

Rollout of European Monitoring of Biodiversity in Agricultural Landscapes (EMBAL)

Final Report

Project - n° 4013299

E F T A S Fernerkundung
Technologietransfer GmbH

and

Institute for Agroecology
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1 Introduction

Europe is confronted with a dramatic loss of wild pollinators, primarily driven by biodiversity and habitat loss in agricultural landscapes. While the decline is alarming, there is no clear picture on European scale.

In frame of this context the DG Environment initiated “**Rollout of the European monitoring of biodiversity in agricultural landscapes (EMBAL)**” (Contract N° 09.0201/2021/864765/SER/ENV.D.2). Aim of this rollout is to collect a baseline of agri-environmental information in all 27 EU Member States, in order to allow objectively measuring, evaluating and monitoring the complex interdependencies between nature value, ecosystem services, and socio-economic impacts of arable land at European scale.

The objective of this final report is to provide a comprehensive overview of the project's implementation, and survey activities and providing a first insight in the collected data.

1.1 Objectives

The EMBAL Field Survey collects baseline data and monitors biodiversity in agricultural landscapes, addressing knowledge gaps in the evaluation and development of EU policies related to biodiversity. It specifically aligns with the EU Biodiversity Strategy for 2030, EU Pollinators Initiative, and Common Agricultural Policy.¹

EMBAL provides data on land use, biodiversity and ecological value of agricultural landscapes and addressing the main sectors relevant for a wide range of agricultural and environmental concerns:

- Land cover and land use
- Landscape elements
- Nature value of all surveyed land use units and landscape elements
- Habitat types (EUNIS classification)
- Biodiversity of grassland, arable land, fallow land as well as plot biodiversity
- Nature value of the landscape
- Pollination potential through the assessment of flowering species, their density and distribution

In this context EMBAL is a robust tool to monitor farmland biodiversity and nature value across the European Member States that is comparable between regions and over time.

Following a period of methodological development and a first pilot (see chapter 1.2), EMBAL was rolled out across the EU-27 Member States for the first time in 2022 and 2023, covering in both years 3,000 sample plots. The sample plots have been selected using a stratified sampling approach to allow estimation of parameters at Member State level and biogeographic region.

The collected data establish the first EU in situ baseline for biodiversity over two consecutive years using a standardised approach. This dataset forms the foundation for EU-wide data analysis, assessing the robustness of parameters and methods as well as the variability of parameters between two survey seasons. It lays the foundation for future EMBAL rollouts and sampling scenarios.

The analysis of the EMBAL data will be the task of the DG Environment project: “**Analysis of the EMBAL 2022 and 2023 Surveys and the LUCAS 2022 Grassland Survey**”².

1.2 Background

The EMBAL field survey originates in LISA approach³ (Oppermann et al. 2021) and a number of different previous studies on the development of a methodology for in situ data collection on farmland biodiversity and the ecological structure of agricultural landscapes. Building on the finding of the LISA study the

¹ <https://wikis.ec.europa.eu/pages/viewpage.action?pageId=25560696>

² <https://etendering.ted.europa.eu/cft/cft-display.html?cftid=15450>

³ Oppermann, R., Aguirre, E., Bleil, R., Calabuig, J. D., Šálek, M., Schmotzer, A., & Schraml, A. (2021). A Rapid Method for Monitoring Landscape Structure and Ecological Value in European Farmlands: the LISA approach. *Landscape Online*, 90, 1-24. <https://doi.org/10.3097/LO.202190>.

Commission launched the EMBAL project in 2017 to develop a monitoring system. This was followed by a pilot in 2019-2021 to refine the EMBAL method in the field in a selected number of countries and formulate rollout scenarios. Following the pilot, DG Environment initiated the first rollout of EMBAL in all EU27 Member States in two subsequent years 2022 and 2023 for 3,000 EMBAL plots.

Particularly the related manuals, a fine-tuned survey protocol, as well as data collection tools that were elaborated in the recently accomplished precursor project “**EMBAL methodological enhancement and demonstration**” are essential inputs for the implementation of this contract.

EMBAL is spatial and methodological harmonised with the LUCAS (Land Use and Coverage Area frame Survey), in particular with the LUCAS Grassland Module (Sutcliffe et al. 2019)⁴

1.3 Contractual setup

The EMBAL project team that implemented the survey campaigns on 3,000 sample plots in both 2022 and 2023, consists of consortium of **EFTAS Fernerkundung Technologietransfer GmbH** and the **Institute for Agroecology and Biodiversity – IFAB**.

Field survey was executed by **freelance surveyors**, the **Institute of Agricultural Resources and Economics - AREI** in the Baltics countries as well as parts of Sweden and Finland and by **Data Immigrant** (Hungary) in 25 survey lots across Europe.

The complete field database from 2022 and 2023 have been delivered to DG Environment, ANNEX 2 provides a list of all EMBAL 2022 and 2023 rollout deliverables and the implemented project workplan. The deliverables were provided as FTP download.

ANNEX 1 provides an overview of the identified project risks.

ANNEX 3 and 4 provide information on the use restrictions of the Ground documents (including orthophotos) produced for the EMBAL survey and delivered to DG Environment.

⁴ Sutcliffe, L. , Schraml, A., Eiselt, B. & Oppermann, R. (2019). The LUCAS Grassland Module Pilot – qualitative monitoring of grassland in Europe. Eurasian Dry Grassland Group, Scientific Report, p.27. Online: [DOI: 10.21570/EDGG.PG.40.27-31](https://doi.org/10.21570/EDGG.PG.40.27-31).

2 Realisation of the surveys

The EMBAL rollout entails surveying a scenario of 3,000 sample plots, each measuring 500x500m, across all 27 EU Member States in both the years 2022 and 2023.

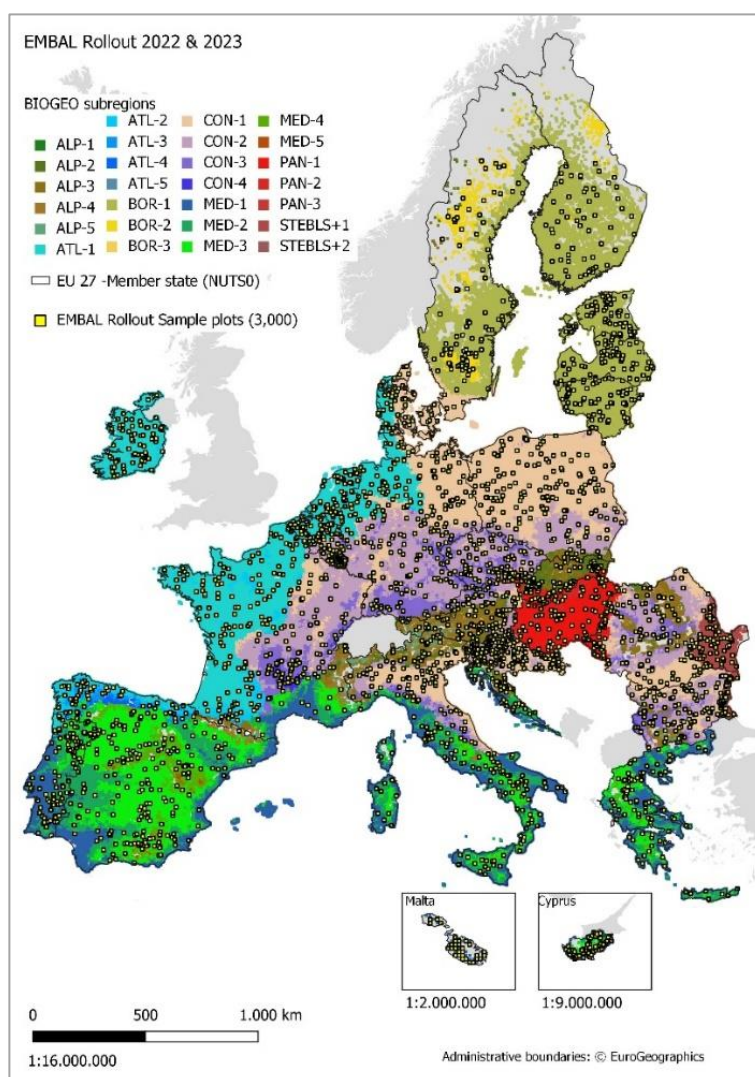


Figure 1: EMBAL rollout sample and biogeographical subregions

The sample plots were selected with a stratified random sampling approach, using Member States and biogeographical subregions as strata. The subregions are defined by the biogeographical region⁵ and altitude zones from 1 to 5. The number of sample per country and biogeographical subregion was selected proportionally to the area under agricultural use, with a minimum number of plots per Member State to ensure estimation at Member State level. The plots were selected from the EMBAL 2020 Master Sample frame, a 2x2km grid based on the LUCAS Master grid and including only agricultural areas. Figure 1 shows the distribution of the sample plots across the EU 27 Member States and biogeographical subregions.

After the 2022 survey, the sample was updated for the 2023 survey, wherein 107 plots, reported as not observable, were replaced with new plots from the same strata.

Details of the sampling process are described in the *EMBAL 2022 Inception Report* and *EMBAL 2022 2023 Sampling Strategy*⁶.

⁵ <https://www.eea.europa.eu/data-and-maps/figures/biogeographical-regions-in-europe-2>

⁶ EMBAL2022_2023_Sampling_Strategy.pdf

2.1 Workflow

An EMBAL plot consist of three spatial levels of mapping units (Figure 2).

- **Plot** 500x500m square (25ha)
- **Parcels and landscape elements (LE)** – polygons - inside the plot. Arable and grassland parcels, landscape elements and non-agricultural areas.
- **Vegetation transects** - lines – a pair (interior and margin). Detailed observation of vegetation parameters in selected arable and grassland parcels.

For each element specific parameters are collected during the field survey and the geometries of the parcels and LEs are adjusted according to the situation in the field. The transects are observed with the highest level of detail.



Figure 2: EMBAL sample units

The EMBAL workflow for data collection consists of five general steps (Figure 3):

- **Pre-processing**, of the EMBAL plots before the survey. To streamline the field survey process, digital orthophotos are utilized to map the parcels and LEs. In a second step the proposed vegetation transect are allocated in the parcels. The source of the orthophotos used in the EMBAL rollout is listed in ANNEX 4.
- The actual **field survey** by the surveyors. The required parameters are collected for all elements according to the *EMBAL Survey Manual*, including changes of geometry and documentation with photos. The data collection process is standardized and facilitated by a mobile app and complemented by ground documents such as field maps.
- The **post processing** of the recorded data in Geographic Information System (GIS). Adjustment of the parcel and LE geometries from the pre-processing based on the findings in the field.
- The **data delivery** with the central office and **quality control** loops.

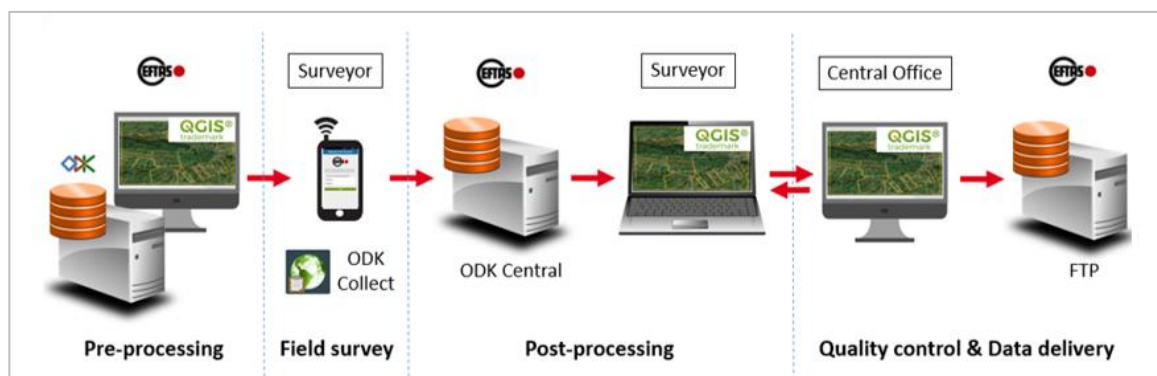


Figure 3: EMBAL Workflow

The EMBAL field survey is planned to follow the optimal time period per Biogeographical region and altitude level. The survey period shall ensure to capture the vegetation parameter at a suitable phenological stage and before major agricultural management takes place (mowing, grazing, ploughing or harvesting). Figure 4 shows the optimal survey period for the EMBAL 2023 sample

2.2 Fieldwork 2023 and 2022

The realisation of the survey 2022 and 2023 followed the same overall structure and data collection workflow defined in the *EMBAL survey protocol*. The field survey in 2022 is described in detail in the *EMBAL 2022 Interim Report*. Therefore the following chapters focus on the realisation of the 2023 survey and highlights changes compared to the 2022 survey execution.

The bulk of sampling and pre-processing of the EMBAL plots has been executed in preparation for the 2022 survey. Based on the results from the 2022 survey 107 plots reported as not observable were removed from the sample and replaced with new samples from the same strata.

For the 2023 survey 36 additional sample plots were selected strategically in close proximity to test sites from the projects **“Preparatory action for monitoring of environmental pollution using honey bees”**⁷ (INSIGNIA) and **“Strengthening pollinator recovery through indicators and monitoring”**⁸ (SPRING), aiming for further harmonization between EMBAL and other pollinator initiatives. The selection of the additional samples was done in close exchange with the SPRING and INSIGNIA project coordinators. The 36 plots were selected outside the EMBAL statistical sample.

The pre-processing for the 2023 survey was therefore limited to the 107 new sample plots and 36 additional plot selected close to INSIGNIA and SPRING sites. This was executed before the start of the survey in March and April 2023.

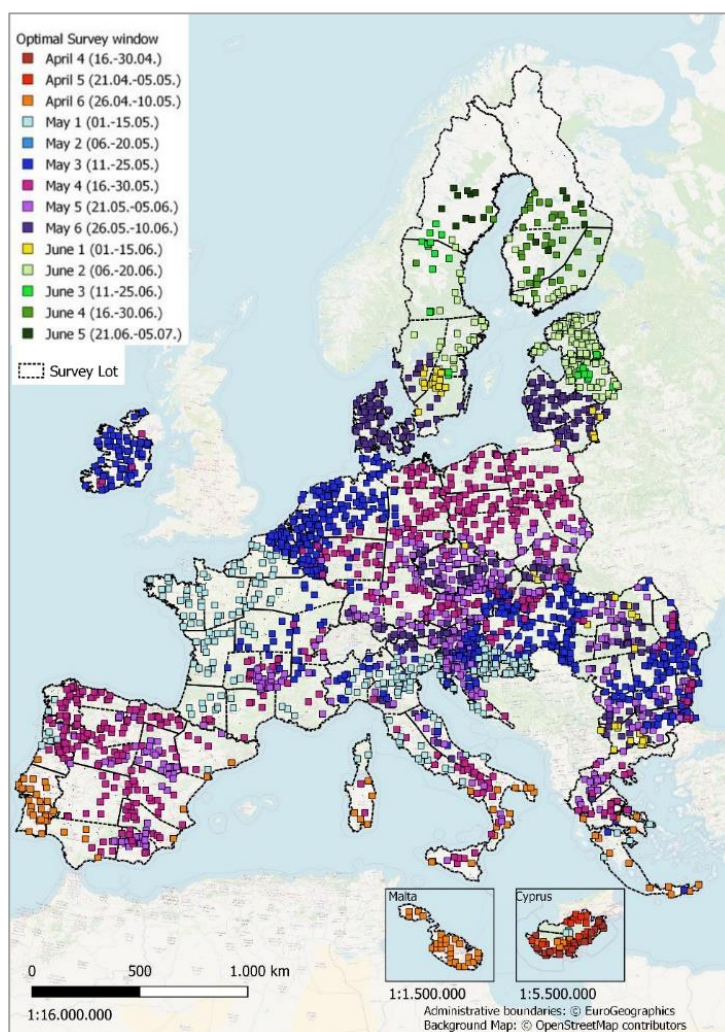


Figure 4: EMBAL 2023 sample plots – Survey lots and optimal survey period

⁷ <https://wikis.ec.europa.eu/pages/viewpage.action?pageId=36702461>

⁸ <https://wikis.ec.europa.eu/display/EUPKH/SPRING+project>

As in 2022 the workload in the 27 countries was arranged in equal work packages “lots”, accounting for an approximated workload of 15-20 field days per lot and considering accessibility and optimal survey period. Only minor updates in the arrangement of the lots compared to 2022 were integrated, mainly to optimize accessibility within lot and adjust to the updates in the sample. Figure 4 shows the 128 survey lots in EU 27 countries and the optimal survey periods of the plots.

The surveyor equipment and material for the EMBAL Survey include (Figure 5):

- *EMBAL Survey Manual and Indicator species list*
- Ground documents
- Accreditation letter in different languages
- Additional supporting technical documents (Posy photo background, Nomenclature short list, etc..)
- Digital maps and data packages for the field data collection and post-processing

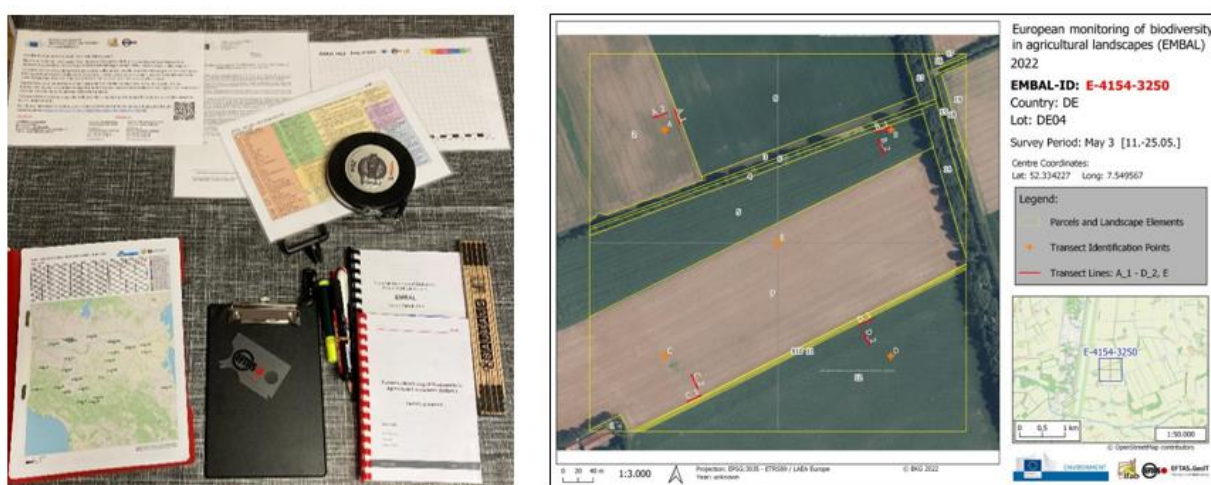


Figure 5: EMBAL Survey Equipment & Ground document layout

The Ground Documents are comprehensive field maps featuring an orthophoto background, indicating the EMBAL plot (500x500m), parcel and LE geometries, and proposed transect positions. Produced for each selected EMBAL plot, these documents are delivered as non-georeferenced PDF files. It's important to note that the orthophotos utilized in generating the Ground documents are subject to distinct license conditions (refer to ANNEX 4). The EMBAL 2022 / 2023 Ground documents are therefore provided with a restriction on use. Access is limited to internal use within the EMBAL 2022 / 2023 project, exclusively within DG Environment, and solely in non-georeferenced PDF format. Further details can be found in Annex 3 for clarification.

For the 2023 survey of EMBAL, the workflow and material and documentation underwent refinement and further specification based on the experiences gained from the 2022 survey. The updates encompassed:

- Enhancement of the Survey Manual and Indicator Species List, detailed in the EMBAL Survey Manual 2023.
- Inclusion of additional parameters and nomenclature to more accurately record complex landscape structures with multiple land uses.
- Introduction of a specific change assessment process, enabling surveyors to assess the reasons for changes observed from 2022 to 2023 by providing them with the results from the 2022 survey.
- Improvement of the quality control (QC) mechanism by introducing mandatory quality control checks and dedicated feedback loops after the first survey day.

The training of surveyors was organized in five sessions (Figure 6). In comparison to 2022, the training sessions were extended by 1-2 days, totalling 4-5 days. This extension aimed to provide a more focused approach to specified QC procedures, workflow routines, and GIS processing, the last two addressing bottlenecks identified in the data flow during the 2022 survey.



Figure 6: EMBAL 2023 Surveyor Trainings (Italy, Germany, Hungary, Latvia)

The 2023 survey was started as planned and the first plot was observed at 12th of April in Malta, the last plot was observed in at 15th August in northern Sweden. As in 2022 EFTAS and IFAB maintained a very close follow up on the survey progress (Figure 7) and the data flow.

Weekly monitoring of survey progress

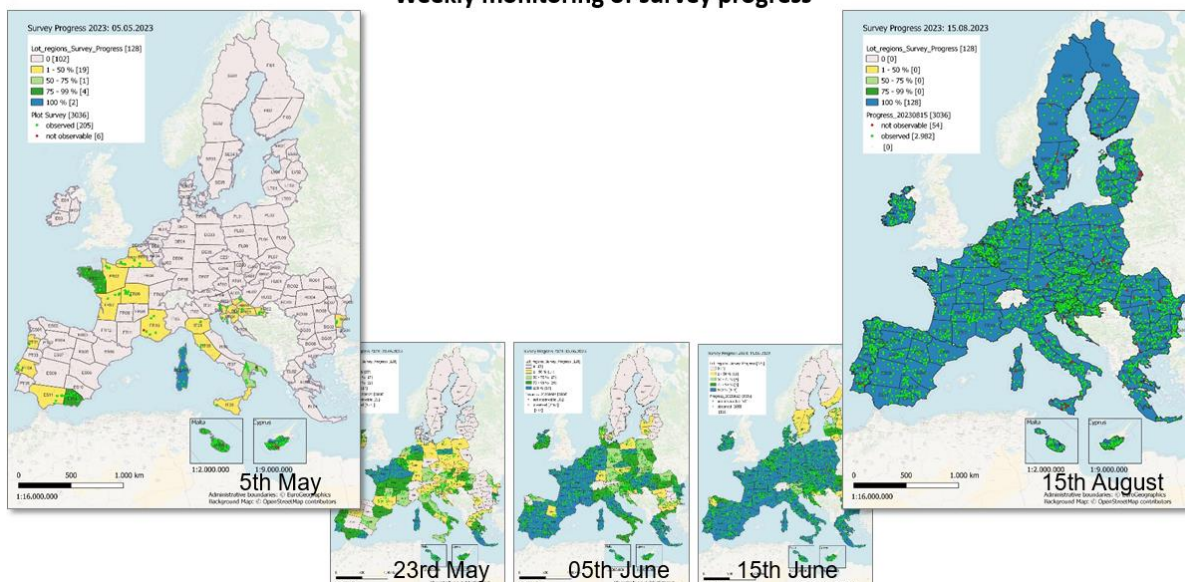


Figure 7: EMBAL 2023 - Survey progress

The overall data collection for the survey was successfully concluded within the planned timeframe. In total around 85% of the plots were observed within the optimal survey period +/- 5 days. Figure 8 shows a comparison of the actual survey date compared to the optimal survey period for the 2023 and 2022 field campaign.

Minor delays in certain regions were attributed to unforeseen adverse weather conditions (e.g. Italy, Croatia), surveyors discontinuing their assignments prematurely (e.g. Poland), or challenges in assigning all Lots to surveyors before the survey's commencement (e.g. Portugal, Spain, Romania, Bulgaria, Ireland).

The delay in the 2022 survey is mainly due to a lack of surveyors to do the field work in the planned time. In 2023 the availability of surveyors was significantly improved compared to 2022. This improvement can be attributed, in part, to the absence of a LUCAS survey in 2023 and the reengagement of about one-third of the surveyors from the 2022 EMBAL survey.

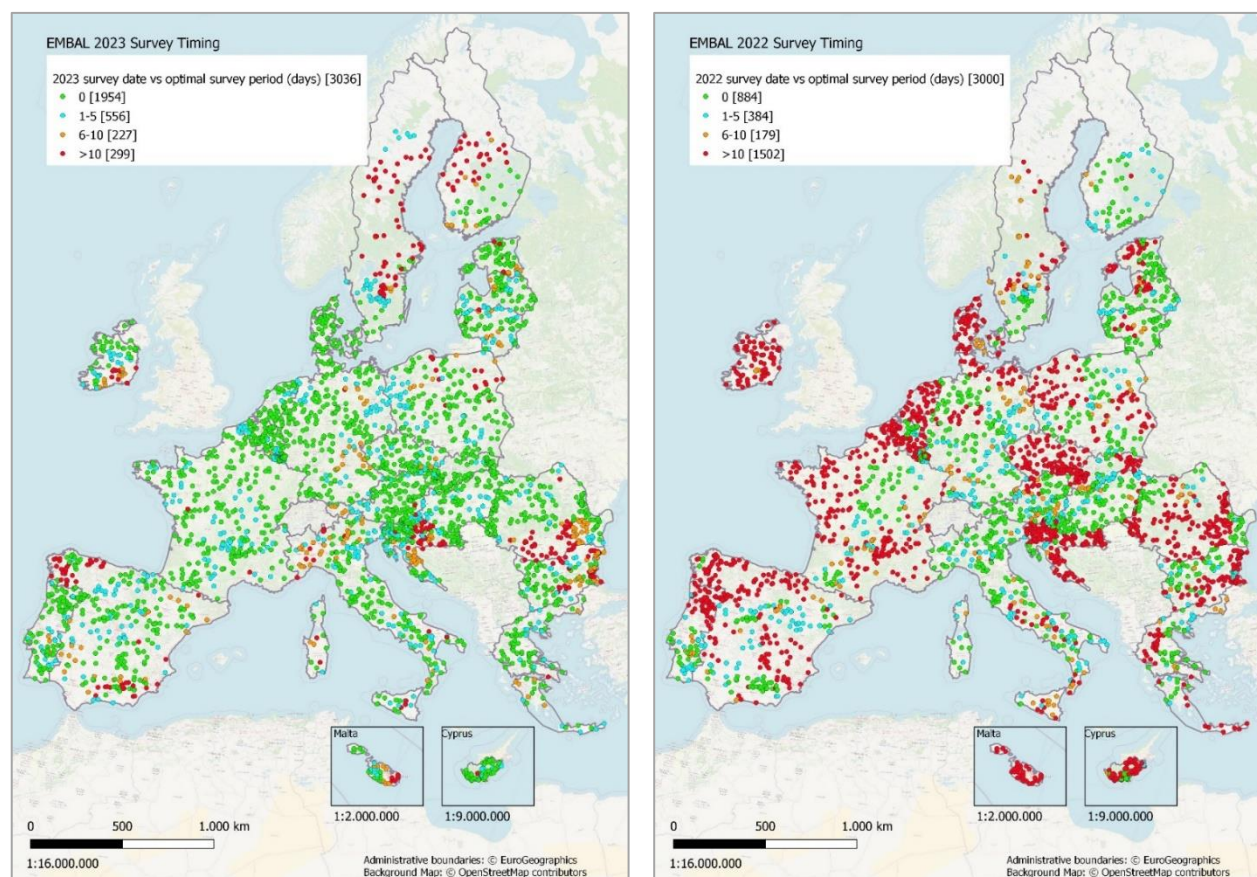


Figure 8: EMBAL 2023 and 2022 - survey date compared to optimal survey period

Accessibility of plot, parcels and transects was improved compared to 2022. 54 plots could not be observed in 2023 (99 not observed in 2022). Notably, 2,803 plots from 2022 were successfully observed again in 2023, enabling direct comparison. Table 1 provides a summary of observed plots, parcels, and transects in 2023, with a higher rate of observed elements across all categories. The column "Observed PI" refers to the observation of non-accessible parcels using photo interpretation (PI) of ground documents. This option was introduced in the 2023 survey and was limited to non-agricultural elements such as forests or settlements.

Table 1: EMBAL 2023 - Access to plots, parcels and transects

	Sample plots	Plot		Parcel / LE				Transects	
		Access	No Access	Observed	Partially observed	Observed PI	Not observed	Observed	Not observed
Sum	3,000	2,946	54	98,197	6,217	334	5,889	20,487	4,033
%		98%	2%	89%	6%	0%	5%	84%	16%

The major reason for not observing entire plots in 2023 was:

- *denied permission by land owners or farmers* , mentioned 25 times
- *no access road or blocked access*, mentioned 19 times
- *dangerous area* , mentioned 14 times

Similar to 2022, a major impediment to plot observation in 2023 was the denial of access or permission by landowners. Surveyors encountered hostile reactions in several instances, with reports ranging from punctured tires of surveyors' cars to an alarming incident where a surveyor was physically attacked by a landowner.

The elevated count of "dangerous" plots pertains to a group of plots near the Belarus border that were not observed due to the insecure border situation resulting from the attempted coup d'état involving the Wagner mercenary group. Other "dangerous" plots refer to the presence of wild animals (bears, boars) in the plot.

2.3 Technical setup and quality control

The technical setup for the EMBAL field surveys in both 2022 and 2023 follows the EMBAL Survey protocol available on the EC EMBAL website⁹. In both surveys the data workflow was managed through two primary systems:

- Data exchange between the surveyors and central office using FTP including:
 - Provision of data required for the survey, i.e. digital work packages per survey Lot.
 - Transfer of post-processed data from the surveyor to the Central office
 - Exchange of survey data between QC team and the surveyor as part of the QC loops.
- Data collection in the field using Open data Kit (ODK) tools and post-processing in QGIS:
 - Recording all required parameters in the field using guided entry forms, taking of photos and transect GPS tracing using ODK Collect mobile app.
 - Sending the collected field data to a central ODK server hosted at EFTAS
 - Integrating the collected field data from the server to QGIS for post-processing

Compared to the 2022 survey, refinements were implemented in the technical workflow to address issues and bottlenecks identified in the 2022 survey, this included:

- Enhancements in the ODK field forms related to the refinements of the Survey manual 2023. Simplification in data collection by combining arable and grassland transects in one transect form. Implementing considerably more additional business rules to prevent the input of inaccurate combinations of parameters or values.
- The post-processing workflow underwent adjustments and refinements in the EMBAL 2023 survey. The primary focus was on simplifying the QGIS post-processing, identified as a bottleneck, especially for surveyors with limited experience in GIS-related work. Additionally, further quality control routines were integrated into the workflow, emphasizing the structured entry or adjustment of parameters within QGIS. These changes aimed to enhance efficiency and accuracy, particularly for surveyors less familiar with GIS processes.

The workflow is further described in the *EMBAL Interim report* and the *EMBAL 2023 Technical Workflow* document.

⁹ <https://wikis.ec.europa.eu/pages/viewpage.action?pagelId=25560696>

Maintaining continuous communication with surveyors throughout the training and survey period is crucial. Building on the positive experience from 2022, communication with surveyors during training and the survey was once again organized through Slack. This platform proved highly effective, enabling close monitoring and rapid response to any issues or questions that arose, as well as facilitating the seamless sharing of information. The mobile application for Slack played a key role in facilitating quick and preferred communication with surveyors while in the field. Moreover, it fostered collaboration among surveyors, streamlining decision-making processes for challenging questions or technical issues. Additionally, it served as a platform for the exchange of experiences from the field, enhancing team spirit.

Quality control of the data is conducted at various stages throughout the EMBAL survey process:

- During field recording embedded in the ODK entry forms which prevent incomplete or inaccurate entries.
- Immediate QC loop after the first surveyed plots.
- During post-processing the surveyor have to perform quality checks for completeness and validity of geometries.
- Quality control of post-processed data is done by EFTAS and IFAB (formal and content based checks).
 1. Initial control on completeness of delivered data.
 2. Quality control on the survey parameters. This was supported by photos taken during the survey and provided to the quality control team.
 3. Data completeness and consistency check of delivered data for entire lot. Cleaning of geometric errors and incorrect parameters.

In 2023, there was a particular emphasis on enhancing the quality control (QC) loop during the initial stage of the survey. This “first flush QC” required each surveyor to promptly submit the first two recorded plots for immediate quality control assessment, with feedback provided within one day. This approach, demanding well-timed organisation and communication, proved to be successful in reducing systematic errors or misunderstandings right from the beginning and fostering the surveyor's confidence in the survey method.

To support quality control in 2023 additional parcel photos were included in the survey workflow, but also for verification of parameters in post-processing or to document impediments or special survey circumstances. In total around 12,000 plot, 75,000 transect and 70,000 parcel photos were recorded in 2023.

3 Outcomes and achievements

The EMBAL survey encompasses the collection of diverse data concerning biodiversity and land use. This chapter presents some key findings and initial visualizations of the survey data, offering a glimpse into possible analyses of the EMBAL data. It is important to note that the numbers and figures presented are preliminary and may be subject to change.

3.1 Survey timeliness

Timing of the EMBAL survey is crucial to maximize the meaningfulness of the biodiversity data.

Plant growth and development is most pronounced in late spring/early summer, with key indicator species for biodiversity such as Orchids flowering during this time. The timing of the survey also has to consider farming practices, and the survey window is designed to capture the vegetation at the peak of its growth and before mowing, (heavy) grazing or harvesting.

EMBAL follows a time-framing which was designed for the LUCAS grassland survey. It was designed with botanical experts from different regions of Europe to account for the different phenology in different biogeographical regions and altitudes. Each EMBAL plot thus has a limited 14 day window, in which the plot should be visited and data recorded.

The accuracy of the time-framing can be evaluated by looking at the proportion of grasslands which were not yet mown or pastured in the current season. On such parcels a full survey is possible. More than half of all grassland parcels in each Member State, save three, fell into this category (Figure 9).

This indicates an already good fit of the time-framing in the Member States, also considering use intensity of grasslands in the individual Member States. Member States with more intensively used grasslands have a lower fit, as the first cut or grazing of the grassland occurs earlier in the season, even before the “optimal survey period”. This is due to the high fodder demands of high intensity animal husbandry, which makes early harvesting of grasslands necessary. Use intensity is of course not the only aspect influencing the time-framing and state of the vegetation. Local agricultural practices, regulations for grassland use in nature protection areas and especially weather and seasonal changes play a large role in when a grassland is first cut or grazed in each plot and year.

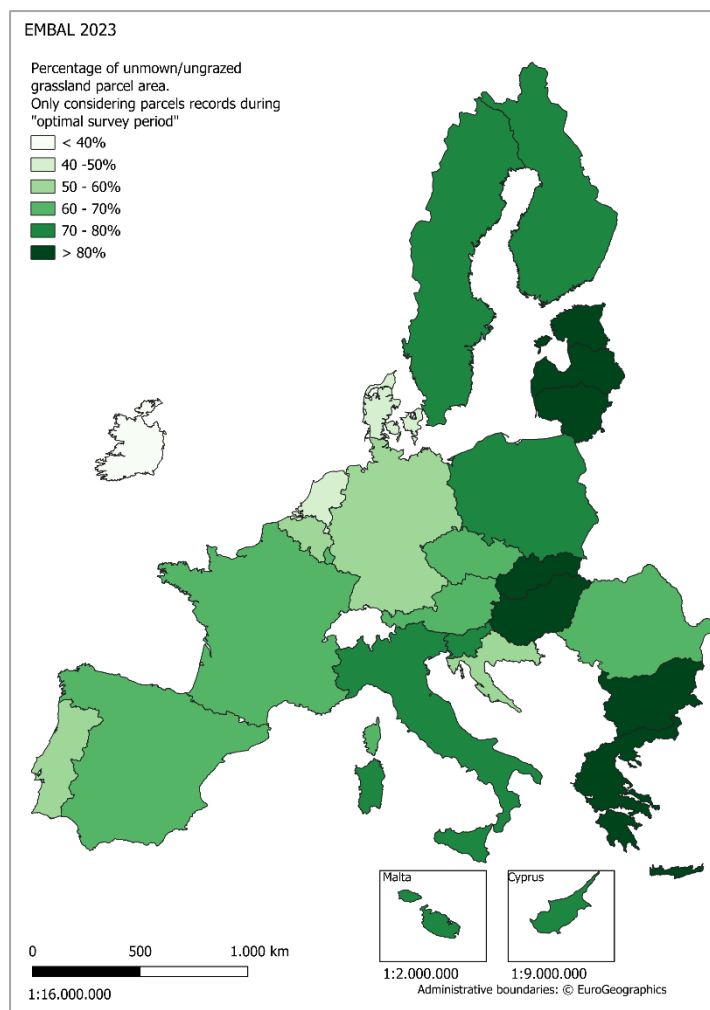


Figure 9: Percentage of grasslands with unmown or ungrazed vegetation observed during the “optimal survey period”

3.2 Nature Value of agricultural landscapes

EMBAL generates both general data on land use at parcel and plot level and vegetation data on a transect level. The general data such as the parameter “subjective Nature Value”, is an estimation of the capacity of

a landscape within the plot to support biodiversity as seen by the surveyor. As they are the person on the ground, they have the best overview of any given landscape and can take all the different elements influencing biodiversity into account.

The “subjective nature value” allows a check of other results for plausibility, and it will be complemented by an objective nature value index calculated from other biodiversity-relevant parameters in the longer term.

The “subjective nature value” can be viewed in conjunction with other objective survey parameters reflecting the biodiversity value of the plot, such as the record of “currently flowering indicator species”. The vegetation transect component of the EMBAL survey contains an assessment of specified “indicator species”. These are single species or groups of species which are both easily identifiable in the field and can give information about the overall biodiversity present in the area. The species in the list have been chosen after expert consultations and previous validation efforts in the LUCAS and EMBAL survey development process.

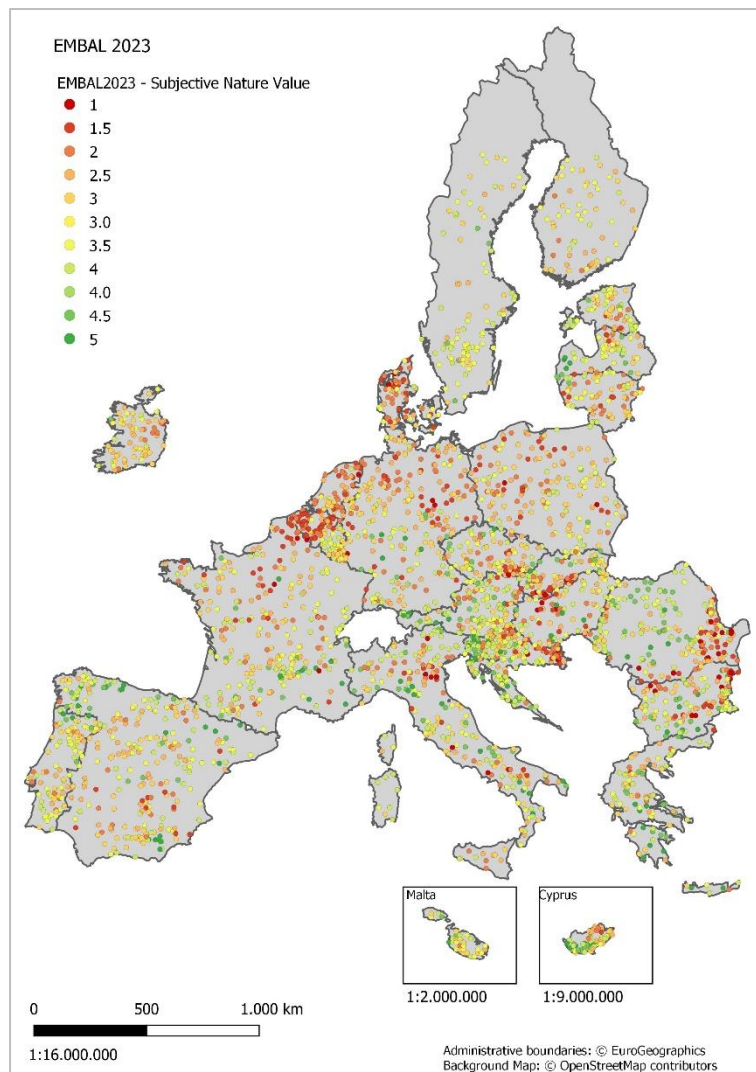


Figure 10: Map of the assessment of the “subjective nature value” per plot in the 2023 EMBAL survey. A low “subjective nature value” indicates a lower level of biodiversity in the plot as assessed by the surveyors.

With rising “nature value” assessments, a rise in the average number of “indicator species” would be expected. While the distribution of indicator species in transects on arable fields is relatively even (see Figure 11), there is a slight trend towards higher average indicator species numbers in grassland transect assessments (see Figure 12). However, the subjective nature value is based on the impression of the whole plot, in which landscape elements play a significant role, and not just the grassland and arable parcels in which transects were walked, so a close linear relationship is unlikely.

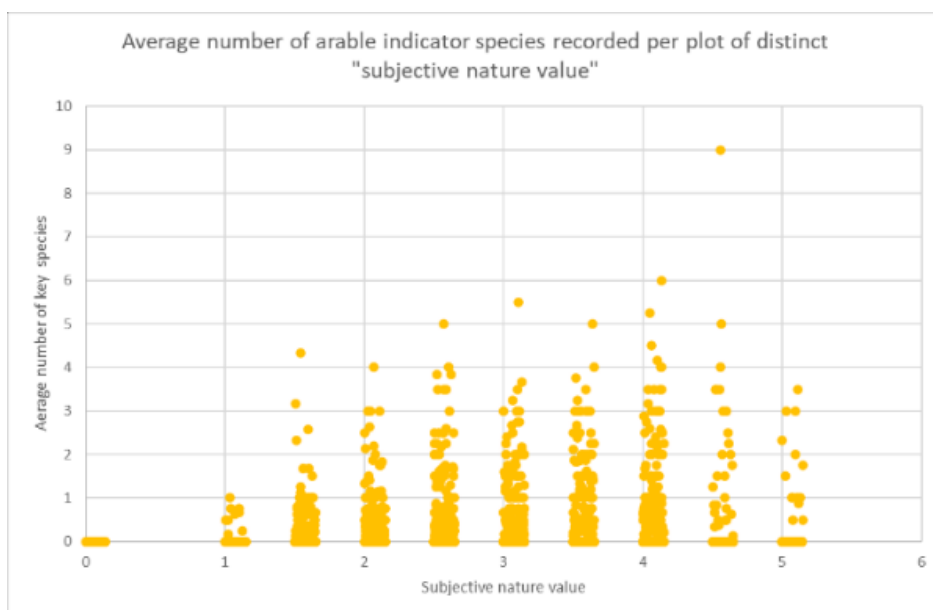


Figure 11: Average number of arable indicator species recorded in each plot, sorted by the "subjective nature value" of the plots.

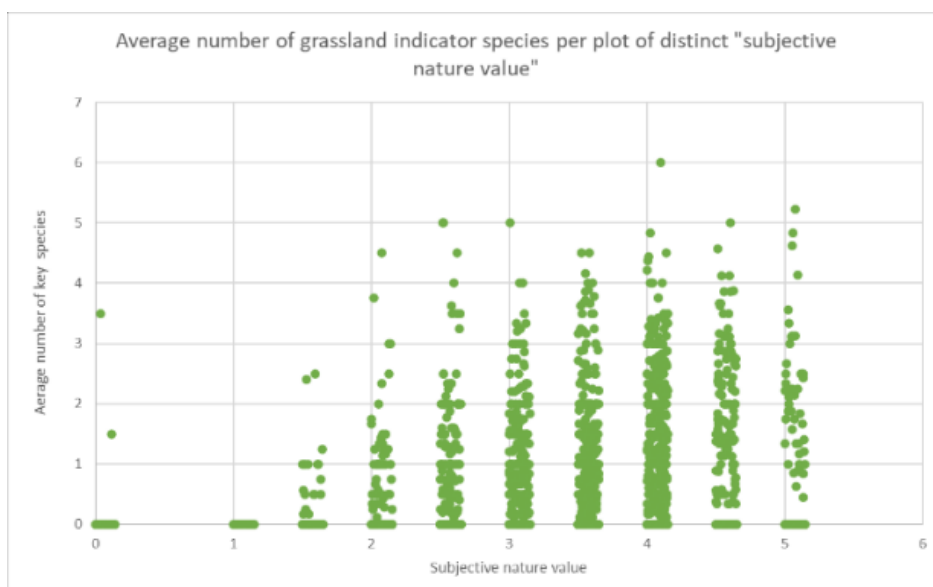


Figure 12: Average number of grassland indicator species recorded in each plot, sorted by the "subjective nature value" of the plots.

It should also be noted that the subjective nature value is not evenly distributed, but more resembles a normal distribution, with fewer plots receiving the minimum or maximum "subjective nature value" (see Figure 13).

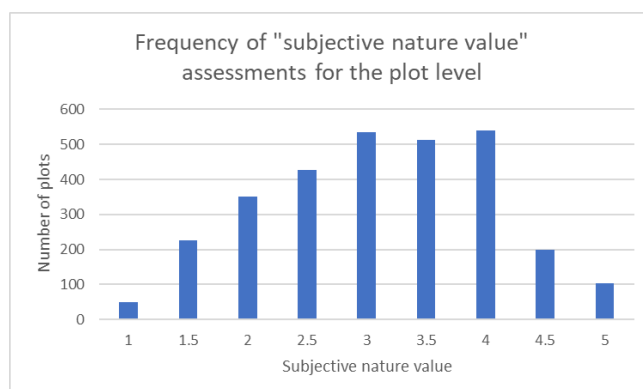


Figure 13: Number of plots according to their "subjective nature value" as assessed in the 2023 rollout.

3.3 Landscape heterogeneity

As EMBAL is designed to survey entire landscapes of 25 ha, the survey delivers data on the make-up and heterogeneity of landscapes. As landscapes with more, smaller parcels can offer varied habitat opportunities, monitoring trends in the change of parcel numbers is an important part of the EMBAL approach. Parcel numbers are highest in mountainous or hilly regions, especially in the mediterranean. Member States with flat terrain and where land collectivization has taken place have generally lower numbers of parcels per plot. Figure 14 shows the average of parcels per plot on Member State level, the plot values are weighted to consider the non-proportional sampling allocation in the different strata.

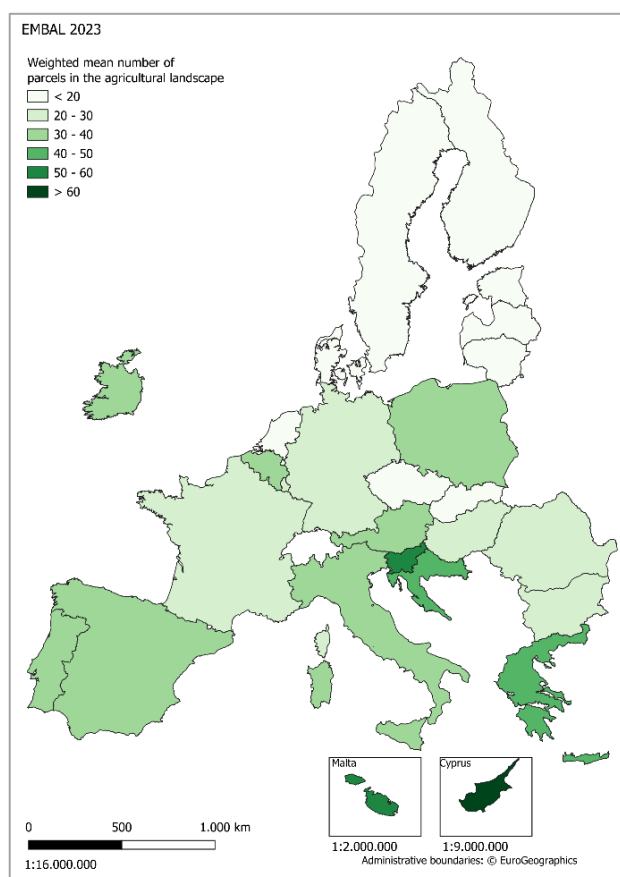


Figure 14: Weighted mean number of parcels in the agricultural landscape.

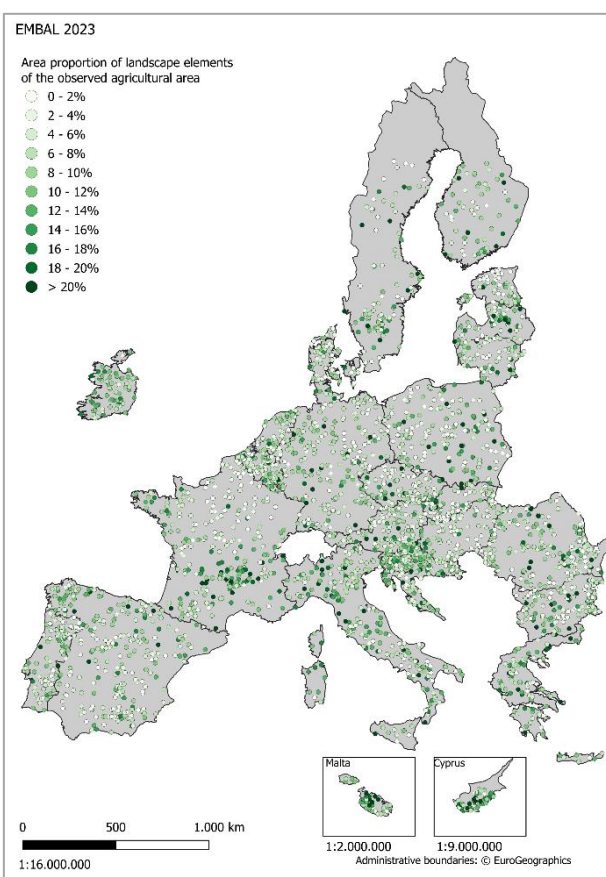


Figure 15: Average proportion of landscape elements of the area of the agriculturally used landscape of each plot.

Landscape heterogeneity is also linked with the distribution of “landscape elements” – areas of non-agricultural use such as ditches, hedges, stone walls or farm tracks between the agriculturally used parcels. These elements provide habitat opportunities and refuge for species of agricultural landscapes and thus provide a benefit for overall biodiversity. A similar picture as with parcel number is visible when reviewing the proportion of landscape elements in the agricultural landscape, with a higher proportion of landscape elements in the Mediterranean (Figure 15).

3.4 Use example – Grassland biodiversity

The intensity of grassland use has many implications for biodiversity. Grasslands, which are a mostly man-made habitat, provide habitat opportunities for many different plant and animal species. Through changes in land-use however, a trend towards less species diverse and more economically productive grasslands has occurred. Through the land cover classification of EMBAL, grasslands get not only assessed according to their land-use, but also the use intensity. This allows for an overview of where intensively used grasslands are prevalent (see Figure 16).

Due to high inputs of fertilizers and practices such as ploughing and re-seeding with grass species, grasslands in some European regions decrease in biodiversity. This is apparent in a general parameter such as the “Graminoid Forb ratio”, which describes the make-up of grasslands. Surveyors estimate whether a grassland is dominated by either grasses or forbs, or if the composition of the grassland is balanced. Vegetation dominated by grasses tends to produce more biomass but provide fewer resources for biodiversity, and especially pollinators. Grassland dominated by forbs tends to support higher levels of biodiversity but be less productive. A balanced distribution, with grasses and forbs making up about half of the vegetation each, provides a middle ground for species diversity and grassland productivity. The distribution of such “balanced grasslands” can be viewed in conjunction with other parameters, such as the use intensity (see Figure 16 and Figure 17). Balanced grasslands are less often recorded in areas of high use intensity.

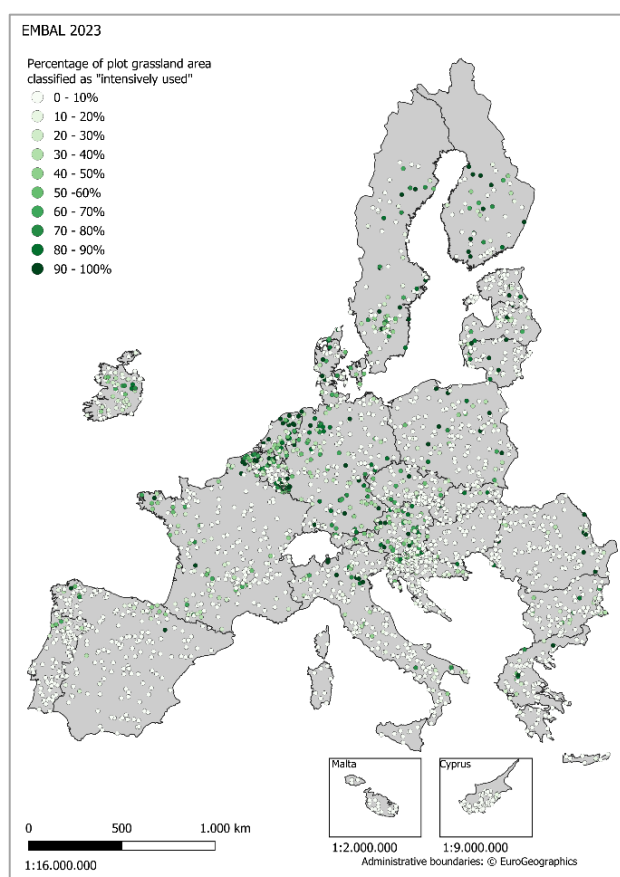


Figure 16: Percentage of intensively used grassland area among the entire grassland area of a given plot

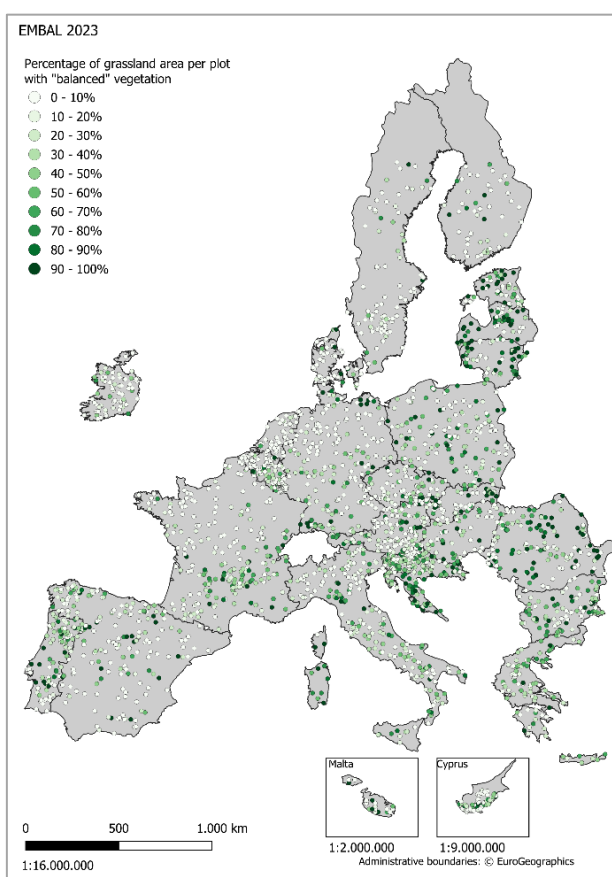


Figure 17: Percentage of „balanced grassland area“ among all whole grassland area of a plot.

The impacts of use intensity can also be seen in regards to species diversity. On the parcel level, the currently visible number of flower colours is recorded, as a proxy for overall species diversity. When comparing the

average number of flower colours for different types of grassland use and use intensity, a trend towards more visible flower colours is visible for more extensively used parcels (Figure 18).

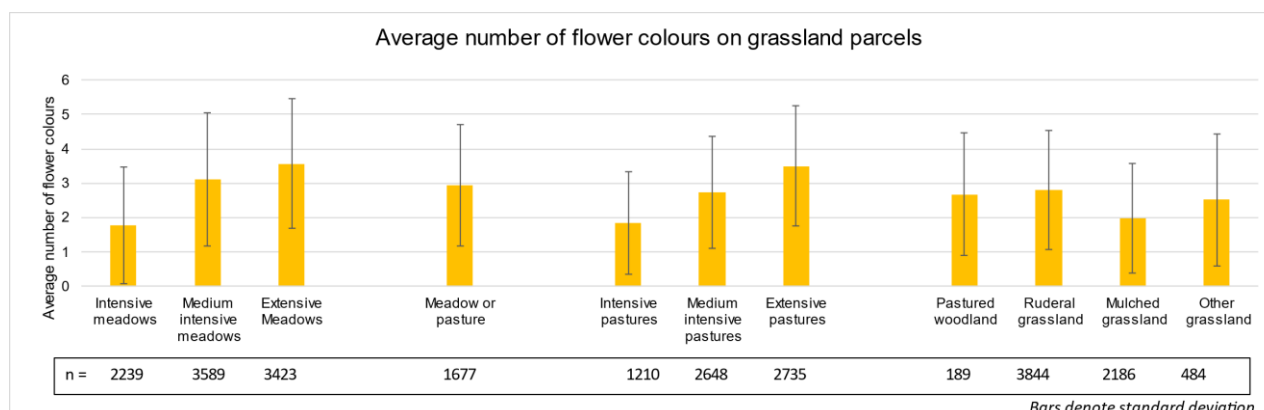


Figure 18: Average number of flower colours recorded on parcels different types of grassland use and use intensity. Mean taken for all surveyed grassland parcels.

Additionally to the more general parameters such as graminoid-forb ratio, detailed vegetation information is collected during transect walks on grasslands and arable fields. These provide insights into parameters such as the number of flowering forbs (see Figure 19) as a proxy for overall species diversity.

Similar to the “graminoid forb ratio”, the impacts of grassland use intensity can be seen when viewed through the average number of currently flowering forbs recorded during the transect walks (see Figure 20). Regions with more extensive grassland use have higher average numbers of flowering forb species, indicating higher average species diversity.

A similar trend is again visible in the most detailed species observation, the “indicator species” (see Figure 21). The indicator species are carefully chosen plant species or species groups, which represent proxies for different environmental variables and overall species diversity. When again viewed over the different types of grassland, a trend towards higher numbers of reported indicator species for extensively managed grassland is apparent. As there are only 12 different indicator species, average values may also be lower than one, indicating that there was a substantial number of grassland transects where no indicator species were found.



Figure 19: Collection and documentation of flowering forbs during the transect survey.

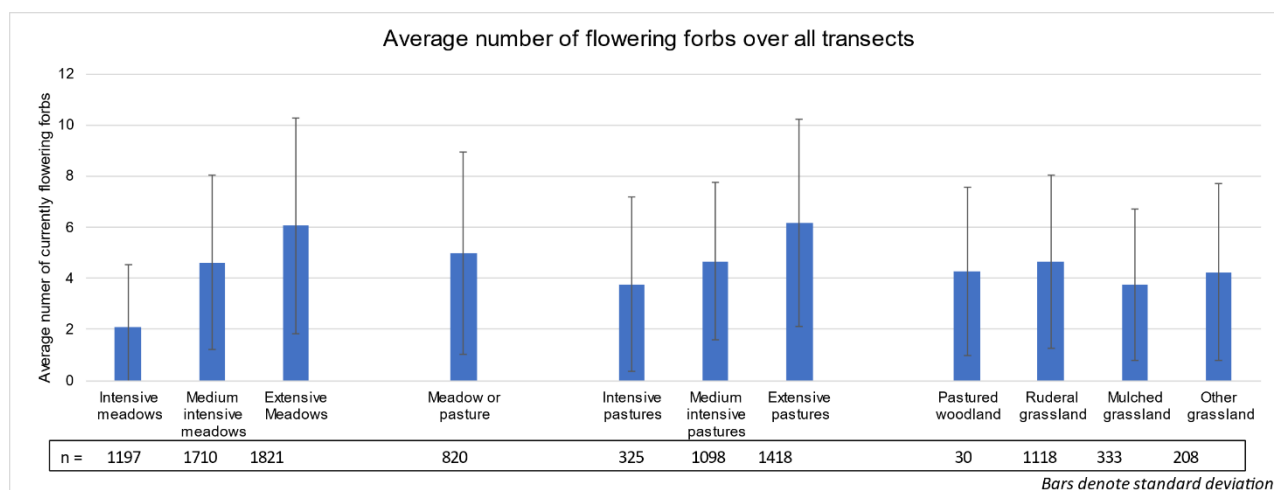


Figure 20: Average number of „currently flowering forbs” for different use intensities observed all grassland transects assessed during EMBAL 2023.

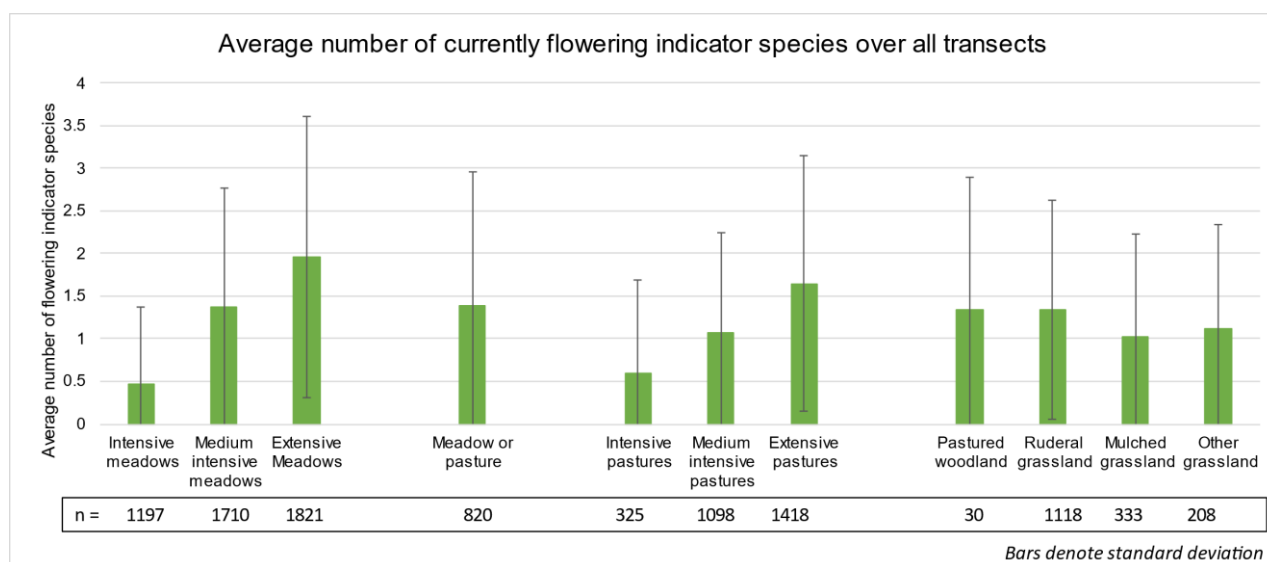


Figure 21: Average number of „currently flowering indicator species” for different use intensities observed all grassland transects assessed during EMBAL 2023.

4 Conclusion and recommendations

The EMBAL survey methodology has proven to be a solid and resilient tool for rapid biodiversity field survey. The combined approach of parcel and transect survey allow for insights on different spatial levels and monitoring of effects impacting biodiversity. Minor alterations to the survey methodology were completed during the rollouts of 2022 and 2023, enhancing data reliability and meaningfulness without impeding comparability of the collected data. Further adaptations of the survey methodology could be carried out for future surveying efforts to further enhance the surveying process and data quality. The basic principles such as the list of survey parameters and the layered approach of plot-parcels-transects should not be changed, as it would impact comparability of the data negatively.

Possible adaptations include:

- Alterations to LC-Codes, introduction of new parameters to cover more areas of interest and reviewing the exact choices available for different parameters.
- Further enhancing survey documents with further images, showing different types of land-use or visualizing parameters.

The methodological approach has been successfully implemented in two EU wide surveys in two different years, the now available dataset should provide the “real data” base to refine the method focusing on optimisation by:

- Testing the statistical effect of reducing EMBAL sample unit size and number while maintaining planned statistical precision.
- Creating predefined sampling scenarios for continuous monitoring within fixed time frames aims to streamline organizational efforts in the survey process. This approach optimizes resource allocation, improves efficiency, and ensures consistent and reliable monitoring.

Apart from methodological refinements, improvement in the survey data workflow would increase the robustness of collected data and reduce the workload of surveyor. Refinements should include:

- Developing a seamless field survey and database system for mobile data collection and post-processing, integrating previous survey information for change detection and monitoring.

Denied permission of land owner or residents are one of the main reasons for missing or incomplete data collection. Conflicts with farmers and in few cases even threats and physical attacks have been reported by surveyors in both surveys. Future survey rollouts shall therefore consider:

- Improving communication with farmers and landowners to enhance acceptance and cooperation for EMBAL.
- Clarifying and strictly restricting the disclosure of collected data to the public or authorities.
- Creating a legal basis for access to and the collection of data in agricultural land.

ANNEX

ANNEX 1 – Risks

ID	Affected Task(s)	Identified Risk	Description	Likelihood	Impact	Response Strategy
R01	All	Delayed kick off	Delay of the contractual kick off will impact the overall preparation and training phase with possible impacts on the adequate survey period in the worst case	Medium to high	High	Immediate start of the preparatory activities with specific focus on pre-processing and the creation of Ground Documents that require the inputs of task 1. => Utmost synergies will be arranged within the partnership. => delays in access of recent DOPs will be supported through an anticipated photo interpretation by means of open access data, which possibly require a second round of photo interpretation as soon as the actual DOPs are accessible.
R02	All	Key expert might drop out	A key expert of any of the teams might drop out due to personal reasons	low	strong	We will nominate a back-up for each key expert
R03	2	Lack of surveyors	Insufficient availability of suitable surveyors due to the seriously short available time and the demand of LUCAS 2022 surveyors	High	Strong	Immediate and proactive promotion and advertisement of the requested surveyor positions in combination with other major survey initiatives of EFTAS and IFAB already before the submission of this tender. Close harmonisation with the LUCAS leaders in the lots 1-5 and the strategy to seek for students of botanically relevant disciplines.
R04	3	Unsuitable weather conditions for field work	Fieldwork is supposed to be conducted in two particular weeks.	low	moderate	EMBAL relies on vegetation surveys that can be conducted under almost all weather conditions. Dangerous weather conditions in remote areas (e.g. mountains) would lead to a slight adaptation of the survey
R05	3	Objection of landowners	Due to legitimate objections the landowners might refuse the execution of an EMBAL observation on their land	Moderate	Low	In general, the surveyors will be well trained to explain the objectives of this project and to listen and understand the possible reaction of farmers / landowners. In case of rejections, a substitution will be explored in order to replace affected sampling sites through others.
R06	All	Misunderstandings or mistakes	Misunderstandings or mistakes might occur during all stages of the project and could have strong implications on results and conclusions	moderate	moderate (potentially high)	Quality management in WP40 aims at detecting misunderstandings and mistakes, and in trying to find their reasons in order to reduce the possibility of further mistakes during similar tasks.
R07	2	CoVid-19 interferences	Individual infections in the team	Medium to high	High	Isolation of the relevant persons until recovery. If other employees are affected by quarantine, switch to home office (coordination, QC, PI). In the case of training, this can lead to postponements or the continuation with remote solutions.
R08	2	CoVid-19 interferences	Ordered lockdowns with limited mobility	Medium	High	Individual assessment of the situation, analysis of the potential duration and spatial extent (region, country) as well as the impact

ID	Affected Task(s)	Identified Risk	Description	Likelihood	Impact	Response Strategy
						on professional activity in the field or in offices. In extreme cases, interruption or serious restriction of activities and postponement or change of tasks in close coordination with DG ENV.
R09	2	Natural impacts	Heavy rains, storms, flooding, landslides wildfires	Medium	High	Switch surveys to replacement plots in unaffected regions.
R10	2	Error in plot or transect localisation	Problems to find or reach the plot or transects	Medium	High	Precise observation depends on sound survey documentations. Therefore precise DOP will be used in all countries. Inaccessible areas needs to be well documented and plots or transects will be replaced in 2023.
R11	2	Error in point identification	Problems to recognize land cover in PI	Medium	High	Precise observation depends on sound survey documentations. Therefore precise DOP colour composites will be used in all countries
R12	2	Accidents or injuries	LUCAS is an outdoor activity. Injuries or accidents can happen	Medium	High	Good preparation, security training, sufficient time buffer for SUs and back up SU in order to ensure smooth completion before the end of the vegetation period.
R13	all	Staff rotation	Operators might change or rotate	Medium	Medium	Sound selection, good training, good management and sufficient back up SUs and planned buffer in survey period
R14	2	Overall shortage of skilled workers	It has become increasingly difficult to find enough and good experts in the fields of earth observation and ground surveys. This is increased through the delay in this procurement that shifted from Q2 to Q3 2021	High	High	Shortage of skilled surveyors will have negative impact on the performance of task 8 and in case of major unforeseen incidents, such as forest fire risks, COVID lockdowns, or others. Most critical is the timely collection of the grassland points as well as the bio soil points. EFTAS started to inform many former LUCAS surveyors about the current call for tender prior to the submission of this tender, in order to promote and emphasize the possible SUs to consider a LUCAS campaign for their next summer work plan – even if EFTAS will not be selected,
R15	2	Increase in survey costs	Costs for transportation and travelling in the field have considerably increased along with overall costs.	High	High	Increase of survey costs are a financial risk for the survey execution.
R16	2	Military conflict in Ukraine	The war in Ukraine is a security risk in survey areas close to the Ukrainian borders	High	Medium	EFTAS is in close exchange with surveyor to assess the situation and adopt the survey execution if required. Plots in risk areas are considered as not accessible.

ANNEX 2 – Project Deliverables and workplan

Table 2: Major EMBAL project deliverables

Project Deliverables	Date of delivery	Delivery Note
Inception Report v1.0	2022-03-15	9867/12
Interim Report v1.0	2022-12-05	10282/23
Final Report v1.2	2024-02-14	10606/34
Field Database 2022 revised v2	2023-02-27 2023-12-15	10345/23 10594/34
Field Database 2023 revised v2	2023-11-17 2023-12-20	10580/34 10597/34
Material & Tools Update	2023-12-15 2023-12-20	10593/34 10597/34

The FINAL Delivery of the EMBAL rollout was provided under **Delivery Note: 10597/34** on 20.12.2023 via FTP. Table 3 lists all items and documents of the Final Delivery.

Table 3: EMBAL 2022 and 2023 - Final delivery

EMBAL 2022-23 rollout – Field data	
EMBAL field data 2022	<i>EMBAL_2022_RESULTS_Parcel_LE_v2.gpkg</i> <i>EMBAL_2022_RESULTS_Arable_TransLn_v2.gpkg</i> <i>EMBAL_2022_RESULTS_Arable_TransPt_v2.gpkg</i> <i>EMBAL_2022_RESULTS_Grassland_TransLn_v2.gpkg</i> <i>EMBAL_2022_RESULTS_Grassland_TransPt_v2.gpkg</i> <i>EMBAL_2022_RESULTS_OverallPlot_v2.gpkg</i> <i>EMBAL_2022_Photos (.jpg)</i> <i>EMBAL_2022_Structure-of-parameters_field-data_v2.xlsx</i>
EMBAL field data 2023	<i>EMBAL_2023_RESULTS_Parcel_LE_v2.gpkg</i> <i>EMBAL_2023_RESULTS_TransLn_v2.gpkg</i> <i>EMBAL_2023_RESULTS_TransPt_v2.gpkg</i> <i>EMBAL_2023_RESULTS_OverallPlot_v2.gpkg</i> <i>EMBAL_2023_Photos (.jpg)</i> <i>EMBAL_2023_Structure-of-parameters_field-data_v2.xlsx</i>
EMBAL 2022-23 rollout – Material and Tools	
Sampling Strategy	<i>EMBAL2022_2023_Sampling_Strategy_v1.pdf</i> <i>EMBAL2022_Sampling_weights_v1.txt</i> <i>EMBAL2023_Sampling_weights_v1.txt</i> <i>EMBAL_2022_Sample_Plots_v1.gpkg</i> <i>EMBAL_2023_Plots_close_to_InsigniaSpring_v1.gpkg</i> <i>EMBAL_2023_Sample_Plots_v1.gpkg</i>
Survey Manual	<i>EMBAL2022_Survey_Manual_v4.0.pdf</i> <i>EMBAL2023_Survey_Manual_v2.0.pdf</i> <i>EMBAL2022_Key_Species_Guide_v1.0.pdf</i> <i>EMBAL2023_Key_Species_Guide_v1.0.pdf</i>
Survey Workflow and Tools	<i>EMBAL_Survey_workflow_v2.pdf</i> <i>EMBAL_ODK_FORM_1_Parcel_Survey_2023_v1.xlsx</i> <i>EMBAL_ODK_FORM_2_Transect_Survey_2023_v1.xlsx</i> <i>EMBAL_ODK_FORM_3_Overall_Plot_Survey_2023_v1.xlsx</i> <i>EMBAL_rollout_QGIS_odk_import_plugin.zip</i>
Ground documents	<i>E-xxxx-yyyy_2022_GD_Map.pdf (3000 pdf)</i> <i>E-xxxx-yyyy_2023_GD_Map.pdf (3036 pdf)</i> <i>EMBAL_2022_2023_Metadata_GD_v1.pdf</i>
CAPI objects from Pre-processing	<i>EMBAL_2022_CAPI_objects_v1.gpkg</i>

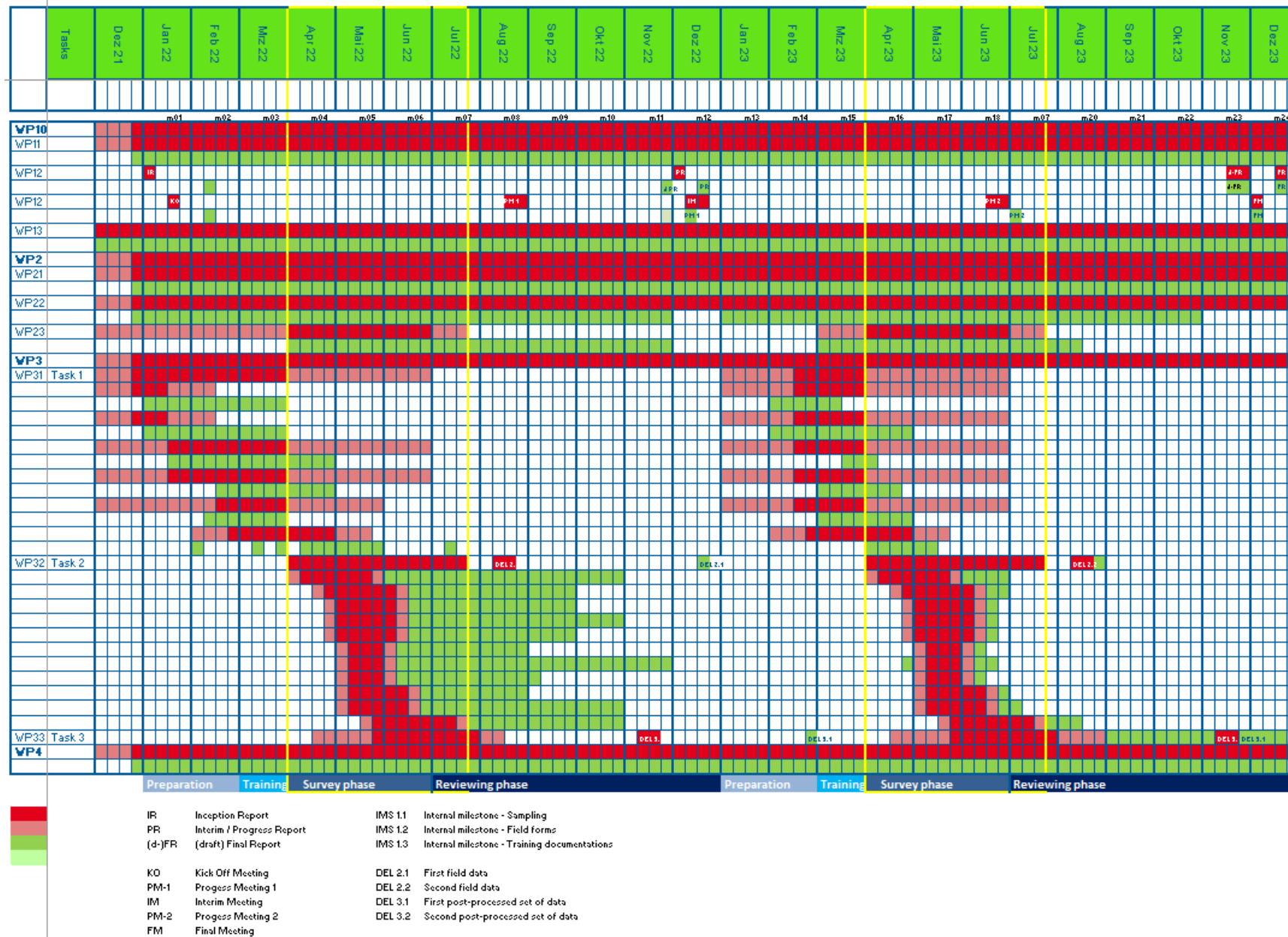


Figure 22: EMBAL workplan

ANNEX 3 – Metadata of EMBAL Ground Documents

Name of the dataset	EMBAL Ground documents 2022 EMBAL Ground documents 2023
Description	The EMBAL Ground document (GD) were produced for the execution of the field survey in the EMBAL rollout 2022 and 2023. The Ground Documents contain field maps with orthophoto as background and showing the location of the EMBAL plot (500x500m), parcel and landscape geometries and the location of the proposed transect positions. The GDs are produced for each EMBAL plots selected for the field survey as non-georeferenced pdf files. The GDs are used for Quality control and by the surveyor to navigate in the field and identify the position and extent of the different EMBAL sample units (Plot, Parcel and LE and Transects).
Country	EU 27
Metadata contact	EFTAS GmbH Mr. L. Kleinewillinghöfer 0049 /251 - 133070 0049 / 251 - 1330758 Oststrasse 2-18 48145 Muenster Germany luca.kleinewillinghoefer@eftas.com www.eftas.com
Metadata creation date	2023-12-07
Provider contact	See Metadata contact
Licence conditions	Various licence conditions apply for the used orthophotos: purchase / public access / restricted access via national authorities
Use restrictions	The use and circulation of EMBAL 2022 / 2023 Ground documents are restricted. - limited to internal use within the EMBAL 2022 / 2023 project - circulation is restricted specifically to DG Environment - documents can only be shared in a non-georeferenced PDF format
Dataset reference year	Ground document: 2022 / 2023
Dataset time span	Orthophotos: 2012 - 2021
Data format	pdf
Spatial resolution (terrain)	various
Coordinate system reference name	Field Map: ETRS 89 LAEA
Coordinate system reference code	EPSG 3035
Completeness	Complete
Maintenance	2022-2023
Description of processes	Assembling of Ground document elements in GIS print template: Orthophoto background, parcel polygons, transect lines, legend, ID, ... Exporting in .pdf format, non-georeferenced

ANNEX 4 – Source of Orthophotos

Recent orthophotos are used in EMBAL for three purposes:

- Mapping the different land cover elements in the sample plot (500x500m) before the field survey
- Identifying the exact location and extent of the parcels and landscape elements during the field survey – using Ground Documents.
- Controlling the quality of the work.

The table below shows the sources of the orthophotos used and the applicable licence conditions. In most countries, orthophotos are accessible to the public under open license conditions. Conversely, in the remaining countries, the contractor has used orthophotos with specific and restricted license conditions.

Country	Provider / website	Licence conditions
AT	https://www.data.gv.at	Public access – open licence conditions
BE	https://www.geo.be	Public access – open licence conditions
BG	Ministry of Agriculture	Restricted access and licence conditions
CY	https://portal.dls.moi.gov.cy	Public access – open licence conditions
CZ	https://geoportal.cuzk.cz	Public access – open licence conditions
DE	https://gdz.bkg.bund.de	Restricted access and licence conditions
DK	https://datafordeler.dk	Public access – open licence conditions
EE	https://inspire.maaamet.ee	Public access – open licence conditions
EL	https://gis.ktimanet.gr	Public access – open licence conditions
ES	https://datos.gob.es	Public access – open licence conditions
FI	https://www.maanmittauslaitos.fi	Restricted access and licence conditions
FR	https://geoservices.ign.fr	Public access – open licence conditions
HR	https://geoportal.nipp.hr	Public access – open licence conditions
HU	https://lechnerkozpont.hu	Restricted access and licence conditions
IE	Goggle satellite	Public access – restricted licence conditions
IT	http://www.pcn.minambiente.it	Public access – open licence conditions
LT	https://www.geoportal.lt	Public access – open licence conditions
LU	https://data.public.lu	Public access – open licence conditions
LV	https://www.lgia.gov.lv	Public access – open licence conditions
MT	https://msdi.data.gov.mt	Public access – open licence conditions
NL	https://service.pdok.nl	Public access – open licence conditions
PL	https://www.geoportal.gov.pl	Public access – open licence conditions
PT	https://dados.gov.pt	Public access – open licence conditions
RO	National Geospatial Defence Agency	Restricted access and licence conditions
SE	https://www.lantmateriet.se	Restricted access and licence conditions
SI	http://www.geoportal.gov.si	Public access – open licence conditions
SK	https://www.geoportal.sk	Public access – open licence conditions