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► **To cite this version:**

Stéphanie Airon, Sabrina Dreisiebner-Lanz, Jacopo Goracci, Tine Grebenc, Stefan Kirchweger, et al.. Implementing High-Diversity Landscape Features on farms: small changes but large gains. EU Cap Network. 2023. hal-04668959

HAL Id: hal-04668959

<https://hal.science/hal-04668959v1>

Submitted on 7 Aug 2024

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EU CAP NETWORK FOCUS GROUP ENHANCING THE BIODIVERSITY ON FARMLAND THROUGH HIGH-DIVERSITY LANDSCAPE FEATURES

Implementing High-Diversity Landscape Features on farms: small changes but large gains

**Stéphanie Aviron, Sabrina Dreisiebner-Lanz, Jacopo
Goracci, Tine Grebenc, Stefan Kirchweger, Xavier
Mesmin, Orsolya Nyárai**

July 2023

*Keywords: ecosystem services, biodiversity, suitable management, landscape,
performance indicators, economic costs and benefices, innovation.*



Introduction

The European Union sets ambitious goals for 2030 within EU biodiversity strategy, and one of them is to **set 10% of the farmland under high-diversity landscape features** (HDLFs hereafter) in order to enhance biodiversity in agricultural landscapes. Depending on regions of Europe, HDLF cover varies greatly and can include hedgerows, trees (either isolated, in lines or grouped), flower or grassy strips, ditches and ponds, stonewalled terraces, etc. (details in the introductory paper of the Focus Group). By contrast with the Ecological Focus Areas highlighted in the previous CAP, the focus is now set up on **non-productive HDLFs**, and excludes productive covers such as cash crops and nitrogen-fixing crops, that are of limited interest regarding biodiversity conservation targets (Pe'er et al. 2017). The successful implementation of HDLFs on farms can face limited motivation from farmers due to several issues:

- › The lack of relevant information regarding practical success stories illustrating that small changes to set up HDLFs can lead to large gains on farms, not only for biodiversity conservation but also for ecosystem services from which farmers benefit.
- › The lack of knowledge regarding appropriate practices to optimise HDLFs installation and management on farms.
- › Critical concerns and lack of understanding with regard to the mostly unknown and long-term potential economic benefits of HDLFs for farmers, with regard to the short-term economic costs of conserving, managing and implementing these elements on farms.
- › Concerns about negative effects on cultivated crops or negative appraisal by neighbouring farmers;

The goal of the present mini-paper is to highlight the potential **ecological and economic benefits of HDLFs for farmers**, illustrate practical **success stories**, and to point out **research needs** regarding the implementation and assessment of HDLFs. The focus is put on HDLFs that can sustain large ecological benefits while requiring a small amount of land or low effort in terms of time or costs, i.e. especially hedges, flower strips or grass strips or maintenance of existing HDLFs, such as ditches. The focus is also deliberately set on the benefits retrieved from HDLFs, and possible costs related to disservices are also discussed.

What are the potential “large” ecological gains of maintaining or introducing HDLFs on individual farms?

1. HDLFs sustain biodiversity and ecosystem services of direct interest for farmers

Services provided by agroecosystems to farmers are manifold: crop pollination, natural pest control, improvement of soil structure, organic matter recycling, nitrogen mineralization, prevention against undesirable weather conditions, etc. Several of these services are provided by organisms (hereafter called “beneficials”) that **move between crops and HDLFs** to find the full spectrum of resources they require to accomplish their life-cycle. HDLFs, especially those positioned at field borders or near cultivated fields, can then play a role via hosting beneficials.

a. Natural pest control

Pest natural enemies can be schematically divided in three groups: **generalist predators** (e.g. most carabids, spiders, staphylinids, harvestmen), **specialist predators** (e.g. coccinellids, syrphids, sphecids) and **parasitoids**. In the first group, several species need **perennial habitats** especially for **overwintering**, as is the case of *Brachinus sclopeta* overwintering almost exclusively in field margins cultivated in oilseed rape the year before. For such species



grassy strips or hedgerows are therefore necessary. Building on this trait two simple HDLFs were designed:

- › “beetle banks”, i.e. mid-field grassy ridges, were developed in the UK and advised as early as 1995. Several studies indicate that they support aphid control by polyphagous predators (including many carabids) in adjoining fields.
- › In France, recent works conserved intercrop strips while sowing maize. These strips hosted beneficials and supported natural pest control nearby.

Among specialist predators (e.g. syrphids) and parasitoids, many species **feed on flowers** (pollen and nectar) at the adult stage. These can therefore benefit from flowers provided by hedges and flower strips. Not all flowers though, because insect mouthparts limit the types and sizes of flowers that they can visit. Other specialist predators, especially in sphecid wasps, need woody habitats like hedges as nesting sites and benefit from hedge connectivity.

b. Pollination

Pollinators have been much studied (mini-paper 3). They need at least three resource types:

1. **Flowers** (i.e. nectar and pollen). Expectedly, flower strips were repeatedly proven beneficial to pollinators such as bumblebees, solitary bees, honey-bees or flies. The benefit of flower strips typically decreases as we progress within the field and is usually significant only in the first 10 metres adjoining the strip. Consequently the increase in pollinator abundance and diversity on the flower strip does not always translate into increased flower visitation in the adjoining fields.
2. **Nesting sites**. Wild pollinators such as solitary bees benefit from bushy or woody HDLFs.
3. **Water**. Pollinators can benefit from ponds nearby.

c. Other services

Depending on their structure, HDLFs can also provide other **direct services to the farmer**:

- › Hedgerows can serve as **windbreaks** and enhance the protection of crops or livestock against **undesirable weather conditions**. Regarding crops, the presence of windbreaks leads to a reduction of crop production close to hedgerows (because of competition between crops and shrubs and trees in hedges) but to an increase in yield further away. This beneficial effect varies according to field size-to-hedge height ratio, and to hedge structure. The added-value of hedgerows through livestock protection is rarely investigated, but there is evidence these HDLFs can enhance livestock production thanks to their sheltering effects.
- › HDLFs can also contribute to reducing **soil erosion, flooding** and associated crop damage, increasing the capacity to store nutrients or to decompose pollutants such as pesticides.
- › Hedgerows can provide to farmers **timber, fuel wood, and food** when containing fruit trees.

2. HDLFs sustain other ecosystem services of broader concern in agricultural landscapes

HDLFs provide a set of ecosystem services of broader concern, for the farmers but also for society in general.

In addition to sustaining pollination and pest regulation, hedgerows also provide an important service regarding the **conservation of biodiversity *per se***. Apart from species visiting hedges but mostly living inside the fields, hedgerows can host species that are restricted to woody habitats, that are not good dispersers and that would otherwise be absent. This is typically the case of longhorn beetles, some of which need veteran trees with dead branches to complete their multiyear larval stages. Scattered trees are also keystone structures for biodiversity in landscapes. Indeed, in a global meta-analysis of 2018, Prevedello et al. showed that the local



abundance of arthropods, vertebrates and woody plants was 1.6 to 4 times greater and overall species richness was 1.5 to 2 times higher in areas with scattered trees than in open areas. As wooded structures, hedgerows might also significantly contribute to **climate change adaptation and mitigation**. Carbon stocks in hedgerows were found to be on average comparable to those in forests, suggesting that the establishment of hedgerows on farmland could be an effective measure for carbon sequestration, while sustaining other ecosystem services. For more details, see companion mini-paper 3.

HDLFs also contribute to **landscape aesthetic**, in relationship with the **cultural heritage of the place**. This cultural service is highly subjective and depends on stakeholder expectations, but is important to consider if we are to design multifunctional rural landscapes.

Optimising ecological effectiveness of HDLFs

In spite of their overall demonstrated benefits, HDLFs may show variable effectiveness to sustain biodiversity and ecosystem services of direct interest for farmers, depending on ecological requirements of farmland species, on the practices of farmers to implement or restore HDLFs on farms, as well as on the characteristics of the landscapes in which HDLFs and farms are embedded. Thus, several issues should be addressed when introducing or restoring HDLFs on farms to optimise their effectiveness.

1. Promote diverse HDLFs on farms

The conservation or implementation of **diverse types of HDLFs** should be favoured on farms to provide the widest range of niches for biodiversity. Achieving this goal is important for several reasons:

- › **To sustain farmland species that need different types of habitats to feed, reproduce or overwinter.** For instance, wild pollinating insects need woody HDLFs (woodlots, hedgerows), herbaceous field margins and flower strips to find nectar, pollen and nesting sites.
- › **To sustain different groups of farmland species that do not need the same ecological conditions.** For instance, different invertebrate groups such as butterflies, bumblebees, beetles, bugs and spiders, do not prefer the same types of field margins.

2. Adopt diverse ecologically-relevant practices to implement and manage HDLFs on farms

The quality of HDLFs for biodiversity can be greatly affected by inappropriate practices, either when managing existing HDLFs or when creating new ones on farms. **To be effective in promoting biodiversity, the design and management of HDLFs should be tackled in order to optimise the habitat and sheltering conditions they offer to biodiversity.**

a. Hedgerows planting and management

There is much evidence that biodiversity is enhanced in wide and large hedgerows, with structural complexity at the base, with different vegetation layers (herbs, shrubs, trees), few vegetation gaps and high plant species diversity. For these reasons, considerable ecological benefits might be achieved through **the adoption of management practices to restore the quality of existing (potentially degraded) hedgerows for biodiversity**, such as following:

Introduction of structural complexity (e.g. creation of a bank or ditch) at the base of hedgerows,

- › Enhancement of herbaceous plant diversity with sowing of native flowering plants at hedgerow margins,
- › Maintenance of unsprayed herbaceous margins along hedgerows,



- › Maintenance of management of shrubs and trees, with parsimonious and rotational cutting of shrubs and trees,
- › Use of native plant species to plant new hedgerows on farms.

Table 1. Summary of possible ecologically relevant practices for hedgerow planting and management.

| Targeted features to promote biodiversity | Recommended management practices |
|--|---|
| Structural complexity | Maintenance of wide hedgerows, through the preservation of herbaceous margins at each hedge side |
| | Creation / maintenance of a bank and/or ditch |
| | Maintenance of herbaceous, shrubs and tree layers |
| Habitat quality (vegetation composition and structure) | Maintenance of unsprayed herbaceous strips (no herbicides or fertilisers) along hedgerow margins |
| | Reduce and avoid drift of herbicides or fertilisers to hedgerows and other non-target sites by optimising sprayers |
| | Restoration of hedge herbaceous margins through the sowing of native flowering plants |
| | Use of native shrub and tree species to restore or plant hedgerows |
| | Maintenance of management (no abandonment) of shrubs and trees |
| | Rotational cutting of shrubs and trees to avoid over-management |
| | Parsimonious cutting to avoid vegetation gaps |
| Avoidance of direct effects on biodiversity survival | Reduce / avoid drift of insecticides or fungicides to hedgerows and other non-target sites by maintaining buffer, unsprayed herbaceous strips and by optimising sprayers. |

b. Flower strip sowing and management

The choice of species-rich seed mixtures is essential to encourage diverse taxa of beneficial insects, because different insect groups prefer different plant species. The applied management regimes might also condition their effectiveness for beneficial organisms. Several recommendations can be done to increase the beneficial role of flower strips for pollinating insects and natural enemies of crop pests on farms:

- › Sowing of flower strips with pollen- and nectar-rich mixes, which are especially attractive for domestic and wild pollinating insects.
- › Sowing of flower strips with mixes comprising plants with diverse floral morphologies (flat, tubular, etc.) and flowering periods, to provide resources for diverse beneficial insects at different times in summer
- › No use of pesticide treatments on flower strips, and cutting once in winter.

The management recommendations listed above are identified as suitable to increase the habitat and sheltering quality of hedgerows and flower strips for biodiversity. However, one should keep in mind that diverse management regimes should be encouraged on different HDLFs on farms rather than standardised “good” ones to allow the maintenance of heterogeneous habitat conditions for biodiversity.

3. Implement HDLFs with a landscape perspective



The persistence of biodiversity relies on processes that operate at the landscape level, in relationship with the amount (surface area), diversity and spatial arrangement (spatial connectivity) of habitats on farmland. **The efficiency of HDLFs to sustain high biodiversity levels will not only be driven by their local characteristics and management regimes, but also by the complexity of their landscape context.**

Because many plant or animal species respond to landscape patterns at scales that often go beyond the individual farm, **actions aiming at restoring landscape complexity might require the involvement of groups of farmers and collective work.** The chances of success will increase with collaboration and coordination between neighbouring farmers.

The implementation of new HDLFs on farms or groups of neighbouring farms should integrate the following issues:

- › Identification of the **agricultural areas to prioritise for landscape restoration** (i.e. areas with low amount of existing HDLFs or semi-natural habitats, and low proximity between them)
- › Creation of new HDLFs in areas requiring the increase in habitat amount for biodiversity
- › Creation of new HDLFs close to existing HDLFs and other semi-natural habitats, to increase connectivity between habitats

However, one should be aware that a critical issue emerges from the contrasted requirements of species or taxa regarding landscape structures, which could result in antagonistic responses of taxa to landscape restoration measures. For instance, complex landscapes with dense hedgerow networks can at the same time be beneficial for plant and pollinator diversity, but detrimental to predatory insects like carabids because hedgerows impede their dispersal.

4. Let time take its course

With the restoration or implementation of HDLFs, farmers expect to have some direct benefits over the short term, especially regarding ecosystem services provided by natural enemies and pollinating insects. **However, these benefits might only be visible after several years.** Actually, biodiversity may not respond immediately to changes in management practices, and time might also be needed to allow the development of appropriate conditions in restored or newly-created HDLFs.

In hedgerows, several years are needed to improve habitat quality for biodiversity:

- › To increase the structural complexity of shrubs and trees
- › To allow the shifts from herbaceous communities dominated by grasses and ruderal plant species to more diverse communities with the presence of forest plant species

In wildflower strips, mixed trends are observed:

- › Pluriannual strips offer better feeding, nesting and overwintering conditions for certain beneficial insects (pollinators and some natural enemies)
- › Old flower strips left uncut (such as in Switzerland) become less beneficial to biodiversity (invasion of grasses and weeds to the detriment of sown wild flowers).
- › Ensuring the presence of strips of different ages on farms might optimise their overall benefit for biodiversity.

5. How to assess the relevance of HDLFs for biodiversity?

HDLFs can support several services for farmers and for the society in general, but all types of HDLFs are not equivalent. Moreover, within a given HDLF type, different botanic compositions, vegetation structures, and managements are likely to lead to contrasted services. Many farmers therefore expect tools to assess the **efficiency of HDLFs.**

This need has elicited the development of various biodiversity indicators. In this context, indicators are figures that are 1) **easy to obtain** and 2) highly **correlated with the biodiversity under assessment.** They are usually a compromise between these two goals. Although many



initiatives emerged for about 10 years, **we still miss methods to compare the performances of HDLFs** regarding biodiversity conservation, natural pest control, pollination, or biodiversity conservation services for instance. Projects are under way to fill this gap (see examples in Table 2), such as the [Ecobordure method](#), that characterises the ecological quality of field borders based on indicator plant species reflecting existing management practices. Such indicators targeting HDLFs specifically may be **used on their own**, but may also be included in **larger frameworks assessing the multi-performance of farms**. Several methods emerged in recent years in this perspective, bridging the gap between scientific knowledge and application in farms (Table 2).

Table 2. List of indicators / sets of indicators to assess the biodiversity performance of HDLFs or farming systems and associated HDLFs.

| Indicator / Set of indicators | Designed in | Focused on | Type of biodiversity addressed | Type of indicator |
|--|-------------|------------|---|---|
| Ecobordure method | France | HDLFs | Flora | Biodiversity measures (botany) |
| PGDH | France | HDLFs | Biodiversity in general | Farmer survey and landscape description |
| Streamlined European Biodiversity Indicators | Europe | Region | Depending on indicator | Farmer survey and landscape description |
| Biodiversity Performance Tool | France | Whole farm | Biodiversity in general | Farmer survey and landscape description |
| Agribest | France | Whole farm | Biodiversity in general, specifically tested on flora, pollinators and pest natural enemies | Farmer survey and landscape description |
| Cool Farm Tool | France | Whole farm | Biodiversity in general | Farmer survey and landscape description |
| Pollinator scorecard | Ireland | Whole farm | Pollinators | Farmer survey and landscape description |
| Wild Atlantic Nature | Ireland | Whole farm | Remarkable species or habitats (esp. in Natura 2000 areas) | Biodiversity measures (esp. botany) |

Most of these indicators are “predictive” indicators, meaning that they use data that can be retrieved from farmer surveys or from landscape description. The validation of these indicators is generally done before, with some of them coming directly from published evidence in peer-reviewed journals. Not always though, meaning that **for the time some indicators lack robust evidence** supporting their use as efficient descriptors of the biodiversity in HDLFs or in farms.



What are the economic consequences of implementing HDLFs on farms?

Literature analysing the cost-benefit trade-offs of biodiversity on farmland provide contrasting evidence, suggesting farmers may have economic benefits, an economic break-even or costs from biodiversity management. Benefits as well as costs of biodiversity management in order to enhance ecosystem service delivery depend on the kind of HDLF as well as on the level of management effort (e.g. degree of habitat enhancement or land-use intensity reduction). However, there is scarcity of evidence of the economic profitability of HDLFs and further economical-ecological analyses are necessary.

Direct economic benefits for farmers are related to better ecosystem services due to HDLFs. Ecosystem services with an immediate effect on farming comprise, inter alia, those provided by beneficial organisms (pollinators / pest natural enemies), reduction of erosion and enhancing of water holding capacity. Thus, enhanced natural water retention leads to increased soil moisture, reduced need for irrigation and reduced yield loss at times of drought, reduced risk of flooding and consequently less soil erosion. As a consequence of providing habitats for natural enemies of pests, the need for pesticides and associated costs are reduced. On the whole, higher biodiversity is linked to higher crop production and lower amount of agrochemicals. However, the benefits of higher biodiversity and HDLFs on farms is currently underestimated by farmers themselves and society.

A crucial aspect is the timeframe: for both direct and indirect effects, time may be needed to observe economic benefits of HDLFs, but costs accrue on a short-term scale. In the long run, farmers may potentially save costs by protecting or establishing HDLFs on their farmland and biodiversity might contribute to the overall resilience of the farm, the agricultural production and ecosystems.

The costs for setting up, conserving and maintaining HDLFs on farmland highly depend on the level of management effort, the type of HDLF, the initial situation and land use. Related costs can be :

- › Negative effects on production and dis-services for farmers: e.g. shading or higher air humidity due to hedges or tree lines can lead to lower yield or higher occurrence of fungal infections near the HDLF; extensively managed flower strips and hedgerows can also provide habitats for pests as aphids or root voles.
- › Investment costs for implanting: especially for hedges or trees, relatively high costs for planting material occur
- › Costs for maintenance: costs for special machinery, costs for labour, considering the raising shortage of labour
- › Higher cost for crop management through e.g. smaller fields
- › Opportunity costs for land: the implementation of HDLFs may lead to a reduced productive area and therefore reduce productivity

Such factors have direct impacts on farm agronomics and therefore on farm gross margins and can be valorised using simpler farm and plot specific economic modelling. The gross margin is a major decision criterion for farmers' production planning and does not require to calculate fixed costs, which is very data demanding.

As mentioned in Section 1.2, HDLFs do not only directly affect the farmers, but also other ecosystem services which are relevant for the society as a whole. Even though such societal benefits of HDLFs do not directly support farmers, they might do so if public or private payments schemes are implemented focusing on the compensation of ecosystem services. In order to identify the value of the payments it is necessary to assess and valorise these services. For the assessment and economic valorisation of ecosystem services, several methods have been developed. Classic valuation techniques include contingent valuation



methods, also called Willingness-To-Pay (WTP) studies, whereby values are assigned by constructing demand curves reflecting survey respondents' reactions in choice experiments or empirical data analysis. Alternatively, hedonic pricing approaches may be used, whereby values are inferred from indirect expenditure choices. Comprehensive approaches to estimate the contribution of agriculture for society and environment comprise all aspects of production, including biodiversity. One example is the Regionalwert-Leistungsrechnung (<https://www.regionalwert-leistungen.de/>).

Examples of success stories that illustrate the potential of “small changes – large gains” of HDLFs

1. Short Rotation Forestry (SRF) plantations in Italy

At the end of the last century, Short Rotation Forestry (SRF) plantations – defined as dedicated plantations in which woody species are grown for energy purposes (González-García et al. 2012) – rapidly expanded in EU with the aim to reduce fossil fuel dependence, GHGs emissions, and waste production. Recently, in Italy some SRF plantations developed in the 90s have been abandoned or managed more extensively through the reduction in tree density and longer rotation periods. In this way SRF plantations shift toward complex ecological systems characterised by higher levels of multifunctionality and ecological complexity (Di Candilo and Facciotto 2011). Even if it is important to point out that in abandoned natural and artificial systems, ecosystem services supply is sub-optimal and forest restoration practices are the tool to regain ecosystem functionality and the forest capacity to provide multiple ecosystem services (Marchi et al. 2018), in the case study presented by Paletto et al. (2023) the application of extensive management techniques and the development of the naturalisation process of SRF abandoned plantations seemed to ensure their role of “stepping stone”, helping their evolution toward semi-natural systems mainly oriented to biodiversity conservation, habitats provision and carbon sink.

2. Agroforestry (AF) hedgerows

In western France, hedgerow planting programmes are currently sustained by regional authorities to restore the traditional Bocage landscapes. **Agroforestry (AF) hedgerows planted by farmers of the “[Terres et Bocage association](#)” illustrate an innovative approach to reintroduce hedgerows on farms** and to restore hedgerows network landscapes (Figure 1) (Thenail et al. 2017a). The specificity of AF hedgerows is that they are considered as multifunctional components of agricultural systems and landscapes.

They are **designed with multiple aims** including restoring biodiversity, preventing nitrogen leaching for water protection, restoring the connectivity of bocage landscapes, creating windbreaks, providing shelter for livestock, and producing valuable products from trees. The practices of hedgerow planting and management are designed to promote a logic of tree development. The tree species and modes of hedgerow establishment are chosen according to farmers' objectives, the use of their fields, the local conditions on farms, the observed vegetation structures, and local native tree species in the surrounding area. An assessment of AF hedgerows planted 15 years ago show that their expected agroecological benefits can already be perceived, in terms of flora and fauna diversity (Thenail et al. 2017b). New AF hedgerows also reinforce the spatial structure and ecological functions of the bocage landscape, and improve landscape aesthetic and farmers well-being. AF hedgerows contribute to enhance crop and livestock production, by sheltering crops and livestock in pastures against inclement harsh weather. The farm use and the sale of wood chips and logs contribute to cover on-going hedgerow maintenance costs. Mutual aid, recycling of material (e.g. for mulch) and the principle of parsimonious pruning contribute to controlling costs for farmers. The “Terres et



Bocage association” offers farmers the opportunity to join active groups of stakeholders sharing agronomic and environmental concerns in relationships with hedgerows and bocage. Through participatory fieldwork and action-learning sessions, the association ensures relevant knowledge and experience is shared with and among farmers. They benefit from technical issues and assistance by the advisors employed by the association. See also:

https://www.agforward.eu/documents/leaflets/09_Multi-functional_hedgerows_in_thebocage_system_in_France.pdf

Another example of innovative uses of hedgerows is currently being under exploitation and implementation in the EIP project in Slovenia. The project “Hedgerows as a support for biodiversity, preservation of the traditional and disappearing cultural pattern of the Slovenian countryside and provision of ecosystem services” is facing challenges in improving and multiplying ecosystem services in agriculture lands through implementation on new knowledge, and a bottom-up approach in bringing fresh ideas from individual farmers to broader community. An innovative idea was also how to increase visibility and production potential of hedgerows in growing truffles, if environmental conditions are suitable.



Hedgerow plantation through participatory field work



Animal sheltering is one of the multiple services provided by new hedges



Restoration of hedgerow networks, through the plantation of several hedges.

Figure 1. Agroforestry hedgerows introduced by the “Terres et Bocage association” in Brittany, Western France.



3. Flowering intercrops in permanent crops

In permanent crops as vineyards or orchards the establishment of flowering strips is possible in and next to the productive area. There are several possibilities for the implementation within:

a) sowing flowering mixtures in the whole row

b) sowing biodiversity mixtures only in the middle of the rows, where no wheels are running. This option causes lower costs as less seed is necessary and is especially preferable when erosion and trafficability are relevant factors. Furthermore, many herbs and legumes don't withstand the frequent passing over which is necessary in permanent crops.

c) adapt management strategies in order to enhance biodiversity of natural vegetation and foster herbs and legumes. A possible strategy is to avoid mowing in the middle of the row. This can easily be achieved by corresponding technical solutions (mulcher without blades in the middle or rolling).



Figure 2: Flowering mixtures in vineyards in Styria/Austria. Source: Life VineAdapt / Agricultural Research and Education Center Raumberg-Gumpenstein (AREC), Bernhard Krautzer

In any case, suitable technique has to be used for seedbed preparation and sowing. Appropriate management strategies have to be chosen to maintain a diverse vegetation: many herbs and legumes do not tolerate low mowing or need to flower and sow out.

Depending on climate and soil conditions, matching and specific seed mixtures (e.g. with focus on regional varieties, compatible plant combinations) should be used for sowing. The native plant mixes should be selected to target the taxa which sustain ecosystem services expected by farmers. See also: <https://www.life-vineadapt.eu/en/aktuelles>

4. Small extensive managed grasslands (EMG) in Alpine regions

Whereas there is an ongoing and economic driven trend in grassland management to cultivate the fields intensively (early cuts and high amounts of nitrogen) and at the same time, some husbandry farmers follow the so called graded meadow cultivation. This takes into account that not all fields are cultivated at the same intensity level and are not cut at the same time. This results in a tessellated structure of different management practices, including small extensive managed grassland plots. These Plots are preferably located on marginal land where intensive cultivation is costly. The harvested fodder can be used for feeding the heifers.



This results in several and scattered biodiversity hotspots (Spiegelberger et al. 2006) around the whole farm delivering a big bundle of ecosystem services and in turn with fairly little loss of economic profitability for the farm.



Figure 3: Small extensive managed grasslands in Alpine regions. Source: Bio Austria

Conclusions: Lessons learnt

HDLFs are **multifunctional landscape features** that sustain multiple ecosystem services of direct interest for farmers and of broader importance for the society.

Larger benefits from HDLFs to promote biodiversity and associated ecosystem services on farms can be attained if **the following key issues** are considered:

- › Small changes can bring large gains; however, if changes are “small” or “big” depends on the individual situation on the farm. We recommend identifying the farms where changes are within reach of farmers to start enhancing biodiversity and ecosystem services through HDLF implementation or optimisation.
- › We identified some good practice examples, which illustrate the “small changes - large gains” concept. They comprise the restoration of existing, but degraded HDLFs through the adaptation of management practices. In addition, it is favourable to avoid direct negative effects of agrochemicals or fertilisers on biodiversity survival.
- › New HDLFs are ideally designed (i) by using regional, native plant species, and (ii) selecting plant species or mixes which supports the ecosystem services that are expected or most needed by the farmer
- › When new HDLFs are established, the landscape perspective should be considered to increase HDLF connectivity and landscape complexity. Areas requiring landscape restoration should be targeted preferentially, involving the collaboration between neighbouring farmers.
- › Diverse types of HDLFs and diverse management regimes should be promoted and implemented to maximise their positive effects on biodiversity and ecosystem services.
- › Benefits might only be visible after several years. Yet the maintenance of appropriate management practices is crucial.

However, there are some open questions:

- › Most measures focus on above-ground biodiversity, although the soil is the basis of any agricultural production - there is a knowledge gap and a lack of attention to below-ground biodiversity
- › Regarding the landscape perspective, there is a lack of knowledge regarding possible trade-offs in the responses of different species groups to HDLF connectivity and landscape complexity. Tools are also needed to identify and depict primary areas to restore, considering existing HDLFs on farms. In addition, the implementation of a landscape



perspective does not only concern the farm scale and requires coordination and cooperation between farmers.

- › To assess the quality, efficiency and value of HDLFs, tools and biodiversity indicators are needed.
- › Regarding the economic consequences, there is a discrepancy between the costs, which accrue on a short-term scale and long-term benefits. Consequently, there is scarcity of evidence of the economic profitability of HDLFs.
- › The last two points subsequently lead to the need for suitable support mechanisms or incentive systems.

Research needs from practice

a. Locate the most relevant sites for HDLF setup.

Keywords: cartography, prioritization, assessment.

- › Advising farmers to implement HDLFs requires identifying the agricultural areas to prioritise for landscape restoration and the extent to which additional habitat amount and complexity should be increased. Evidence-based results and spatially-explicit tools are needed to assess the contribution of individual farms to produce spatial patterns of ecological importance at the landscape level for diverse taxa.
- › This research need applies to the European level.
- › This issue is relevant for both crop and livestock farming.

b. Develop indicators to provide guidance for the best setup and management of HDLFs.

Keywords: indicators, decision support tool.

- › Although some initiatives were reviewed in §2.5, we miss indicators robustly validated by science to provide guidance for the appropriate setup and management of HDLFs. Indicators are needed to assess the quality *a priori* and *a posteriori* of HDLFs on farms regarding the services expected, including the services benefiting the society in general in order to provide incentives for farmers.
- › This research need applies to all Europe.
- › This research need applies to both crop and livestock farming.

c. Assess the costs and economic benefits associated with HDLFs at the farm level.

Keywords: economy, incentives.

- › The economic assessment of the costs and benefits associated with HDLFs at the farm level is still largely missing. Especially, there is a need to better understand the trade-offs between economic and ecological performances, including the identification of economic and ecological optima with regard to the number and size of HDLFs on different farm types.
- › This research need applies to all Europe.
- › This research need applies to both crop and livestock farming.



d. Understand the variety and intensity of interactions between above and below-ground biodiversity.

Keywords: soil fauna, interaction networks.

- › How the health and effective functioning of soil organisms is affected by the presence and health of above-ground biodiversity is still in need of further research. To fill this gap, research on the influence of above-ground biodiversity on the ecological benefits provided by below-ground biodiversity is needed.
- › This research need applies to all Europe.
- › This research need applies to both crop and livestock farming.

Innovative ideas

a. Compile possibilities to integrate HDLFs in a productive manner.

Keywords : productivity, direct services

- › Some HDLFs can be productive and integrated in the functioning of farms, to compensate for implementation costs for farmers, and to increase multiple benefits on farms. Examples are e.g. (i) the establishment of **ecotourism**, driven by cultural HDLFs such as drystone walls, kurgans, etc. (ii) **the direct use of HDLF products**, as fruits or timber (iii) **secondary use as living space**, e.g. for growing truffles. The task would be to identify the potentials for **productivity** of HDLFs, depending on the legislation and interaction with subsidies and gathering accessible knowledge of existing policies, incentive measures and private contracts to increase benefits for farmers.
- › This innovative idea applies to all of Europe.
- › This innovative idea applies to all farming sectors.

b. Improve the management of scattered trees.

Keywords : tree, landscape configuration

- › Scattered trees can be very beneficial for biodiversity, especially in homogeneous landscapes, with low structural diversity. The challenge here is to find the right management and long-term policies to retain or re-establish scattered trees in many farming landscapes in both forest, pastures and arable land.
- › This idea applies to all of Europe, especially farming areas with homogeneous, openfield, landscapes.
- › This idea applies to all farming sectors.

c. Improve the cooperation between farmers, advisors, and citizens to reduce the workload associated with the setup and management of HDLFs for farmers.

Keywords: collaboration, workload.

- › Setting and managing HDLFs takes a lot of time, usually taken over by the farmer itself. However we saw previously that the spatial arrangement of HDLFs is crucial, and that the services provided benefit the society in general. It makes sense to try to think collectively for this challenge, and try to foster collaboration between farmers, local authorities and other actors to achieve a coordinated approach with a maximum of effect. Collective work, involving mutual aid and participatory fieldwork, can



increase farmers' motivation and knowledge to implement or restore HDLFs and contribute to reducing costs.

- › This Innovative Idea applies to all of Europe, and especially to HDLFs that are very labour intensive for the setup and/or management, typically hedgerows or drystone walls.
- › This Innovative Idea applies to all farming sectors

d. **Maximise the connectivity of HDLFs. Keywords: ecological continuity, network.**

- › We saw that the spatial arrangement of HDLFs is crucial to ensure continuity of resources provided by woods, flowers, water... The challenge here is to use GIS tools to produce maps suggesting concrete scenarios of HDLFs setup based on current breaks in resource continuity.
- › This applies to all of Europe, but especially to areas with already existing HDLFs, as the idea is more to improve existing connectivity than to create a new network from the beginning.
- › This Innovative Idea applies to all farming sectors.



References cited

- Di Candilo, M. & Facciotto, G. (2011). Perspectives of woody crops dedicated to biomass production for energy use. In: Lo sviluppo delle colture energetiche in Italia. Presented at the II contributo dei progetti di ricerca Suscace e Faesi, Roma (Italy), pp. 293–308.
- González-García, S., Mola-Yudego, B., Dimitriou, I., Aronsson, P. & Murphy, R. (2012). Environmental assessment of energy production based on long term commercial willow plantations in Sweden. *Science of The Total Environment, Special Section: Reviews of Trace Metal Pollution in China*, 421–422, 210–219.
- Marchi, M., Paletto, A., Cantiani, P., Bianchetto, E. & De Meo, I. (2018). Comparing Thinning System Effects on Ecosystem Services Provision in Artificial Black Pine (*Pinus nigra* J. F. Arnold) Forests. *Forests*, 9, 188.
- Paletto, A., Ceotto, E., Becagli, C., Casagli, A., Manici, M.L. & De Meo, I. (2023). The role of abandoned Short Rotation Forestry (SRF) plantations in plant carbon storage: a case study in Central Italy. Preprint from research square. <https://doi.org/10.21203/rs.3.rs-2594512/v1>
- Pe'er, G., Zingrebe, Y., Hauck, J., Schindler, S., Dittrich, A., Zingg, S., et al. (2017). Adding Some Green to the Greening: Improving the EU's Ecological Focus Areas for Biodiversity and Farmers. *Conservation Letters*, 10, 517–530.
- Thenail, C., Aviron, S., Viaud, V., Ghéhenneuc, T., Menguy, C. (2017a). Multi-functional hedgerows in the bocage systems of France. Rejuvenating a traditional system through farmer-led innovation. https://www.agforward.eu/documents/leaflets/09_Multi-functional_hedgerows_in_thebocage_system_in_France.pdf
- Thenail, C., Aviron, S., Viaud, V. (2017b) Lessons learnt: Bocage Agroforestry in France.. <https://www.agforward.eu/documents/Les>

