiversity monitoring, by building a transnational (pan-European) network of harmonised monitoring schemes on common priorities for Biodiversa+ members. For this, Biodiversa+ works on the development and deployment of new technologies/approaches for biodiversity monitoring and aims at building a roadmap that shows the current state of deployment of novel technologies across Europe and Biodiversa+ partners. To achieve this, we released a survey to relevant Biodiversa+ partners in order to collect data on the state of deployment of operational entities that use novel technologies for biodiversity monitoring aimed at supporting EU Biodiversity strategy 2030 and National and subnational counterparts. The potential of these novel technologies has been recognised by biodiversity research and monitoring activities, but their actual level of deployment in policy relevant biodiversity monitoring still needs to be explored as major bottlenecks have been identified in previous assessments.

This roadmap will guide future Biodiversa+ work on novel technologies and approaches for biodiversity monitoring, including the set-up of **capacity building events, building on recent work performed by EuropaBON** (Deliverable 4.2, 2023), our key collaborator, which consulted experts within their network on their use of novel technologies and their technology readiness level.

In this report, Section I will present the definitions and methodologies used by Biodiversa+ to develop this roadmap. Section II will detail the obtained results of the survey and investigate the trends and assessment of the state of deployment of novel technologies. Section III will present the gaps and constraints of the state of deployment of novel technologies and approaches exhibited by the Biodiversa+ partners. Lastly, Section IV will discuss the deployment level of the selected new technologies in relation to the previous report of EuropaBON (Deliverable 4.2), the studied taxa and associated constraints, and the targeted Essential Biodiversity Variables, as well as the overall conclusions of this report.

2. Definitions and methodology

Our objective of building a roadmap started with a survey aimed at Biodiversa+ partners. We wanted to gather information on the level of deployment of novel technologies in their respective parties. This would allow us to understand not only what types of technologies Biodiversa+ partners use to monitor biodiversity, but how far Biodiversa+ partners are in their deployment and where they may have challenges in deploying these novel technologies. This in turn would indicate where to focus our efforts to support the development of future pilots and guide the use of our EC top-up under the 3rd instalment.

A novel technology can be defined as a method/technology that is "*not yet widely applied in biodiversity monitoring, regardless of when proof of concept was published or otherwise released*" (EuropaBON deliverable 4.2). We limited our survey to five novel technologies to allow us to grasp a deeper understanding of each method's use and to keep the survey at a decent length for the respondents. We selected the following novel methodologies using the EuropaBON deliverable 4.2 and WildLabs survey (WILDLABS, 2021) as a reference:

- Bioacoustics: The production, transmission, and reception of animal sounds in nature. Examples of the use of novel bioacoustics methods include but are not limited to species classifiers (Artificial intelligence, *i.e.* BirdNET).

- Camera traps: Devices used remotely to record wildlife activity. They can be left in the field for long periods of time and can be activated to take photos or videos.

- Unmanned Aerial Vehicles (UAVs)/drones: Air vehicles that fly autonomously or are remotely piloted. Examples of novel methods with the use of UAVs include, but are not limited to, three-dimensional (3D) mapping, aerial imaging, oblique photogrammetry, sensing, laser scanning, the Internet-of-Things (IoT), computer vision, and artificial intelligence (AI).

- eDNA/Genomics: A technique that involves collecting DNA or RNA samples from the environment, such as from water, soil, sediment or air. There are several eDNA novel analyses which include but are not limited to, metabarcoding, shotgun sequencing or quantitative PCR.

- Sensor networks: Highly distributed networks of sensors, devices that gather environmental information at a specific location, such as temperature, pressure, and relative humidity. They are usually deployed in large numbers to monitor an environment or system.

In order to understand the level of deployment of the novel technology we have used an adaptation of the NASA Technology Readiness Scale also used in EuropaBON Deliverable 4.2, whereby a scale is used to assess the readiness of the technology. In this case, we are only interested in the actual deployment level of the novel technology as this was our task objective. Therefore, we have taken the top three levels of the NASA Technology Readiness Scale from the deployment category and added our own bottom three levels that indicate levels of "no deployment" and levels of interest (Figure 1).

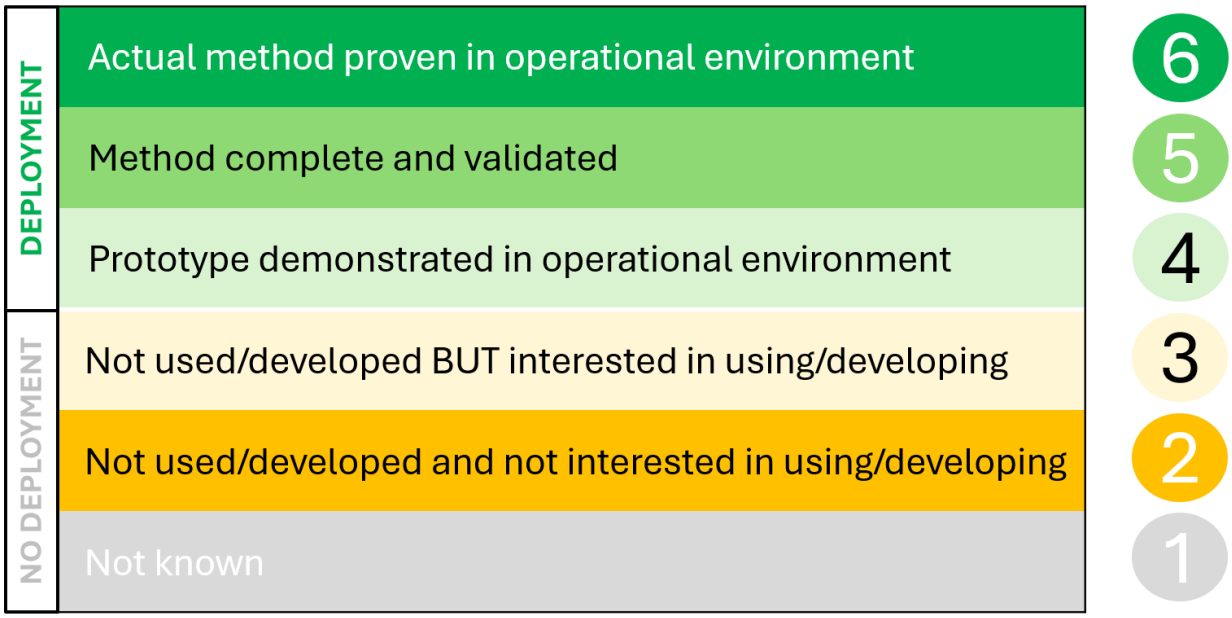

Fig. 1. Adapted NASA Technology Readiness Scale. Levels 4-6 fall under one category in NASA's scale of deployment, while levels 1-3 were adapted for this report in order to quantify the state of "no deployment."

The survey also contained questions on:

- Gaps and challenges faced by partners that may hinder their ability to further develop or use the novel technologies.
- The type of biodiversity monitoring carried out by partners per novel technology.
- The monitored taxa by novel technologies (*i.e.*, algae, amphibians/reptiles, aquatic invertebrates, birds, fish, mammals, plants or terrestrial invertebrates).
- Essential Biodiversity Variables (EBVs) targeted by novel technologies when monitoring biodiversity. The EBVs selected were grouped as follows:
    - Species traits: Morphology, movement, phenology and physiology.
    - Species populations: Species abundance and species distribution.
    - Ecosystem structure: Ecosystem vertical profile, ecosystem distribution, liver cover fraction.
    - Ecosystem functioning: Primary productivity and ecosystem disturbances.
    - Community composition: Community abundance, interaction diversity, taxonomic/phylogenetic diversity, trait diversity.
    - Genetic composition: Effective population size, inbreeding, genetic differentiation and intraspecific genetic diversity.

3. Results – Trends and assessment of the state of deployment/use of novel technologies and approaches

In total, 21 respondents from 18 countries completed our questionnaire. Figure 2 shows an overview of the deployment stage of the five novel technologies in the survey across the Biodiversa+ partners, and respective countries across Europe, who completed the survey. Overall, camera traps have the highest level of deployment, with 16 out of 21 respondents actually using them in the operational environment. eDNA and bioacoustics have also shown high levels of deployment, with 12 and 11 out of 21 respondents using them in the operational environment, respectively. The novel technologies with the lowest level of deployment were UAV/drones and sensor network methods, with only 8 and 4 out of 21 respondents using them in the operational environment. However, many participants were at a lower level of deployment for some of the novel technologies, *e.g.*, 19 out of 21 responded to at least demonstrating a prototype in the operational environment for camera trap methods, and 18 out of 21 respondents showed this for UAV/drones.

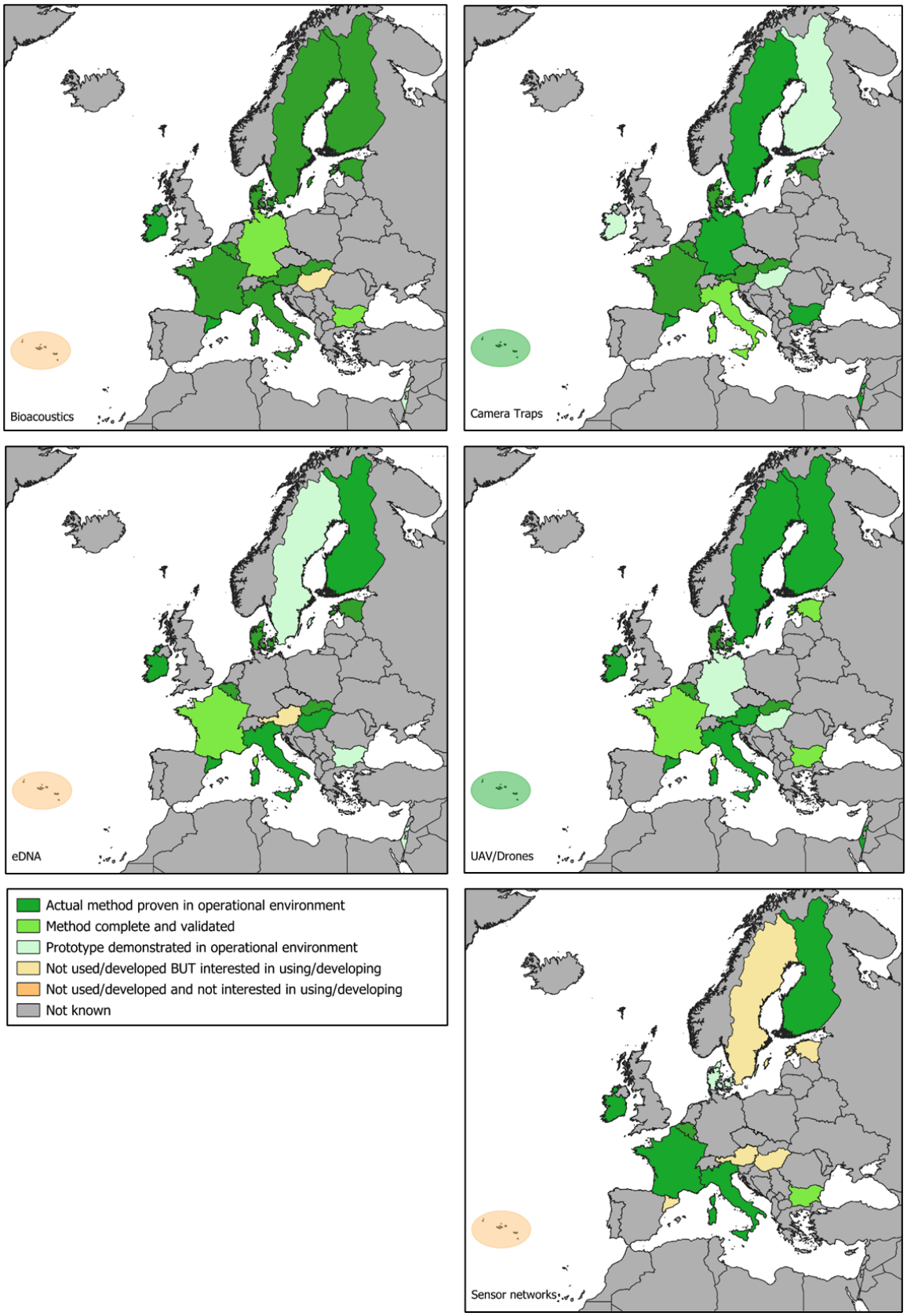

Fig. 2. The state of deployment for Biodiversa+ partners (countries) across Europe for five novel technologies. Respondents to the survey, including country and organisation, are available on Annex II.

Bioacoustics

Survey respondents have described several uses of bioacoustics in biodiversity monitoring. Many have mentioned the use of devices such as Wildlife Acoustics Song Meters, hydrophones, ultrasound detectors, audiomoths, batlogger A+, and a few also mentioned the use of the software BirdNET.

A variety of taxa were found to be monitored with novel bioacoustics tools (Figure 3), with mammals and birds having the highest levels of deployment (respectively, 70% and 65%). Amphibians/reptiles and aquatic invertebrates showed the lowest levels of deployment with no respondents using bioacoustics novel methods for both taxa, although 30-25% of all respondents, respectively, were interested in developing/using bioacoustics methods for both taxa. In addition, there was one respondent that mentioned monitoring *Zostera sp.* (a seagrass species) using echosounder techniques verifying visual detection of its depth distribution.

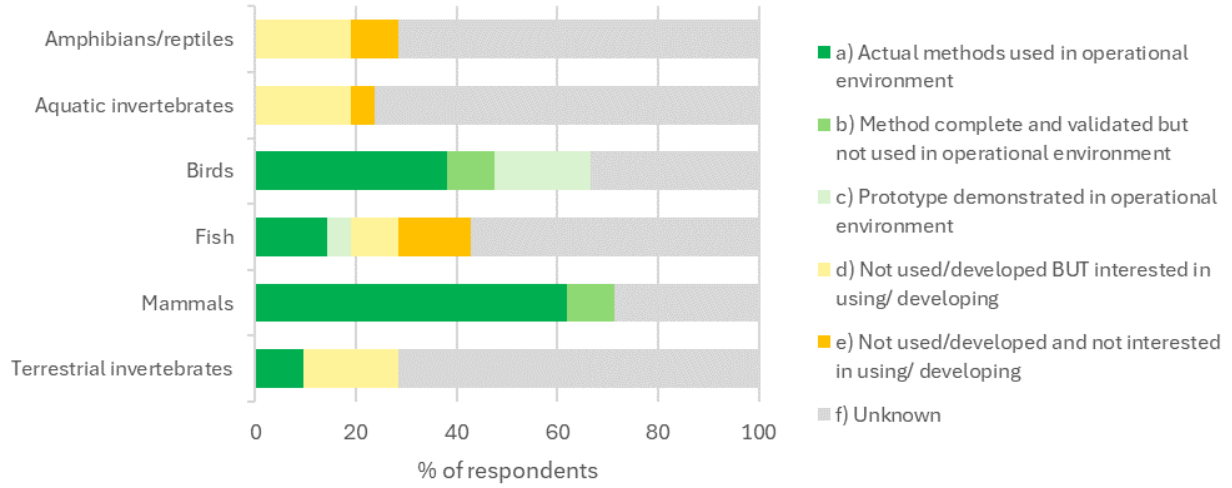

Fig. 3. Percentage of respondents from our survey that monitor the above taxa with novel bioacoustics methods and their level of deployment.

Respondents have also indicated some use of data synthesis systems for the monitoring of biodiversity with bioacoustics novel methods. Such systems include mobile applications in mammals and birds, artificial intelligence tools for birds, mammals and terrestrial invertebrates, data management tools for birds, fish, mammals, terrestrial invertebrates and aquatic invertebrates and non-AI computational tools used for mammals and terrestrial invertebrates.

EBVs were also investigated, whereby species populations, (*i.e.*, species distributions and abundances, Figure 4) were the most common EBV monitored with bioacoustics novel methods (both 70% of all respondents), and ecosystem functioning were the least common EBVs (between 0 and 15% of respondents).

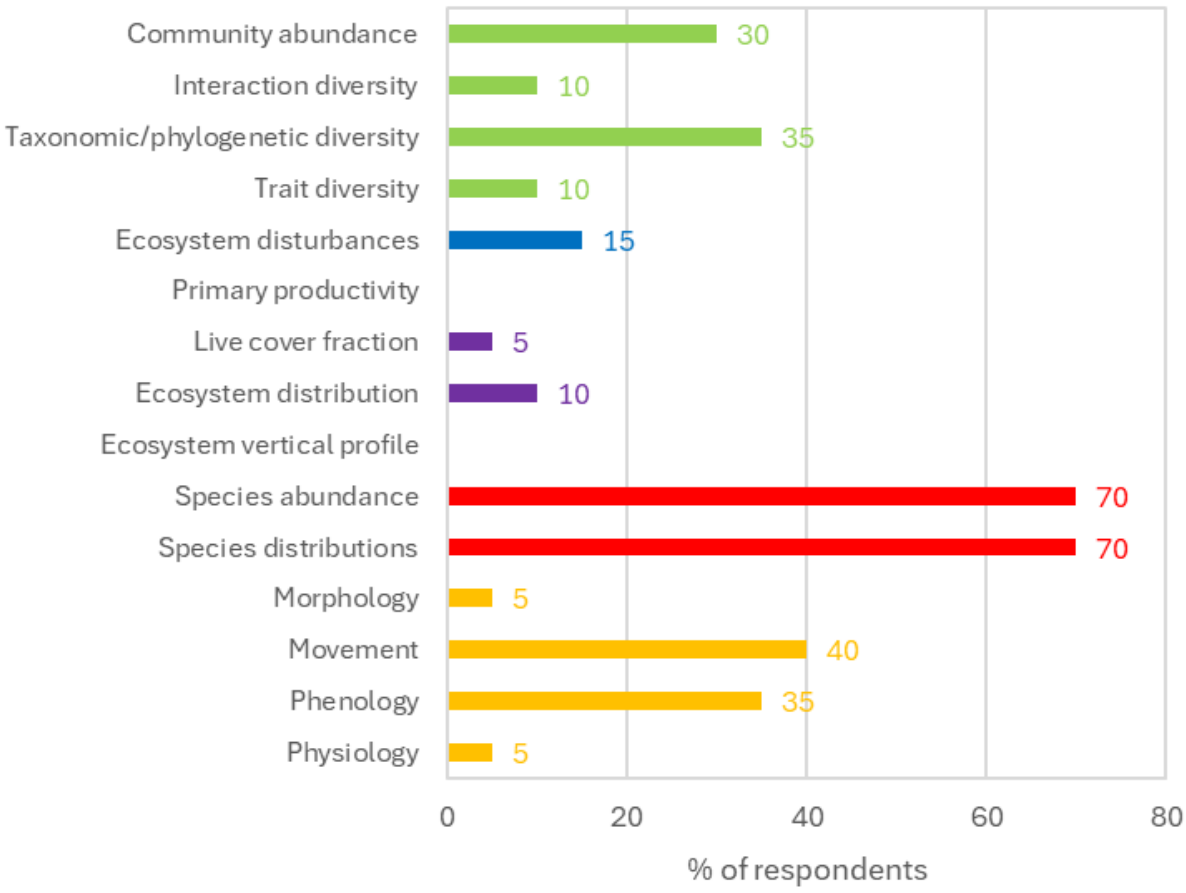

Fig. 4. Monitored Essential Biodiversity Variables (EBVs) using novel bioacoustics methods where the following colours represent grouped variables; species traits (yellow), species populations (red), ecosystem structure (purple), ecosystem functioning (blue), and community composition (green).

Camera traps

Survey respondents have described several uses of camera traps in biodiversity monitoring, using devices such as AMI traps, Model Wilsus, Wildlife Monitoring Solutions, CamAlien monitoring, Home Vista Secacam and Digital Trail Camera OGM H501.

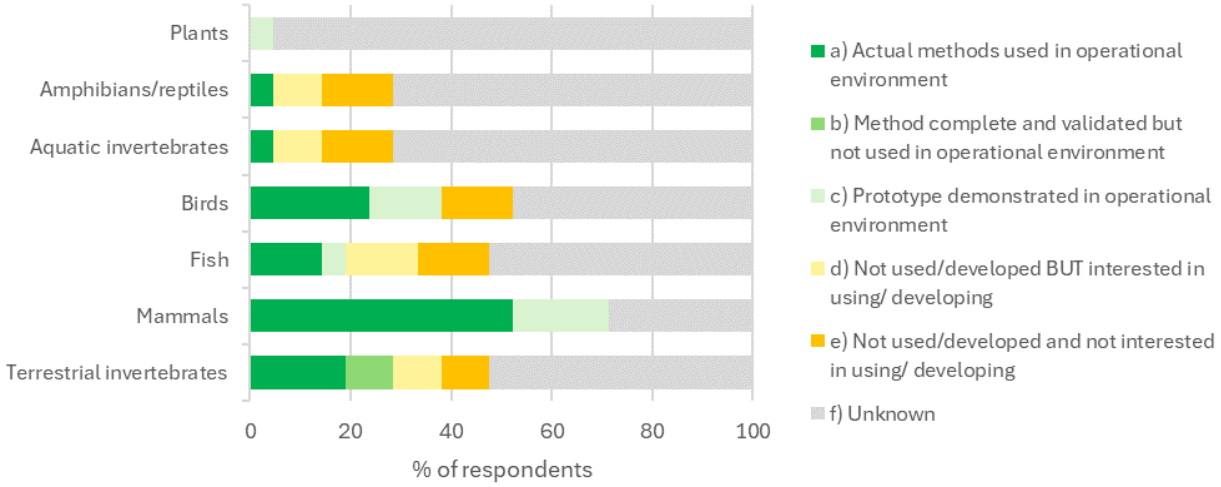

Fig. 5. Percentage of respondents from our survey that monitor the above taxa with novel camera trap methods and their level of deployment.

A variety of taxa were found to be monitored with novel camera trap tools (Figure 5), with mammals having the highest levels of deployment (75% of respondents having methods at a deployment level), followed by terrestrial invertebrates (28% of all respondents having deployed camera trap methods). Plants, amphibians/reptiles and aquatic invertebrates showed the lowest levels of deployment, all three with 5% of respondents using camera trap methods.

Respondents also indicated some use of data synthesis systems for the monitoring of biodiversity with novel camera trap methods. Such systems include mobile applications for mammals, birds, and aquatic and terrestrial invertebrates; artificial intelligence tools for mammals, terrestrial invertebrates, birds and aquatic invertebrates; data management tools for mammals, terrestrial invertebrates and birds, and fish and aquatic invertebrates; and non-AI computational tools used for mammals and birds.

Species populations were the most common EBVs monitored with novel camera trap methods (80-75% of respondents), whereas ecosystem structure (0-20% of respondents) and functioning (0-15% of respondents) were very rarely monitored with this method (Figure 6).

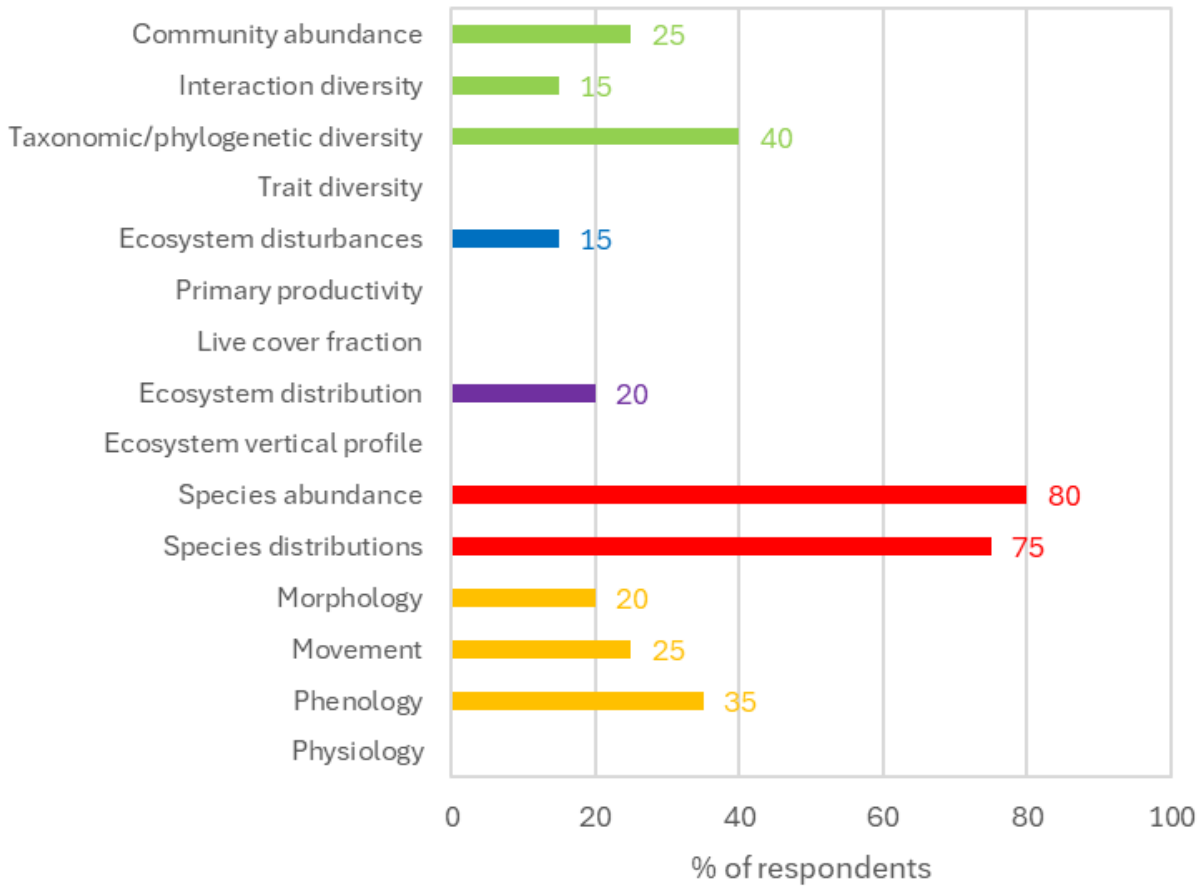

Fig. 6. Monitored Essential Biodiversity Variables (EBVs) using novel camera trap methods where the following colours represent grouped variables; species traits (yellow), species populations (red), ecosystem structure (purple), ecosystem functioning (blue), and community composition (green).

UAV/Drones

Survey respondents have described several uses of drones in biodiversity monitoring, such as aerial drones for lidar and thermal imagery techniques, remotely operated vehicles (ROT) for underwater monitoring, and Multispectral and NDVI drones.

Although there is a high number of taxa being monitored by drones, there are several taxa with low levels of deployment, such as fish, amphibians/reptiles and aquatic invertebrates (Figure 7). Birds were shown to have the highest levels of deployment (with 30% of respondents at a deployment stage), followed by mammals (with 25% of respondents at a deployment stage). One respondent also mentioned the use of lidar monitoring for peatland restoration work.

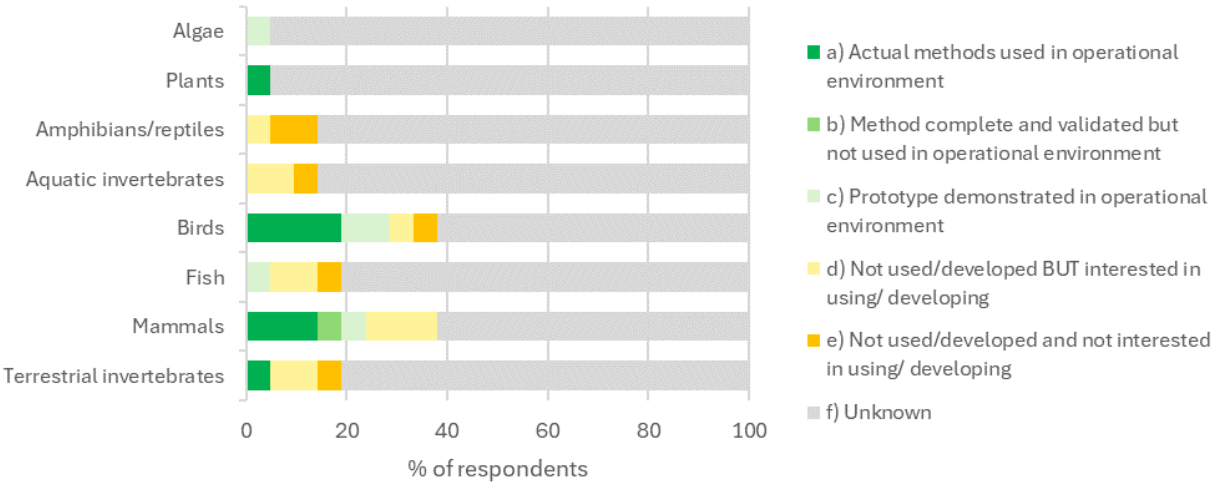

Fig. 7. Percentage of respondents from our survey that monitor the above with novel drone methods and their level of deployment.

Respondents indicated little use of data synthesis systems (25% of all respondents) for the monitoring of biodiversity with novel drone methods. Mobile applications, protected area management tools and data management and processing tools are in use for birds, and data management and processing tools are used for mammal biodiversity monitoring.

In terms of EBVs monitored with drones, there was a dispersed proportion of respondents using a variety of EBVs (Figure 8), with the most common: species distributions (30%) and abundances (25%), ecosystem disturbances (25%) and distributions (20%), and community abundance (20%).

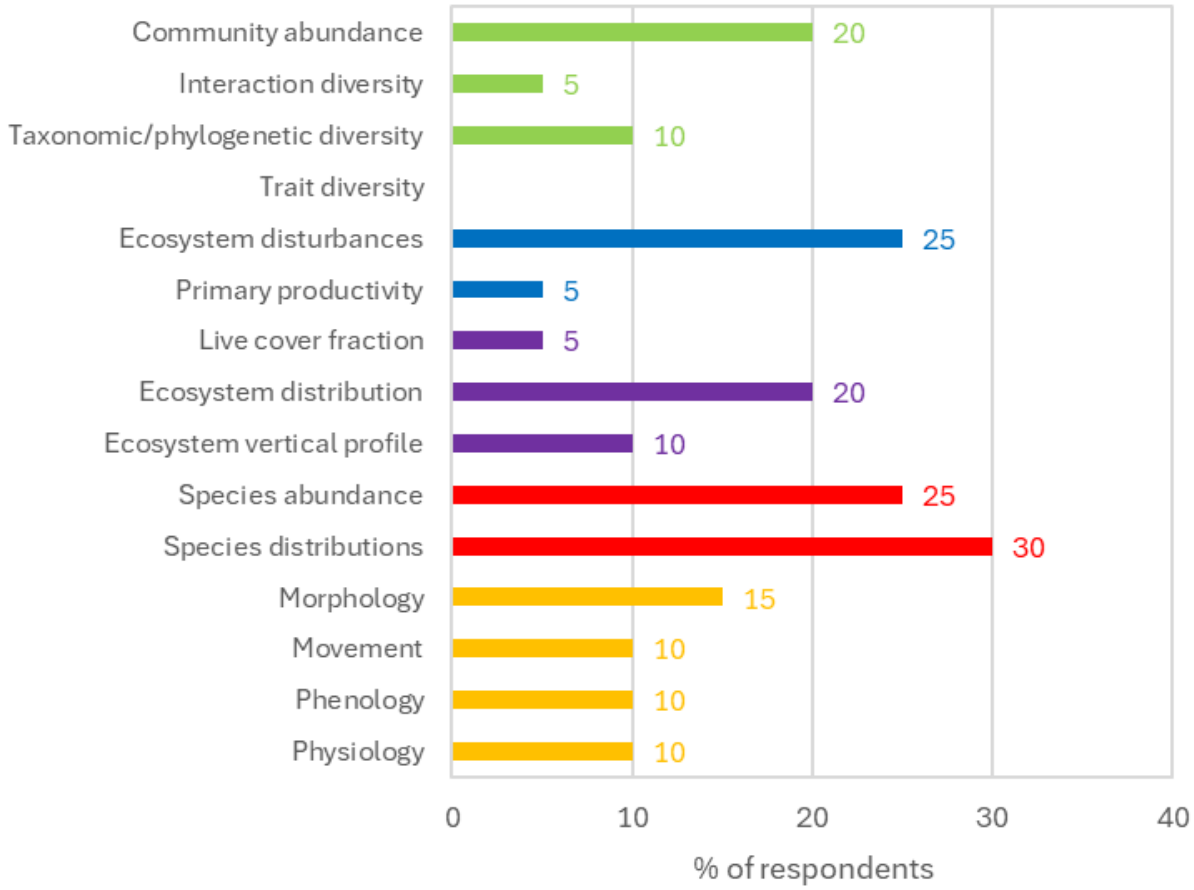

Fig. 8. Monitored Essential Biodiversity Variables (EBVs) using novel drone methods where the following colours represent grouped variables; species traits (yellow), species populations (red), ecosystem structure (purple), ecosystem functioning (blue), and community composition (green).

eDNA

Survey respondents have described several techniques to use eDNA in biodiversity monitoring. For example, metabarcoding, airbourne eDNA, bat genomics, using 12S genetic markers for identification, IOLR, ddPCR targeted detection, PCR-based techniques (Microsatellite markers, Mitochondrial DNA analysis, Genetic sex determination), and qPCR techniques.

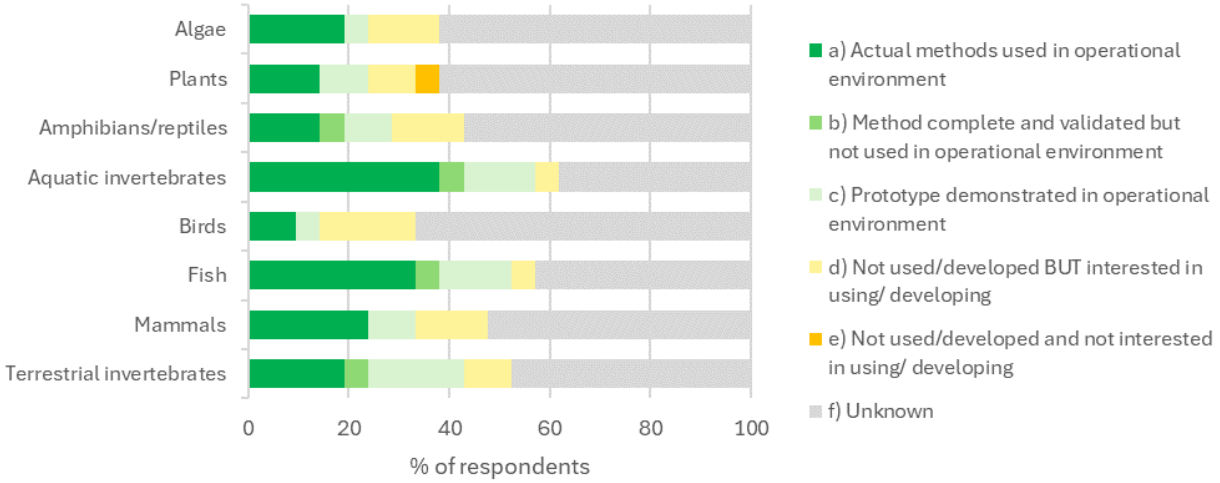

Fig. 9. Percentage of respondents from our survey that monitor the above with novel eDNA methods and their level of deployment.

eDNA techniques were used to monitor all eight different taxa in this questionnaire. At least 45% of respondents monitor three different taxa (aquatic invertebrates, fish, and terrestrial invertebrates) each at the deployment stage. Birds, plants and algae had between 15% and 25% of respondents with actual eDNA methods used in the operational environment but in general these three taxa showed the lowest levels of deployment (Figure 9).

Respondents indicated little use of data synthesis systems for the monitoring of biodiversity with novel eDNA methods. Non-ai computational tools were the most common, used for biodiversity monitoring in all eight taxa. Mobile applications were found to be used in fish, mammals, and terrestrial invertebrate monitoring; data management processing tools in aquatic invertebrates, fish, mammals and terrestrial invertebrates; protected area management tools in fish, and artificial intelligence tools in terrestrial invertebrates and fish.

The most common EBV monitored using novel eDNA methods was species populations (55-65% of respondents studying these traits; Figure 10), followed by community composition (10-45%). The least monitored were ecosystem functioning and structure (5-15% of respondents).

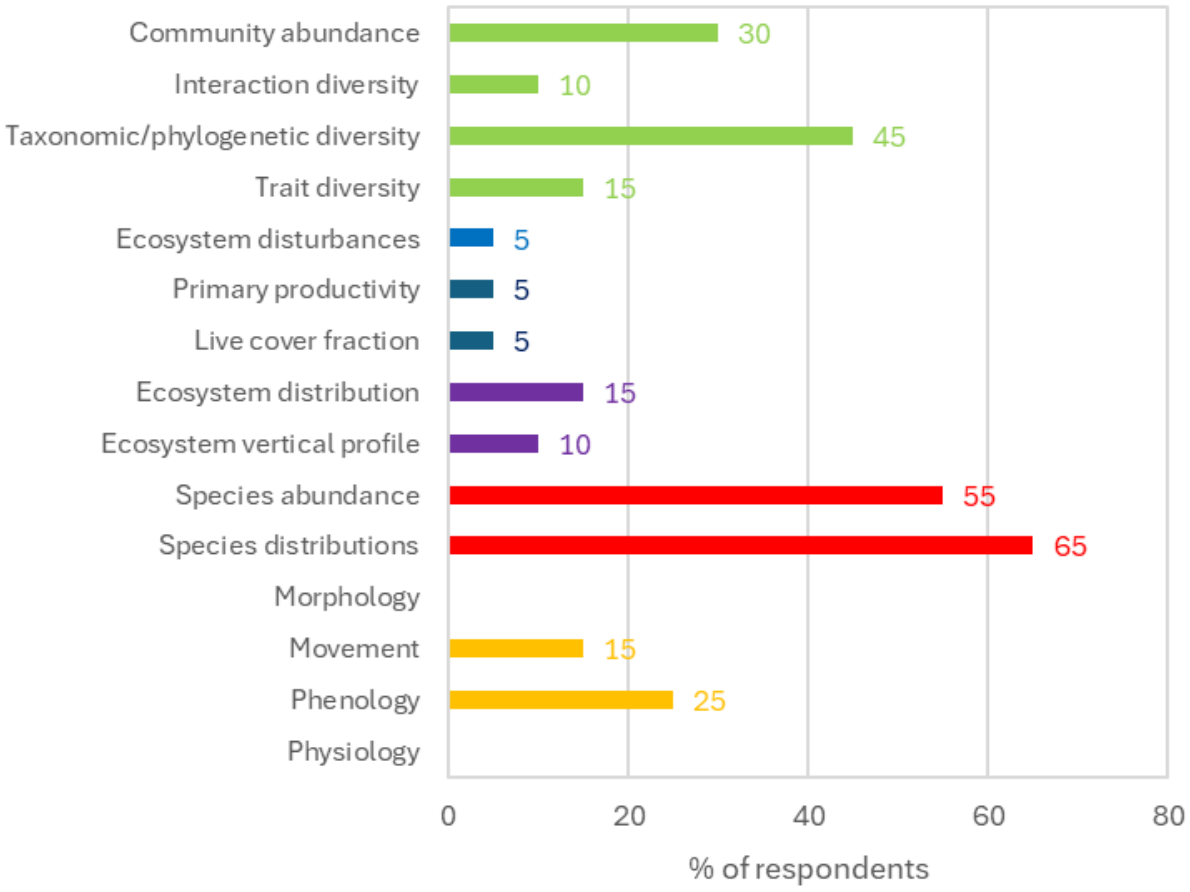

Fig. 10. Monitored Essential Biodiversity Variables (EBVs) using eDNA novel methods where the following colours represent grouped variables; species traits (yellow), species populations (red), ecosystem structure (purple), ecosystem functioning (blue), and community composition (green).

Sensor networks

The few sensor networks methods that were described to be used by the respondents varied between using TMS4 loggers, using a monitoring program to measure ambient conditions of the sea, flux towers to monitor and help restore peatlands, 3D mobile bird radars to monitor flying height and routes, habitat monitoring machine learning software, organic sensors, and Barotrauma detection systems (BDS) sensors that measure water abiotic variables in conjunction with fish backpack sensors for telemetry investigations of fish. In addition, one respondent described a highly integrated system that has several microclimate stations which collect several parameters of the air and soil and vegetation, all of which is remotely accessible, powered by photovoltaic systems and automated in terms of the flow of data and images collected.

Sensor networks were found to be very under deployed, as seen from the higher proportion of unknown and “no development” classes selected by respondents or a complete lack of response (Figure 11). Fish were shown to be the only taxon that had actual sensor network methods deployed in the operational environment (10% of all respondents).

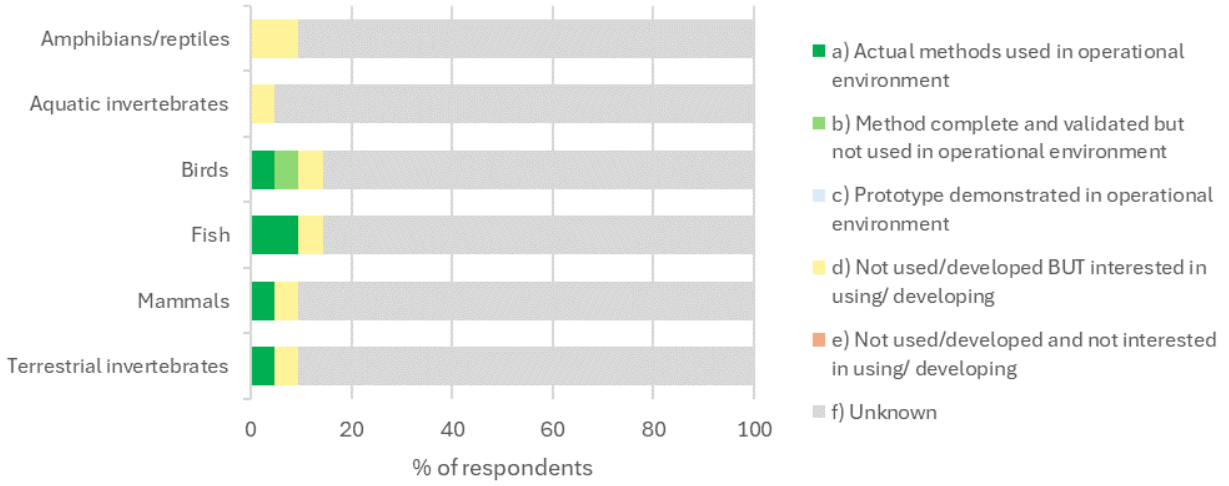

Fig. 11. Percentage of respondents from our survey that monitor the above with novel sensor network methods and their level of deployment.

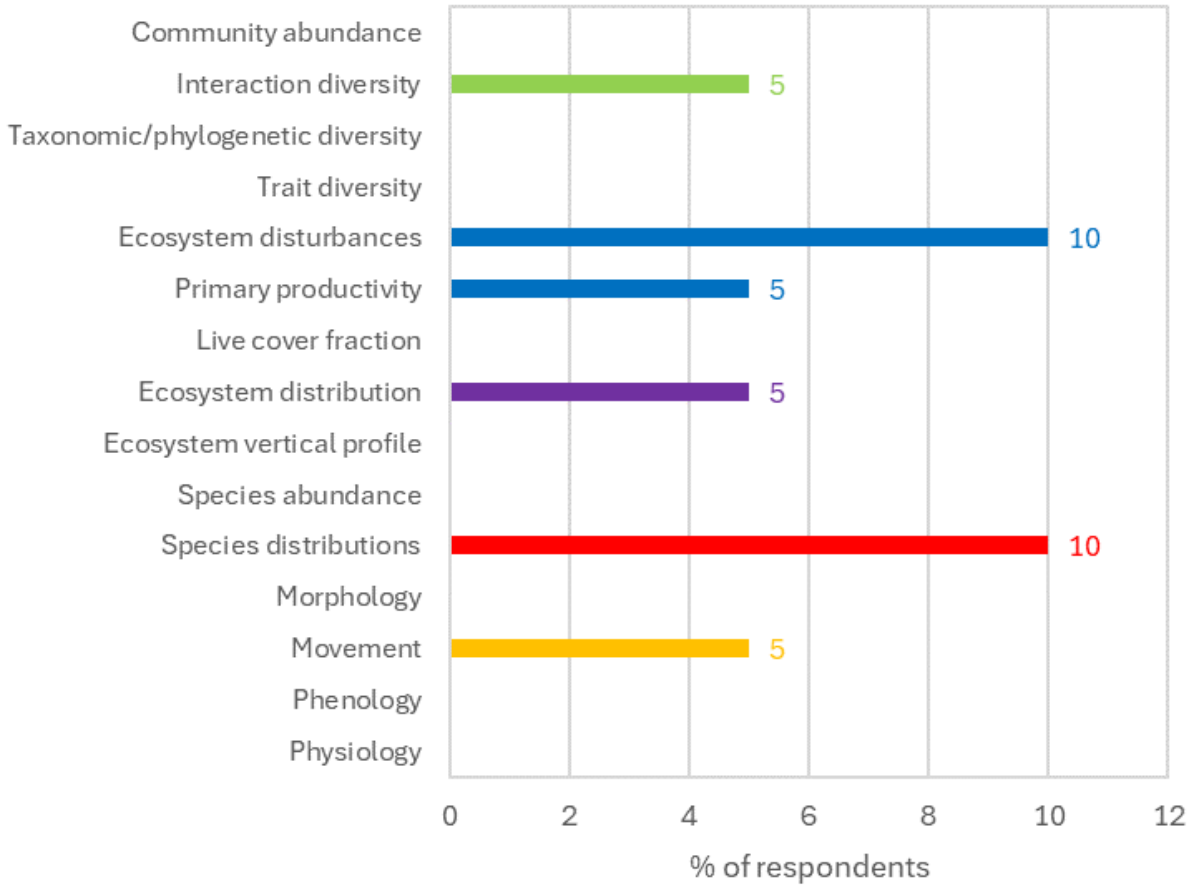

Fig. 12. Monitored Essential Biodiversity Variables (EBVs) using sensor networks where the following colours represent grouped variables; species traits (yellow), species populations (red), ecosystem structure (purple), ecosystem functioning (blue), and community composition (green).

Respondents have shown very little use of any data synthesis systems for sensor networks, with only 2% of the respondents using data management processing tools for mammals and terrestrial invertebrates, and 1% using artificial intelligence tools for monitoring terrestrial invertebrates.

As very few respondents use sensor networks there was a small proportion of respondents that monitor any EBVs, however the most common were species distributions and ecosystem disturbances (both with 10% of respondents; Figure 12).

4. Results – Gaps and constraints of the state of deployment of novel technologies and approaches

Respondents seem to be facing a variety of constraints (27 in total, including others specific to respondents, grouped into 8 categories) in their deployment of the selected novel technologies (Figure 13). In general, respondents most commonly face data issues such as data storage, analysis, synthesis, and integration (31% of all constraints across all five novel technologies). Other common constraints were lack of capacity/training, costs, and technical difficulties (16% of all constraints across all five novel technologies for each challenge).

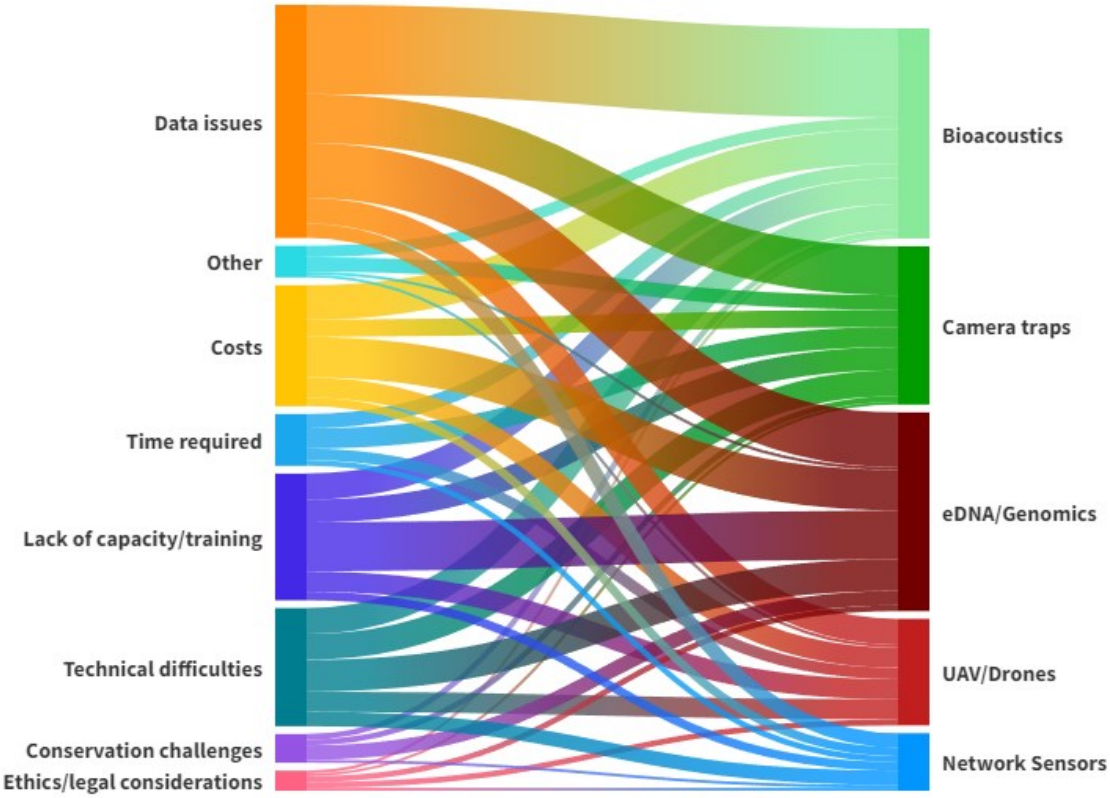

Fig. 13. Sankey diagram displaying the number of challenges and constraints (left-hand side) faced by Biodiversa+ partners in the development and/or use of the novel technologies (right-hand side). Coloured bands indicate relationships between them.

Bioacoustics

Out of all respondents that deploy bioacoustics novel methods, 96% indicated facing constraints in their deployment of novel bioacoustic methods for biodiversity monitoring, with records from 18 different constraints in total. The most common constraints were data related (41% of all respondents), specifically data analysis, storage, and synthesis. Costs, technical difficulties, and lack of capacity/training (16%, 12% and 12% of all respondents, respectively) also showed to be common constraints for the

respondents. On the other hand, six respondents mentioned plans for deploying bioacoustic methods further. A few mentioned the monitoring of new taxa and others mentioned using new methods such as automation of bat echolocators by SPNI.

Camera traps

Respondents mentioned 15 different challenges faced by the deployment of camera traps, with 95% of respondents mentioning at least one. Data related issues (29% of all respondents), specifically data storage and data integration, scored the highest. Other common constraints were technical difficulties (16% of all respondents), lack of capacity/training (14% of all respondents) and funding costs (10% of all respondents). There were also several respondents that mentioned difficulty in the automation process in terms of species identification, describing a lack of software. Notably, ten respondents mentioned interest in further developing their camera trap methods, most of which described expansion in the use of automation and machine learning for image analysis.

UAV/Drones

Respondents mentioned 16 different challenges faced by the deployment of drones, with 55% of respondents mentioning at least one. Data related issues was the most common constraint (24% of all respondents), specifically data storage and difficulty in comparing results. Other common constraints were technical difficulties and costs (18% of all respondents for both), specifically lack of funding. Lack of capacity/training was also a common constraint (14% of all respondents). Three respondents mentioned plans for further developing their drone methods for biodiversity monitoring.

eDNA

Fifteen constraints were mentioned for eDNA methods by 90% of the Biodiversa+ respondents. Data issues were the most common constraint (27% of all respondents), specifically difficulties in comparing results (11% of respondents). Lack of capacity/training was the second most common constraint (24% of all respondents). Other common constraints found for the deployment of novel eDNA methods were costs (20% of respondents) and technical difficulties (18%). eDNA was also the only novel technology whereby zero respondents selected time required as a constraint. Four respondents mentioned plans for further developing their use of eDNA novel methods.

Sensor networks

A small number of respondents (35% of respondents) mentioned constraints in their deployment of sensor networks, indicating 14 different constraints in total. Technical difficulties and data issues were the most common constraint (24% of all respondents for both constraints), followed by lack of capacity/training and costs (14% of all respondents for both constraints). Two respondents mentioned plans for further developing their sensor network methods.

5. Discussion and Conclusions

Results from our survey indicate differences in deployment stages across the five novel technologies. The number of respondents that were deploying each novel technology in an operational environment ranged between five and 20. Most in use for biodiversity monitoring are camera traps, not only across taxa, but also across EBVs. Sensor networks were shown to be at the lowest stages of deployment, with few respondents actually deploying sensor networks for biodiversity monitoring and with several even indicating that this was their first-time hearing about this novel technology.

Novel technologies deployment in comparison to EuropaBON Deliverable 4.2

Although the EuropaBON (deliverable 4.2) quantified the level of technology readiness in three ranges (*i.e.*, research - development - deployment), and our report only examines this by using a binary metric (non deployment - deployment), the results are comparable among the common novel technologies, as we use part of the scale from NASA (NASA Technology Readiness Scale), and therefore consider the levels of deployment in EuropaBON (deliverable 4.2) similar to the level of deployment in our report. In addition, the EuropaBON deliverable consulted experts on novel technologies, contrary to this report, in which we consulted the use of novel technologies by biodiversity managers in support of the EU Biodiversity strategy 2030 and National and subnational counterparts.

For bioacoustics, we obtained opposite results depending on the taxa, with very high levels of deployment in operational environments for some taxa (mostly mammals and birds, but also fish and terrestrial invertebrates), and conversely no deployment or even interest in implementing these methodologies for other taxa even when potential application in them appears possible in some cases *i.e.* amphibians/reptiles or aquatic invertebrates. Some of our results were similar to EuropaBON (deliverable 4.2), which reported a high level of development and deployment, mostly relevant for birds and with potential application for fish according to experts. However, in EuropaBON analyses, they also report the interest in applying bioacoustics for amphibians in combination with AI technologies, which was not reflected by the results of our survey.

Our results also matched those of EuropaBON (deliverable 4.2) regarding the use of camera traps. We observed high levels of deployment in most taxa (particularly mammals), and EuropaBON (deliverable 4.2) reported interest of experts in applying this methodology for amphibians/reptiles which, among other groups, were still in the development area. This is consistent with the low levels of deployment but interest in use reported in our survey for both amphibians/reptiles and aquatic invertebrates. In fact, EuropaBON (deliverable 4.2) reported some deployment examples for terrestrial invertebrates in line with our results.

The deployment of UAVs/drones according to our survey was high, with actual use in the operational environment mostly for birds and mammals, but also for plants and terrestrial invertebrates, and with less deployment reported for algae and fish. These results are consistent with those of EuropaBON (deliverable 4.2), where they also reported high deployment levels for mammals, birds, and plants under the UAVs or remote sensing.

Methodologies associated with eDNA/genomics appeared to be among the most widely deployed technologies with actual methods used in the operational environment according to our respondents and experts of EuropaBON (deliverable 4.2). In our survey, we observed high deployment levels especially for aquatic invertebrates and fish, with dispersed level of deployment across respondents, and interest in using it for the eight taxa consulted. Similarly, EuropaBON (deliverable 4.2) described eDNA techniques as some of the most likely methods to be implemented due to its high number of records and use. They reported how eDNA was also highly applied in most taxa, and that it was one of the few exclusive methods that could be highly deployed for some, such as amphibians/reptiles, or that were particularly relevant for others, such as aquatic invertebrates.

When looking at the results from the EuropaBON (deliverable 4.2), sensor networks also showed a low number of mentions/records during the workshop, in comparison to other novel methodologies. However, of those records, the technology readiness level was always at least (and with most records) at a high development stage (method demonstrated in relevant environment), with very few records at a high deployment stage. This is similar to our results, both in the low number of respondents using this novel technology, and in the majority of respondents not being at any deployment stage.

Deployment by taxa and associated constraints

A more detailed analysis of the different taxa and the state of deployment of the novel technologies showed terrestrial invertebrates more commonly monitored with camera traps and eDNA with actual methods deployed in the operational environment. A few respondents described monitoring pollinator species using time lapse cameras (camera traps) as well as metabarcoding and barcoding techniques (eDNA). This was similar to the results from EuropaBON (deliverable 4.2) whereby the most highly ranked novel methods identified were automated imaging and recognition techniques for insects. The constraints for this, however, were found to be related to lack of taxonomically comprehensive and precise reference data/training data libraries, which was one of the most common constraints found in our survey for the deployment of eDNA.

Mammals were shown to be monitored using all five technologies; however, bioacoustics and camera traps had the most records at the highest deployment stages. Several respondents monitor marine mammals and bats with novel bioacoustic methods. Camera traps are also used to monitor large terrestrial mammals such as ungulates and carnivore species. These results were similar to those found in the EuropaBON deliverable (4.2) whereby camera traps have had a strong history for monitoring mammals, as well as bioacoustic monitoring for vocalising species. Lack of funding was found to be a common constraint for the development of camera traps in this survey as well as by experts (EuropaBON deliverable 4.2).

Environmental DNA was the most commonly deployed technology in the biodiversity monitoring of fish. This was dissimilar to what was mentioned by experts (EuropaBON deliverable 4.2) as currently (2023) a large portion of fish monitoring relies on fishery-dependent techniques or in situ-diver surveys in Europe. However, experts did suggest that the use of eDNA was a budding approach for fish monitoring, mentioning the poor standardisation and reference libraries which were found to be common constraints in the use of eDNA in this survey as well.

Birds were the taxa most commonly monitored and with highest stages of deployment by novel bioacoustics methods. UAVs and camera traps were also often used and had high stages of deployment for the biodiversity monitoring of birds. Experts (EuropaBON deliverable 4.2) also found that biodiversity monitoring of birds varied in the novel monitoring methods used. Constraints found with the deployment of bioacoustics for monitoring birds include data analysis and synthesis challenges mentioned both by experts and respondents from our survey. EuropaBON (deliverable 4.2) similarly mentioned the use of data synthesis systems such as mobile applications that have been used for bird monitoring both by experts and survey respondents to aid with data structure and usability (that gathered from citizen science projects).

Environmental DNA was most commonly used and most highly deployed novel technology for the biodiversity monitoring of aquatic invertebrates, like in the EuropaBON deliverable 4.2. Respondents have described using novel eDNA techniques for monitoring aquatic invertebrates such as coral species, crustacean species, freshwater mussels and aquatic insects. Similar to fish, poor standardisation (difficulties in comparing results) and lack of reference libraries which were found to be common constraints in the use of eDNA by experts and in this survey as well.

Amphibians/reptiles, algae and plants overall had lower deployment levels across all novel technologies in comparison to other taxa, however all three showed highest deployment levels in eDNA methods. This was similar to what was mentioned by the experts (EuropaBON deliverable 4.2), whereby novel methods for monitoring amphibians and reptiles were ranked the lowest in their technology readiness largely due to the need for validation and testing, with eDNA being the only method type identified as suitable. In the case of plants, the most dominant method type was remote sensing, which is probably why there were very low deployment levels and responses from Biodiversa+ partners for the five technology types questioned in the survey. Although eDNA was mentioned and suggested as a method to monitor plant biodiversity. Algae was not mentioned in the EuropaBON deliverable 4.2.

Essential Biodiversity Variables targeted by the novel technologies

Overall, the monitoring of the different EBVs varied depending on the novel technique employed, but we observed a slightly higher tendency to monitor species population and community composition variables for all five novel techniques consulted. These results, although less evident in our report, are consistent with the results of the EuropaBON (deliverable 4.2), where they observed an overwhelming majority of novel methods being used for quantifying species distributions and abundances. In contrast, none of the respondents in our survey appeared to monitor any of the genetic composition EBVs using the five selected novel techniques, contrary to the results indicated by EuropaBON (deliverable 4.2), where the genetic composition variables were among the least studied but were at least represented in the results. The lack of representation of genetic composition EBVs in our survey compared to EuropaBON could be due to the previous selection of novel techniques we established in our survey (since EuropaBON deliverable 4.2 did not restrict the number of techniques for their report) or due to the limited scope we obtained in our survey despite having similar number of responses to EuropaBON (deliverable 4.2).

Among the five technologies targeted in our survey, four of them (*i.e.*, camera traps, eDNA/genomics, bioacoustics and UAV/drones) were used to monitor several traits (at least two out of the traits included in each EBV groups) from three main EBV groups: species population, species traits and community

composition; whereas traits related to ecosystem (*i.e.,* ecosystem structure and functioning) were not as often targeted. UAV/drones and bioacoustics were the two novel technologies that targeted the most traits, UAV/drones being used for monitoring all included EBVs except for trait diversity (community structure group) and the genetic composition variables. Bioacoustics were also used to monitor all traits except for ecosystem vertical profile (ecosystem structure), primary productivity (ecosystem functioning) and genetic composition variables. On the contrary, we observed that the novel technology that targeted the least amount of EBVs was sensor networks, likely due to the lack of respondents employing this novel technology for monitoring.

In our report, the least commonly targeted metrics were trait diversity, primary productivity, live cover fraction, ecosystem vertical profile and physiology. Among those, ecosystem vertical profile and genetic diversity were similar to EuropaBON (deliverable 4.2). In contrast, the metric interaction diversity, which was also among the least targeted metric in EuropaBON (deliverable 4.2), was relatively targeted in our survey with between 5-15% of respondents monitoring this EBV in the five selected novel technologies.

6. Key takeaways

Our survey has uncovered a wealth of knowledge on Biodiversa+ partners' state of deployment of novel technologies for biodiversity monitoring across Europe. The limited number of respondents makes it difficult to generalise results beyond the countries contributing to the survey, but some patterns can be described. Thus, we observed that the selected novel technologies in our survey targeted rather species or community EBVs compared to ecosystem EBVs, which might be indicative that novel technologies are moving faster to analyse species ecology instead of ecosystem features.

The state of deployment of the targeted five novel technologies is highly variable, however, all methods are fully deployed in the field by at least one partner. This means that, among the partners, we at least have all the skills and knowledge needed for other partners to improve their current deployment levels. In fact, some methods like eDNA, UAVs or camera traps appeared to be widely implemented for some taxa, which can lead to increased range of taxa monitored by Biodiversa+ partners. This kind of situation could be improved by strengthening the ties across partners using novel technologies in different countries in order to share experience, tools and standards used. Technical difficulties also hamper the deployment in different countries thus making the advancement of these technologies arduous and time and resource consuming. For instance, the development of workflows and pipelines to collect and analyse novel technology data is now advancing in different countries, but more cooperation and joint ventures could be promoted across partners collecting this information with the objective of reducing the implementation cost.

It is already clear that the implementation of all these new technologies is not without its problems. Like in any field, procedures need to be standardised to compare results, and the accumulation of data can lead to problems with data management or data storage. Capacity building webinars and workshops will be needed to share expertise and allow for collaboration across regions and countries. Technology challenges are shared by all partners. Developing common protocols and technical applications for shared data management and analysis may be a more difficult path initially than working unilaterally, but in the medium to long term it can generate scale multiplier effects in the use and application of these types of new technologies. Europe should work towards a network that could facilitate the continuous development, standardisation and implementation of novel technologies for biodiversity monitoring. One such network is the European research infrastructure eLTER, which is combining >60 mandatory measurements, among them acoustic biomonitoring, flying insects, soil and water eDNA, at about 200 sites across all ecosystem types in Europe. Also, the proposal of an European Biodiversity Observation Coordination Center (Liquete et al. 2024) could work to provide the needed venue to bring novel technology experience across Europe together. These initiatives will help the Biodiversa+ partners to better articulate and jointly respond to emerging challenges and advance towards more effective harmonisation across Europe in the tools and research used for biodiversity monitoring.

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ANNEX I – Survey sent out to partners

Biodiversa+ survey towards a roadmap on biodiversity monitoring novel technologies and approaches

Introduction

One of the main objectives of Biodiversa+ is to promote and support transnational biodiversity monitoring, by building a transnational (pan-European) network of harmonised monitoring schemes on common priorities for Biodiversa+ members. This current survey is built upon deliverable 4.2 by EuropaBON, "Novel technologies of biodiversity monitoring" and is specifically related to Biodiversa+ task 2.3 "**Develop and/or deploy new technologies/approaches for biodiversity monitoring** " (https://doi.org/10.3897/arphapreprints.e105600).

This survey aims at tackling the **testing and deployment of new technologies and approaches for biodiversity monitoring across Biodiversa+ partners** aimed at supporting EU Biodiversity strategy 2030 and National and subnational counterparts. The potential of these novel technologies has been recognized by biodiversity research and monitoring activities, but their actual level of deployment in policy relevant biodiversity monitoring still needs to be explored major constraints bottlenecks identified in previous assessments.

This survey specifically aims at:

1. Understanding the level **of deployment of novel technologies used for policy relevant biodiversity monitoring activities by Biodiversa+ partners at several scales** (transnational, national and sub-national). We will focus, more specifically, on five novel technologies, bioacoustics, camera trapping, eDNA and genomics, sensor networks, and UVAs/drones.
2. **Identify challenges and gaps Biodiversa+ partners** are facing with their deployment/use of novel technologies for the monitoring of biodiversity.

This survey is specifically addressed to Biodiversa+ partners and in the case that you are unable to answer questions due to limited information, we highly encourage you to complete it with the support of your colleagues and when relevant to your third parties. Please share names and contact details of any third party that have helped to complete this survey in the respective sections.

To get more detailed feedback on some elements, bilateral interviews may follow for a better understanding on the state of deployment of novel technologies used for biodiversity monitoring in your country or region. **The results will be used to further guide the Biodiversa+ biodiversity monitoring capacity building activities for partners, as well as to develop roadmaps on how novel technologies can be operationalized for transnational pan-European biodiversity monitoring** (due May 2024).

Please note that the deadline to send us back your answers is on the **17rd of April** (at 10am CEST).

Many thanks in advance for your support!

Privacy Notice

Biodiversa+ conducts this survey to develop a roadmap on biodiversity monitoring novel technologies and approaches.

By answering this questionnaire, you accept that DACC, FRB, MoE_FI, three Biodiversa+ partners, will collect your contact details namely: your first and last names, the full name of your organisation, the

acronym and country of your organisation, your email address will be processed to better analyse your answers and contact you later on, if needed.

These data will be securely processed and stored, in compliance with the European General Data Protection Regulation 2016/679, and used only for the purposes of this consultation. The deletion of your personal data will take place on the 30th of September 2028, at the end of Biodiversa+.

At any time, please keep in mind that you will have the possibility to consult, modify, update or delete your personal data by contacting the Biodiversa+ Operational Team at the following email address: cecile.mandon@fondationbiodiversite.fr

☐ By ticking this box, I confirm that I read the above-mentioned conditions and accept to share my personal data.

Information on your organisation

Name

Email address

Name of your organization (in English)

Acronym of your organisation (as mentioned in the Biodiversa+ Grant Agreement)[1]

Country of your organisation (in English)

Level of the information that you are going to present (national/ federal/ subnational…)?

Realms on which you conduct policy relevant biodiversity monitoring. (multiple answers possible)

- Terrestrial
- Marine
- Freshwater

Type of respondent (select from list)

- Ministry of Environment
- Environmental Agency
- Research Ministry
- Other (if other: free text) [2]

Section I – Novel Technologies

A novel technology can be defined as a method/technology that is “not yet widely applied in biodiversity monitoring, regardless of when proof of concept was published or otherwise released” (https://doi.org/10.3897/arphapreprints.e105600).[MH3] This questionnaire targets the use of novel technologies in policy related biodiversity monitoring overseen by the respondent.

Ia) Do you use any of the following novel technologies to monitor biodiversity?

- Bioacoustics
    - **If yes, to what level of deployment is each technology being used currently?**

        - § Actual method used in operational environment
        - § Method complete and validated but not used in operational environment
        - § Prototype demonstrated in operational environment
        - § Not used/developed but interested in using/developing
        - § Not used/developed and not interested in using/developing
        - § Not known
- Camera trap
    - **If yes, to what level of deployment is each technology being used currently?**
        - § Actual method used in operational environment
        - § Method complete and validated but not used in operational environment
        - § Prototype demonstrated in operational environment
        - § Not used/developed but interested in using/developing
        - § Not used/developed and not interested in using/developing
        - § Not known
- UAVs/Drones
    - **If yes, to what level of deployment is each technology being used currently?**
        - § Actual method used in operational environment
        - § Method complete and validated but not used in operational environment
        - § Prototype demonstrated in operational environment
        - § Not used/developed but interested in using/developing
        - § Not used/developed and not interested in using/developing
        - § Not known
- eDNA/Genomics
    - **If yes, to what level of deployment is each technology being used currently?**
        - § Actual method used in operational environment
        - § Method complete and validated but not used in operational environment
        - § Prototype demonstrated in operational environment
        - § Not used/developed but interested in using/developing
        - § Not used/developed and not interested in using/developing
        - § Not known
- Sensor networks
    - **If yes, to what level of deployment is each technology being used currently?**
        - § Actual method used in operational environment
        - § Method complete and validated but not used in operational environment
        - § Prototype demonstrated in operational environment
        - § Not used/developed but interested in using/developing

- Not used/developed and not interested in using/developing
- Not known

Section II – Bioacoustics

Bioacoustics is the the production, transmission, and reception of animal sounds in nature. The use of bioacoustics can, for example, give insight into species diversity, habitat health, and wildlife behaviour (WildlifeAcoustics, 2024). Examples of the use of novel bioacoustics methods include but are not limited to species classifiers (Artificial intelligence, *i.e*. BirdNET).

If you use bioacoustics in the operational environment, or have completed and validated bioacoustics methods but have not yet used them in the evironment or have a prototype(s) in the operational environment, please answer the following questions.

IIa) At what scale are you using bioacoustics techniques at?

- National scale
- Sub-national scale
- Protected area scale
- Habitat scale
- Other:

IIb) Do you use bioacoustics novel techniques for addressing the monitoring of:

- Species traits
  - Physiology
  - Phenology
  - Movement
  - Morphology
- Species populations
  - Species distributions
  - Species abundances
- Genetic composition
  - Effective population size
  - Inbreeding
  - Genetic differentiation
  - Intraspecific genetic diversity
- Ecosystem structure
  - Ecosystem vertical profile

- Ecosystem distribution
- Live cover fraction

· Ecosystem functioning
- Primary productivity
- Ecosystem disturbances

· Community composition
- Trait diversity
- Taxonomic/phylogenetic diversity
- Interaction diversity
- Community abundance

IIc) Describe what bioacoustics techniques/technologies you use.[LB4]

IId) What taxa do you use bioacoustics novel techniques for? To what level of deployment is each technology being used currently? [LB5]

- Terrestrial invertebrates[6]
  - How many species of this taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level
    a) Actual method used in operational environment
    b) Method complete and validated but not used in operational environment
    c) Prototype demonstrated in operational environment
    d) Not used/developed but interested in using/developing
    e) Not used/developed and not interested in using/developing
    f) Not known
  - If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
    · Mobile applications
    · Artificial intelligence tools
    · Protected Area management tools
    · Data management and processing tools
    · Non-AI computational tools
    · Other:

· Mammals
  - How many species of this taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level
    a) Actual method used in operational environment

b) Method complete and validated but not used in operational environment
c) Prototype demonstrated in operational environment
d) Not used/developed but interested in using/developing
e) Not used/developed and not interested in using/developing
f) Not known

- If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
  - Mobile applications
  - Artificial intelligence tools
  - Protected Area management tools
  - Data management and processing tools
  - Non-AI computational tools
  - Other:

- Fish
  - How many species of this taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level

a) Actual method used in operational environment
b) Method complete and validated but not used in operational environment
c) Prototype demonstrated in operational environment
d) Not used/developed but interested in using/developing
e) Not used/developed and not interested in using/developing
f) Not known

  - If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
    - Mobile applications
    - Artificial intelligence tools
    - Protected Area management tools
    - Data management and processing tools
    - Non-AI computational tools
    - Other:

- Birds
  - How many species of this taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level

a) Actual method used in operational environment
b) Method complete and validated but not used in operational environment
c) Prototype demonstrated in operational environment

d) Not used/developed but interested in using/developing
e) Not used/developed and not interested in using/developing
f) Not known

- If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
  - Mobile applications
  - Artificial intelligence tools
  - Protected Area management tools
  - Data management and processing tools
  - Non-AI computational tools
  - Other:

- Aquatic invertebrates
  - How many species of this taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level

a) Actual method used in operational environment
b) Method complete and validated but not used in operational environment
c) Prototype demonstrated in operational environment
d) Not used/developed but interested in using/developing
e) Not used/developed and not interested in using/developing
f) Not known

  - If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
    - Mobile applications
    - Artificial intelligence tools
    - Protected Area management tools
    - Data management and processing tools
    - Non-AI computational tools
    - Other:

- Amphibians/reptiles
  - How many species of this taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level

a) Actual method used in operational environment
b) Method complete and validated but not used in operational environment
c) Prototype demonstrated in operational environment
d) Not used/developed but interested in using/developing
e) Not used/developed and not interested in using/developing

f) Not known

- If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
  - Mobile applications
  - Artificial intelligence tools
  - Protected Area management tools
  - Data management and processing tools
  - Non-AI computational tools
  - Other:

- Other taxa
  - How many different species of other taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level
    a) Actual method used in operational environment
    b) Method complete and validated but not used in operational environment
    c) Prototype demonstrated in operational environment
    d) Not used/developed but interested in using/developing
    e) Not used/developed and not interested in using/developing
    f) Not known
  - If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
    - Mobile applications
    - Artificial intelligence tools
    - Protected Area management tools
    - Data management and processing tools
    - Non-AI computational tools
    - Other:

IIe) When using bioacoustics methods for biodiversity monitoring, are you involving other international/ national/ sub-national/ other entities? If yes please provide details on at what level (data collection/analysis...), what taxa/scale of monitoring, and with whom you are involved with. Please also share this organisation/entity website/link with us.

IIf) Do you find any constraints/challenges you-re facing with the use or deployment of bioacoustics novel methods?[MH7] [MH8]

- None
- Competition between data standards

- Conservation challenges
- Ethics/legal considerations
- Data storage
- Data integration
- Data security
- Data analysis
- Data synthesis
- Unharmonized sound libraries
- Lack of funding
- Lack of technical skills
- Lack of knowledge on use of approaches
- Time required
- Maintenance costs
- Training access
- Technical difficulties
- Lack of data/model infrastructures
- Other:

IIg) Do you have plans on innovating/developing the use of this tech more? (if yes please describe what and how).

Section III – Camera Trapping[MH9]

Camera traps, devices used remotely to record wildlife activity. They can be left in the field for long periods of time and can be activated to take photos or videos (Green et al., 2020). Examples of the use of novel camera techniques include but are not limited to, the use of artificial intelligence and image classification.

If you use camera traps in the operational environment, or have completed and validated camera trapping methods but have not yet used them in the environment or have a prototype(s) in the operational environment, please answer the following questions.

IIIa) At what scale are you using camera trapping techniques at?

- National scale
- Sub-national scale
- Protected area scale
- Habitat scale
- Other:

IIIb) Do you use camera trapping novel techniques for addressing:

- Species traits
    - Physiology
    - Phenology
    - Movement
    - Morphology
- Species populations
    - Species distributions
    - Species abundances
- Genetic composition
    - Effective population size
    - Inbreeding
    - Genetic differentiation
    - Intraspecific genetic diversity
- Ecosystem structure
    - Ecosystem vertical profile
    - Ecosystem distribution
    - Live cover fraction
- Ecosystem functioning
    - Primary productivity
    - Ecosystem disturbances
- Community composition
    - Trait diversity
    - Taxonomic/phylogenetic diversity
    - Interaction diversity
    - Community abundance

IIIc) Describe what camera trapping techniques/technologies you use.

IIId) What taxa do you use camera trapping novel techniques for? To what level of deployment is each technology being used currently?

- Terrestrial invertebrates[10]
    - How many species of this taxa (and which ones) do you use this novel tech to monitor:
    - Deployment level
        a) Actual method used in operational environment

b) Method complete and validated but not used in operational environment
c) Prototype demonstrated in operational environment
d) Not used/developed but interested in using/developing
e) Not used/developed and not interested in using/developing
f) Not known

- If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
  - Mobile applications
  - Artificial intelligence tools
  - Protected Area management tools
  - Data management and processing tools
  - Non-AI computational tools
  - Other:

- Mammals
  - How many species of this taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level

a) Actual method used in operational environment
b) Method complete and validated but not used in operational environment
c) Prototype demonstrated in operational environment
d) Not used/developed but interested in using/developing
e) Not used/developed and not interested in using/developing
f) Not known

  - If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
    - Mobile applications
    - Artificial intelligence tools
    - Protected Area management tools
    - Data management and processing tools
    - Non-AI computational tools
    - Other:

- Fish
  - How many species of this taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level

a) Actual method used in operational environment
b) Method complete and validated but not used in operational environment
c) Prototype demonstrated in operational environment

d) Not used/developed but interested in using/developing
e) Not used/developed and not interested in using/developing
f) Not known

- If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
  - Mobile applications
  - Artificial intelligence tools
  - Protected Area management tools
  - Data management and processing tools
  - Non-AI computational tools
  - Other:

- Birds
  - How many species of this taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level

a) Actual method used in operational environment
b) Method complete and validated but not used in operational environment
c) Prototype demonstrated in operational environment
d) Not used/developed but interested in using/developing
e) Not used/developed and not interested in using/developing
f) Not known

  - If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
    - Mobile applications
    - Artificial intelligence tools
    - Protected Area management tools
    - Data management and processing tools
    - Non-AI computational tools
    - Other:

- Aquatic invertebrates
  - How many species of this taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level

a) Actual method used in operational environment
b) Method complete and validated but not used in operational environment
c) Prototype demonstrated in operational environment
d) Not used/developed but interested in using/developing
e) Not used/developed and not interested in using/developing

f) Not known

- If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
  - Mobile applications
  - Artificial intelligence tools
  - Protected Area management tools
  - Data management and processing tools
  - Non-AI computational tools
  - Other:

- Amphibians/reptiles
  - How many species of this taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level
    a) Actual method used in operational environment
    b) Method complete and validated but not used in operational environment
    c) Prototype demonstrated in operational environment
    d) Not used/developed but interested in using/developing
    e) Not used/developed and not interested in using/developing
    f) Not known
  - If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
    - Mobile applications
    - Artificial intelligence tools
    - Protected Area management tools
    - Data management and processing tools
    - Non-AI computational tools
    - Other:

- Other taxa
  - How many different species of other taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level
    a) Actual method used in operational environment
    b) Method complete and validated but not used in operational environment
    c) Prototype demonstrated in operational environment
    d) Not used/developed but interested in using/developing
    e) Not used/developed and not interested in using/developing
    f) Not known

- If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
  - Mobile applications
  - Artificial intelligence tools
  - Protected Area management tools
  - Data management and processing tools
  - Non-AI computational tools
  - Other:

IIIe) When using camera trapping methods for biodiversity monitoring, are you involving other international/ national/ sub-national/ other entities? If yes please provide details on at what level (data collection/analysis...), what taxa/scale of monitoring, and with whom you are involved with. Please also share this organisation/entity website/link with us.

IIIf) Do you find any constraints/challenges you-re facing with the use or deployment of this novel technology?[MH11]

- None
- Competition between data standards
- Lack of/limited capacity
- Conservation challenges
- Ethics/legal considerations
- Data storage
- Data integration
- Lack of funding
- Lack of technical skills
- Lack of knowledge on use of approaches
- Time required
- Maintenance costs
- Training access
- Technical difficulties
- Data security
- Lack of data/model infrastructures
- Other:

IIIg) Do you have plans on innovating/developing the use of this tech more (if yes please describe what and how).

Section IV – eDNA and Genomics

Environmental DNA (or eDNA) is a technique that involves collecting DNA or RNA samples (genomics) from the environment, such as from water, soil, sediment, or air (Norros et al., 2022). There a several eDNA novel analyses which include but are not limited to, metabarcoding, shotgun sequencing or quantitative PCR (Winding, 2024).

If you use eDNA/Genomics in the operational environment, or have completed and validated eDNA/Genomic methods but have not yet used them in the environment or have a prototype(s) in the operational environment, please answer the following questions.

IVa) At what scale are you using eDNA/Genomics techniques at?

- National scale
- Sub-national scale
- Protected area scale
- Habitat scale
- Other:

IVb) Do you use eDNA/Genomics novel techniques for addressing:

- Species traits
    - Physiology
    - Phenology
    - Movement
    - Morphology
- Species populations
    - Species distributions
    - Species abundances
- Genetic composition
    - Effective population size
    - Inbreeding
    - Genetic differentiation
    - Intraspecific genetic diversity
- Ecosystem structure
    - Ecosystem vertical profile
    - Ecosystem distribution
    - Live cover fraction
- Ecosystem functioning

- Primary productivity
- Ecosystem disturbances

· Community composition
- Trait diversity
- Taxonomic/phylogenetic diversity
- Interaction diversity
- Community abundance

IVc) Describe what eDNA/Genomics techniques/technologies you use.

IVd) What taxa do you use eDNA/Genomics novel techniques for? To what level of deployment is each technology being used currently?

- Terrestrial invertebrates[12]
  - How many species of this taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level
    a) Actual method used in operational environment
    b) Method complete and validated but not used in operational environment
    c) Prototype demonstrated in operational environment
    d) Not used/developed but interested in using/developing
    e) Not used/developed and not interested in using/developing
    f) Not known
  - If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
    · Mobile applications
    · Artificial intelligence tools
    · Protected Area management tools
    · Data management and processing tools
    · Non-AI computational tools
    · Other:

· Plants
  - How many species of this taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level
    a) Actual method used in operational environment
    b) Method complete and validated but not used in operational environment
    c) Prototype demonstrated in operational environment
    d) Not used/developed but interested in using/developing

e) Not used/developed and not interested in using/developing
f) Not known

- If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
  - Mobile applications
  - Artificial intelligence tools
  - Protected Area management tools
  - Data management and processing tools
  - Non-AI computational tools
  - Other:

- Mammals
  - How many species of this taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level

a) Actual method used in operational environment
b) Method complete and validated but not used in operational environment
c) Prototype demonstrated in operational environment
d) Not used/developed but interested in using/developing
e) Not used/developed and not interested in using/developing
f) Not known

  - If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
    - Mobile applications
    - Artificial intelligence tools
    - Protected Area management tools
    - Data management and processing tools
    - Non-AI computational tools
    - Other:

- Fish
  - How many species of this taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level

a) Actual method used in operational environment
b) Method complete and validated but not used in operational environment
c) Prototype demonstrated in operational environment
d) Not used/developed but interested in using/developing
e) Not used/developed and not interested in using/developing
f) Not known

- If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
  - Mobile applications
  - Artificial intelligence tools
  - Protected Area management tools
  - Data management and processing tools
  - Non-AI computational tools
  - Other:

- Birds
  - How many species of this taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level
    a) Actual method used in operational environment
    b) Method complete and validated but not used in operational environment
    c) Prototype demonstrated in operational environment
    d) Not used/developed but interested in using/developing
    e) Not used/developed and not interested in using/developing
    f) Not known
  - If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
    - Mobile applications
    - Artificial intelligence tools
    - Protected Area management tools
    - Data management and processing tools
    - Non-AI computational tools
    - Other:

- Aquatic invertebrates
  - How many species of this taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level
    a) Actual method used in operational environment
    b) Method complete and validated but not used in operational environment
    c) Prototype demonstrated in operational environment
    d) Not used/developed but interested in using/developing
    e) Not used/developed and not interested in using/developing
    f) Not known

- If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
  - Mobile applications
  - Artificial intelligence tools
  - Protected Area management tools
  - Data management and processing tools
  - Non-AI computational tools
  - Other:

- Amphibians/reptiles
  - How many species of this taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level
    a) Actual method used in operational environment
    b) Method complete and validated but not used in operational environment
    c) Prototype demonstrated in operational environment
    d) Not used/developed but interested in using/developing
    e) Not used/developed and not interested in using/developing
    f) Not known
  - If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
    - Mobile applications
    - Artificial intelligence tools
    - Protected Area management tools
    - Data management and processing tools
    - Non-AI computational tools
    - Other:

- Algae
  - How many species of this taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level
    a) Actual method used in operational environment
    b) Method complete and validated but not used in operational environment
    c) Prototype demonstrated in operational environment
    d) Not used/developed but interested in using/developing
    e) Not used/developed and not interested in using/developing
    f) Not known

- If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
  - Mobile applications
  - Artificial intelligence tools
  - Protected Area management tools
  - Data management and processing tools
  - Non-AI computational tools
  - Other:

- Fungi
  - How many species of other taxas (and which ones) do you use this novel tech to monitor:
  - Deployment level
    a) Actual method used in operational environment
    b) Method complete and validated but not used in operational environment
    c) Prototype demonstrated in operational environment
    d) Not used/developed but interested in using/developing
    e) Not used/developed and not interested in using/developing
    f) Not known
  - If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
    - Mobile applications
    - Artificial intelligence tools
    - Protected Area management tools
    - Data management and processing tools
    - Non-AI computational tools
    - Other:

- Other taxa
  - How many different species of other taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level
    a) Actual method used in operational environment
    b) Method complete and validated but not used in operational environment
    c) Prototype demonstrated in operational environment
    d) Not used/developed but interested in using/developing
    e) Not used/developed and not interested in using/developing
    f) Not known

- If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
  - Mobile applications
  - Artificial intelligence tools
  - Protected Area management tools
  - Data management and processing tools
  - Non-AI computational tools
  - Other:

IVe) When using eDNA/Genomics methods for biodiversity monitoring, are you involving other international/ national/ sub-national/ other entities? If yes please provide details on at what level (data collection/analysis...), what taxa/scale of monitoring, and with whom you are involved with. Please also share this organisation/entity website/link with us.

IVf) Do you find any constraints/challenges you-re facing with the use or deployment of this novel technology?[MH13]

- None
- Competition between data standards
- Difficulties in comparing results
- Lack of/limited capacity
- Conservation challenges
- Ethics/legal considerations
- Lack of funding
- Lack of technical skills
- Lack of knowledge on use of approaches
- Lack of reference data bases/libraries
- Time required
- Maintenance costs
- Training access
- Technical difficulties
- Data security
  - Lack of human forces
  - No strong policy support
- Other:

IVg) Do you have plans on innovating/developing the use of this tech more (if yes please describe what and how).

Section V – UAV/drones

Unmanned Aerial Vehicles (UAVs), also known as drones, are air vehicles that fly autonomously or are remotely piloted. Examples of novel methods with the use of UAVs include, but are not limited to, three-dimensional (3D) mapping, aerial imaging, oblique photogrammetry, sensing, laser scanning, the Internet-of-Things (IoT), computer vision, and artificial intelligence (AI) (Mohsan et al., 2023).

If you use UAV/Drones in the operational environment, or have completed and validated bioacoustics methods but have not yet used them in the environment or have a prototype(s) in the operational environment, please answer the following questions.

Va) At what scale are you using UAV/drones techniques at?

- National scale
- Sub-national scale
- Protected area scale
- Habitat scale
- Other:

Vb) Do you use UAV/drones novel techniques for addressing:

- Species traits
    - Physiology
    - Phenology
    - Movement
    - Morphology
- Species populations
    - Species distributions
    - Species abundances
- Genetic composition
    - Effective population size
    - Inbreeding
    - Genetic differentiation
    - Intraspecific genetic diversity
- Ecosystem structure
    - Ecosystem vertical profile
    - Ecosystem distribution
    - Live cover fraction

- Ecosystem functioning
    - Primary productivity
    - Ecosystem disturbances
- Community composition
    - Trait diversity
    - Taxonomic/phylogenetic diversity
    - Interaction diversity
    - Community abundance

Vc) Describe what UAV/drones techniques/technologies you use.

Vd) What taxa do you use UAV/drones novel techniques for? To what level of deployment is each technology being used currently?

- Terrestrial invertebrates[14]
    - How many species of this taxa (and which ones) do you use this novel tech to monitor:
    - Deployment level
        a) Actual method used in operational environment
        b) Method complete and validated but not used in operational environment
        c) Prototype demonstrated in operational environment
        d) Not used/developed but interested in using/developing
        e) Not used/developed and not interested in using/developing
        f) Not known
    - If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
        - Mobile applications
        - Artificial intelligence tools
        - Protected Area management tools
        - Data management and processing tools
        - Non-AI computational tools
        - Other:
- Mammals
    - How many species of this taxa (and which ones) do you use this novel tech to monitor:
    - Deployment level
        a) Actual method used in operational environment
        b) Method complete and validated but not used in operational environment
        c) Prototype demonstrated in operational environment

d) Not used/developed but interested in using/developing
e) Not used/developed and not interested in using/developing
f) Not known

- If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
  - Mobile applications
  - Artificial intelligence tools
  - Protected Area management tools
  - Data management and processing tools
  - Non-AI computational tools
  - Other:

- Fish
  - How many species of this taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level

a) Actual method used in operational environment
b) Method complete and validated but not used in operational environment
c) Prototype demonstrated in operational environment
d) Not used/developed but interested in using/developing
e) Not used/developed and not interested in using/developing
f) Not known

  - If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
    - Mobile applications
    - Artificial intelligence tools
    - Protected Area management tools
    - Data management and processing tools
    - Non-AI computational tools
    - Other:

- Birds
  - How many species of this taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level

a) Actual method used in operational environment
b) Method complete and validated but not used in operational environment
c) Prototype demonstrated in operational environment
d) Not used/developed but interested in using/developing
e) Not used/developed and not interested in using/developing

f) Not known

- If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
  - Mobile applications
  - Artificial intelligence tools
  - Protected Area management tools
  - Data management and processing tools
  - Non-AI computational tools
  - Other:

- Aquatic invertebrates
  - How many species of this taxa do you use this novel tech to monitor:
  - Deployment level
    a) Actual method used in operational environment
    b) Method complete and validated but not used in operational environment
    c) Prototype demonstrated in operational environment
    d) Not used/developed but interested in using/developing
    e) Not used/developed and not interested in using/developing
    f) Not known
  - If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
    - Mobile applications
    - Artificial intelligence tools
    - Protected Area management tools
    - Data management and processing tools
    - Non-AI computational tools
    - Other:

- Amphibians/reptiles
  - How many species of this taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level
    a) Actual method used in operational environment
    b) Method complete and validated but not used in operational environment
    c) Prototype demonstrated in operational environment
    d) Not used/developed but interested in using/developing
    e) Not used/developed and not interested in using/developing
    f) Not known

- If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
  - Mobile applications
  - Artificial intelligence tools
  - Protected Area management tools
  - Data management and processing tools
  - Non-AI computational tools
  - Other:

- Other taxa
  - How many different species of other taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level
    a) Actual method used in operational environment
    b) Method complete and validated but not used in operational environment
    c) Prototype demonstrated in operational environment
    d) Not used/developed but interested in using/developing
    e) Not used/developed and not interested in using/developing
    f) Not known
  - If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
    - Mobile applications
    - Artificial intelligence tools
    - Protected Area management tools
    - Data management and processing tools
    - Non-AI computational tools
    - Other:

Ve) When using UAV/Drones methods for biodiversity monitoring, are you involving other international/ national/ sub-national/ other entities? If yes please provide details on at what level (data collection/analysis...), what taxa/scale of monitoring, and with whom you are involved with. Please also share this organisation/entity website/link with us.

Vf) Do you find any constraints/challenges you-re facing with the use or deployment of this novel technology?[MH15]

- None
- Competition between data standards
- Difficulties in comparing results

- Lack of/limited capacity
- Scaling sustainably
- Conservation challenges
- Ethics/legal considerations
- Lack of funding
- Lack of technical skills
- Lack of knowledge on use of approaches
- Time required
- Maintenance costs
- Training access
- Technical difficulties
- Data security
- Data storage
- Data integration
- Other:

Vg) Do you have plans on innovating/developing the use of this tech more (if yes please describe what and how).

Section VI – Sensor networks

Sensor networks are highly distributed networks of sensors (which are devices that gather environmental information in a specific location, such as temperature, pressure, and relative humidity) usually deployed in large numbers to monitor an environment or system (Goulart et al., 2022). Examples of the sensor networks include but are not limited to the use of IoT and off-grid communications.

If you use sensor networks in the operational environment, or have completed and validated sensor networks methods but have not yet used them in the environment or have a prototype(s) in the operational environment, please answer the following questions.

VIa) At what scale are you using sensor networks techniques at?

- National scale
- Sub-national scale
- Protected area scale
- Habitat scale
- Other:

VIb) Do you use sensor networks novel techniques for addressing: (tick relevant boxes)

- Species traits
    - Physiology
    - Phenology
    - Movement
    - Morphology
- Species populations
    - Species distributions
    - Species abundances
- Genetic composition
    - Effective population size
    - Inbreeding
    - Genetic differentiation
    - Intraspecific genetic diversity
- Ecosystem structure
    - Ecosystem vertical profile
    - Ecosystem distribution
    - Live cover fraction
- Ecosystem functioning
    - Primary productivity
    - Ecosystem disturbances
- Community composition
    - Trait diversity
    - Taxonomic/phylogenetic diversity
    - Interaction diversity
    - Community abundance

VIc) Describe what sensor networks techniques/technologies you use.

VId) What taxa do you use sensor networks novel techniques for? To what level of deployment is each technology being used currently?

- Terrestrial invertebrates[16]
    - How many species of this taxa (and which ones) do you use this novel tech to monitor:
    - Deployment level
        a) Actual method used in operational environment
        b) Method complete and validated but not used in operational environment
        c) Prototype demonstrated in operational environment

d) Not used/developed but interested in using/developing
e) Not used/developed and not interested in using/developing
f) Not known

- If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
  - Mobile applications
  - Artificial intelligence tools
  - Protected Area management tools
  - Data management and processing tools
  - Non-AI computational tools
  - Other:

- Mammals
  - How many species of this taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level

a) Actual method used in operational environment
b) Method complete and validated but not used in operational environment
c) Prototype demonstrated in operational environment
d) Not used/developed but interested in using/developing
e) Not used/developed and not interested in using/developing
f) Not known

  - If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
    - Mobile applications
    - Artificial intelligence tools
    - Protected Area management tools
    - Data management and processing tools
    - Non-AI computational tools
    - Other:

- Fish
  - How many species of this taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level

a) Actual method used in operational environment
b) Method complete and validated but not used in operational environment
c) Prototype demonstrated in operational environment
d) Not used/developed but interested in using/developing
e) Not used/developed and not interested in using/developing

f) Not known

- If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
  - Mobile applications
  - Artificial intelligence tools
  - Protected Area management tools
  - Data management and processing tools
  - Non-AI computational tools
  - Other:

- Birds
  - How many species of this taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level
    a) Actual method used in operational environment
    b) Method complete and validated but not used in operational environment
    c) Prototype demonstrated in operational environment
    d) Not used/developed but interested in using/developing
    e) Not used/developed and not interested in using/developing
    f) Not known
  - If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
    - Mobile applications
    - Artificial intelligence tools
    - Protected Area management tools
    - Data management and processing tools
    - Non-AI computational tools
    - Other:

- Aquatic invertebrates
  - How many species of this taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level
    a) Actual method used in operational environment
    b) Method complete and validated but not used in operational environment
    c) Prototype demonstrated in operational environment
    d) Not used/developed but interested in using/developing
    e) Not used/developed and not interested in using/developing
    f) Not known

- If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
  - Mobile applications
  - Artificial intelligence tools
  - Protected Area management tools
  - Data management and processing tools
  - Non-AI computational tools
  - Other:

- Amphibians/reptiles
  - How many species of this taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level
    a) Actual method used in operational environment
    b) Method complete and validated but not used in operational environment
    c) Prototype demonstrated in operational environment
    d) Not used/developed but interested in using/developing
    e) Not used/developed and not interested in using/developing
    f) Not known
  - If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
    - Mobile applications
    - Artificial intelligence tools
    - Protected Area management tools
    - Data management and processing tools
    - Non-AI computational tools
    - Other:

- Other taxa
  - How many different species of other taxa (and which ones) do you use this novel tech to monitor:
  - Deployment level
    a) Actual method used in operational environment
    b) Method complete and validated but not used in operational environment
    c) Prototype demonstrated in operational environment
    d) Not used/developed but interested in using/developing
    e) Not used/developed and not interested in using/developing
    f) Not known

- If a, b, or c were ticked: **do you use novel methods in any data synthesis systems (**the integration of separate datasets conducted across various locations and time points to obtain an overall signal or trend)**? If so, please select:**
  - Mobile applications
  - Artificial intelligence tools
  - Protected Area management tools
  - Data management and processing tools
  - Non-AI computational tools
  - Other:

VIe) When using sensor network methods for biodiversity monitoring, are you involving other international/ national/ sub-national/ other entities? If yes please provide details on at what level (data collection/analysis...), what taxa/scale of monitoring, and with whom you are involved with. Please also share this organisation/entity website/link with us.

VIf) Do you find any constraints/challenges you-re facing with the use or deployment of this novel technology?

- None
- Competition between data standards
- Difficulties in comparing results
- Lack of/limited capacity
- Conservation challenges
- Ethics/legal considerations
- Lack of funding
- Lack of technical skills
- Lack of knowledge on use of approaches
- Time required
- Maintenance costs
- Training access
- Technical difficulties
- Data security
- Data storage
- Data integration
- Deployment difficulties
- Management difficulties
- Other:

VIg) Do you have plans on innovating/developing the use of this tech more (if yes please describe what and how).

Section VII – Final Remarks

VIIa) Do you have any additional comments of anything you would like to share with us about your experience using/deploying novel technologies for biodiversity monitoring?

VIIb) Please list the names and contact details of any third parties that were involved in answering any questions or sharing data for the completion of this survey.

VIIc) Would you be available for a bilateral interview that follows the completion of this survey for a better understanding of the state of deployment of novel technologies used for biodiversity monitoring in your country/region? Please provide our contact details if so:

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