Raising the Bio-based Industrial Feedstock in Marginal Lands

Monitoring protocol

D2.3.

Date: 31. January 2024

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[1] PU = Public
PP = Restricted to other programme participants (including the Commission Services)
RE = Restricted to a group specified by the consortium (including the Commission Services)
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Document history

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MarginUp! in a nutshell

MarginUp! is developing sustainable and circular value chains to produce bioproducts and biofuels in innovative business models from natural raw materials grown on marginal lands. In the project, climate resilient and biodiversity-friendly non-food crops will be introduced on marginal and low-productivity lands, not competing with food crop production. To further improve biodiversity and environmental benefits, MarginUp! will contribute on understanding which marginal lands are suitable, with regards to the lowest impact for indirect land-use change (ILUC) biomass production. The project will identify good practices for sustainable biomass production and bio-based products that safeguard biodiversity and local ecosystems. All this will be done in close collaboration with land managers, farmers and stakeholders from the growing bioeconomy industry.

Hence, MarginUp! is expected to provide viable outcomes to ecosystems degraded by e.g. water-stress or desertification due to human activity and/or climate change. The project will also contribute to restoration and stimulation of ecosystems in abandoned mine lands, as well as boosting land yield and health in low productivity marginal lands. Through this innovative approach, MarginUp! will increase farming system resilience, enhance rural areas, and promote stakeholder participation.

MarginUp! is building on learnings from seven use-cases: Five implementations across Europe (Spain, Greece, Sweden, Germany and Hungary), and two use-cases in Argentina and South Africa, together increasing the replication potential of the project's results. Each use-case considers the current use and properties of its area and proposes crops and crop rotation strategies that promote biodiversity and increase soil productivity according to local requirements of Mediterranean soils in Spain, mining lands in Greece, boreal soils in Sweden, wetlands in Germany, lands exposed to desertification in Hungary, degraded pastures in Argentina, and areas with invasive bush species encroachment in South Africa. The proposed crops create a sustainable supply of resources to foster the development of the bioeconomy businesses at local and regional levels while providing ecosystem benefits and building resilience to climate change.

On this basis, the MarginUp! project will enhance European industrial sustainability, competitiveness, and resource independence, by reducing the environmental footprint, considering biodiversity aspects, enabling climate neutrality and increasing resource efficiency (particularly through upcycling and cascading use of biomass) along different value chains in seven use-cases including enhanced technologies and business models for innovative bio-based products that will lessen EU reliance on fossil-based products.

To stay up to date with MarginUp! project events and reports, follow us on Twitter (@MarginUp_EU), LinkedIn (MarginUp! EU) or visit www.margin-up.eu.

Summary

This monitoring protocol contains detailed methodological instructions for the implementation of data collection and data management for the biodiversity monitoring in WP2 of MarginUp!. It aims to facilitate the data inputs for the planned model-based assessment of the biodiversity effects caused by the new cultivation systems for renewable raw materials on marginal sites tested in the MarginUp! use cases. The planned application of habitat value models (HVM) in MarginUp! serves to verify the knowledge-based assessment of the biodiversity effects of the cultivation of new crop species from Deliverable 2.2. (Implementation guidelines of various industrial crops on marginal lands regarding biodiversity impacts). It also provides input data for the Life Cycle Assessment in WP4 and allows the identification of optimisation needs for the new cultivation system in WP2 task 2.4. (Monitoring implementation effects).

This report explains the input data requirements resulting from the application of the habitat value models and selects and assigns relevant parameters to the three submodules "Shelter", "Resources" and "Disturbances" of the HVM.

For the selected and prioritised data requirements of the HVM, detailed, generally applicable method specifications for data collection are provided, as well as standardised specifications for data coding, data storage and raw data processing. Standardised forms for data collection are provided for the individual parameters in the appendix to this deliverable.

Disclaimer

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HVM	Habitat Value Models
UC	Use case

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- Biodiversity Monitoring
- Habitat Value Models
- Species´ demand
- Supply of cropping systems

1. Introduction

The main objective of MarginUp! is to introduce climate-resilient and biodiversity-friendly non-food crops for sustainable industrial feedstock in marginalised and low-productivity land, resulting in robust and sustainable value chains that benefit both the local biodiversity and ecosystem services. Marginal lands are of great importance for many aspects of biodiversity. There are various types of marginal land, and their ecological values vary. Some areas are currently farmed extensively due to their marginal nature such as extensive natural grasslands, which require agricultural management, often under the concept of extensification or conservation management. Many marginal lands are already located in protected areas. Through the abandonment of marginal land, extensively used agro-ecosystems e.g., extensive grazing systems on grassland, perennial cropping systems, low-input systems (fertilizer, pesticides, rainfed cropping systems) are disappearing and with them the animal and plant species adapted to them. Previous land use systems on marginal land are endangered by both the abandonment and intensification of use. The diversification of land use through new value chains and crops can contribute to securing land use under these special site conditions without competing with favourable sites with the same types of crops and fueling the intensification of land use.

Many recent publications have presented contrasting results on the impact of biomass crops on biodiversity at least in the temperate zone. Dauber et al. (2010) and Rowe et al. (2013) have shown that the main factors determining impacts of biomass crops on biodiversity are: regional landscape type, land use type which is replaced (ILUC), the targeted species groups, the kind of biomass crops and their concrete management. Thus, assessing land use impacts on biodiversity requires a detailed consideration of the landscape conditions and the specific land use management.

The knowledge-based assessment on the potential impacts of the new cropping systems (see WP3) in the particular use cases (UC), as performed based on the questionnaire answered by regional experts in deliverable 2.2 concluded that the main potential impacts of the tested cropping systems would be mostly positive mainly due to sustainable and extensive agricultural practices (such as a lower use of fertilizers, pesticides/herbicides, etc). MarginUp! is going to verify these assumptions by performing a comparative assessment of the biodiversity impacts of various regional options for industrial crops by using field data from the pilot value chains in 5 European and 2 international use cases. The main aims of the assessment of biodiversity impacts are:

- *The quantification of impacts,*
- *The identification of potential trade-offs,*
- *The determination of options for further optimisation of the biodiversity impacts,*
- *The generation of implementation recommendations, and*
- *The provision of inputs for Life-cycle assessment as performed in WP4.*

Since the biodiversity effects of cropping changes are very sensitive to impacts from the concrete landscape surrounding, yearly weather conditions, yearly cropping conditions and particular management decisions, the assessment of biodiversity impacts will be carried out by habitat value models (HVM) for selected indicators listed within the regional adapted biodiversity indicator system (RABIS, see deliverable 2.1). The inputs for the HVM will be collected with an accompanying monitoring of the new cropping systems in the use cases (see WP3). Biodiversity impacts of new biomass crops on marginal land result on assessments on the fit or misfit between the habitat requirements of the species included in the regional indicator system and the habitat qualities as provided by the new crops and their management. Therefore, the new biomass crops and their management systems must be described in terms of the biodiversity indicator system input data needs.

2. Methodological approach

The biodiversity impact assessment framework of MarginUp! is intended to be applicable in a very wide range of contexts, while at the same time being able to address specific regional needs and requirements. This apparent contradiction was resolved by the developed regional indicator system RABIS, which consists of a universal, valid, basic structure of basic elements that apply equally to all UCs. RABIS consists of 20 to 30 indicator species per UC. Due to the large number of different species overall, direct monitoring of all indicator species is not carried out.

Moreover, regarding the generalisability of the results on the biodiversity effects of the pilot solutions, direct monitoring of indicator species has some severe methodological shortages:

- *The selection of species determines the transferability of outcomes.*
- *The monitoring of several species groups is time intensive and costly, thus must be limited to single indicators, which might produce contrary results.*
- *The direct monitoring provides only a snapshot of the current state of a certain area, for a certain setting of frame conditions with a limited transferability.*
- *Monitoring results are biased with frame conditions and recent management decisions.*
- *Some effects only manifest with a time lag, e.g. for perennial crops, the effects of the establishment phase might be overrated (e.g. if trees are included).*

In order to overcome these shortages, WP2 in MarginUp! applies an indirect monitoring approach through modelling the **potential habitat values** of the single cropping systems. The models are fed with detailed data on the performance of the cropping systems in the particular use cases. Data requests for the habitat value assessment are covered by well introduced data collection schemes, which are partly common practice even in monitoring agricultural performance of the cropping system (e.g. crop stands monitoring, pest and disease monitoring, protocolling farming management).

2.1. Habitat value assessment

The assessment of biodiversity impacts of new value chains for new biomass crops on marginal land requires consideration of a wide range of different frame conditions and options, to estimate replication potential. The habitat value models (HVM) are rule-based on the approach of mirroring the habitat requirements of the species included in the regional indicator system (RABIS D2.1) and the habitat qualities as provided by the new crops and their management to assess fits or misfits. The new biomass crops and their management systems must be described in terms of the biodiversity indicator system data needs. The areas that represent the decisive factors in terms of habitat suitability for the particular indicators have been divided into 3 submodules: Shelter, Resources and Disturbances (Figure 1). The target species have their respective demands linked to the 3 submodules and cropping systems. If the demand of species matches with the supply of the cropping system, the habitat has a positive habitat suitability (positive habitat value) for the selected indicator species.

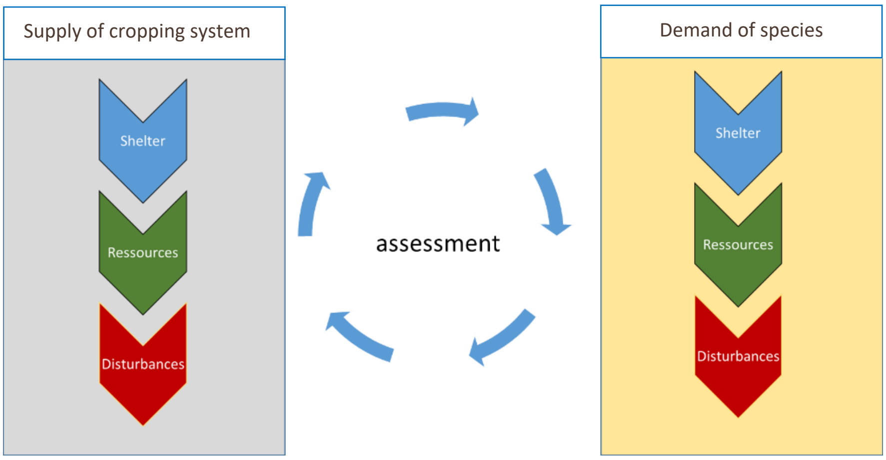

Figure 1. Mirroring the supply of cropping systems with the demand of target species

Both population development of the biodiversity compounds as well as crop stands and management impacts at the agricultural fields show a seasonal dynamic. Biodiversity impacts of cropping is related in general to the temporal coincidence of habitat qualities with the species demands and disturbances with sensitive phases in population developments (Figure 2). Thus, data for the biodiversity impact assessments must be time-explicit.

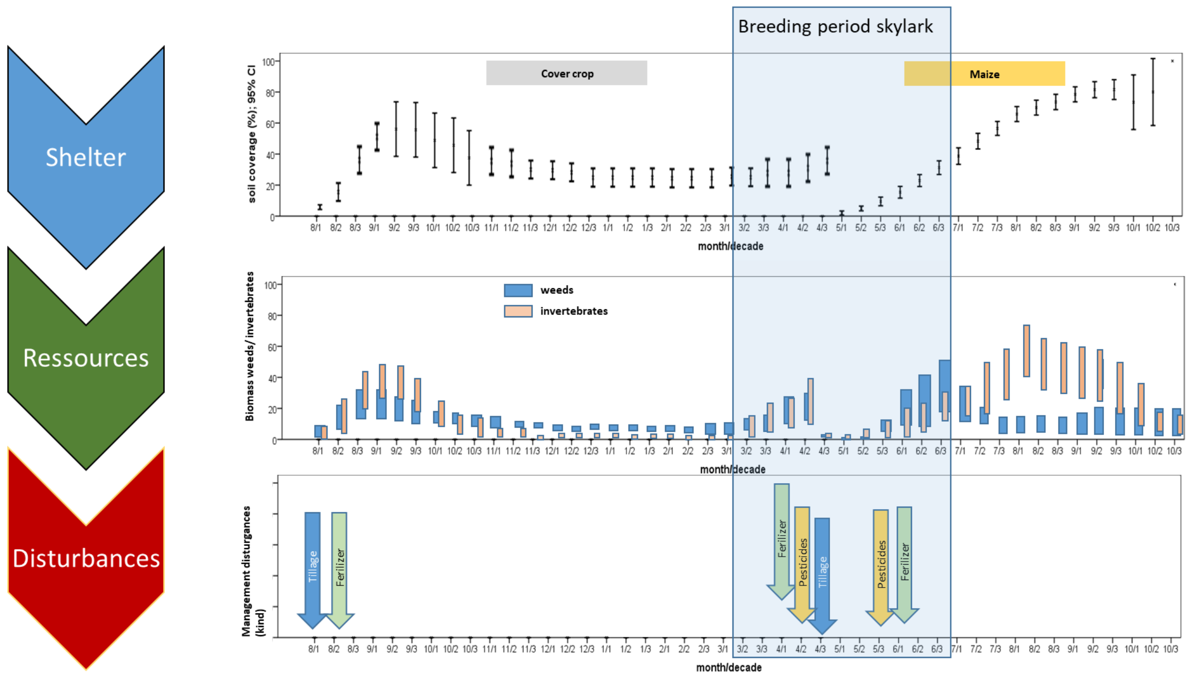

Figure 2. Temporal co-incidence of habitat demands and supply as well as the temporal coincidence of disturbances with sensitive phases of habitat build the core of the habitat value assessment (conceptual graph)

Moreover, habitat uses vary among the species. Some of them reproduce on the agricultural fields, while others just feed there or use the land as shelter against predators. The main types of habitat uses relate to different demands regarding the habitat qualities of agricultural fields. Figure 2 pictures exemplarily for the application of the HVM during the breeding period of the skylark in an agricultural field. The skylark prefers a soil coverage of 20-50% for nesting (Laux et al., 2015). The supply of food resources decreases in the middle of the breeding period (biomass of weeds and invertebrates), resulting in the agricultural management measures shown.

2.1.1. The submodule Shelter

Using vegetation on agricultural land as shelter against predators is one of the most common kinds of habitat uses of agricultural land by the wildlife. This habitat function is mostly combined with other habitat uses by the wildlife, just as

- *Breeding/reproduction,*
- *Feeding,*
- *Trespassing/spreading/connecting core habitats, or*
- *Resting.*

Shelter needs and functions are strongly connected to vegetation height and density. The concrete demands for shelter vary much between species, life cycle phases for population development of species and habitat functions. Basically most of the wildlife species require a minimum of vegetation density or height to serve as shelter against predators. Too dense or too high vegetation might hinder species' assess to the soil surface, to move across the fields, to recover nesting places, etc. Vegetation shelters may also impact microclimate of the habitat, thus habitat quality.

2.1.2. The submodule Resources

The submodule of resources intends to provide information about the provision of different kinds of food resources for the target species. Here we basically distinguish between diets focusing on plants and insects as well as mixed diets which can be measured in the presence and biomass of weeds and invertebrates. Other relevant diet types are fungal resources or dead organic material (saprophytic), which will not be involved into the assessments due to missing data and valuation rules. Diversity of resources is another factor that plays a role here and is taken into account for individual groups of organisms.

2.1.3. The submodule Disturbances

Interventions in the habitat that can potentially harm animals and plants directly are covered by the disturbances submodule. Disturbances can be connected to land management practices (e.g. use of machinery or (toxic) substances). The submodule addresses direct (affecting the target species directly) and indirect (affecting the target species indirectly e.g. through their food resources, or nests/reproduction places) disturbances. Most of the disturbances on arable land are results of management interventions (also following seasonal dynamic) such as soil tillage, fertilization, pest management, harvesting measures or cuttings.

2.2. Link with RABIS (regional adapted biodiversity indicator system)

The monitoring activities addressed by this document serve the biodiversity impact assessment in WP3. The assessments build on the indicator system 'RABIS', developed in D2.1. The intention of RABIS is to be applicable in a very wide range of contexts, while at the same time being able to address specific regional needs and requirements (D2.1.). Therefore, it is made up of a large number of building blocks (Figure 3) which act as the base for the methodological approach (chapter 2) of this monitoring design.

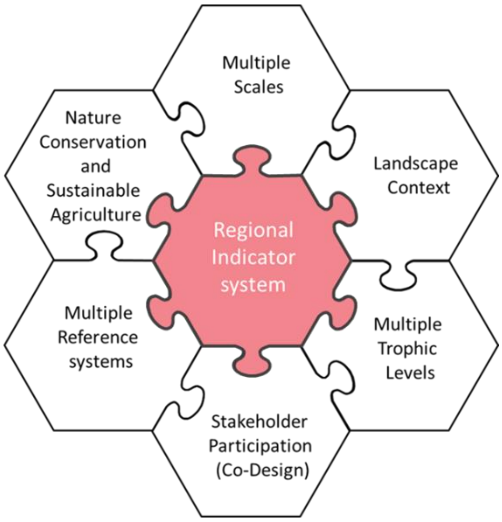

Figure 3. Building blocks of RABIS

The final indicator list for every single UC comprises a list of 20-30 individual indicators, which cover the following statement areas:

- Contribution to biodiversity targets at various scales (national. regional, local),
- Contribution to nature conservation and ecosystem service targets,
- Covering at least three different trophic levels,
- Reflecting priority biodiversity targets of local stakeholders.

The Habitat Value Assessment will apply a selection of 10-15 indicators for every single UC, according to the above-mentioned statement areas. The selection will be made based on data availability on habitat requirements of the target species.

2.3. Data collection process and monitoring activities

The input data for the habitat value assessment, both, on the demand of the target species and on the supply by the cropping systems, are structured in 3 submodules: shelter, resources and disturbances. This allows a comparison of the two perspectives (species' demand and crop supply). While the needs of the target species are to be provided by the species´ knowledge of local biodiversity experts3.1, information on the supply of the cropping systems will be collected through monitoring activities (Figure 1).

The planned monitoring activities require collaboration with biodiversity experts within the respective UCs. The complete monitoring plan is developed by ZALF in consultation with the UCs. The implementation is then carried out by the experts who will get a technical introduction to the methods beforehand (chapter 2.4). Those expert panels consist of 1-3 persons per country and are set up in collaboration with the team.

An online meeting was held for each UC between 1st December and 15th December 2023 with an introduction of the methodological approach. The basic feasibility was queried.

2.4. Technical introduction into monitoring methods

A technical introduction of the selected resource monitoring methods as well as a determination of the number of repetitions is planned on site during the Consortium meeting which will take place in Hungary between 21st and 24th May 2024. The designed monitoring protocols (chapter 3) will be printed and filed in together in a folder and and handed out to the UCs. The people in charge will further receive a personal online introduction on the enrollment of monitoring activities and will be then responsible for conducting the monitoring inventories.

2.5. Pilot and reference areas

In order to be able to assess the effects of the MarginUp! value chains on biodiversity, measurements on pilot plots must be compared with other systems, which will serve as controls. Monitoring will therefore take place on the pilot fields as well as on reference areas (compare D.2.1. chapter 3.2.4. Multiple reference systems), which are listed in the table below (table 1). The exact reference fields/areas will be chosen and marked on a map in collaboration with the expert panels (chapter 2.4) of the UCs. As crop rotations change within the different project year, a detailed plan on pilot plots and reference areas will be elaborated. A minimum number of 2 reference areas is obligatory, while optimally 3 reference areas will be included in the monitoring activities. The number of reference areas depends on the local conditions and availability. On each area (pilot plot and reference areas) 5 permanent sampling points will be installed for the duration of the project. Each monitoring point will be numbered individually.

Table 1. Pilot and reference areas

UC	Reference 1 Pre-dominant Landuse	Reference 2 Previous Landuse	Reference 3 Semi-natural Landuse	Pilot plot MarginUp! Alternative
Germany	Pastures, meadows on fenland	Abandoned land, willow succession	-	Paludi cultures (reed, cat tails, segges, reed canary grass)
Sweden	Fodder grass timothy (*Phleum pratense*), meadow fescue (*Festuca pratensis*), red clover (*Trifolium pratense)*	spring cereals; barley (*Hordeum vulgare L.*), oat	Forest	Turnip Rape (*Brassica rapa ssp. oleifera*).
Greece	Old Fallow land	Mining area, bare soil	Forest	Black locust (*Robinia pseudoacacia* L.) + Lavender (*Lavandula angustifolia* Mill.)
Hungary	Orchards, vineyards	Arable crops: winter wheat (*Triticum aestivum L.*), maize (*Zea mays L.*), sunflower (*Helianthus annuus L.*),	Forest	Energy willow (*Salix viminalis L.*) + Virginia fanpetals, virginia mallow (*Ripariosida hermaphrodita* (L.) Weakley & D.b. Poind)
Spain	Annual: Tomato (*Solanum lycopersicum*)	Corn (*Zea mays L.*)	Dry grassland, Pastoral used land	Kenaf (*Hibiscus cannabinus* L.), Hemp (*Cannabis sativa L.*)

The conceptual picture from the Hungarian UC below (Figure 4) demonstrates how reference areas could be selected (concrete sites will be selected in a later stage).

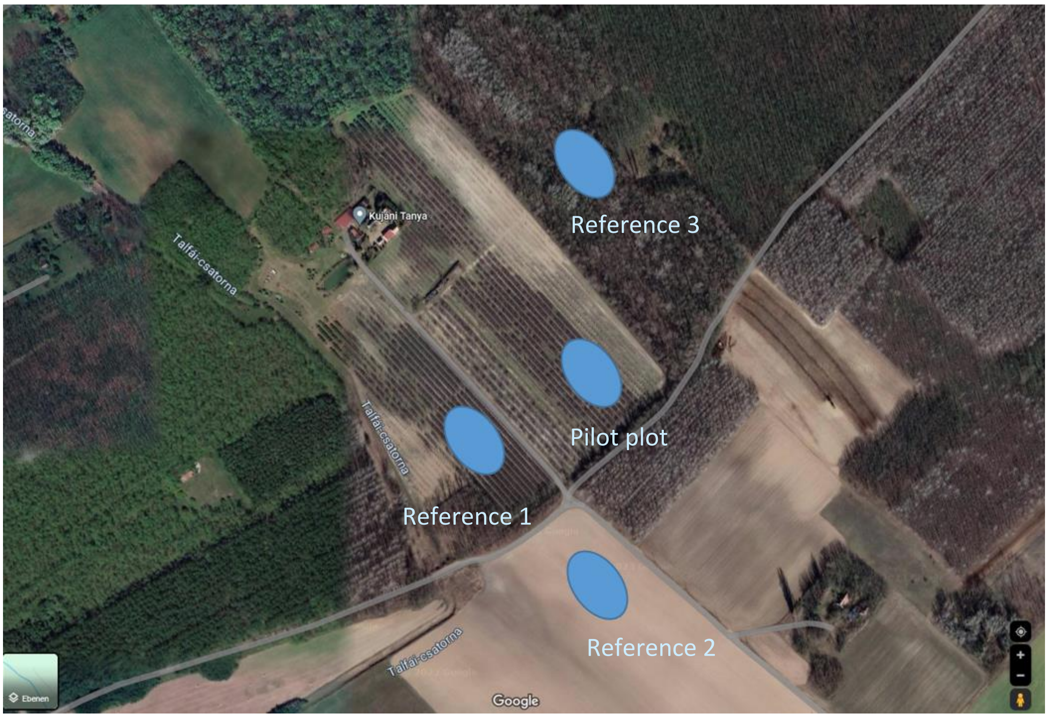

Figure 4. Conceptual example of reference areas in the Hungarian UC

3. Parameter selection and monitoring methods

This chapter introduces a choice of monitoring methods that should be applied in frame of the biodiversity assessments of MarginUp!. The list is made up of mandatory parameters and optional parameters. In individual consultation with the UCs, the optional parameters will be discussed, as well as how the mandatory parameters can be realised. The selection of optional parameters corresponds to the interests of the respective UCs. The monitoring methods refer to the 3 submodules earlier described in this document. All pieces of information need to be inserted into an excel document (one page per parameter) which will be sent to the persons in charge.

The cropping system supply will be monitored in frame of the 3 submodules of shelter, resources and disturbances. Here, chosen parameters describing the habitat quality as supplied by the cropping systems and the respective data needs for the 3 mentioned submodules are introduced. Since the project covers 7 regions with very different natural conditions, a reduction to just a few, carefully selected parameters is intended to guarantee a focus on the uniform recording of the parameters, thus minimising the risk of deviations in the recording process. Uniform monitoring forms are prepared for the respective modules which can be found in the Annex (6).

3.1. Overview on selected monitoring parameters

Table 2. Selected monitoring parameters

Modul	Parameter	Status	Monitoring method
Shelter	Crop stand height	M	Manual measuring
	Crop stand coverage	M	Digital photographs
	Weed flora coverage	M	Digital photographs
Resources	Weed flora coverage	M	Digital photographs
	Weed flora composition	O	Digital photographs/ field survey
	Pollinators abundance and biomass	O	Pan traps
	Pollinators nesting activity	O	Nesting boxes
Disturbances	Crop management activities: - *Ploughing* - *Fertilization* - *Plant protection* - *Tillage* - *Sowing* - *Harvest*	M	Data from farming calendar

Legend: M - mandatory; O – Optional

3.2. Monitoring protocols

Data inputs for the HVM submodules of shelter and resources will be gathered through field measurements at the pilot plots and reference areas. To present the methods clearly, a data recording template has been prepared (table 3). The respective printed monitoring form (Annex 6) is filled in on site and is afterwards inserted into the corresponding page of the Excel document.

Table 3. Table template monitoring methods

<table>
<tr><th>Parameter:</th><th>Submodule:</th></tr>
<tr><td>Time frame:</td><td rowspan="2">Equipment list:</td></tr>
<tr><td>Time interval between samplings:</td></tr>
<tr><td>Number of sampling points per plot:</td><td>Number of replications per sampling point:</td></tr>
<tr><td>Spatial distance between sampling points:</td><td>Distance to field/plot edge:</td></tr>
<tr><td>Number of persons needed for sampling:</td><td>Sampling height:</td></tr>
<tr><td>Preparations before monitoring:</td><td rowspan="3">Technical description of workflow:</td></tr>
<tr><td>Data form/way of transfer:</td></tr>
<tr><td>Further remarks/descriptions:</td></tr>
</table>

Every method description table is supplemented by a monitoring form (chapter 3.3) which will be handed out in printed versions to the persons in charge to ensure the standardisation of the methods in all UCs. It is recommended to conduct the monitoring of the submodules of shelter and resources contemporaneously.

The data inputs for the disturbance submodule will be assessed by an information query in the form of a table (table 3). This table will be part of the Excel document and needs to be supplemented by the person in charge with information concerning the applied agricultural management measures (Annex D).

3.2.1. Data for the submodule Shelter

To picture the shelter supply of the cropping system, the parameters crop stand height and vegetation coverage have been chosen for the monitoring. All parameters will be monitored once per month. The respective monitoring time windows are determined individually for the UCs and depend, among other things, on the duration of the regional vegetation period, flowering periods and the crop growing period.

3.2.1.1. Crop stand height

Table 4. Method description for crop stand height

Parameter: Crop stand height	**Submodule: Shelter**
Time frame: Beginning of vegetation period until end of vegetation period (if annual crop: between sowing and harvest), for perennial crop also after the cuttings **Time interval between samplings:** 4 weeks	**Equipment list:** - *Meterstick* - *Folder of printed monitoring forms* - *Pen*
Number of sampling points per plot: 5	**Number of replications per sampling point:** 10 (plants)
Spatial distance between sampling points: min. 50, better 100m *(possible to locate sampling points in line; optimally located in middle of plot)*	**Distance to field/plot edge:** min. 20m, better 50m
Number of persons needed for sampling: 1	**Sampling height:** -
Preparations before monitoring: - **Data form/way of transfer:** - *Measurements (or estimates) are noted on site into the monitoring form and afterwards transferred to the referring Excel sheet* **Further remarks/descriptions:** - *In case of references with inhomogeneous vegetation height, the focus will be on the typical vegetation type and minimum and maximum heights will be selected (but need to represent at least 10% of the area)* - *Weather conditions are not relevant for this monitoring method*	**Technical description of workflow:** - *At every sampling point, the height of a choice of 10 typical individual plants should be measured to the highest point with a meterstick* - *In case of vegetation >2m, height estimation in 30cm steps*

Figure 5. Measuring crop stands height of 10 individual crop plants per sample point (left: Smith, 2017, right: Glemnitz, 2013)

3.2.1.2. Crop stand coverage

Table 5. Method description for crop stand coverage

Parameter: Crop stand coverage	**Submodule: Shelter**
Time frame: Beginning of vegetation period until end of vegetation period (if annual crop: between sowing and harvest), for perennial crop also after the cuttings **Time interval between samplings:** 4 weeks	**Equipment list:** - *Digital camera with at least 5 Megapixel* - *Camera tripod* - *Measuring stick* - *Folder of printed monitoring forms* - *Pen*
Number of sampling points per plot: 5	**Number of replications per sampling point:** 1 (photo)
Spatial distance between sampling points: min. 50, better 100m *(possible to locate sampling points in line; optimally located in middle of plot)*	**Distance to field/plot edge:** min. 20m, better 50m
Number of persons needed for sampling: 1	**Sampling height:** 1.5m
Preparations before monitoring: - *Loading camera battery* - *Checking free capacity on memory card* **Data form/way of transfer:** - *The photographs need to be saved in the named folder in the project cloud* - *Form: UC name _CSC _Plot_Sampling Point_Replication Nr_Date.jpg* **Further remarks/descriptions:** - *Please perform measurement under good light conditions (not on rainy day, not early in the morning, not at noon)*	**Technical description of workflow:** - *The 2m long meterstick is folded in a 90 degree angle downwards and located on the ground to serve as a scaling factor to estimate the horizontal size of the plants from the pictures* - *If the crop stands height is <1.5m , the camera tripod is installed at the sampling point with a height of 1.5m and an angle of 180 degrees, pointing directly downwards* - *In case of vegetation height is >1.5 m, it should be estimated, how much the crop stand is shading the ground of destinct area coverage (using square meters as unit), in 10% steps, according to a later provided rating scale* - *1 picture per sampling point needs to be taken* - *If possible, activate date stamp on the photos or note the corresponding date of photos (metadata of a photo file alao includes the date and time)* - *Photos must be taken during daylight (actual time is not important)*

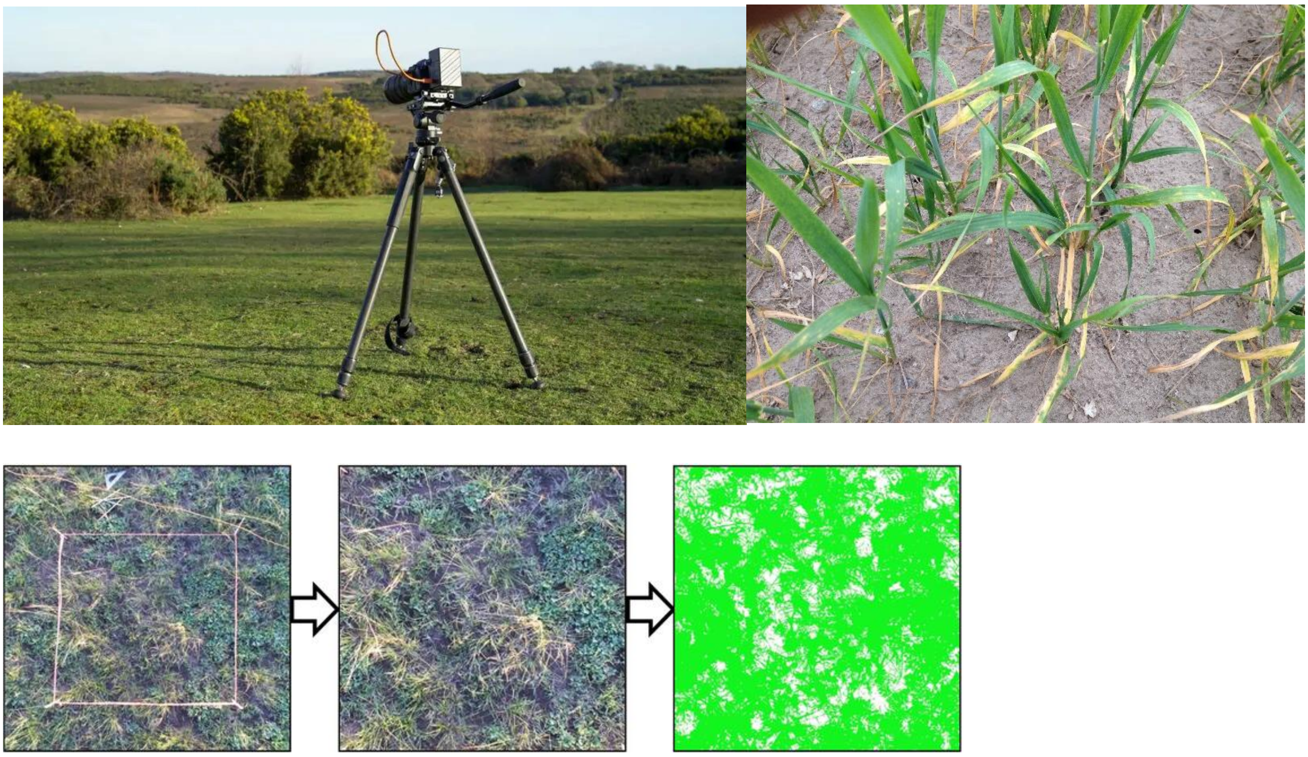

Figure 6. Crop stands coverage are gained from vertical digital pictures and their processing/ interpretation (left up: Box et al., 2021; right up: Glemnitz, 2024; down: Wang et al., 2015)

3.2.1.3. Weed flora coverage

Table 6. Method description weed flora coverage

Parameter: Weed flora coverage	**Submodule: Shelter**
Time frame: Beginning of vegetation period until end of vegetation period; (if annual crop: between sowing and harvest), for perennial crop also after the cuttings **Time interval between samplings:** 4 weeks	**Equipment list:** - *Digital camera with at least 5 Megapixel* - *Folder of printed monitoring forms* - *Pen* - *Camera tripod* - *Meterstick*
Number of sampling points per plot: 5	**Number of replications per sampling point:** 1 (photo)
Spatial distance between sampling points: min. 50, better 100m *(possible to locate sampling points in line; optimally located in middle of plot)*	**Distance to field/plot edge:** min. 20m, better 50m
Number of persons needed for sampling: 1	**Sampling height:** 0.5m
Preparations before monitoring: - *Loading camera battery* - *Checking free capacity on memory card* **Data form/way of transfer:** - *The photographs need to be saved in the named folder in the project cloud* - *Form: UC name _WC_ Plot_Sampling Point_Replication Nr_Date.jpg* **Further remarks/descriptions:** - *Please perform this measurement under good light conditions (not on a rainy day, not early in the morning, not at noon)* - *If possible perform this photographs at the same point, where the crop stand coverage is pictured (or nearby)* - *The picture making procedure is identical with those for the crop stand coverage with different sampling height*	**Technical description of workflow:** - *The 2m long meterstick is folded in a 90 degree angle downwards and located on the ground to serve as a scaling factor to estimate the horizontal size of the plants from the pictures* - *If the crop stands height is <0.5m , the camera tripod is installed at the sampling point with a height of 0.5m and an angle of 180 degrees, pointing directly downwards* - *In case of vegetation height is >0.5 m, it should be estimated, how much the crop stand is shading the ground of destinct area coverage (using square meters as unit), in 10% steps, according to a later provided rating scale* - *1 picture per sampling point needs to be taken* - *If possible, activate date stamp on the photos or note the corresponding date of photos (metadata of a photo file also includes the date and time)* - *Photos must be taken during daylight (actual time is not important)*

3.2.2. Data for the submodule Resources

Four parameters were selected to partly picture the resource availability within the cropping system. Those are weed flora coverage, weed flora composition, pollinator abundance and biomass as well as pollinators nesting activities. The flowering period of the crop stands will simply be recorded with the starting and ending day, whereas the weed composition and weed flora coverage will be monitored once a month with an inventory.

3.2.2.1. Weed flora coverage

This measurement will be done once and is used in both submodules for shelter and resource supply. Weed flora coverage is highly correlated with weed flora biomass and can thus be used as proxy for resource provision (plant biomass as food) by weed flora. The monitoring procedure is identical with the protocol as described in chapter 3.2.1.3.

3.2.2.2. Weed flora composition

Table 7. Method description Weed flora composition

Parameter: Weed flora composition	**Submodule: Resources**
Time frame: Beginning of vegetation period until end of vegetation period; (if annual crop: between sowing and harvest), for perennial crop also after the cuttings. **Time interval between samplings:** 4 weeks	**Equipment list:** - *Folder of printed monitoring forms* - *Pen* - *Digital camera or smartphone* - *Eventually: plant identification app or identification book*
Number of sampling points per plot: 5	**Number of replications per sampling point:** 1 (photo)
Spatial distance between sampling points: min. 50, better 100m *(possible to locate sampling points in line; optimally located in middle of plot)*	**Distance to field/plot edge:** min. 20m, better 50m
Number of persons needed for sampling: 1	**Sampling height:** -
Preparations before monitoring: - **Data form/way of transfer:** - *The photographs need to be saved in the named folder in the project cloud* - *Photos will be named in form of: UC name_ WFC_Plot_Sampling Point_Replication Nr_Date.jpg* **Further remarks/descriptions: -**	**Technical description of workflow:** - *Please use the pictures taken for weed flora coverage see 3.2.1.3 (same scaling reference is applied) and identify 3-5 main weed species which are visible on the photos* - *Species identification can be done by regional experts or plant identification app (photos can also be sent to ZALF for identification support)* - *Use the joint sample identification code to relate the species to the sample points and dates (Annex A)*

Figure 7. The 3-5 most frequent weed species should be pictured and estimated by experts or by taxonomic Apps (left: Glemnitz, 2013; right: Konrad, 2023)

3.2.2.3. Pollinators abundance and biomass

Table 8. Method description Pollinator abundance and biomass

Parameter: Pollinator abundance and biomass	**Submodule: Resources**
Time frame: Crop flowering period (start to end)	**Equipment list:** - *Coloured pans* - *Catching liquid (water + 1 drop of odorless dishwashing liquid as detergent)* - *Conservation liquid (alcohol >70%)* - *Sieve/filter paper* - *Storage boxes/jars* - *Scale* - *Digital camera or smartphone*
Time interval between samplings: after 3-4 days, traps need to be emptied; for crops flowering shortly (< 4weeks) no gap between samplings, if flowering period is > 4 weeks than 1 week gap between every sampling interval	
Number of sampling points per plot: 5	**Number of replications per sampling point:** 1
Spatial distance between sampling points: min. 50, better 100m *(possible to locate sampling points in line; optimally located in middle of plot)*	**Distance to field/plot edge:** min. 20m, better 50m
Number of persons needed for sampling: 1	**Sampling height:** at crop stands height level (adjusted)
Preparations before monitoring: - *Installation of trap construction (pile with bowl)* - *ZALF prepares plastic bowls with a diameter of 12x5.15x5 cm, h: 6.5 cm, 0.75 l, sprayed with SprayVar UV fluorescent paint in the colour of the respective plant flower of the crop (important!)* - *Bowls will be sent to the Ucs* - *In each UC: Person in charge installs the trap with wire rings to a pile (height of 1.0m or 1.5m)*	**Technical description of workflow:** - *The traps are filled three-quarters with water and a drop of odorless dishwashing liquid* - *After 3-4 days, traps are emptied* - *The catch is then separated from the catching liquid using a sieve (e.g. tea bag)* - *Individual animals are counted* - *3 groups of animals are distinguished (bumble bees, beetles, flies)* - *Drained weight Biomass of each catch is measured with a scale* - *Counted catch is stored in a labeled storage box with conservation liquid (alcohol >70%)* - *One catch per plot (of one single bowl) is sent to analysis in order get a better picture of the invertebrate's composition (will be clarified later!)*
Data form/way of transfer: - *Data is either noted in the printed monitoring forms and afterwards transferred to the respective Excel sheet or directly entered in the Excel table*	
Further remarks/descriptions: - *Traps must be checked after heavy rainfall to prevent overflow. If necessary, traps must be emptied and refilled with trapping fluid* - *Please note the prevailing weather conditions during the trap opening*	

Figure 8. Estimating pollinator abundance and biomass with coloured pan traps. For MarginUp! only one colour will be used, depending on the colour of the crop stand to avoid attracting non-target species (left up: LfL, 2023; right up: Versuchszentrum Laimburg, 2022; down: Glemnitz, 2015)

3.2.2.4. Pollinators nesting activities

Table 9. Pollinators nesting activities

Parameter: Pollinators nesting activities	Submodule: Resources
Time frame: From beginning of vegetation period till the end of vegetation period **Time interval between samplings:** 2 control dates per year	**Equipment list:** - *Pile* - *Nesting boxes* - *Digital Camera or smartphone* - *Folder of printed monitoring forms* - *Pen*
Number of sampling points per plot: 3	**Number of replications per sampling point:** 1 (box)
Spatial distance between sampling points: min. 100, better 200m	**Distance to field/plot edge:** min. 20m, better 50m
Number of persons needed for sampling: 1	**Sampling height:** 1.5m
Preparations before monitoring: - *Installation of nesting boxes on piles* **Data form/way of transfer:** - *Information on counts is transferred to the respective Excel sheet and/or noted on the printed monitoring form first* - *The photographs need to be saved in the named folder in the project cloud* - *Photos will be named in form of: UC name _PNA _Plot_Sampling Point_Replication Nr_Date.jpg* **Further remarks/descriptions:** - *Please note the prevailing weather conditions during the trap opening*	**Technical description of workflow:** - *The nesting boxes will be controlled 2 times per year* - *Nested tubes of single plates are counted* - *Single plates are photographed*

Figure 9. Simple and standardised nesting boxes used for wild bee nesting monitoring (left: Alpenbiene, 2023; right: Dieker, P. (n.d.))

3.2.3. Data for the submodule Disturbances

To analyse the risk of management related disturbances to the target species on the plots, relevant information on the agricultural measures is collected. This information consists of data on the machinery, the usage of agrochemicals, the date of actions/interventions and the scope/intensity of an intervention (e.g. in depth, amount/quantity/content). A questionnaire table (Annex D) is sent as a sheet of the Excel document to the persons in charge who will enter the needed information. The table further asks to specify several dates of interventions separately (table 17).

Disturbance potential that might harm the species is linked to land management measures and will be covered with the following main management categories:

- *Soil Tillage*
- *Fertilization*
- *Plant protection*
- *Mechanical/physical weed control*
- *Sowing*
- *Harvest/ cuttings*

One important source of the collection of the needed information is the farming calendar of the land managers.

3.3. Monitoring forms

For each monitoring parameter, WP2 provides corresponding monitoring forms (Annex 6). The monitoring forms for the individual monitoring activities need to be filled out by the person conducting the data sampling during the monitoring activities. The data should afterwards be transferred into the sheets of the excel document, which refer to the monitoring forms. Using a standardised and predefined code for every single data set is mandatory (Annex A).

4. Conclusions

This monitoring protocol serves as a basis for the collection of input data for the model-based assessment of the effects of new value chains and the new cultivation systems implied for the cultivation of renewable raw materials on marginal land.

The monitoring focusses on obtaining the input data required for the application of the habitat value models for the regional indicator species from the RABIS indicator system for the individual use cases. The monitoring aims to describe the potential habitat quality of the new crops in the use case pilots and uses real metadata to describe the crops. A distinction is made between three categories of necessary monitoring data: Data describing the "shelter" function, data describing the provision of food "resources" and data describing the intensity of management related to "disturbances". Relevant parameters were identified for the individual categories, which primarily describe the cultivation systems and represent generally valid and at the same time evidence-based descriptors for the habitat quality of agriculturally relevant wildlife species. The parameter list was deliberately kept short for reasons of better transferability and a focus was placed on well-established agricultural monitoring methods.

The feasibility of the methods is coordinated with the individual UCs.

Forms for standardised coding and data collection are provided in the appendix to this method protocol.

5. References

Alpenbiene (2023). Nisthilfen für Insekten. https://alpenbiene.de/Nisthilfen-fuer-Insekten l (last access 30.01.2024)

Cox, S., D.T. Booth, and R. Berryman (2021) Ground-Based Image Collection and Analysis for Vegetation Monitoring. Technical Note 454. U.S. Department of the Interior, Bureau of Land Management, National Operations Center, Denver, CO.

Dauber, J., Jones, M. B., & Stout, J. C. (2010). The impact of biomass crop cultivation on temperate biodiversity. Gcb Bioenergy, 2(6), 289-309.

Dieker, P. (n.d.) from: https://wildbienen.thuenen.de/mitmachen/nisthilfe-patenschaft/anleitung/ausflugaufsatz#c17081 (last access 30.01.2024)

Glemnitz, M. (2013): Identification and classification of weed species from images.-unpublished /personal communication.

Glemnitz, M. (2015): Adjusting yellow pan traps tot he crop stands height. Unpublished /personal communication.

Glemnitz , M. (2024) Crop stand cover in winterwheat. Personal communication.

Glemnitz , M. (2024) Measuring crop stand heights in peas. Personal communication

Konrad., J. (2023): identifiation of plant species by using Web-Apps. –personal communication

Laux, D., Bernshausen, F., Bauschmann, G. (VSW) (2015). Maßnahmenblatt Feldlerche (Alauda arvensis). Biodiveristät in Hessen.

LfL (2023). Bestäuberfreundliche Agrarlandschaften – derzeitige Situation und Entwicklungspotenziale (FarmerBeeWild). https://www.lfl.bayern.de/iab/kulturlandschaft/292742/index.php -downloaded 217.01.2024 (last access 30.01.2024)

Rowe, R.L., Goulson, D., Doncaster, C.P., Clarke, D.J., Taylor, G. and Hanley, M.E. (2013), Evaluating ecosystem processes in willow short rotation coppice bioenergy plantations. GCB Bioenergy, 5: 257-266.

Smith, G. (2017) Drones and 3D imaging could help farmers measure crop height (24. October 2017), https://www.newfood-magazine.com/news/45649/drones-3d-imaging-help-farmers-measure-crop-height/ (last access 30.01.2024)

Versuchszentrum Laimburg (2022). Laimburg: Forschung für die Südtiroler Berglandwirtschaft. Neue Ergebnisse bei der Kräuterfachtagung des Versuchszentrums Laimburg präsentiert (20. Oktober 2022) https://www.gabot.de/ansicht/laimburg-forschung-fuer-die-suedtiroler-berglandwirtschaft-419443.html (last access 30.01.2024)

Wang, L., Yang, R., Tian, Q., Yang, Y., Zhou, Y., Sun, Y., & Mi, X. (2015). Comparative analysis of GF-1 WFV, ZY-3 MUX, and HJ-1 CCD sensor data for grassland monitoring applications. Remote Sensing, 7(2), 2089-2108.

6. Annex

Annex A. Coding policy

The code below is intended to be used for naming the recorded data within the framework of the parameter monitoring introduced in chapter 3.

Table 10. Data Coding policy

Code:	
UC name_Parameter_Plot_Sampling Point_Replication Nr_Date	
UC name	Please name the referring UC country (e.g. UC Spain, UC Greece)
Parameter	Please indicate the referring Parameter (Crop stand height = CSH, Crop stand coverage = CSC, Weed flora coverage = WC, Weed flora composition = WFC, Pollinator abundance and biomass = PAB, Pollinators nesting activities = PNA)
Plot	Please indicate the referring plot (Reference 1=R1, Reference 2=R2, Reference 3=R3, Pilot plot=PP)
Sampling point	Please indicate the referring sampling point: SP1, SP2, etc. (Sampling points will be numbered permantently during the installation)
Replication Nr	Please enter the replication number per samplingt point: RN1, RN2, etc. (The numbers of intended replications per sampling point are indicated in the method descriptions in chapter 3.2)
Date	Please enter the date of the respective sampling activity

Annex B. Data for the submodule Shelter

Please fill in one form per plot and indicate the relevant plot (reference 1, reference 2, reference 3, pilot plot).

Annex A1. Crop stand height

Table 11. Monitoring form crop stand height

Crop stand height			**Date**					**Sampling Nr**		
UC			**Name sampling person**					**Plot**		
Sampling point	**Height of plant 1 to 10 (in cm)**									
1	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
2	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
3	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
4	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
5	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Remarks *(please indiacte on backside of page)*										

Annex A2. Crop stand coverage

Table 12. Monitoring form crop stand coverage

Crop stand coverage	**Date**		**Sampling Nr**
UC	**Name sampling person**		**Plot**
Sampling Point	**Please tick for confirmation**	**Estimations on ground shading coverage (in %)**	**Remarks**
1	O Picture		*(or indicate remarks on backside)*
2	O Picture		
3	O Picture		
4	O Picture		
5	O Picture		

Annex A3. Weed flora coverage

Table 13. Monitoring form weed flora coverage

Weed flora coverage	**Date**		**Sampling Nr**
UC	**Name sampling person**		**Plot**
Sampling Point	**Please tick for confirmation**	**Estimations on ground shading coverage (in %)**	**Remarks**
1	O Picture		*(or indicate remarks on backside)*
2	O Picture		
3	O Picture		
4	O Picture		
5	O Picture		

Annex C. Data for the submodule Resources

Please fill in one form per plot and indicate the relevant plot (reference 1, reference 2, reference 3, pilot plot).

Annex C1. Weed flora composition

Table 14. Monitoring form weed flora composition

<table>
<tr><td colspan="3">Weed flora composition</td><td>Sampling Nr</td><td>Date</td></tr>
<tr><td colspan="5">Flowering season (in months) Start: End: (fill in only once)</td></tr>
<tr><td>UC</td><td colspan="2">Name sampling person</td><td colspan="2">Plot</td></tr>
<tr><td>Sampling point</td><td colspan="2">Please name the 3-5 most common weed species and tick if picture taken</td><td colspan="2">Remarks</td></tr>
<tr><td>1</td><td>1.
2.
3.
4.
5.</td><td>O Picture 1
O Picture 2
O Picture 3
O Picture 4
O Picture 5</td><td colspan="2"></td></tr>
<tr><td>2</td><td>1.
2.
3.
4.
5.</td><td>O Picture 1
O Picture 2
O Picture 3
O Picture 4
O Picture 5</td><td colspan="2"></td></tr>
</table>

Sampling point	Please name the 3-5 most common weed species and tick if picture taken		Remarks
3	1. 2. 3. 4. 5.	O Picture 1 O Picture 2 O Picture 3 O Picture 4 O Picture 5	
4	1. 2. 3. 4. 5.	O Picture 1 O Picture 2 O Picture 3 O Picture 4 O Picture 5	
5	1. 2. 3. 4. 5.	O Picture 1 O Picture 2 O Picture 3 O Picture 4 O Picture 5	

Annex C2. Pollinator abundance and biomass (pan traps)

Table 15. Monitoring form pollinator abundance and biomass

Pollinator abundance and biomass		**Date**	**UC**
Name sampling person		**Sampling Nr**	**Plot**
Sampling point	**Number of Individuals**	**Individuals per species group**	**Weight biomass (in g)**
1		Bumble bees: Beetles: Flies: Unidentified:	
2		Bumble bees: Beetles: Flies: Unidentified:	
3		Bumble bees: Beetles: Flies:	
4		Bumble bees: Beetles: Flies: Unidentified:	
5		Bumble bees: Beetles: Flies: Unidentified:	
Remarks: *Please use backside of form*			

Annex C3. Pollinators nesting activities (nesting boxes)

Table 16. Monitoring form pollinators nesting activities

Pollinators nesting activities		**Date**	**Sampling Nr**
UC		**Name sampling person**	**Plot**
Sampling point	**Number of nisted tubes**	**Information on present species if possible**	**Tick if photos taken** *(1 per plate)*
1			O Photos
2			O Photos
3			O Photos
Remarks			

Annex D. Data for the submodule Disturbances

Table 17. Data submodule disturbance

Parameter	Quality	Remarks
Soil Tillage before sowing	Type of machine: Depth in cm: Date:	
Fertilization before or together with sowing	Kind of fertilizer: (organic, mineral) Name: Nutrient content (mainly Nitrogen): Amount per ha: Date:	*If needed, specify several dates separately on backside of form*
Plant protection (Herbicides and insecticides only!)	Type of product: Amount: Date:	*Only insceticides and herbicides,* *If multiple applications are done, please list every single application separately*
Tillage for sowing/seedbed	Type of machine: Depth in cm: Replication: Date:	*If multiple applications are done, please list every single application separately*
Sowing	Machinery: Seed quantity:	

Parameter	**Quality**	**Remarks**
	Seed variety: Date:	
Chemical plant protection between sowing and harvesting	Type of product: Amount: Date:	*If needed, specify several dates separately on backside of form*
Non-chemical plant protection between sowing and harvesting	Type: Machine: Date:	*If needed, specify several dates separately on backside of form*
Fertilization between sowing and harvesting	Type of fertilizer: Nutrient content: Date:	*If needed, specify several dates separately on backside of form*
Harvest/cuttings	Machine Date:	*If needed, specify several dates separately on backside of form*
Other:		