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D3.4 Cost-effectiveness analysis of monitoring schemes

Tom Breeze, Miguel Fernandez, Ian McCallum, Alejandra Morán-Ordóñez, Henrique Pereira, Jessi Junker

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D3.4 Cost-effectiveness analysis of monitoring schemes

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Institution leading task	**University of Reading (UREAD)**
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EC project officer	**Laura Palomo-Rios**

Deliverable description	Using the information collected in T3.1-3.3, online surveys (developed in the online software Qualtrics, translated into local languages) and interviews with scheme managers, the project will, for all schemes with suitable data, evaluate: i) The actual direct annual costs of conducting, administering and archiving the scheme, both in total and on a per site and per species or group of organisms- basis. ii) shadow costs of the scheme, measured as the monetary value of time given by volunteers to the scheme, representing the value added by the scheme and giving a metric of the total human capital in the scheme. iii) the level of engagement within the scheme such as numbers of repeat volunteers, training courses and other activities run in parallel to data collection, data use by authorities and research

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	organizations and the schemes links with the wider community. Following these surveys, workshops held later in the project will allow scheme leaders to come together and discuss ways of increasing their effectiveness and impact. From this, the project will i) identify opportunities to increase cost- effectiveness through schemes exchanging knowledge and adopting new methods and technologies, ii) measure the full human capital provided by the scheme, iii) identify the non- economic value-added by schemes as knowledge generation, capacity building and community engagement
Keywords	Biodiversity monitoring, Citizen Science, Cost-effectiveness, Bottlenecks.

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Summary

Financial factors are among the most widely cited bottlenecks around biodiversity monitoring but are relatively poorly studied compared to monitoring methodologies. The existing body of literature on the cost-effectiveness of monitoring focuses heavily on the hypothetical costs of generating data rather than the practical realities of undertaking and managing monitoring. To address this EuropaBON uses a combination of surveys and semi-structured interviews with 67 biodiversity monitoring managers to provide an in-depth exploration of how financial factors affect their cost-effectiveness in generating biodiversity monitoring data. Overall, the responses demonstrate that monitoring efforts are able to generate more data at a lower cost when they have a) higher numbers of volunteers, b) greater densities of sites and c) monitor a wider range of taxa and habitats. Overall budgets, volunteer recruitment and specialists are significant bottlenecks to monitoring activities while hiring more staff, monitoring more sites and supporting additional training were the most widely identified priorities for new spending. From the results we produce nine key messages and associated recommendations for future expansions of biodiversity monitoring networks.

1: Improving biodiversity monitoring requires long-term financial commitment. Supporting biodiversity monitoring will require both upfront investment and a commitment to sustaining schemes into the long term. Providing dedicated investment for monitoring infrastructure, tools and establishing a skills base will be important first steps for overcoming monitoring gaps and bottlenecks. However, without long-term funding guarantees and support, organizations will not be able to plan adequately and retain their established skill base and are vulnerable to cost shocks such as inflation. This will hamper their ability to deliver high quality data and affect their cost-efficiency over time, meaning more will ultimately have to be spent to get the same result.

2: Monitoring organizations need specialist expertise to keep costs down and increase their outputs. One of the main challenges identified by respondents was the lack of suitably qualified staff, both for conducting monitoring data gathering and for other roles such as data management, volunteer co-ordination, legal issues and data analysis. In some cases, respondents were using expensive contractors to fill these gaps, greatly increasing their costs. Committing to recruiting and retaining staff is key to supporting both primary data collection and the full breadth of activities that organizations undertake to produce high quality, accessible monitoring data.

3: Rising demands for data and from inflation are significant pressures on monitoring organizations. Many respondents identified the impact that increasing demand for monitoring data has on their staff. As national and international policies, (e.g. EU bioeconomy strategy or Nature Restoration law) increasingly draw upon data collected by monitoring organizations, accounting for the time and cost burden of meeting these increased demands should be considered to prevent a decline in the quality of data collected.

4: Investing in volunteers is extremely valuable. Volunteers contributed over 1.08M hours per year to 32 organizations surveyed, greatly increasing their relative cost-efficiency, even before the monetary value of this additional labour (€10.4M) was considered. By contrast, difficulties in recruiting and retaining volunteers were some of the most common bottlenecks affecting respondents. Although volunteer training, engagement and co-ordination can be costly and require specialist expertise, the benefits in terms of data generation and longevity are likely to greatly exceed this investment.

5: Monitoring organizations are prioritising actions that will make them more cost-efficient but may not be what users and policy makers want. Among respondents, the highest priorities for further investment are increasing the number of sites, the number of skilled staff and the number of volunteers they work with. Even if this increases overall costs, all of these factors can, over time.

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naturally increase the cost efficiency of their data collection, giving a greater return on the investments made in them in the short- and long-term. However, these may be at odds with the growing demands of data availability and data products from users and policy and dialogue is important to address this potential mismatch and build trust.

6: Supporting collaboration and diverse data collection could greatly increase cost-efficiency. The most cost-effective organizations were those that delivered the highest diversity of data, often by collecting data on additional taxa and habitats alongside their core monitoring. However, to date very few organizations are actively collaborating with one another to maximise data gathering. Identifying opportunities for monitoring efforts to collect additional data at sites they monitor, co-locate and integrate their data collection efforts or readily access other data sources could improve both the cost-efficiency of monitoring EBVs and the capacity of their data to understand the drivers of these trends and effectiveness of response.

7: Lower income countries will need additional support to overcome economic and cultural challenges to monitoring. Many lower income countries have substantial gaps in the knowledge base around monitoring for many taxa (e.g. Santana et al., 2023). Respondents from these countries regularly highlighted the economic challenges that low wages pose to building capacity as poor relative wages make remaining in the country to develop the skills and knowledge base necessary to deliver monitoring. Achieving fully interconnected biodiversity monitoring that spans Europe should factor in the need to invest in both capacity building and wages for managers in these countries, to avoid data gaps and differences in data quality.

8: New technologies beyond data collection are important cost-saving tools. Many respondents identified new field, genetic and remote sensing methods that would support their data collection activities. However, there was also considerable interest in using technologies, such as apps and machine learning algorithms, that could reduce administrative burden by improving data entry, validation and training and enhance their potential for engagement and outreach.

9: There is no single challenge or solution. Most biodiversity monitoring is affected by cost factors – but exactly how they are affected varies considerably. Total budgets limit what organizations can do but insecure budgets and the lack of volunteer engagement can prevent organizations developing and may jeopardize their survival into the long term. Policymakers and researchers need to collaboratively engage with monitoring organizations to identify their needs, the risks to their long term security and areas for investment.

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Introduction

Finance is widely considered to be a major bottleneck on biodiversity monitoring activities (Moersberger et al., 2022; Morán-Ordóñez et al, 2023). Monitoring activities are often costly in time and labour and can vary significantly between methods, sampling design and countries (e.g. Potts et al., 2021). This has led to significant discussion within the ecological research community about the cost- effectiveness of biodiversity monitoring, in order to maximise the amount and quality of data generated by a given amount of investment. To date, the majority of studies into cost-effectiveness have focused on the development of specific methods and sampling strategies (e.g. Bennett et al., 2018, Bolam et al., 2019, Breeze et al., 2021). Although a useful perspective for planning, these studies do not fully account for many of the broader costs, in terms of time and money, of monitoring organizations. For example, many crucial monitoring activities are based on citizen science, which often requires considerable effort to engage and maintain an appropriate volunteer base (Domrose & Johnson, 2017, Mason & Arathi, 2019), yet these costs are seldom considered. Furthermore, the actual value of volunteer labour and its broader impact on the cost-efficiency of organisations has not been assessed.

Although financial factors are often thought to affect monitoring, the actual impacts of this on monitoring activities are seldom studied. Discussion on additional investment also tends to focus on field sampling rather than the specific needs of the organizations involved. Here, we address these knowledge gaps through a survey of 67 respondents involved in European biodiversity monitoring, with additional semi-structured interviews to further expand upon their answers. The study aims to establish:

1) What are the main drivers of biodiversity monitoring costs across Europe?
2) What factors influence the cost-effectiveness of generating monitoring-data for essential biodiversity variables?
3) How do financial factors act as bottlenecks to biodiversity monitoring activities?
4) What is the scale and economic value of volunteer labour within these activities?
5) What are the spending priorities for biodiversity monitoring?

Based on the responses and insights from statistical and qualitative analyses, we produce a number of key messages and associated recommendations for future research and investment to support establishing wider European Biodiversity Observation Networks.

Methods

Responses to the survey are quoted throughout, however, all respondents are anonymous unless they have deliberately requested otherwise. At the request of several respondents, we do not present individual cost-efficiency.

Data collection

The study takes a mixed qualitative and quantitative approach, combining an online survey with optional face-to-face interviews to elicit more detailed responses. Originally the project had planned to have a short face-to-face workshop, but this was not conducted due to the proximity to other work package workshops.

The questionnaire survey was developed by the author group, including collaborators in Biodiversa+ and checked with European Butterfly Monitoring scheme (eBMS) and European Bird Census Council (EBCC) co-ordinators before distribution. Respondents were able to download the questions as a PDF in advance of completion. In response to early feedback, respondents were also allowed to

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indicate questions that were too difficult for them to provide detailed information on, in which case they were shown simplified questions with 6-9 ordinal responses. The survey (Appendix 1) consisted of seven sections (Table 1) and allowed respondents to freely name up to 15 taxonomic groups that they monitored and indicate which of 10 EUNIS habitat categories they monitored. Cost related questions were framed to be as broad as possible to avoid respondents needing to check detailed information, which many indicated they were unable or unwilling to do.

Table 1: Overview of survey questions

Section	Question overview
1	Respondent details and background questions designed to tailor later parts of the survey and avoid presenting redundant questions.
2	Questions on the taxa and habitats being monitored, the geographical location of the monitoring scheme and on whether field data collection uses specific protocols and/or is from pre-selected sites.
3	Information on the number of paid staff and contractors.
4	Information on which types of data[1] are monitored for which taxa, purpose of the monitoring (e.g. EU policy, biodiversity recording etc.) and on whether this data is sent to other organizations for synthesis.
5	Information on how monitoring is conducted, including the number of sites and how often the data is made available. Three variations of this section were made: monitoring for 1) genetic, 2) in-field and 3) remote sensing data (only shown if relevant to respondents).
6	Information on overall costs of monitoring, and on how costs were distributed and what the overall income associated with monitoring was and where this came from. For respondents that regularly use volunteer data, there were also additional questions on the number of volunteers and volunteer hours involved.
7	Information on how do cost-related factors affect what type of monitoring is done and what the priorities for additional spending may be.

At the end of the survey, respondents were offered an additional one-hour semi-structured interview to discuss their answers further and cover additional information. This consisted of nine further open-ended questions (Appendix 2), although respondents were invited to provide further details on topics of interest to them.

The survey was distributed online between September and November 2022 to organizations in the EuropaBON monitoring database for which contact information was available, and through snowball sampling. The survey was also distributed to members of the European Butterfly Monitoring scheme (eBMS) and the European Bird Census Council (EBCC) via their mailing lists, with reminders sent to both groups. Organizations participating in biological data collection for the Water Information System for Europe programme (WISE-2) were invited to participate after a programme webinar in September 2022. The survey was also promoted by the EFSA funded ENETWILD project and the Baltic Marine Protection Commission (HELCOM). The survey was hosted on Qualtrics and approved by the ethics committee of the University of Reading. Average response time was 45mins.

Although most recipients were able to enter monetary values, several were not able or willing to provide precise monetary estimates of their total costs and/or the relative costs of different aspects of their activities (e.g. staff costs). As such they and a sub-sample of later recipients, were able to respond by selecting from a range of cost categories to indicate the general scale of their costs. Other respondents' costs were then concerted, into these categories for the purpose of analyses in

1: These data types are drawn from the Essential Biodiversity Variable names (Geijzendorffer et al., 2016)

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order to maximise the data available. While slightly reducing the explanatory power of our analyses, this was necessary to make the survey as accessible as possible.

Estimating the Shadow costs of Volunteer labour

To estimate the equivalent value of volunteer labour, we used survey responses on the number of volunteers and hours of labour that volunteers provided and multiplied these by national minimum wages or equivalent per hour income in 2022, assuming a standard 40hr working week over 4.33 weeks per month (Appendix 3). The total value was summed across all volunteers, using a median when respondents had provided a range of volunteers or hours of voluntary work. We used median numbers of volunteers and hours where a range was provided and a minimum of one hour per volunteer where the number of volunteer hours was not provided (two respondents).

Measuring cost-efficiency

Within the published literature, cost-efficiency of monitoring is usually based on the principle of value of information, that is, the relative change in the probability of achieving an outcome relative to the costs of generating the data (e.g. Bolam et al., 2019). Although very useful for designing monitoring efforts, this is a highly theoretical top-down approach that is useful to informing the design of a scheme but less reflective of the realities of implementing monitoring and does not consider the costs of personnel and other management challenges in monitoring. Furthermore, given the breadth of organizations surveyed and the diversity of key data collected, this approach is not viable because of the lack of statistical power analyses and other data necessary to determine the effects of schemes on detection.

Instead, we take a broader approach based on the quantity and quality of data generated by respondents and compare this to their costs in order to identify how respondents cost-efficiency is affected by different factors. As the EuropaBON project is focused on developing the monitoring of key Essential Biodiversity Variables (EBVs) (Geijzendorffer et al., 2016) and addressing issues around their implementation, we consider cost-efficiency in terms of costs per type of EBV data generated. In theory more cost-efficient organizations will be able to generate EBV data at a lower cost.

To measure the number of EBV data types collected, respondents were asked to identify the different types of data that they collected (e.g. species abundance of birds, species abundance of mammals, species distribution of mammals etc.) for each taxa/habitat monitored (Figure 1). These data types matched the 21 EBVs names in Geijzendorffer et al., (2016). To keep results consistent with other work in EuropaBON EBV data types, we align taxa with those identified in EuropaBON Deliverable 4.1 (Junker et al., 2023). For example, dragonflies were classed as freshwater insects. We did not include a taxa where only a small number of species were monitored, for example where bird monitoring organizations also monitor mice but no other mammals. To avoid double counting, where monitoring efforts included specialist schemes for individual species or small groups, these were counted in with the parent taxa: for example, monitoring of Marsh Fritillaries was not countered separately from other butterfly monitoring. Finally, for the purposes of determining total EBV data types, habitats are grouped by realm.

The total number of <u>all EBV data types</u> is therefore the sum of the types of data (based on the EBV names) monitored across all taxa/habitats. In addition, we also identified a number of <u>key EBV data types</u>, where the data collected is relevant to the key EBVs identified by the EuropaBON project (Junker et al., 2023). These are not analysed separately but are reviewed in Appendix 4.

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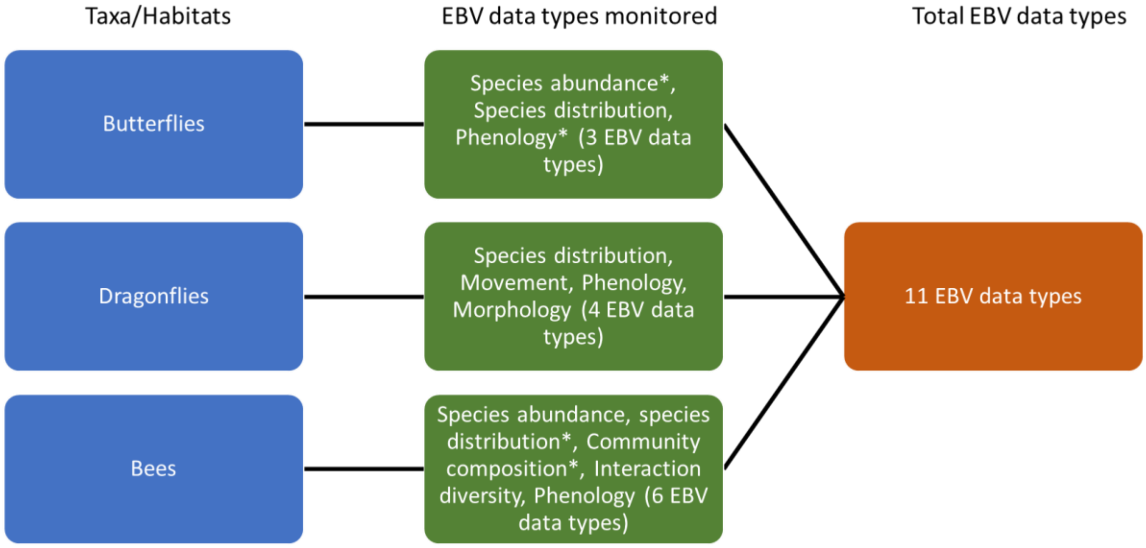
Figure 1: Overview of EBV data type collection



*These are identified as key EBVs

However, simply looking at the costs relative to the number of EBV data types may exaggerate the perceived costs-inefficiencies of specialist monitoring organizations that focus on large scale or highly detailed data collection for a few limited taxa/habitats. As such, we further transformed this data in two ways: 1) multiplying the number of EBVs by the number of sites monitored in order to provide an estimate of cost per EBV data type per site and 2) by multiplying the number of EBVs by a general metric of data quality, based on the average of three, highly correlated factors:

1. A 1-4 score of the density of sites for each taxon/habitat monitored. This is to account for replication in a manner that is unbiased by the size of the region being monitored. This is taken by dividing the number of sites by the area of the country, region(s), coastline (in the case of marine archipelago birds) or body of water (in the case of marine mammals) that were monitored. We then grouped them as follows: 1: < 0.1 sites per 100km, 2: 0.1-1 site per 100km, 3: 1.1-10 sites per 100km, 4: More than 10 sites per 100km. Marine sites were automatically set to the highest category as their surveys spanned the whole of the water body.
2. The sum of 0-2 scores for a) structured monitoring (0: not structured, 1: mix of structured and unstructured, 2: entirely structured) and b) site selection (0: no pre-selected sites, 1: a mix of pre-selected and other sites, 2: entirely pre-selected sites)[2].
3. The proportion of taxa/habitats for which data was validated or curated, multiplied by 4 to allow for similar scaling with the other two components. Only four respondents indicated values of between 0% and 100%.

This increases the value of data when a) there is a large sample size of sites, b) the data is collected in a structured manner from sites that have been specifically selected and c) the data is validated. This weights all the input variables equally as we have no basis to weight one above the other. We use the costs per EBV data type per site as the basis for further analyses but compare this metric with the data quality weighting.

Value added by volunteers: In addition to these analyses, we also conducted a secondary analysis where the shadow costs of volunteers were added to the stated costs. This combined was then used as the denominator in the three analyses above. The difference between the estimates with and

[2] In four organizations with >5000 sites, data was mostly opportunistic and thus were downweighted by 2

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without the shadow costs reflects the added value, in terms of increased cost-efficiency, of volunteer labour.

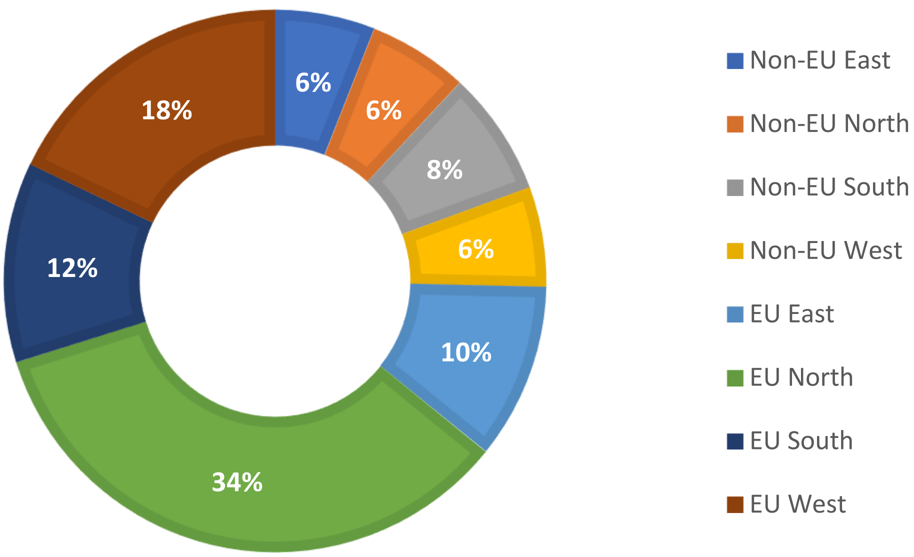
It is important to note that cost-efficiency is not intended as a value judgement on respondents as they may generate considerable added value through other activities which are not adequately reflected in this survey for example: EBV generation, modelling for national statistics, volunteer engagement, conducting environmental impact assessments, prosecuting wildlife crime and publicity. These analyses are intended only to provide an overview of the factors affecting cost-efficiency in terms of generating high quality EBV data and examine what, if any, trends there are among these respondents. Although the survey included question on the distribution of staff and field data among monitoring activities, not enough respondents answered these questions to divide costs accurately among taxa or habitats.

Finally, all data were analysed using a series of correlation, mean/median tests and regression analyses in R (R project, 2022). These analyses are detailed in Appendix 5.

Results

In total, 67 completed surveys were returned, and 12 interviews were conducted. Another 7 responses were not sufficiently complete for analysis, but their qualitative responses are included in the discussion. This represents a response rate of ~42% of those who received the survey link. Approximately 75% of respondents were from EU countries and 64% were from Northern and Western Europe (Figure 2). Most respondents represented universities/research institutions (43%) and NGOs/charities (42%) and a majority were specialized around a single taxon (most often birds, butterflies or bats).

Figure 2: Distribution of respondents among EU and non-EU countries and by European Region[3]



Respondents[4] monitored an average of ~2 taxa, with birds, butterflies, terrestrial mammals (bats and other mammals) and plants being the most common taxa monitored (Figure 2). Only one-third (27%) of the respondents surveyed undertook habitat monitoring, often as a part of their species

[3] As classified by the UN Geoscheme for Europe; (UN Statistics Division, 1999)

[4] We refer to respondents rather than organizations as some respondents answered for different schemes at the same organization

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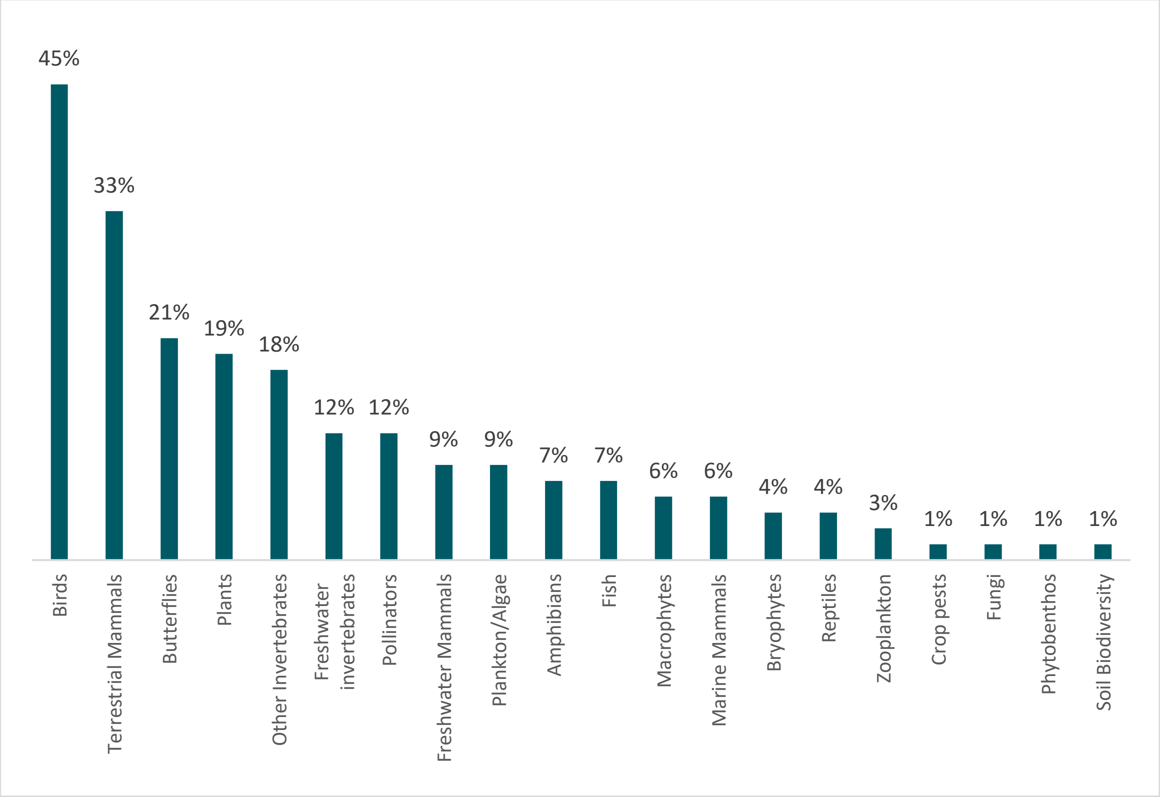
monitoring schemes, covering on average 3 EUNIS habitat types. The number of taxa monitored correlated with the number of EUNIS habitats monitored. In terms of methods, all respondents collected or used primary field data while only 12% used genetic methods and 25% used remote sensing techniques.

Figure 3: Proportion of respondents monitoring different taxa



Sites and Staff

Respondents monitored between 7 and 33000 sites, although the definition of a site varied greatly, ranging from individual points to multi km transects. Site density ranged from <0.01/100km² to 230/100km². Neither the number of sites and site density were not correlated with either the number of taxa or number of habitats respectively, meaning that the scale of activities was not related to the diversity of taxa/habitats monitored.

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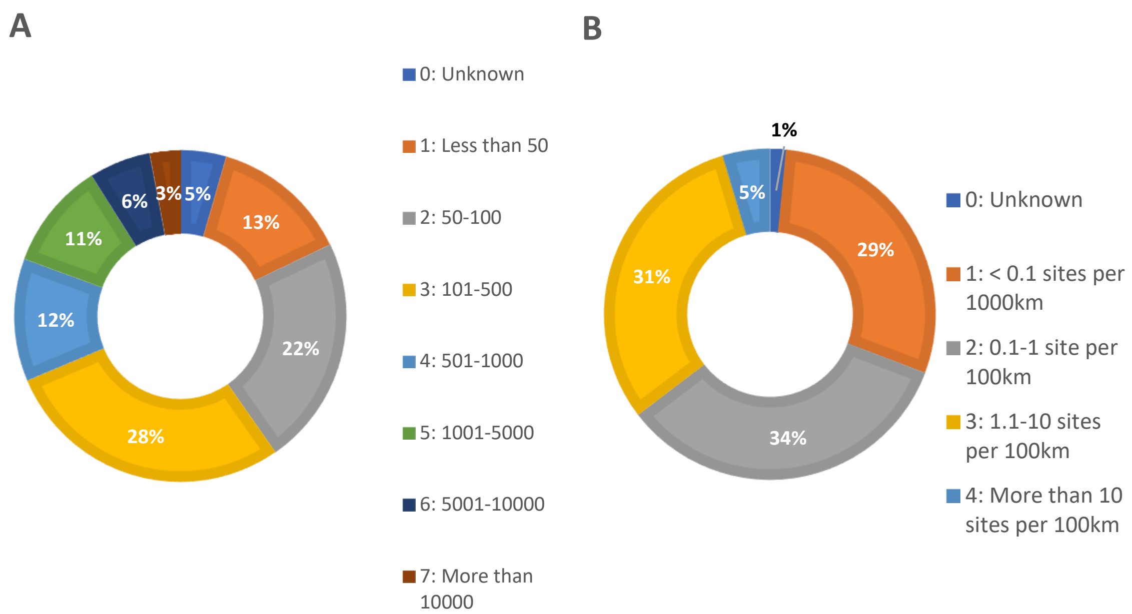
Figure 3: The proportion of respondents monitoring different A) numbers and B) densities of sites



Staff numbers ranged from 2 to more than 50, however many respondents noted that the number of people working on a paid basis often included staff who had other duties. Outside paid staff, 40% of respondents indicated that they hired contractors each year (between 1-100) and 63% indicated that volunteers were regularly part of their data collection, with between 10 and 13,000 volunteers collecting data. Number of staff, volunteers and contractors did not correlate with one another (Appendix 5), indicating that these numbers are largely independent of one another. However there were significant correlations between staff numbers and the number of taxa and habitats monitored and with the number of EBV data types monitored.

All respondents used at least some standardized monitoring methods, but it is not possible to say what proportion of the sites that they monitored used standardized methods. However, 61% of the respondents surveyed indicated that their monitoring was entirely structured. Most respondents collected data from pre-selected sites with 24 (36%) respondents using exclusively pre-selected sites and only four not using any pre-selected sites. In terms of field data, approximately 84% applied some form of validation or curation process to all the data that they collected. Five out of twelve respondents that collected genetic data validated their data, while five did not indicate any validation. Nine of the 27 respondents that used remote sensing validated all of their data, with eight using their own data to do so.

EBV Data Types

In total, accounting for both, taxon and EBV data type (Figure 1), respondents collected data for 1-96 (average: 10.8) EBV data types. Data on species distribution and abundance were most commonly collected (99% of respondents) while data on inbreeding and phylogenetic abundance were collected the least (<15% of respondents). Among these, respondents collected EBV data relevant to 1-16 (average: 4) of the Key EBVs identified in Junker et al (2023), summarised in Appendix 4. Poisson regression analysis (Appendix 5) indicated that the number of EBV data types monitored was positively influenced by i) the use of genetic methods, ii) the number of taxa and iii) habitats monitored and iv) the participation of volunteers. These are expected as the use of genetic methods allows for unique types of data to be collected and a higher diversity of taxa will naturally lead to a greater number of potential EBVs generated.

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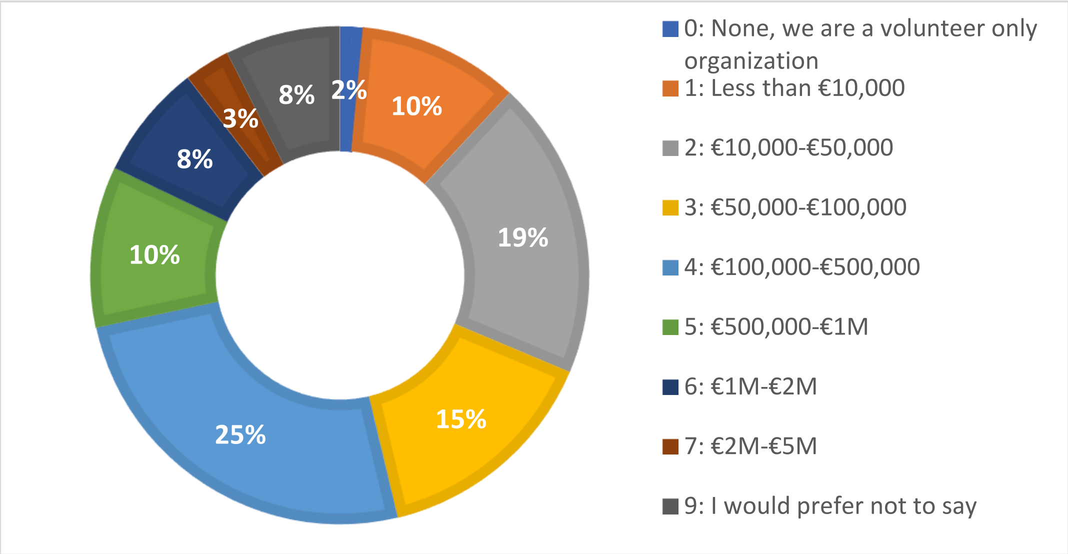
The relationship between number of EBV data types and the participation of volunteers reflects monitoring efforts where volunteers are able to monitor the main focal taxa, freeing up paid staff for more focused monitoring of habitats and taxa. The total number of EBV data types monitored was also negatively influenced by per capita GDP and the use of remote sensing methods. These effects are likely to reflect the sample, as many respondents were government funded initiatives from high-income countries focused on monitoring a small number of taxa for targeted data with remote sensing often being used to supplement field observations of specific taxa (e.g. marine mammals).

Costs and Income

Respondent costs ranged from ~€3,000 to over €2M. Over half of the respondents had costs in the €50,000-500,000 range (figure 4). Many respondents found it difficult to identify their income sources as separate from their costs, but six respondents (8%) indicated that their costs were higher than their income, while two organizations (3%) indicated that their income was higher than their costs. Moods median tests indicated there were no significant differences in costs between EU and non-EU countries (Z = -0.882, p = 0.378).

Figure 4: Distribution of respondent costs



From respondent's breakdown of their costs[5], payroll (inc. overheads) was the most significant cost, accounting for >50% of the budget in 29 responses (44%) and >25% of costs in a further 19 (20%). Staff were not stated to be costs by five respondents: three of which were universities or other research institutes where salary costs were paid separately and two were entirely voluntary staff. Respondents indicated that paid staff spanned a range of schemes and often took on specific responsibilities besides field work and co-ordination.

> *"We have several monitoring schemes and subschemes [...]. Every subscheme has its own paid staff coordinator." – Respondent 53*

> *"there are 7 people that work on this for a substantial part of their job. Four people that coordinate and do the analysis, one person that does database design and management, one person that does mainly volunteer support and 1 person who does mostly fieldwork (but most do this from time to time" – Respondent 17*

[5] Three respondents did not complete the cost breakdown and are excluded from this analysis

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Ten (16%) and nine (14%) respondents reported that in-situ data collection accounted for more than 50% and 25% of their costs, respectively. Although respondents were asked to state how their costs were divided among taxa, most indicated that 100% of their costs went to monitoring one or two taxa only, with other taxa and habitats being monitored as an aside.

> *"Almost all focus is on birds. Mammals and amphibians are recorded "while" counting birds"* – Respondent 6

Contractors were mostly a minor cost for respondents, only accounting for more than 10% of costs in four responses (6%). However, not all respondents who indicated that they employed contractors gave a proportionate cost for them. The costs of validation are highly correlated with the number of contractors, indicating that some of these contractors may be performing validation only (ρ=0.314, p-0.009).

> *"We have biologists that assign contracts to contractors, monitor their work and utilize the outcomes"* – Respondent 11

Data management and validation costs were highly correlated, with 17 (25%) and 12 (19%) respondents indicating that these accounted for >25% of their costs respectively. Data management costs were also highly correlated with Per Capita GDP, reflecting the requirement to submit data to government funders in some higher income countries. Among the remaining respondents, about half said that data management and validation resulted in minor costs and the other half reported no costs at all for these activities. Capacity building/training costs were common, with 43 respondents indicating that this was a cost for them, but only nine respondents indicated that these amounted to >10% of their costs. Other costs, genetic analyses, rent and utilities and services from other sources, were uncommon, being mentioned only by less than 50% of respondents. Genetic analysis was only stated to be a cost by three respondents out of the 12 who used the method. However, there was a strong correlation between respondents using genetic analysis and the costs of rent and utilities, inferring that they may be captured through these costs and several respondents indicated that these analyses were conducted elsewhere and thus may have included them as contractors.

Beyond these stated costs, we used regression analyses to examine trends among organization costs (Appendix 5). The final selected model indicates that costs were significantly influenced by the GDP, the number of sites monitored and hiring contractors but not by the number of staff or by the presence of volunteers. The first two are to be expected as countries with larger economies also have higher wages and more sites will necessarily involve more labour to collect and manage data.

Many respondents did not feel capable of providing estimates of their income from monitoring activities. However, of those who did, three had higher income than their costs while six had higher costs than their income. Most (n=65) respondents were able to provide information on the sources of their income, with government funding making up >50% of funding to 48 (74%) respondents, with 27 (42%) of these being entirely funded by government. Ten respondents however, received no government funding. Eight of these were NGOs/Charities, one was a research institution and one was a private company. Research grants were the next most common source of income, with 26 respondents receiving some funding from this source. Of these, three respondents were entirely funded by grants while another three received more than half of their funding from grants. Income from grants can come with significant transaction costs from the need to repeatedly issue and amend grant agreements and contracts.

Other sources of income, such as consultancy, sale of data and membership fees were uncommon, with >80% of respondents indicating that they received no income from these streams. Consultancy

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activities can potentially generate new data but may not add to the data products that a respondent produced.

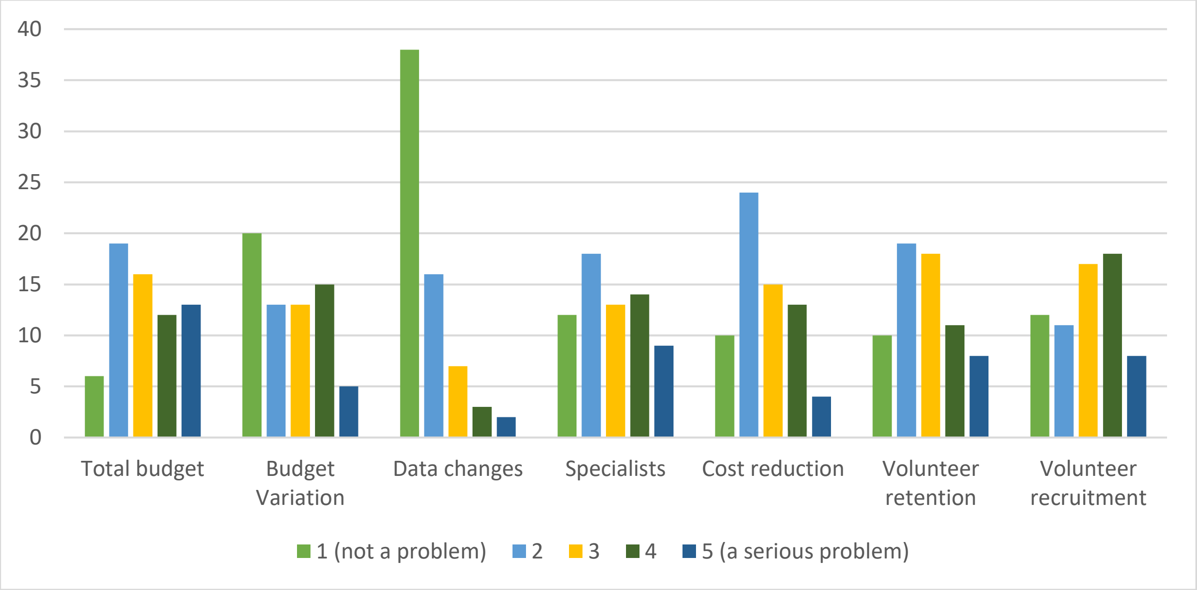
> *"The consulting part in monitoring comes from the applied projects which require additional monitoring effort outside the agreed national and international monitoring period. This contributes to the monitoring costs/expenses but the result is usually not used for official monitoring reports, rather they contribute to new knowledge/ecological studies/development of management and conservation measures/environment impact assessments."* – Respondent 38

Bottlenecks and Priorities

Respondents were asked to indicate, on a scale of 1-5, a) how severe a series of cost and value-for money related bottlenecks, identified from the User and Policy needs assessment (Moersberger et al., 2022) were to their activities and b) how highly they would prioritise a series of items, should they have additional funding. Throughout this section, we present an analytical review of these responses, accompanied by quotes from respondents to underline key points to aid in interpretation and highlight additional points not captured in the quantitative survey questions.

Of the bottlenecks, respondents scored total budget as the most significant barrier (average = 3.11), followed by volunteer recruitment (average = 2.98), the availability of specialists (average = 2.85) and volunteer retention (average = 2.82). The distribution of these scores is illustrated in Figure 5. On average, respondents scored 2.67 items as more serious problems (score 4 or 5), with 27 scoring less than two items in these high categories while 13 respondents scored 4 or more items this highly. The average respondent score across all seven bottlenecks was negatively correlated with GDP Per Capita (ρ= -0.272, p=0.027) and number of sites monitored (ρ= -0.282, p=0.023), indicating that well-established and centrally funded monitoring has fewer bottlenecks.

Figure 5: Distribution of respondent scores for each of the seven suggested barriers



Full barrier texts: Total budget = Overall budget available, Budget variation = Budget variation between years, Data changes = Changes to data needed between years, Specialists = Availability of specialists, Cost reduction = Pressure to reduce costs, Volunteer retention = Ability to retain volunteers, volunteer recruitment = Ability to recruit volunteers

Of the nine spending priorities, monitoring additional sites (average score: 3.58) and hiring new staff

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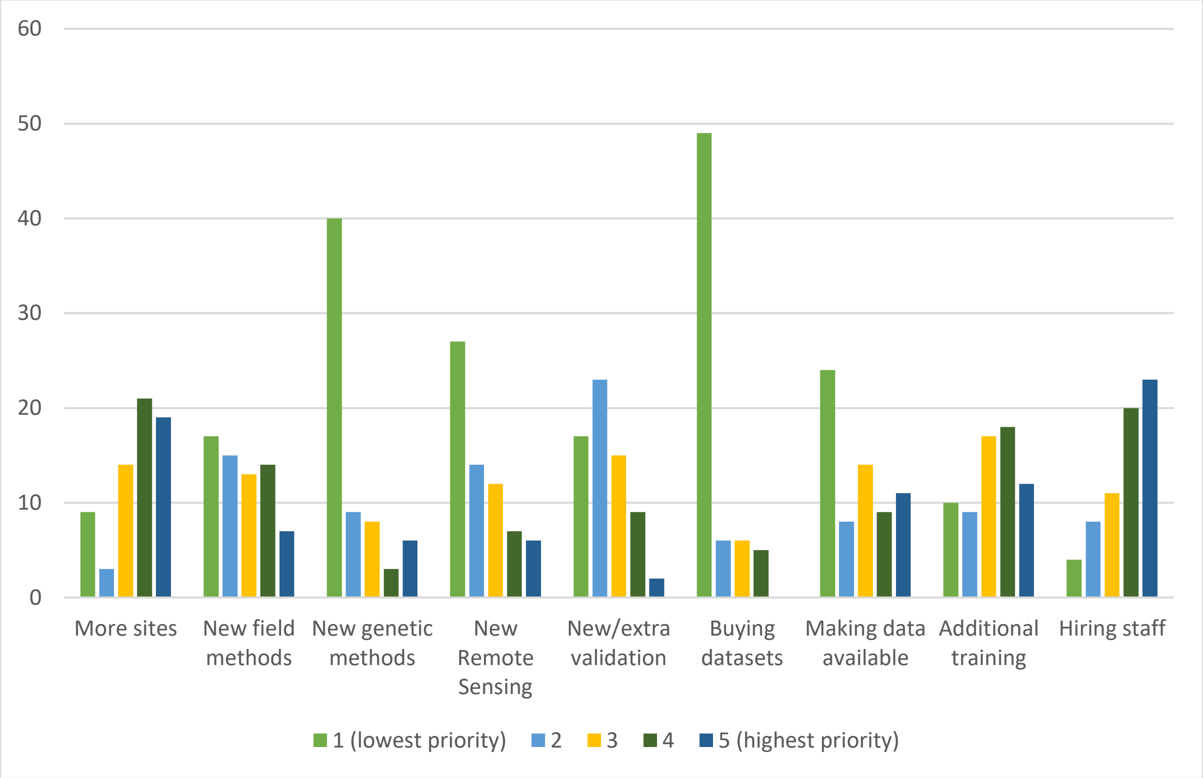
(average score: 3.76) were consistently the highest rated. The distribution of these scores is illustrated in figure 6. Respondents scored an average of 2.91 items as high or highest priority (score 4 and 5), with 13 respondents scoring less than two items in these categories compared with nine respondents who scored 4 or more priorities this highly.

Figure 6: Distribution of respondent scores for each of the nine suggested priorities



Key: More sites = Monitoring more sites, New field methods = Adopting new field monitoring methods, New genetic methods = Adopting new genetic methods, New remote sensing methods = Adopting new remote sensing methods, New/Extra validation = New or additional data validation, Buying datasets = Purchasing access to other datasets, Making data available = Making data or data products available more regularly, Additional training = Additional training, Hiring staff = Hiring more paid staff

Cost-efficiency

Across all respondents, comparing costs to the quality weighted number of EBV data types generated gave estimates of between €139-€264,392 per weighted EBV data type. When the number of sites was factored in then the costs ranged from €1 to €5,000/EBV data type per site. When data quality was factored in, this reduced costs to between €0.3 and €2,143/EBV data type per site. Many of these differences are taxa specific, due to the substantially different monitoring efforts (Table 4), however sample size was not sufficient to estimate the effects between taxa statistically.

Table 4: Average costs per EBV data type per site grouped by respondents main taxa (N≥3 only)

Row Labels	Number of respondents	Costs/EBV data type/site	Costs/EBV data type/site (weighted by data quality)
Bats	8	€ 181.9	€ 66.5
Birds	23	€ 246.2	€ 104.0
Butterflies	9	€ 174.4	€ 63.0
Freshwater	5	€ 976.5	€ 269.0
Pollinators	3	€ 456.0	€ 184.6
Seals	4	€ 1,739.6	€ 808.6

Main taxa are defined as the respondents primary taxa either due to the large majority of sites monitored or being the primary focus of an NGO or scheme. Respondents that monitor a broad range of taxa are excluded as it is not possible to disambiguate the costs of these schemes.

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The composite data quality metric indicated that most respondents were generating good quality data, with a median score of 3 (average 2.83) out of a maximum 4. Only two respondents scored the maximum of 4. The metric was negatively correlated with the number of EBV data types, indicating a trade-off in data quality when focusing on more taxa. However, this effect disappeared from regression modelling and only GDP per capita and costs had a significant influence on the metric (Appendix 5). Lower scores were most often driven by lower site densities (average 2.28, median 2), with 59% of respondents in the lower two categories.

It should be emphasised that this analysis only focuses on the generation of data for EBVs and not the generation of the EBVs themselves as not every organization has the capacity and expertise to generate EBVs in full. Furthermore, some organizations stated that they did not regularly collect all data. Furthermore, the survey did not capture many of the other activities that monitoring organizations can undertake such as data hosting, education and activism.

Shadow costs of volunteers and value added

Volunteer labour represents a significant added value for monitoring respondents. In total, approximately 37,000 volunteers were estimated to provide 1.08M hours of labour annually across all respondents. Multiplying these costs by the hourly minimum wage (or an equivalent entry level wage) in each country gave an estimate shadow cost of €10.4M annually for labour alone. Approximately €7.36M of this value stemmed from three bird monitoring respondents in high income countries. However, volunteer labour was highly valuable for all respondents and in some cases had a greater monetary value than their other total costs. It is important to emphasise that the shadow cost estimates are based on minimum wages as opposed to the wages that a professional ecologist could expect and thus are likely to be significant under-estimates.

Limitations of the study

Although the survey was distributed as broadly as possible, the sample is ultimately only a small representation of the wider biodiversity monitoring community in Europe with limited response from freshwater and marine monitoring organizations. This ultimately limits our capacity to draw generalised trends among monitoring efforts and may miss important cost related challenges in particular areas and realms. Nonetheless, the key challenges identified here are true to a wide range of respondents and have been widely suggested within the literature.

Although this study has attempted to examine the full range of factors affecting cost-efficiency, the broad nature of the study means we must necessarily sacrifice often quite important nuances for monitoring individual taxa. Our results demonstrate broad trends in the costs, cost-efficiencies, bottlenecks and priorities of European biodiversity monitoring but they should not be used to produce value judgements on organizations or assume a singular solution to any finance related challenges.

Further research should aim to bridge the gap between the work we have done through direct engagement with monitoring organizations and more established methods for examining and improving the cost-efficiencies of biodiversity monitoring. This should comprise more in-depth discussion with organizations at a taxonomic level, including those that are not specialist, on their operational challenges and ideally be combined with evidence synthesis on to guide strategic improvements in sampling design, following e.g. the EU Pollinator Monitoring scheme proposal document (Potts et al., 2021).

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Key Messages

Below, we outline the outcomes of statistical and qualitative analyses of the responses, framed and grouped as a series of key messages from the outcomes of the survey and interviews.

Key Message 1: Improving biodiversity monitoring requires long-term financial commitment

Costs were heavily linked to both the number of sites and data quality, with organizations that spent more tending to survey more sites and generate higher quality data. However, total budget was the most cost bottleneck with the highest average score among the sample. Scores for this bottleneck did not correlate with many other variables, including GDP per capita and costs (Appendix 5). These fundamental cost challenges ultimately result in the weaker overall data collection, with some respondents were forced to make compromises on the quantity and quality of data collected.

> *"Many times we are limited to the finance we have available and therefore are able to conduct limited monitoring and involve a limited number of volunteers. For example, we are restricted to prioritize and carry out a very limited number of monitoring protocols that are the most important (Common Bird Monitoring for example) and post-pone or delay other monitoring that look important (for example Monitoring of the raptor breeding species or Colonial Waterbird species)."* – Respondent 19

> *"There has been no funding from the EU in recent years. The Baltic Sea is the common water area of the EU and Russia. There are no borders for animals living here. Good results on the biodiversity conservation in the sea can be obtained only by joint efforts."* – Respondent 54

> *"We have difficulties to get job vacancies for biological monitoring in our agency"* – Respondent 63

> "*We're often being asked to keep our costs down by sampling sites less often, but I am really concerned that we already don't sample often enough to properly detect changes and trend*s. – Respondent 18

Another widely cited bottleneck was the variation funding between years, with respondents highlighting the negative effects this had upon their ability to plan activities and retain staff, and often incurred additional administrative costs from the need to constantly apply for funds.

> *"We do not have the budget to reliably employ people at each site and this means we continue to face demotivated staff in many areas."* - Respondent 16

> *"Currently the regular monitoring is done using annual money that is not granted. We need to apply again every year and the application process is in the early spring. Thus we can't make field plans before we know if the money is there and sometimes we just hope it is there and start field work before we have the contract. This is however not stable and makes hard to find filed workers."* – Respondent 50

> *"[The] Low level of the available [re]sources and its large annual variation [does] not let [us] improve the network of the observers, their training, development of new scheme, mobile applications for effective data communication with the observers and data analysing capacity"* -Respondent 44

> "*We have been lucky to get it during last five years but you never know about the future. There have been period, when we did monitoring, for example hibernation monitoring,*

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acoustic monitoring of migrating bats on voluntary basis without any funding" – Respondent 40

The bottleneck scores for both total costs and cost variation between years were significantly negatively correlated with the proportion of income from the government, indicating that government funding tends to be more adequate than other sources (appendix 5). However, there is the potential for funds to originate from other sources. During interviews, participants were asked about where they believe that funding should come from, with almost all respondents stating that they would prefer to have greater government funding. Research funds were not seen as reliable because of the need to constantly adjusted what was monitored while the private sector was seen as a risk because of the risks of perceived or real conflict of interest. Of those that did not want greater government funding, this stemmed from a lack of trust in government.

"*Money from the private sector is a potential risk as it can cause conflicts of interest and it only takes one very litigious firm to put us in a very difficult position.*" – Respondent 1

"*The government isn't always using the data for it's intended purposes or uses it selectively when they want to prove they are in the right*" – Respondent 4

"*It is useful to communicate the monitoring results more widely to the country's target society groups, the government and international institutions. Therefore, we think that funds for environmental monitoring and the conservation and management of biological diversity should be allocated for the non-governmental organizations centrally in the EU space through targeted projects financed by the EC.*" – Respondent 14

These findings support widely observed limitations that monetary factors place on biodiversity monitoring (Morán-Ordóñez et al., 2023) but highlight how costs can ultimately result in weaker data and less efficient monitoring in the long term. Sustained investment is essential to better develop and deliver high-quality monitoring but this needs to come from sources that organizations can trust and be used for open, transparent purposes.

Key Message 2: Monitoring organizations need specialist expertise to keep costs down and increase their outputs

Contractors were a significant source of costs for respondents while the availability of specialists was the third highest scoring bottleneck and recruiting new staff was the highest scoring priority for new funds among the respondents. These outcomes clearly demonstrate the needs of organizations for more internal staff that can be hired more cost-effectively than contractors who are often hired because unstable wages and funds act as a bottleneck to retaining staff.

"In our organization, the funding comes from a number of smaller projects, which each have their own partly overlapping but slightly different design (depending on habitat type, etc.). Even if we to a large extent use the same variables, techniques and species lists, there is an administrative cost just in coordinating all these projects. The contracts mostly need to be renewed each year (sometimes with small modifications), which introduces an uncertainty in the budget that makes long-term planning more difficult. The unpredictability makes it more complicated to recruit experienced staff, which is one reason why we have used subcontractors for database and GIS work, for example." – Respondent 23

"*If we cannot make all the monitoring with volunteers, we pay freelance ornithologists for this. We get the money to pay the freelance persons by the environmental ministry*" – Respondent 26

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> *"Unfortunately, the scientific activities are poorly paid and young specialists prefer to work in private sector."* – Respondent 61

This was also seen as a labour saving investment by some respondents who highlighted the impact that having few trained staff had on the time spent validating data.

> "*Validation is a priority as currently it has to be done through manually interviewing people about unusual records*." – Respondent 2

> *"There are only a very small number of people who can properly identify bats from recording so, as you can imagine, it takes a lot of our time to validate it all"* – Respondent 40

In addition, although some respondents indicated that they needed experts with specialised skills to conduct monitoring many others also indicated a need for experts in other fields such as data management, volunteer co-ordination and environmental law in order to reduce the administrative burden on field experts and facilitate activities beyond data collection.

> *"We need very experienced field staff, because a small number of people will work independently to cover a large variety of species-rich habitats all over the land area. It is a challenge to find sufficiently qualified staff, since those employed only during the field season soon get more long-term employment elsewhere. […] Our type of monitoring cannot be performed by volunteers, ever."* – Respondent 23

> *"The problem with sufficient algae specialists, the problem of obtaining experts for individual groups of aquatic organisms for monitoring and identification purposes."* – Respondent 49

> *"Incomes are dedicated to the production of field observations and we are lacking resources for correctly analyse them statistically."* – Respondent 48

> *"We have only one technician for lab work with a non-permanent contract. He is in a training phase and if his contract is not extended, we will need to get another person and start the training processing again."* – Respondent 55

> *"We don't have anyone in our staff who can do the statistics so, apart from the data we send to the government to meet the requirements of the birds directive, not a lot of it ever gets analysed. It would be easier if we had access to students but we're not formally affiliated with a university so it's difficult."* – Respondent 26

> *"So much of our time gets taken up trying to prosecute wildlife crime, we really need a legal expert to help us keep up with this so we can focus on the monitoring work"* – Respondent 4

These findings demonstrate a need to further support the staffing needs of monitoring organizations in both the short and long-term (building capacity), both in relation to data collection and to the full breadth of activities they are involved in.

Key Message 3: Rising demands for data and from inflation are significant pressures on monitoring organizations

In addition to the bottlenecks presented, many respondents from across several taxa, notably during

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interviews, highlighted increasing demands for data as a growing challenge to their organizations by taking time and administrative resources away from other activities. In particular, environmental impact assessments or prosecuting wildlife crime were significant challenges.

> *"We are getting a lot more requests to assess the impacts of wind farms on bats, but the government hasn't increased our budget to deal with this."* – Respondent 40

> *"[The] need for detailed monitoring information has increased over time (from selected species to all species, from national trends, to provincial and site-level trends, etc.) and so has funding."* - Respondent 53

> "*Development of off-shore windfarms have increased the monitoring effort as described in the box above*." – Respondent 38

Similarly, respondents also highlighted recent events as shocks affecting their costs. High inflation has caused many volunteers to reduce or stop their data collection as they can no longer afford the fuel to travel to sites. For some respondents, this had led to significantly greater costs through higher reimbursement or replacing volunteers with contractors. The Covid-19 has also caused a redistribution in funds that has negatively affected organizations in some countries

> "*In 2022 after the war [started] the price for gasoline increased and the field work could not be accomplished according to the plan*." – Respondent 62

> *"Travel costs are very important. [Our country] is a low income country and with current fuel prices more and more volunteers stop data collection."* – Respondent 10

> "*The Covid-19 pandemic shifted the priorities of various grant donors and even governments, making very difficult to secure funding for projects unrelated to the Covid-19 pandemics. Regular field monitoring became less a priority for less developed countries such as [ours]*." – Respondent 19

In both cases, monitoring organizations were not receiving additional income to compensate for these increased pressures.

> "*[The government] don't give us any extra funding for doing all this Environmental Impact Assessments. They see it as part of what we are paid for already, not something extra."* – Respondent 40

> *"Not in the last years but as for 2023 we will have to cut our budget as there were two indexations during 2022 but the budget set aside for the monitoring in 2023 was fixed since early 2022 and could not be negotiated."* – Respondent 55

These findings highlight the need for funders to properly understand and incorporate pressures and shocks on monitoring budgets in order to maintain consistent and high quality outputs. As the demands for monitoring data are likely to increase, this should be explored as a matter of urgency.

Key Message 4: Investing in volunteers is extremely valuable

Comparing cost efficiency with shadow costs included (i.e. if the respondent organization were to pay for volunteer labour), the cost per EBV data type per site increased by between 6% and 303%. In absolute terms, volunteer labour produced a saving of between €0.09-€300/EBV data type per site. In common with other studies (Alfonso et al., 2022), this demonstrates that volunteer labour is

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allowing monitoring efforts to deliver significantly greater outputs for their costs, as well as making valuable contributions to data, knowledge exchange and policy engagement (Aceves-Bueno et al., 2015). Although volunteers are associated with lower data quality, this is often due to the need to engage them with simpler methods (e.g. Garratt et al., 2019; Roy et al., 2013), or their self-selecting distribution reducing the density of sites monitored, particularly pre-selected sites (Tulloch et al., 2013). In reality, volunteers are often capable of generating data of sufficient quality for EBVs.

Regression modelling (Appendix 5) indicates that costs per EBV data type per site increased with higher GDP Per Capita (representing higher wages) but was significantly negatively affected by the number of volunteers, the density of sites and the total number of taxa and habitats monitored, indicating that these three factors can significantly increase cost-efficiency (i.e. reduce the costs per EBV data type per site). This was also the case when the data were weighted by data quality (Appendix 5).

However, volunteer recruitment and retention were also high scoring bottlenecks for many respondents with some noting that limited recruitment and issues with retention was causing patchy spatial coverage, often concentrated on certain areas, or losing sites entirely as volunteers stop participating.

> *"Most of the bat experts who could train volunteers are distributed around a few of the big cities so there are some places where our monitoring is very limited"* – Respondent 40

> *"We have lost track of some key roosts because of losing volunteers and staff"* – Respondent 32

Volunteer labour is not free of costs. Fifteen respondents indicated that they provided some funds to volunteers to help cover their fuel costs, which was often factored in as field data collection costs and, volunteers can still represent a cost through training and engagement activities necessary to maximise retention and data quality (Andow et al., 2016, Mason & Arathi, 2019). These costs can be significant, often requiring dedicated and fully funded training courses (although some are able to charge for attendance) or high-quality reports to be produced which can, without dedicated staff to support them, act as a bottleneck on the number and the quality of data generated. Despite these costs, engaging with citizen scientists was widely seen as a key component to successful monitoring. Respondents from organizations that had a good volunteer bases often highlighted the value of retention and engagement activities, while those with smaller bases pointed to need to invest in personnel and events to engage with them.

> "*We make a dedicated effort to produce a report for our members right before the start of the next season so they can see how their data has contributed to something bigger. It's time consuming but absolutely worth it because it gets them excited about going out for the next season*" – Respondent 4

> *"When seeking to attract more young people into citizen monitoring activities is necessary to obtain more funds and pay them for training courses in monitoring methodologies and bird identification in the field, per diems and salaries, and to recover expenses of using their transport during fieldwork. Then young people will be more interested in nature and better participate in environmental monitoring activities, and will be enough qualified people in the country. The need to recruit volunteers for bird monitoring activities will be satisfied, even if the volunteers join the monitoring activities during holidays and days off."* – Respondent 14

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> *"The state does not have a long-term monitoring plan or finances and volunteer based monitoring would request a certain amount of finances and a long term position of a coordinator/animator working only with volunteers."* – Respondent 45

These findings demonstrate that the impacts of volunteer labour on cost-effectiveness are substantial and widely recognised but that this is not without some long-term costs. Investing in staff and materials to support volunteer recruitment and retention should be a key funding priority going forward.

Key Message 5: Monitoring organizations are prioritising actions that will make them more cost-efficient but may not be what users and policy makers want

Of the nine priorities for further investment, the highest scoring were increasing the number of staff (discussed above), sites and training activities, particularly targeted at volunteers. Based on the regression analysis of cost-effectiveness, all of these are likely to reduce the relative costs per EBV data type per site, making them naturally more cost-effective. Increasing site numbers was not elaborated upon by respondents and had very few correlations with other variables of note, indicating that this was simply a generic want to increase the reach of monitoring activities. However training was widely seen as both means to increase site coverage and to reduce the costs and demands on time of other staff.

> *"In [our country], as in other parts of Eastern Europe, we are facing the problem that too few people has enough skill to identify species of wild birds in nature. Therefore, it is good to obtain and allocate funds not only for training in monitoring methodology, but also for better identification of bird species in nature."* – Respondent 2

> "*Our dragonfly monitoring has been really successful but it's limited by the number of volunteers who are able and willing to do it. They need more training than other taxa*" – Respondent 17

> "*The experienced observers (30+ years of work in the field) are working part time, with current funding it is difficult to find new observers to be trained to carry out the aerial and boat surveys task in future, as the investment into training, compared to the potential income from just some days of paid survey is out of balance.*" – Respondent 38

> "[…]*we could do lots more with the data if we could spend less time on training. However, there is not a large pool of capable bumblebee recorders with time to carry out standardised monitoring […]. A hypothetical injection of extra funding would allow us to employ another staff member specifically to lead the training work, who would then have more time to build a more mentoring approach to training and greater provision of resources (online and in- person training), with a focus particularly on upskilling volunteers in areas with populations of under-recorded hard-to-ID taxa and recruiting new volunteers in areas where there is little surveying at present* " – Respondent 8

Training needs were not exclusively focused on volunteers however as there was no significant correlation with volunteer numbers, but there were significant relationships with several perceived bottlenecks availability of specialists, volunteer recruitment, volunteer retention and budget variation.

By contrast making data more widely available, identified by users and policy as an important need for their activities (Moersburger et al., 2022) was a medium priority for most respondents. The

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priority score here was positively correlated with the proportion of costs spent on field data and negatively correlated with number of sites, reflecting the potential difficulties in making large volumes of data more widely available, and the proportion of income from government sources. Respondents typically made their field data publicly available on an annual basis (54% of respondents), although a sizable portion made their data publicly available less often than this or not at all (36% of respondents). Similarly, genetic and remote sensing data were almost exclusively only available on an ad hoc basis if they were available at all. Nonetheless, all respondents supplied their data to at least one other organizations, often open repositories such as GBIF or funding ministries. Most respondents did not comment on data availability in itself. However several respondents, especially from lower income and non-EU countries expressed concerns about how their data was to be used. Although some of this was attributed to the lack of qualified staff for analysing the data, some respondents highlighted a lack of understanding among decision makers, the unwillingness to engage with their activities or misuse of their data.

> *"Although our country has a lot of biodiversity, the ministries simply don't know what to do with all of the data. We send our data off to four ministries and two of them we're sure don't do anything with them."* – Respondent 45

> *"The government isn't always using the data for it's intended purposes or uses it selectively when they want to prove they are in the right. There needs to be more transparency between what the goals and outcomes of the work are."* – Respondent 10

> *"We provide our data to another organization to be analysed but it's only used to produce the minimum data required by the birds directive."* – Respondent 26

These findings demonstrate that monitoring organizations priorities for investment will make them more cost-efficient but may ultimately not be the same priorities as those of users and policy. Addressing this imbalance, and the negative perceptions around data sharing, will be important to establishing reliable workflows between organizations and users into the future.

Key Message 6: Supporting collaboration and diverse data collection could greatly increase cost-efficiency

The number of taxa and habitats monitored greatly reduced the relative costs of monitoring per EBV data type per site. Several respondents also indicated a willingness to expand their data collection to wider numbers of species, habitats and data types.

> *"We would like to be able to go beyond the roosting surveys and cover more detailed information on bat movement and populations."* - Respondent 32

> *"[…], our approach is to iteratively add to the number of taxon and the complexity of questions. […] In 2023 the first habitat mapping of protected areas of [our country] will be coordinated by us. […] In years to come we hope to add still more approaches, but our priority remains the operationalisation of methods within Pas [Protected Areas]."* – Respondent 16

As above, this has the potential to greatly increase their cost-efficiency but may require additional upfront investment in appropriate capacity building. An alternative approach would be to encourage greater overlap between monitoring organizations, with each collecting different data at the same sites to add value or individuals conducting joint data collection (e.g. the same individual recorder collecting pollinator data for one organization and plant data for another). However, when asked about what overlap there was, very few organizations were actively overlapping their data collection

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efforts and many of those that were often co-locating in general areas rather than precise sites.

> *"Many [of our monitoring activities] are carried out on nature reserves owned by other NGOs as well as other organisations, all of which are monitored for aspects of biodiversity to varying degrees"* – Respondent 8

> *"For mammals a small overlap exist with few little organization or hunting association or protected areas."* – Respondent 27

> *"There might be some overlapping of our areas with monitoring activities conducted by national parks but we don't know exactly the extent of the overlap (potentially very low)."* – Respondent 55

However, 16 respondents did specifically name organizations conducting monitoring in the same sites as them. The full impacts of these co-locations is not possible to assess from the data gathered here. Given the observed impact of multi-taxa/habitat monitoring on cost-efficiency, looking for opportunities to build upon and refine this synergy is a potentially key step to expanding biodiversity monitoring across Europe and may add further value by allowing the detection of co-occurring pressures and impacts.

Key Message 7: Lower income countries will need additional support to overcome economic and cultural challenges to monitoring

Respondents from lower income countries highlighted several areas where financial factors were more significant than other countries. Firstly uncompetitive wages were cited as a major barrier for building capacity, with many highlighting the flight of younger people to other countries or industries where wages are higher and more secure. If capacity building in these countries is to occur then it will require raising the wages of the staff involved to ensure that they are secure enough to encourage recruitment and retention.

> *"This problem is deeper and more complex. E.g., the country's young people lack the potential jobs they enjoy, and the wages offered him are too low, and a large part of active young people move to work in other EU countries."* – Respondent 2

> *"As [our country] has serious economic challenges, average salaries here are quite low.[…] Less and less young professionals want to work for NGOs, and they rather leave the country or simple change profession, for instance going into IT industry which pays way more. The low income also prevents us to budget more as all donors know average net salary in [our country] and they would not give us more funds for the staff."* – Respondent 10

> *"People think we have high wages in our country because it's a high-income country but ecology is still poorly paid and that makes it hard to find good staff."* – Respondent 17

Secondly, respondents in lower income countries also had greater difficulty accessing government funds, sometimes even facing hostility from governments due to their activities. This made them more reliant upon research grants and other funding from organizations – often forcing them to constantly change their data collection in order to present enough scientific novelty to qualify.

> *"Our major work is related to bird monitoring. We are having major difficulties to fund this work as the Government is very hostile to NGO work, it prevents us for collecting data and it does not fund any data collection and monitoring. […] The government has this push for economic growth that they think we're opposed to. We're not opposed to growth, we're*

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> *just opposed to unsustainable growth and want companies to behave responsibly. We want to be more collaborative and less reactive."* – Respondent 10

> *In all the time we've been monitoring bats, we've only received money from the government once. We pay for everything ourselves. And that is a limiting factor. There is no other organization in [our country] that monitors bats.* – Respondent 41

> *"The government doesn't want to support us much because we are often prosecuting wildlife crime that interferes with tourist development. […] Since we don't get a lot of money from anywhere except projects, we have to keep changing up what we do to make sure we can still apply for funds. We have to try and work in the right data collection in the same sites to make sure we at least get the data we need but it's sometimes very hard."* – Respondent 4

Finally the lack of a well-established culture of engaging with nature was seen as affecting the number of people who were willing to spend time volunteering.

> "*People here recognize that nature is important but they think it's government's responsibility to do something about it. I think that can change with time but it's going to take effort from us and support from the government."* - Respondent 45

> *"The low number of available volunteers is the main challenge that does not allow expanding our monitoring programmes. […] What we really hope is that people here will eventually be more "westernized" and take more of an interest in nature and biodiversity. Lots of people have the time but they don't see why they should do it."* - Respondent 2

These findings collectively demonstrate the need to target additional financial and research resources towards developing monitoring efforts in these lower income countries. Failure to do so would risk not only these countries falling short of their targets but, in the case of species that migrate or otherwise have wide movement ranges, could leave significant gaps in the understanding of the pressures affecting these species.

Key Message 8: New technologies beyond data collection are important cost-saving tools

Throughout the survey and interviews, participants identified a number of new technologies they were interested in adopting. Many of these were technological field based methods such as acoustic monitoring (bats), camera-based monitoring (terrestrial and marine mammals) or remote sensing methods, such as GPS tracking or drones that could improve sampling coverage and capture new data types.

> *"[We would like to adopt new remote sensing methods] for landscape characterisation"* – Respondent 55

> *"[Genetic methods would help us to] identify hard to identify rare species"* – Respondent 8

> *"To adjust our monitoring methods to environmental changes more supporting research and funding for that is needed - in order to keep the monitoring data comparable."* – Respondent 39

Priority scores for adopting new field methods and remote sensing methods were positively correlated with the proportion of costs on field work and the score for the pressure to reduce costs bottleneck, indicating that respondents saw these as a means to reduce their field data collection

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costs, although none directly mentioned this in their open answers. The score was also negatively correlated with the number of volunteers, likely reflecting a preference for large, volunteer driven monitoring efforts to maintain existing methods. Adopting genetic methods by contrast had no such trends.

However, although data availability and validation were not scored as high priorities for further investment by respondents, they often emphasised the need for new technologies to help with data entry, management and validation as well, highlighting that this would free up the time of many of the most knowledgeable staff to better analyse the data and increase the speed at which it was made available. Apps were also widely mentioned as a desirable way to engage with volunteers, both for data collection and training purposes (e.g. bird identification).

> "*More systematic validation such as machine learning would be useful. At the moment we have to do a lot of manual checking for anomalous records ourselves which can take quite a bit of time*." – Respondent 4

> "*We need new data entry systems but they will need to be designed in collaboration between bioinfomaticians and programmers as the two often don't really understand one another - and they need to! We need systems with a consistent output even if they have to have different inputs*." – Respondent 1

> "*Online training seems very useful because it can be made available all year round and really accessible*." – Respondent 17

Much of the emphasis on developing novel technologies has thus far focused on data collection rather than other aspects of monitoring workflows (e.g. Chow et al., 2022). However, these other tools were seen as having great potential to reduce the costs in administrative time and greater emphasis should be placed upon their capacity, along with other novel technologies, to increase monitoring cost-efficiency.

Key Message 9: There is no single cause or solution to financial bottlenecks

Perhaps most fundamentally, the findings of the study show a wide variety of issues that are faced by monitoring organizations. Some of the most significant and widespread ones are discussed in depth below but they are by no means universal and some respondents mentioned completely unique challenges that are not covered elsewhere. Any attempts to address these should be based around the bespoke needs of each organization and stem from dialogue between organizations and their funders and other, independent researchers. We outline a series of recommendations to this end in the section below but also include a number of other issues that were important but not widely raised (Table 6).

Table 6 – Other cost and finance issues identified by participants

Challenge	Example
Administrative restrictions	*"We are not allowed to purchase equipment (fixed assets) from governmental projects. We are not allowed to purchase the equipment and supply from abroad ourselves, we must act through intermediaries."* – Respondent 61
Sexism and other biases	*"We still have problems with sexism here. As a woman, I often find that men, especially older men, just don't want to listen to me."* – Respondent 32

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Maintenance of monitoring equipment	*"We often have to spend money on maintaining and fixing our detectors because they're expensive and we can't easily replace them if they are lost"* – Respondent 40
Systems maintenance	*"Recorder 6, our main data entry system, is in danger of obsolescence and once it goes there's nothing that can really replace it. We badly need a new and better system for biological records"* – Respondent 1
Varying common names	*"A challenge in recruiting volunteers is that we have a lot of different regional common names for species. […] A single national guide that addresses these could be very helpful in recruiting volunteers"* – Respondent 5

Recommendations and Outlook

This study provides the first widespread exploration of biodiversity monitoring across Europe. Respondents ranges from small charities focusing on particular taxa to large, well-funded and government supported organizations. It has identified a number of significant challenges in current biodiversity monitoring funding that affect the cost-efficiency, sustainability and growth capacity of different schemes that cannot be addressed with a single solution. Nonetheless, from our key messages we are able to derive a number of recommendations for future biodiversity monitoring that should be considered by academics, monitoring organizations and funders moving forward.

Immediate Priorities

1. Conduct a Horizon Scan of national and EU level policies to identify the data needed from existing monitoring into the future. Across multiple respondents, there was a concern over the costs of meeting the increasing demand for their data, often without a proportionate increase in funding. National policy makers or researchers should conduct a full horizon scan of all current and proposed national policy to identify where biodiversity monitoring data either a) will be an essential component of the decision making process or b) could add value to decision making in a way that supports wider biodiversity conservation policies. This should be accompanied by an assessment of the risk and negative impacts of necessary monitoring data being delayed, for example the costs of delaying construction of renewable energy projects due to incomplete Environmental Impact Assessment. This will enable more informed decisions about the long-term funding and support needed to ensure that monitoring efforts can provide timely and high-quality data.

2. Engage with monitoring organizations to identify their specific needs in supporting their activities into the long-term. Throughout this study, respondents have identified a wide range of financial, logistic, staff, cultural and policy challenges that affect their cost-effectiveness differently. Funders should urgently engage with monitoring organizations to identify what their immediate cost-related bottlenecks are and how these may threaten the quality and sustainability of their activities and how additional funding can be allocated to support them in the immediate term. This may include simply changing the rate of funding approval from an annual to a multi-annual basis, providing injections of funds to invest in new methods, replace equipment or compensate for inflation or increasing staff salaries to help retain skilled individuals.

3. Invest in growing citizen science through volunteer co-ordination and knowledge exchange. Volunteers can greatly increase the reach and cost-efficiency of biodiversity monitoring. However, they do not come without costs to organizations and in many countries, there are significant challenges with recruitment and retention. At a national scale, funders should look to target bespoke support for volunteer-led organizations to help them expand engagement under changing socio-economic conditions (including hiring specific staff or producing publicity campaigns) and work

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with researchers to develop longer-term methods for public engagement in biodiversity monitoring. At a European Scale, funders should look to provide bespoke support for monitoring co-ordinators and researchers to exchange knowledge on volunteer engagement across taxa, realms and countries, e.g. through online hubs or dedicated workshops.

Long-Term Priorities

4. Collaboratively develop programmes of strategic investment in volunteers, site-sharing, technologies and skills to support cost-effective, long-term monitoring. Researchers and funders should directly engage with monitoring organizations in order to identify a programme of research and investments that can support the expansion of high-quality biodiversity monitoring in a cost-effective manner. For example, funding new taxonomic keys that allow greater citizen science engagement, providing dedicated funding for data scientists embedded within existing monitoring organizations or investing in new technology research to facilitate new methods for data collection and processing that can reduce costs elsewhere.

5. Additional support for lower-income countries, within and beyond the EU, will be essential to maintain Europe-wide monitoring. Respondents from lower income countries highlighted that poor wages and limited citizen science engagement were major barriers to establishing and retaining the skills necessary to deliver high quality monitoring at a national scale. This poses a risk to the effective monitoring of biodiversity across borders. At a European scale, wealthier countries and the European Commission should explore options to provide additional support to these lower income countries, such as dedicated bilateral research and training funds and funding of monitoring organization personnel through intermediary organizations to maintain political neutrality.

6. Commit to the long-term financing of biodiversity monitoring. Most respondents were heavily funded by national government and those that were not, mostly preferred to be. However monitoring budgets are often vulnerable to inflation, recession and other economic pressures and monitoring organizations are often wary of private sector involvement in case it compromises their transparency. With the growing demands for monitoring data for public and private use, governments should work with researchers and monitoring organizations to identify funding mechanisms that can support monitoring and take advantages of the economic benefits of biodiversity monitoring activities. These should be coupled with transparent assessments of the intended use of the data generated to promote trust between organizations and funders and include a degree of hardship funds for funding shocks such as high inflation which can both increase overall costs and reduce the engagement of volunteers.

Beyond these recommendations, the findings of this assessment will inform the further development and co-design of the wider EuropaBON Biodiversity Observation Network. In particular, it will inform the assessment of costs involved in establishing and sustaining existing and new biodiversity monitoring efforts across Europe and how they are to be co-ordinated and co-located across the continent. Notably, issues around staff costs and investment, the challenges of staff wages in lower-income countries and the use of novel technologies to facilitate data entry, validation and management, all emerge as important factors to properly cost future monitoring network. These cost-related issues will be further explored and refined as part of the co-development of EBV workflows and the design of the Biodiversity Monitoring Co-ordination Centre to implement this design.

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Appendix 1 – EuropaBON costs of Monitoring Survey

Thank you for your interest in this survey. Below is the text for all the questions included in the survey. Please note that many of the questions will only be shown to you if you answer others in certain ways. This is to allow us to capture a broad diversity of information from monitoring organizations without overloading respondents with irrelevant questions. In most cases, the answers you will have to choose from or the format that we would ask you to input your answers in, are included in italic text. Please complete the survey online as it will be very difficult to do so properly using this document alone.

Page 1 - Background
Q1: Please give the name, job title and e-mail address of the person in your organization we should correspond with about this survey.

Q2: Which of the following best describes your organization?
(*Answers: Government, NGO, research* etc.)

Q3: Does your organization monitor taxa or plants and/or animals or habitats (tick all that apply - you will have an opportunity to be more specific later)

Q4: How does your organization conduct biodiversity monitoring? Please tick all that apply:
(*Answers: Analyzing genetic material, Collecting observations or samples in-field (including camera traps, sound recording etc.), Using remote sensing, using satellite data to generate new data, Other please state*)

Q5: Does your organization use data collected by volunteers?

Q5b: This survey asks for some detailed information, which, although important to understating your work, may be difficult or sensitive for some organizations to provide. Please indicate below if any of the following are likely to be too time consuming or sensitive to answer - you will be shown different, less detailed, questions instead.
(*Answers*: *Details of Monitoring Activities, Number of Paid Staff, Number of Volunteers, Monitoring Costs, Monitoring Income*).

Page 2 – What you monitor
Q6a: Which taxa or groups of species does your organization monitor? You can specify particular taxa (e.g. birds), groups (e.g. wetland birds, farmland birds etc.) or individual species if you monitor these separately. How many species within each taxon/group does your organization monitor?
(*Answers: You may name up to 15 taxa/groups and for each specify how many species are included, all questions relating to taxa/groups later on in the survey will use the answers you give here*) – **You will only see this question if you indicated that you monitor taxa in Q3.**

Q6b: What habitats does your organization monitor? Please tick all that apply
(*Answers: Marine; Costal; Inland surface waters; Mires, Bogs and Fens; Grasslands and lands dominated by forbs, mosses or lichens; Heathland, scrub and tundra; Woodland, forest and other wooded habitats; Inland unvegetated or sparsely vegetated habitats; Regularly or recently cultivated agricultural, horticultural and domestic habitats; Constructed, industrial and other artificial habitats; Other (please state) – all questions relating to habitats later on in the survey will use the answers you give here*) – **You will only see this question if you indicated that you monitor habitats in Q3.**

Q7: Which countries does your organization conduct monitoring in? Please tell us if there are any

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taxa/habitats that you do not monitor in all of these countries

Q8: Do you collect field data using standardised monitoring protocols? (i.e. all sites are sampled using the same methods).
(*Answers: Yes - all of our data is collected in this way; No - none of our data is collected with standard protocols; Both - some of our data is collected in this way but we also collect data without protocols*)

Q9: Do you collect field data from a pre-selected site network?
(*Answers: Yes - all our data is generated from pre-selected sites; No - none of our data is from pre-selected sites; Both - some of our data is from pre-selected sites but some is sent in ad-hoc*)

Page 3 – Organization structure
Q10: Approximately, how many people are involved are formally employed as part of your monitoring efforts? (The same people can be employed in multiple roles so double counting is ok).
(*Answers: As administrators, to collect field data, to analyse or maintain data, Other (please specify)*)

Q10b: Do you hire contractors to support your monitoring work?

Q10c: Please use this space to tell us how the staff working in your organization are distributed among monitoring work for different taxa and/or habitats (skip this question if it is not relevant)
If you indicated in Question 5b that this information will be difficult or sensitive then you will see the following instead

Q10d: Approximately how many people are paid, full time staff in your organization are involved in monitoring?
(*Answers: Less than 10, 10-25, 25-50, More than 50, I would prefer not to answer*).

Page 4 – Data collected
Q11a: Which of the following genetic variables does your organization monitor? (please tick all that apply for each taxa)
(*Answers: Genetic diversity, Genetic differentiation, Effective population size, Inbreeding, Phylogenetic abundance*) – **You will only see this question if you indicated that you collect genetic material in Q4**.

Q11b: Which of the following species and community variables does your organization monitor? (please tick all that apply for each taxa)
(*Answers: Species, Distribution, Species Abundance, Morphology, Physiology, Phenology, Community Abundance, Taxonomic abundance, Trait diversity, Interaction diversity*). – **You will only see this question if you indicated that you have named at least one Taxa/group in Q6a**

Q11c: Which of the following habitat and ecosystem variables does your organization monitor? (please tick all that apply for each taxa)
(*Answers: Primary Production, Ecosystem Phenology, Ecosystem Disturbances Live cover fraction, Ecosystem distribution, Ecosystem vertical profile, Plant community abundance, Plant taxonomic/phylogenetic abundance, Plant trait diversity, Interaction diversity*) – **You will only see this question if you indicated that you monitor habitats in Q3**

Q11d: Please use this space to tell us about any other variables you monitor.

Q12: What are the overall objectives of your monitoring activities (please tick all that apply)?
(*Answers: Evaluating EU or other International policy goals, Evaluating national or sub-national*

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policy goals, Maintaining a record of biodiversity, Undertaking risk assessments for land management/development, Developing new biodiversity conservation activities, Supporting existing biodiversity conservation activities, Generating data for free distribution, Generating data for private or commercial use, Research into ecological systems, Research into the impacts of human activities on biodiversity, Research into climate change impacts on biodiversity, Other (please specify))

Q13: If the data you generate is sent to any central or co-ordinating organizations, please use this space to tell us about these organizations and what data they generate from the information you supply them (e.g. maps, indicators etc.).

Page 4a – Genetic Monitoring
You will only see these questions if you indicated that you collect genetic material in Q4.
Q14 – Genetic: Please tell us about the genetic monitoring you undertake (based on the average of the last 5 years)
(*Answers: For each taxa/group or habitat that you named in Q6a/b, you will be asked to indicate: Where do you collect DNA from how it is analysed, and if this analysis conducted by a third party*).

(**If you indicated in Question 5b that this information will be difficult or sensitive:** *Answers: For each taxa/group or habitat that you named in Q6a/b, you will be asked to indicate one of the following: We do not collect genetic data, yes – but it is not validated, Yes and it is validated*).

Q15 – Genetic: Please use this space if you wish to provide more details about your genetic analysis methods, why you use them and how you validate this data.

Q16 – Genetic: How regularly do you make the data that you generate through genetic analysis available to users outside your organization (either commercially or publicly)? (**If you indicated in Question 5b that this information will be difficult or sensitive, then you will not see this question**)
(Answers: *For each taxa/group or habitat that you named in Q6a/b, you will be asked to select one of the following answers: Do not make this available; Less than annually, Annually, Monthly, Weekly, Immediately).*

Q16b – Genetic: Please use this space to tell us about how you make your genetic data available (if applicable)

Page 4b – Field Monitoring
You will only see these questions if you indicated that you collect observations or samples in-field in Q4.

Q14 – Field: Please tell us about the monitoring of taxa/groups that you undertake (based on the average of the last 5 years)
(*Answers: For each taxa/group or habitat that you named in Q6a/b, you will be asked to indicate: The monitoring methods used, number of sites and size of sites and whether or not you undertake any lab identification of the data collected by these methods.*)

(**If you indicated in Question 5b that this information will be difficult or sensitive:** *For each taxa/group or habitat that you named in Q6a/b, you will be asked to indicate one of the following: Do not monitor this in field, Traditional methods (e.g. direct observations, pan traps), Technology-based monitoring (e.g. camera traps), A mix of traditional and technological methods. You will also be asked to indicate whether or not you validate this data.*)

In addition, *if you answered in Q8 that you use structured monitoring for some, but not all of your sites, you will also be asked to indicate the proportion of sites that are monitored using structured*

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methods. If you answered in Q5 that volunteers are a part of your monitoring activities you will be asked to indicate the proportion of sites are monitored by volunteers only)

Q15a – Field: Please use this space to tell us about why you use the monitoring methods that you use.

Q15b – Field: Do you apply any validation, curation or quality control methods to the field data you collect? (**If you indicated in Question 5b that this information will be difficult or sensitive you will not see this question**)
(*Answers: For each taxa/group or habitat that you named in Q6a/b, you will be asked to indicate: Whether you validate, curate or apply quality control to all, some or none of the data, and how you do this*)

Q16 – Field: How regularly do you make the field data or variables that you generate available to users outside your organization (either commercially or publicly)? (**If you indicated in Question 5b that this information will be difficult or sensitive you will not see this question**)
(Answers: *For each taxa/group or habitat that you named in Q6a/b, you will be asked to select one of the following answers: Do not make this available; Less than annually, Annually, Monthly, Weekly, Immediately).*

Q16b – Field: Please use this space to tell us about how you make your field data available (if applicable)

Page 4c – Remote sensing monitoring
You will only see these questions if you indicated that you use remote sensing or satellite data in Q4.

Q14 - Remote: Please tell us about the remote sensing monitoring you undertake (based on the average of the last 5 years)
(*Answers: For each taxa/group or habitat that you named in Q6a/b, you will be asked to indicate: The input data used, the remote sensing analysis used, the resolution (in m2), the total area monitored (in km2) and how you validate this data (if applicable)*

If you indicated in Question 5b that this information will be difficult or sensitive: *Answers: For each taxa/group or habitat that you named in Q6a/b, you will be asked to indicate: Do not use remote sensing, satellite based data, other data collection (e.g. drones) and indicate whether this is validated and if so, using field data collected by you*)

Q15 – Remote: Please use this space to tell us about why you use these data modelling methods and how you validate them. (**If you indicated in Question 5b that this information will be difficult or sensitive you will not see this question**)

Q16a – Remote: How regularly do you make the data or variables that you generate through remote sensing available to users outside your organization (either commercially or publicly)? (**If you indicated in Question 5b that this information will be difficult or sensitive you will not see this question**)

Q16b – Remote: Please use this space to tell us about how you make data available (if applicable)

Page 5 – Monitoring Costs
Q17: Based on the last 5 years, approximately what are your organizations total annual gross operating costs for all your monitoring activities? (please specify currency) (**If you indicated in**

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Question 5b that this information will be difficult or sensitive you will not see this question)

Q18a: Approximately, how are these monitoring costs divided? (must add up to 100%) (**If you indicated in Question 5b that this information will be difficult or sensitive you will not see this question**)
(*Answers: you will see a series of sliders, you may drag these to the appropriate position on a 0-100% line. The total must add up to 100%. Items with * are only displayed if you indicate that they are relevant earlier in the questionnaire*
The categories are: Payroll (including overheads), Rent and utilities, Field data collection, Genetic analyses*, Validation of data, Data management, distribution or storage, Services or data from other sources, Capacity building, training and/or events, Contractors, Other (please specify)*)

Q18b: Approximately how are your field data collection costs divided among the different habitats and taxa/group that you monitor? If you cannot divide your costs this way, then please leave this question blank. Total must add up to 100%. (**If you indicated in Question 5b that this information will be difficult or sensitive you will not see this question**)

(*Answers: you will see a series of sliders, one for each taxa/group or habitat that you indicated in Q6a/b, you may drag these to the appropriate position on a 0-100% line. The total must add up to 100%.*)

If you indicated in Question 5b that this information will be difficult or sensitive you instead see this question Q18d: Thinking about the costs of your monitoring work, how much would you estimate is spent on the following?
(*Answers*: *For each cost category you will be asked to indicate one of the following: None, little (<10%), some (10-25%), much (25-50%), a lot (>50%).*
Categories: Payroll (including overheads), Rent and utilities, Field data collection, Genetic analyses*, Validation of data, Data management, distribution or storage, Services or data from other sources, Capacity building, training and/or events, Contractors, Other (please specify)*)

Q18c: Please use this space to provide us with more details about your organizations costs - for example if any of these costs vary between taxa/habitats or if there are any costs that do not occur annually.

Q19: Based on the last 5 years, what is your organizations total annual gross income from monitoring activities? (please specify currency) (**If you indicated in Question 5b that this information will be difficult or sensitive you will not see this question**)

Q20: How much do each of the following funding sources contribute to your organizations monitoring activities (as an approximate %, must add up to 100%) (**If you indicated in Question 5b that this information will be difficult or sensitive you will not see this question**)
(*Answers: you will see a series of sliders, you may drag these to the appropriate position on a 0-100% line. The total must add up to 100%.*
Categories: Direct government funding, Sale of data generated, Sale of membership fees or merchandise, Consultation fees from Private Organizations or NGOs, Research Grants, Other (please specify))

If you indicated in Question 5b that this information will be difficult or sensitive you instead see this question Q20b: In a typical year, how much would you estimate that the following sources contribute to your monitoring income?
(*Answers*: *For each cost category you will be asked to indicate one of the following: We do not get funding from this source, a little (<10%), some (10-25%), much (25-50%), a lot (>50%).*

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Categories: Direct government funding, Sale of data generated, Sale of membership fees or merchandise, Consultation fees from Private Organizations or NGOs, Research Grants, Other (please specify))

Q21: Please use this space to tell us more about your organizations' monitoring income.

Q22: Have there been any factors that have significantly affected your annual costs or income in the last 5 years (e.g. Covid-19)? Please use this space to explain in as much detail as you would like.

You will only see the following questions if you have indicated that volunteers are part of your monitoring organization activities and that it is not sensitive or difficult information.
Qv1: Based on the last 5 years, how many volunteers do you estimate contribute work to your organization (in any form) each year?
(*Answers: By collecting (or helping to collect) data, By analysing data, In any other capacity (please specify)*)

Qv2: How many hours per year do you estimate that volunteers contribute to your organization?
(*Answers: To organizational administration, To lab based work, To field data collection, To data validation or processing, Other (please specify)*)

Qv3: Are there any costs that volunteers typically incur when participating in your monitoring work?

Page 6 – Bottlenecks and Challenges
Q23: Do you know of any other organizations that monitor biodiversity in the same sites or spatial areas as your work? Please use this space to tell us about them (if applicable)

Q24: On a scale of 1 (not a problem) to 5 (a serious problem) how much do any of the following factors negatively affect your ability to collect good quality data?
(*Answers: Overall budget available, Budget variation between years, Changes to data needed between years, Availability of specialists, Pressure to reduce costs, Ability to retain volunteers, Ability to recruit volunteers – you will also be asked to indicate if any Taxa/habitat monitoring is particularly affected by each of these but you can leave that blank*)

Q25: If you received significant additional funding, how would you prioritise spending those funds? (on a scale of 1 (lowest priority) to 5 (highest priority))
(*Answers: Monitoring more sites, Adopting new field monitoring methods, Adopting new genetic methods, Adopting new remote sensing methods, New or additional data validation, Purchasing access to other datasets, Making data or data products available more regularly, Additional training, Hiring more paid staff*).

Q26: Please use this space to tell us more about cost and staff challenges that your organization faces and how they affect your activities.

At the end of the survey you will also be invited to participate in a structured interview to discuss these issues further.

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Appendix 2 - EuropaBON Costs of Monitoring Interview Questions

Questions

1) In the survey you stated that [answer to survey question 24] were significant problems for your organization – can you explain how?
2) Are there any other finance related factors that affect your activities?
3) In the survey you indicated that your main spending priorities would be [answer to question 25] – would you like to discuss that further?
4) [for organizations who use volunteers]: What would you like to do/see done to improve volunteer a) recruitment, b) distribution and c) retention?
5) Are there existing technologies (e.g. equipment, modelling software) that you would like to have access to or training with? [Examples drawn from EuropaBON Deliverable 4.2.]
6) What (if any) taxonomic capacity building would you like to see? (e.g. new guides, training etc.)
7) Do you feel that the data you generate is being put to best use or could more be done with it?
8) What data integration would you like to see? (e.g. access to other datasets, sharing your more widely?)
9) How do you feel further investment in your activities should be funded (e.g. government grants, EU funding, private investment, a combination of these?)

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Appendix 3 – Shadow Cost wage data

Wage data was taken from national minimum wage sources. For countries which do not have a minimum wage, we used the lowest wage of a worker available from relevant statistical databases or, in the case of Italy, where such data is not available, from the European Structure of Earnings report for 2018 (Eurostat, 2021). For countries with monthly minimum wages we assumed a 40hr working week and 4.33 weeks/month. For countries using non-Euro currencies, we used average annual exchange rates from 2021 (2022 data were not complete at the time of analysis) (European Central Bank, 2022; Exchange rates (2022a,b).

It should be emphasised that minimum wages were used to reflect the minimum value of the shadow costs, not as a reflection on the value of volunteer labour. Many volunteers would be considered skilled labourers if employed professionally.

Table A3.1. – Overview of Wage data

Country	Hourly wage	Source	Period	Notes
ALB	€ 1.55	Eurostat (2022)	2022	
AND	€ 6.93	Govorn d'Andorra (2022)	2022	
AUT	€ 11.66	Eurostat (2022)	2018	
BEL	€ 10.64	Eurostat (2022)	2022	
BGR	€ 2.10	Eurostat (2022)	2022	
BiH	€ 1.60	Wageindicator (2022a)	2022	
CHE	€ 26.40	Federal Statistical Office (2022)	2020	No management function (all age groups); lower quartile range
CYP	€ 6.99	Eurostat (2021)	2018	
CZE	€ 3.78	Eurostat (2022)	2022	
DEU	€ 10.07	Eurostat (2022)	2022	
DNK	€ 24.46	Statistics Denmark (2022)	2021	Lower Quartile, non-managerial, hourly paid, General government
ESP	€ 6.74	Eurostat (2022)	2022	
EST	€ 3.78	Eurostat (2022)	2022	
FIN	€ 11.74	Statistics Finland (2022)	2021	Lower decile, upper secondary education
FRA	€ 9.50	Eurostat (2022)	2022	
GRC	€ 4.80	Eurostat (2022)	2022	
HRV	€ 3.59	Eurostat (2022)	2022	
HUN	€ 2.91	Eurostat (2022)	2022	
IRL	€ 10.25	Eurostat (2022)	2022	
ISL	€ 19.42	Eurostat (2021)	2018	
ITA	€ 11.81	Eurostat (2021)	2018	
LTU	€ 4.21	Eurostat (2022)	2022	
LVA	€ 2.89	Eurostat (2022)	2022	
LUX	€ 13.36	Eurostat (2022)	2022	
MKD	€ 2.07	Eurostat (2022)	2021	
MDA	€ 0.97	Ministerul Justiţiei (2022)	2022	
MLT	€ 4.57	Eurostat (2022)	2022	

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MNE	€ 3.07	Eurostat (2022)	2022	
NLD	€ 10.14	Eurostat (2022)	2022	
NOR	€ 16.35	Statistics Norway (2022)	2021	Lower quartile, Skilled agricultural, forestry and fishery workers, Basic Monthly Salary
POL	€ 3.71	Eurostat (2022)	2022	
PRT	€ 4.75	Eurostat (2022)	2022	
ROU	€ 2.98	Eurostat (2022)	2022	
RUS	€ 1.01	Wageindicator (2022b)	2022	
SRB	€ 2.32	Eurostat (2022)	2022	
SVK	€ 3.73	Eurostat (2022)	2022	
SVN	€ 6.20	Eurostat (2022)	2022	
SWE	€ 13.88	Statistics Sweden (2022)	2021	Primary and secondary education 9-10 years
TRK	€ 2.16	Eurostat (2022)	2022	
UKR	€ 1.21	Ministry of Finance (2022)	2022	
UK	€ 8.17	UK Government (2022)	2022	Age 23 and over

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Appendix 4 – Overview of the Key EBVs monitored

From the EBV data types monitored by respondents we identified those that were relevant to the key EBVs identified in Junker et al (2023). The most commonly monitored are included in Table A4.1. The number of key EBV data types monitored were significantly correlated with the number of taxa and habitats monitored ($\rho=0.435$, $p<0.001$ and $\rho=0.311$, $p=0.01$ respectively).

Table A4.1: The most common key EBV data types collected

Key EBVs	Number of respondents
44: Species distributions of terrestrial birds	28
45: Species abundances of terrestrial birds	25
1: Species abundance of freshwater birds	22
46: Species abundance of selected terrestrial mammals	19
47: Species distributions of all terrestrial mammals	18
25: Species distribution of marine birds	14
58: Phenology of migration of terrestrial and wetland birds	13
49: Species abundance of butterflies	12
30: Phenology of migration of marine birds and mammals	11
66: Ecosystem distribution of terrestrial EUNIS Habitats	9
Other key species distribution EBVs	40
Other key EBVs	52

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Appendix 5 – Detailed Statistical Outputs

All statistical analysis was conducted in R version 4.2.2. (R Core team, 2022). Correlation analyses were conducted using Spearman's rho, given the number of ordinal, count and other non-normal data in the dataset. Moods median tests (ordinal data), Fishers' tests (count data) and Kruskal-Wallis tests (continuous data) were used to examine differences between binary groups (e.g. EU membership).To explore the relative importance of different factors on a) costs, b) number of EBV data types and c) the number of sites monitored, we conducted linear regression modelling against a series of continuous and categorical variables from the survey. As not all respondents provided exact monetary estimates of costs, we instead used the median values of the categories as the dependent variable, allowing them to be modelled as continuous variables[6]. Initial models used the dependent variables in Table 2, substituting some variables for others under certain circumstances (noted in the table). Continuous variables were log or square root (if zeroes are present) transformed to improve model fit as appropriate. An Akaike information criterion (AIC) selection process (backward steps) was used to refine the model (Burnham and Anderson, 2002). Models were checked for multicollinearity using Variance Inflation Factor (VIF) and parameters with VIF >2 were removed. We present the models with the highest Adjusted R^2.

Table A5.1: Overview of initial variables used in regression models

Variable	Type	Description
Costs	Continuous	Median values of cost categories (log transformed)
Genetic	Binary	Binary variable denoting whether or not the respondent used genetic methods
Remote Sensing	Binary	Binary variable denoting whether or not the respondent used Remote Sensing methods
Sites	Continuous	Number of sites monitored across all taxa (log transformed)
Volunteers*	Binary/ Continuous	Binary variable denoting whether or not volunteer data was a key component of respondent monitoring or number of volunteers (square root transformed)
Contractors*	Binary/ Continuous	Binary variable denoting whether or not the respondent hired contractors or number of contractors hired (square root transformed)
Data Quality**	Continuous	Composite variable capturing site density, monitoring structure and validation (see above for details).
Number of Taxa	Count	Number of Taxonomic groups monitored
Number of Habitats	Count	Number of EUNIS habitats monitored
Staff	Ordinal	Ordinal categories of the number of staff
GDP Per Capita (PPP)	Continuous	National Gross Domestic Product Per capita (IMF, 2022), adjusted for power purchase parity. This is used as a proxy for national wealth and relative wage (Log transformed)

*Contractors and volunteers are included as a binary variable in all initial models but were replaced with the square root transformed number of volunteers and/or number of contractors if this variable was significant.
** If this variable was not included in the final model, we re-ran the model using its four component variables: Site pre-selection (Ordinal: 0-2 none, some, all), standardised methods (Ordinal 0-2: none, some, all data), % of data validated (continuous) and site density (continuous, sites/km2)

[6] Ordinal logistic regression models using costs as categorical variables were attempted but failed tests of proportional odds and are not presented

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Table A5.2. Correlation matrix (spearman's rho) of common variables

	Number of Taxa	Number of Habitats	Number of Sites	Site Density	Staff	Number of Contractors	Number of Volunteers	Number of EBV Data Types	Costs	GDP Per Capita (PPP)
Number of Habitats	0.279									
Number of Sites	0.195	0.018								
Site Density	0.123	0.091	0.526							
Staff	0.419	0.285	0.196	0.122						
Number of Contractors	0.237	-0.060	0.294	0.195	0.080					
Number of Volunteers	-0.177	-0.335	0.358	0.017	-0.164	0.084				
Number of EBV Data Types	0.650	0.418	0.071	0.036	0.348	0.126	-0.085			
Costs (categorical)	0.222	-0.069	0.541	0.288	0.253	0.498	0.181	0.063		
GDP Per Capita (PPP)	-0.133	-0.343	0.292	0.299	-0.256	0.191	0.268	-0.316	0.443	
Data Quality	-0.002	-0.332	0.188	0.463	0.007	0.178	-0.051	-0.313	0.293	0.386

Cells highlighted are statistically significant at p≤0.05

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Table A5.3. Correlation matrix (spearman's rho) of Cost and Income variables

		Number of Taxa	Number of Habitats	Number of Sites	Site Density	Staff	Number of contractors	Number of Volunteers	Number of EBV data types	GDP Per Capita (PPP)	Data Quality
	Costs	0.222	-0.069	0.541	0.288	0.253	0.498	0.181	0.063	0.443	0.293
% of Costs	Wages	0.216	-0.105	0.346	0.136	0.191	0.060	0.223	0.158	0.179	0.171
	Rent & Utility	0.251	0.095	0.009	-0.070	0.050	0.031	-0.169	0.331	-0.051	0.001
	Field Data	-0.191	0.238	-0.293	-0.101	0.003	-0.001	-0.257	0.024	-0.493	-0.155
	Genetic	0.119	0.170	-0.012	-0.098	0.207	-0.032	-0.133	0.157	-0.034	-0.039
	Validation	0.166	-0.007	0.112	0.180	-0.014	0.314	-0.096	0.093	0.173	0.172
	Data management	-0.024	-0.006	0.179	0.161	-0.072	0.099	0.180	0.056	0.274	0.043
	External services	-0.064	-0.024	-0.065	-0.111	-0.042	0.184	-0.005	-0.047	0.171	0.201
	Capacity building	-0.004	0.098	-0.019	0.013	0.059	-0.036	0.279	0.159	0.089	-0.056
	Contractors	0.226	0.068	0.218	0.142	0.051	0.732	0.048	0.206	0.114	0.186
	Other	-0.071	0.097	-0.091	-0.230	-0.096	0.004	-0.113	-0.238	-0.037	-0.016
% of income	Government	0.152	-0.261	0.239	0.295	0.020	0.212	-0.013	-0.259	0.452	0.521
	Sale of Data	-0.115	-0.065	0.261	0.258	-0.161	0.134	0.264	0.115	0.138	-0.049
	Membership	-0.151	-0.127	0.121	0.065	-0.139	0.229	0.172	-0.074	0.067	0.025
	Consultancy	-0.170	0.002	-0.127	-0.155	-0.004	-0.122	-0.068	-0.043	-0.195	-0.184
	Research grants	-0.063	0.282	-0.199	-0.130	0.081	-0.167	0.025	0.344	-0.257	-0.333
	Other	0.213	0.185	0.064	-0.271	0.005	0.176	0.180	0.169	-0.190	-0.152

Cells highlighted are statistically significant at p≤0.05

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Table A5.4. Correlation matrix (spearman's rho) of Bottleneck and priority scores (scored on a 1-5 basis)

		Number of Taxa	Number of Habitats	Number of Sites	Site Density	Staff	Number of Contractors	Number of Volunteers	Number of EBV Data Types	Costs	GDP Per Capita (PPP)	Data Quality
Bottlenecks	Total Budget	-0.002	0.152	-0.172	-0.075	-0.171	-0.096	-0.112	0.078	-0.201	-0.244	-0.117
	Budget Variation	-0.292	0.018	-0.220	-0.161	-0.054	0.005	-0.030	-0.115	-0.179	-0.202	-0.097
	Data Changes	0.009	0.073	-0.121	0.028	0.067	-0.189	0.001	0.152	-0.049	-0.148	-0.187
	Specialists	0.111	0.151	-0.199	-0.132	0.157	0.087	-0.051	0.152	-0.112	-0.156	-0.210
	Cost Reduction	-0.010	0.156	0.008	0.057	0.327	0.049	-0.104	-0.020	0.086	-0.039	0.079
	Volunteer Retention	-0.123	-0.018	-0.277	-0.345	0.193	-0.006	0.167	-0.020	-0.075	-0.249	-0.248
	Volunteer recruitment	-0.080	-0.038	-0.154	-0.113	0.122	-0.050	0.160	0.037	-0.090	-0.147	-0.206
	Average Score	-0.087	0.096	-0.282	-0.185	0.124	-0.024	0.002	0.041	-0.128	-0.272	-0.206
	Number of High scores	-0.029	0.128	-0.172	-0.084	0.189	0.002	-0.044	0.046	-0.059	-0.230	-0.177
Priorities	More Sites	-0.024	0.208	-0.034	-0.003	0.052	0.088	0.002	0.234	-0.023	-0.309	-0.082
	New Field methods	-0.149	0.038	-0.145	0.111	-0.007	0.115	-0.260	-0.070	-0.174	-0.182	0.147
	New genetic methods	0.212	0.163	-0.210	-0.212	0.170	0.110	-0.151	0.215	-0.043	-0.146	-0.157
	New Remote Sensing methods	0.099	0.285	-0.227	0.060	0.131	0.037	-0.374	0.273	-0.143	-0.395	-0.040
	New Validation methods	-0.126	0.058	-0.009	-0.013	-0.194	-0.184	-0.006	0.071	-0.189	-0.106	-0.205
	Buying datasets	0.141	0.184	-0.278	-0.061	0.054	-0.097	-0.173	0.312	-0.219	-0.307	-0.110
	Making data available	-0.105	0.186	-0.297	-0.251	-0.113	-0.115	-0.098	0.178	-0.383	-0.345	-0.217
	Training	-0.135	0.095	-0.213	-0.220	0.312	-0.038	-0.017	0.111	-0.282	-0.363	-0.275
	Hiring staff	0.141	0.232	-0.150	-0.075	0.143	0.193	-0.251	0.236	0.116	-0.150	-0.158
	Average Score	0.017	0.270	-0.290	-0.091	0.104	0.078	-0.258	0.316	-0.203	-0.414	-0.172
	Number of High scores	-0.082	0.265	-0.248	-0.127	0.088	-0.034	-0.156	0.260	-0.331	-0.457	-0.195

Cells highlighted are statistically significant at p≤0.05

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Table A5.5. Correlation matrix (spearman's rho) of Bottleneck and priority scores (scored on a 1-5 basis) vs costs

		% of Costs									
		Wages	Rent & Utility	Field Data	Genetic	Validation	Data management	External services	Capacity building	Contractors	Other
Bottlenecks	Total Budget	-0.270	0.094	0.081	-0.186	-0.234	-0.136	0.060	-0.106	-0.127	0.143
	Budget Variation	-0.286	0.078	0.283	-0.141	-0.120	-0.085	-0.119	-0.137	-0.156	0.081
	Data Changes	0.060	0.246	0.018	-0.064	-0.078	0.039	-0.092	0.165	-0.174	-0.210
	Specialists	-0.121	-0.071	0.111	-0.139	0.076	-0.044	-0.058	0.072	0.110	-0.112
	Cost Reduction	0.099	-0.029	0.040	0.246	-0.072	-0.050	-0.049	0.112	-0.006	-0.012
	Volunteer Retention	-0.073	-0.099	0.037	0.080	-0.007	0.032	0.118	0.095	-0.064	-0.040
	Volunteer recruitment	0.044	-0.187	0.048	0.002	-0.020	-0.006	-0.003	0.002	-0.272	-0.031
	Average Score	-0.127	-0.021	0.112	-0.054	-0.077	-0.073	-0.013	0.053	-0.174	-0.012
	Number of High scores	-0.080	-0.138	0.036	-0.031	-0.001	-0.022	-0.005	-0.007	-0.174	0.098
Priorities	More Sites	-0.070	0.094	0.215	-0.051	-0.160	-0.147	-0.081	0.016	0.092	-0.175
	New Field methods	-0.082	0.085	0.271	0.211	0.187	0.105	-0.007	0.113	0.218	-0.092
	New genetic methods	-0.062	0.258	-0.138	0.204	0.144	-0.123	0.087	0.050	0.183	0.107
	New Remote Sensing methods	-0.133	0.245	0.467	0.267	0.048	-0.043	0.076	0.126	0.118	-0.032
	New Validation methods	-0.114	0.078	0.100	-0.133	0.011	0.097	0.003	0.217	-0.154	-0.031
	Buying datasets	-0.032	0.173	0.056	0.040	-0.118	-0.251	-0.133	0.048	-0.093	-0.099
	Making data available	-0.131	0.065	0.257	0.010	-0.236	-0.168	-0.023	0.121	-0.180	-0.032
	Training	-0.053	-0.013	0.195	-0.116	-0.015	-0.045	-0.190	0.120	-0.137	-0.121
	Hiring staff	0.034	-0.087	0.111	-0.014	-0.024	-0.008	0.187	0.016	0.224	-0.021
	Average Score	-0.093	0.187	0.273	0.136	0.005	-0.085	-0.004	0.136	0.058	-0.085
	Number of High scores	-0.090	0.015	0.296	0.100	-0.107	-0.110	-0.120	0.028	-0.047	-0.038

Cells highlighted are statistically significant at p≤0.05, Average score = the average score of all bottlenecks/priorities, Number of high scores = the number of bottlenecks/priorities scores as 4 or 5 (out of 5)

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Table A5.6. Correlation matrix (spearman's rho) of Bottleneck and priority scores (scored on a 1-5 basis) vs Income

		% of income					
		Government	Sale of Data	Membership	Consultancy	Research Grants	Other
Bottlenecks	Total Budget	-0.361	0.041	-0.055	0.040	0.199	0.002
	Budget Variation	-0.445	0.131	-0.086	0.159	0.211	0.243
	Data Changes	-0.318	-0.009	-0.065	0.430	0.221	0.039
	Specialists	-0.203	-0.038	-0.101	-0.020	0.072	0.216
	Cost Reduction	-0.113	0.099	-0.170	-0.169	0.301	-0.085
	Volunteer Retention	-0.245	-0.084	0.005	0.048	0.233	0.056
	Volunteer recruitment	-0.181	0.167	0.133	-0.102	0.242	0.018
	Average Score	-0.419	0.069	-0.056	0.088	0.307	0.149
	Number of High scores	-0.373	0.093	-0.020	-0.030	0.252	0.171
Priorities	More Sites	-0.303	0.215	-0.035	0.088	0.209	0.156
	New Field methods	-0.122	0.006	0.034	0.145	0.163	-0.178
	New genetic methods	-0.228	-0.038	-0.008	0.222	0.341	0.100
	New Remote Sensing methods	-0.316	-0.066	-0.147	0.181	0.490	-0.130
	New Validation methods	-0.195	0.187	-0.014	0.006	0.227	-0.070
	Buying datasets	-0.195	0.036	-0.018	-0.056	0.173	-0.022
	Making data available	-0.388	0.153	0.008	0.061	0.180	0.094
	Training	-0.266	0.148	0.017	0.112	0.147	0.117
	Hiring staff	-0.142	-0.089	0.015	-0.102	0.191	0.013
	Average Score	-0.432	0.189	0.017	0.123	0.378	0.021
	Number of High scores	-0.459	0.164	-0.023	0.021	0.361	0.086

Cells highlighted are statistically significant at p≤0.05, Average score = the average score of all bottlenecks/priorities, Number of high scores = the number of bottlenecks/priorities scores as 4 or 5 (out of 5)

Table A5.7. Poisson Regression output of Number of EBV data types

Coefficient	Estimate	Std. Error	t-value	p-value
Intercept	2.349	0.328	7.164	**<0.001**
log(GDP Per Capita)	-0.336	0.078	-4.33	**<0.001**
Genetic Methods	0.655	0.116	5.667	**<0.001**
Remote Sensing Methods	-0.294	0.099	-2.96	**0.003**
Volunteers (binary)	0.288	0.105	2.737	0.054
Number of Taxa	0.308	0.024	12.944	**<0.001**
Number of Habitats	0.093	0.022	4.212	**<0.001**

McFadden Pseudo R2: 0.5170

Table A5.8: Linear regression model outputs of costs

Coefficient	Estimate	Std. Error	t-value	p-value
Intercept	3.930	1.325	2.966	**0.005**
log (GDP per capita)	1.043	0.308	3.388	**0.001**
Genetic methods	0.769	0.525	1.465	0.149
Log (number of sites)	0.399	0.095	4.200	**<0.001**
Log (sites per km)	-0.169	0.091	-1.854	0.070
Percentage of data validated	0.823	0.455	1.810	0.076
Volunteers	-0.569	0.332	-1.714	0.093
Contractors	0.661	0.317	2.085	**0.042**

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Number of taxa monitored	0.149	0.110	1.358	0.181
Number of paid staff	0.408	0.270	1.511	0.137

Adjusted R^2 = 0.574

Table A5.8. Linear Regression model outputs of data quality metric

Coefficient	Estimate	Std. Error	t-value	p-value
Intercept	0.010	0.713	0.014	0.989
Log (GDP Per capita)	0.387	0.175	2.216	**0.031**
Genetic Methods	-0.463	0.275	-1.683	0.098
Sqrt (Number of Volunteers)	-0.008	0.005	-1.764	0.083
Log (Median costs)	0.128	0.062	2.062	**0.044**

Adjusted R2= 0.1977

Table 5.9: Regression model outputs of costs per EBV data type per site

Coefficient	Estimate	Std. Error	t-value	p-value
Intercept	-2.984	1.654	-1.804	0.078
Log (GDP Per capita)	1.885	0.410	4.6	**<0.001**
Sqrt (Number of Volunteers)	-0.034	0.010	-3.335	**0.002**
Log (Sites per Km)	-0.363	0.110	-3.315	**0.002**
Sum number of Taxa & Habitats*	-0.204	0.079	-2.564	**0.013**

Adjusted R^2 = 0.482 * The model initially showed near significant effects of taxa and habitats separately. Including both collectively improved model fit and resulted in overall significance

Table A5.10. Linear regression model outputs of costs per EBV data type per site (weighted by data quality)

Coefficient	Estimate	Std. Error	t-value	p-value
Intercept	-3.759	1.648	-2.28	**0.027**
Log (GDP Per capita)	1.780	0.408	4.365	**0.000**
Remote Sensing Methods	0.685	0.478	1.434	0.158
Sqrt (Number of Volunteers)	-0.032	0.010	-3.116	**0.003**
Log (Sites per Km)	-0.415	0.109	-3.812	**0.000**
Sum number of Taxa & Habitats*	-0.225	0.084	-2.688	**0.010**

Adjusted R^2=04782

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