Interreg Sudoe Fleurs Locales

European Regional Development Fund

Medio ambiente
eficiencia de recursos

Guideline for Restoration Projects Based on Native Seeds

El Proyecto Fleurs Locales está cofinanciado por el programa Interreg Sudoe I Proyecto cofinanciado por el Fondo Europeo de Desarrollo Regional

INDEX

1. Objective and scope of this document

The restoration of degraded environments is a topic of increasing interest within the EU. Many strategies related to the conservation of biodiversity, urban planning, a greener agriculture, and confronting climate change, among other matters, consider the restoration of degraded habitats as a central issue or path toward achieving other environmental objectives.

The use of native seeds in restoration projects or as a part of nature-based solutions (i.e., in the agricultural sector) is largely supported by scientific evidence. The benefits of native seeds include a better adaptation to local conditions, better performance of the plants introduced, faster ecological succession, more resources available for local fauna, better capacity for self-replication, and more. In recent years, there has been a significant development in the technical knowledge needed for the practical use of native seeds in all stages: seed collection, storage, quality assurance, propagation, sowing, etc.

Nevertheless, the use of native seeds in restoration projects or for delivering nature-based solutions remains far from widespread. There are several reasons that explain this situation. For example, most public administrations are just discovering the importance of native seeds and therefore are in the initial stages of promoting them through dedicated policies. This, and the lack of practical knowledge, specifically for some EU regions or groups of flora, limit the development of private initiatives. End-users are generally not informed about the benefits of native seeds, but when selecting this option, they find constraints such as a very restricted market, with few options for plant material, low availability and occasionally high costs. The future of use of native seeds in the EU depends on understanding and overcoming the current limitations in a value chain that includes diverse public and private stakeholders, and which runs from the collection of seeds to their final use.

The main objective of this document is to provide practical information about native seeds and its use on nature-based solution projects. Its aim is not compiling all the existing information but guiding native seed users through the entire process by pointing out the most essential elements in the decision-making process as well as the most essential information to be monitored. Therefore, this document is addressed to anyone engaged in creating a nature-based solution relying on native seeds, from individuals with a project in mind, to local authorities aiming at exploring this type of solution, companies devoted to civil engineering works, SMEs that can find an opportunity in this future niche market, and the like.

To this end, this document covers the aspects to be considered when designing a restoration project using native seeds, including the specific site characteristics, the final target, the selection of species, and other restorative actions that may be considered related to native seeds. Furthermore, the document discusses the available options for the use of native seeds and presents the aspects to consider in a concrete project and the importance of monitoring. Each section will follow the same structure to answer three main questions: why it is important to think about each specific aspect, what elements should be considered, and how to proceed. Included to answer the last question is a simple table or sheet for compiling all the information and preparing it for use in the project.

This document started as an initial work for a common definition of restoration projects based on native seeds in the framework of the ‘Interreg Fleurs locales’ project, which is described in the following chapter. Changes, improvements and adjustments will be included together with the project, following the lessons learnt at the pilot experimentation sites.

2. Interreg Fleurs locales

2.1 Description of the project

‘Fleurs Locales: Biodiversity restoration chains by native seeds in Mediterranean vineyards, agrosystems and natural environments’ is a European project to promote the use of native seeds. It proposes concrete responses to the massive loss of biodiversity, accelerated by climate change: adaptation of restoration protocols to Mediterranean environments and construction of ecological restoration chains with all stakeholders (land managers, scientists, seed producers, institutions, users, et. al.) grouped through ‘local biodiversity management agreements’. Several pilot territories are mobilized in each country. Based on common working methods, each partner implements restoration chains that respond to specific local challenges (green covers in vineyards, flowery meadows, areas damaged by fires). The project partners (scientists, technicians, space managers and socio-economic actors) combine their skills to create indigenous seed mixtures and structure renaturation chains adapted to the diversity of needs of the SUDOE space.

2.2 What is a native seed?

In the framework of the project, native seeds for a restoration project are defined as the **reproductive material** coming from **autochthonous flora** which is harvested as near as possible to the area of intervention and which maintains **the phenotypic and genotypic characteristics of the wild populations** in the area.

In that sense, it is important to note that ‘autochthonous’ is not a synonym of ‘native’ as some species can be autochthonous to an area but also show human-selected characteristics (for example, for gardening purposes) or traits from other biogeographical areas (for example, for plants having a very wide distribution). Nor is ‘native’ a synonym for ‘local’ as our landscapes hold a considerable number of species introduced from other biogeographical areas.

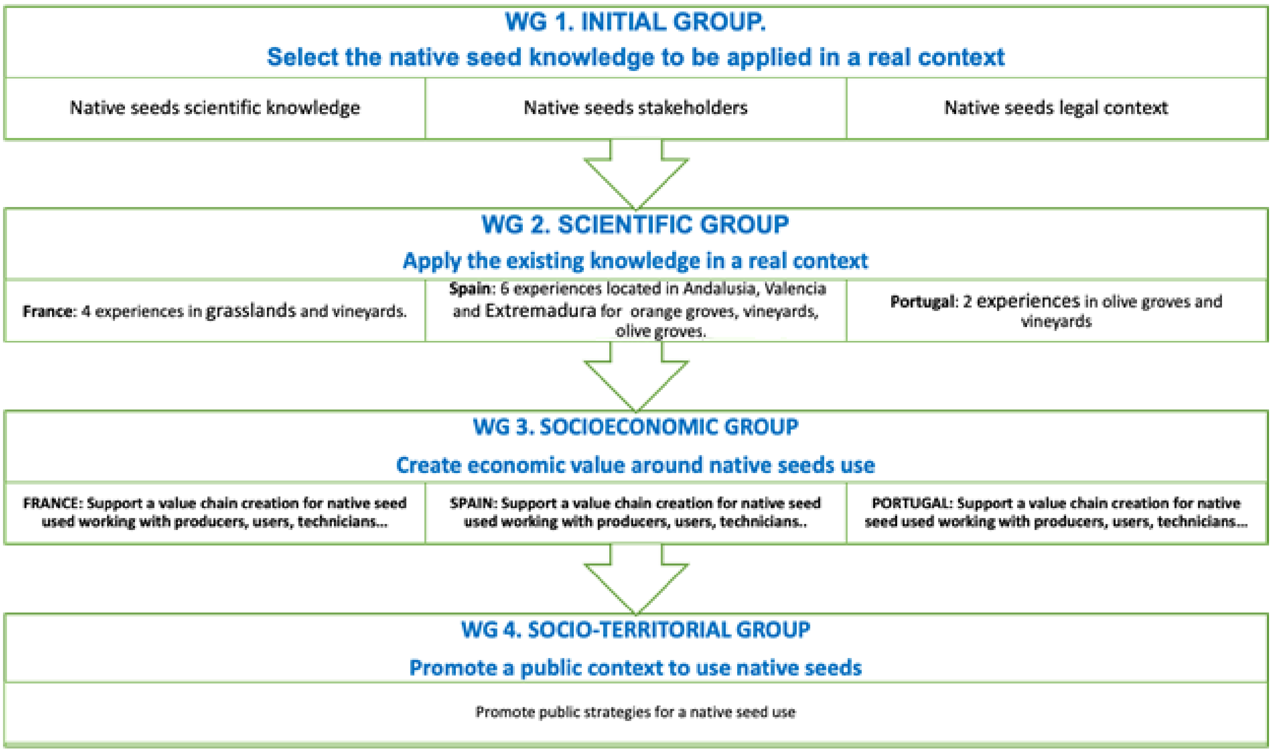
2.3 Goals of the project

The main objective of 'Fleurs locales' is to promote the use of local seeds and to consolidate green businesses that are at the heart of a production and supply chain that recovers degraded soils and promotes biodiversity, particularly in agrosystems and Mediterranean natural environments.

In any case, we can identify three main objectives pursued by the project:

- Elaboration, experimentation, and capitalisation of protocols and technical work paths for the implementation of autochthonous plant mixtures adapted to Mediterranean environments.
- Structuring of value chains for the restoration of biodiversity by means of indigenous plants, interrelating all socio-economic operators from the producer to the consumer.
- Providing support for site managers and territorial decision-makers, in particular public authorities from local to national levels, in the implementation of concerted territorial action plans.

2.4 Actions of the project



2.5 Project partners

Centro de Biología Molecular e Ambiental de la Universidad do Minho (CBMA)

The University of Minho develops research at the regional, national, and international level. It is one of the Portuguese institutions for higher education with the most registered patents, hosting two of the largest Academy-Industry projects (Sensible Car and Easy Rider) led by BOSCH. Of the 31 research units, 7 were rated as 'excellent' and 19 as 'very good'. The research units cover all fields of knowledge and include 1,033 professors, 360 researchers and 19,632 students. UMinho has more than 600 ongoing projects and a direct economic impact of €72 million. UMinho offers master's and doctoral courses in biology, with 100% of the teaching staff holding a doctorate.

CBMA is a research unit that integrates researchers with experience in plant functional biology, botany, and ecology. Its researchers develop partnerships with stakeholders such as municipalities, environmental agencies, and companies.

Conservatoire d'espaces naturels d'Occitanie

The CEN Occitanie is a non-profit association, created in 1990 and institutionally recognised by the 1976 law on nature protection and by a joint State-Region L414-11 CE approval. It owns more than 1,000 hectares and manages 30,000 ha. in the former Languedoc-Roussillon region through partnership agreements involving both public and private owners, farmers, users, and citizens. The CEN Occitanie – 80 employees, over 400 members, a scientific council – promotes the integration of biodiversity into public policies. It implements several conservation programmes to support agroecological management. Numerous activities have already involved managers, farmers, collective agricultural organisations, communities, and institutions with the aim of capitalising and then promoting best practices in biodiversity and landscape, soil conservation and the improvement of water quality in the catchment areas.

Centre d'Initiatives pour Valoriser l'Agriculture et le Milieu rural Garrigues de Thau (FAB'LIM)

Our corporate purpose is to provide support for the creation, coordination, and involvement in partnership projects for participatory research in Occitania and the Mediterranean territories, the fostering of a territorial agriculture which is respectful of ecosystems and resilient to climate change, and of a greater economic cooperation between the actors of the local sectors. Through our activities we encourage the decompartmentalisation of research and society and strengthen the role of innovation of local actors (farmers, processors, distributors, citizens, local authorities, associations, companies, etc.) in order to invent and co-produce solutions. We stimulate participatory approaches and collective constructions. Through our expertise, we have supported around ten projects in the sector. Skills: monitoring of emerging research and social issues, engineering of multi-actor projects, training engineering, capitalisation, and dissemination of knowledge.

Fundación Global Nature

We are a non-profit foundation dedicated to the protection of nature. Our work is based on technical rigour, ethical commitment, and innovation. Since our inception in 1993, we have combined theory and practice: we combine strategy and plan development with fieldwork and applied projects. In recent years, we have received more than 20 awards for our work.

Our activity is divided into three main blocks: habitat and species conservation, agri-food sustainability, and business sustainability. The actions and projects that make up each theme are linked in order to create synergies, increase efficiency in the use of resources and give continuity to each line of action.

Wetlands have always been part of our main line, with their restoration and conservation being the main objective. Our activities have directly benefited more than 100 Spanish wetlands, covering an area of over 14,000 hectares. Wetlands are one of the most important ecosystems for biodiversity conservation.

Vision

To be a reference for innovation in the promotion of sustainable development.

Mission

To make a significant contribution to the protection of nature and biodiversity, promoting sustainability policies and conservation strategies that create value for all sectors involved.

Instituto Nacional de Investigação Agrária e Veterinária – Serviço desconcentrado de Elvas (INIAV)

With extensive experience in the evaluation and conservation of plant genetic resources, INIAV has for many years conducted missions following international guidelines for the prospection and collection of spontaneous and cultivated germplasm in different pedoclimatic regions of Portugal, some of which have been carried out in partnership with other national and international institutions. Samples of the populations collected are kept in the Banco Português de Germoplasma Vegetal (BPGV) in the medium and long term and in the working collections of INIAV-Elvas, which integrates them in its characterisation and evaluation programmes as well as in its genetic improvement and agronomic study programmes. The BPGV registers information on the collected genetic material, morphologically and agronomically evaluates each sample and preserves it whenever possible to improve the valorisation of genetic resources and agricultural systems.

Instituto Politécnico de Bragança

The IPB hosts the CIMO, a research centre in natural and social sciences and engineering aimed at promoting sustainable development based on endogenous resources and the creation of value chains. CIMO brings together 132 researchers (77 integrated PhDs, 40 non-integrated PhDs and 15 collaborators). CIMO has obtained the maximum ranking (EXCELLENT), conferred by the FCT. CIMO is organised in 2 research groups. The Socio-ecological Systems Group deals with human-managed ecological systems based on the interactions between socio-economic and ecological components. Floristics, ecology and agronomy of pastures and vegetation cover have been a few of the main research topics of this group for more than two decades. The relevance and impact of the IPB's research activity is reflected in its top positions in international rankings such as SIR, U-Multirank and Shanghai.

Semillas Silvestres

Semillas Silvestres specialises in seed production technologies from the Mediterranean basin. For almost thirty years, it has been generating knowledge by participating in R&D projects on the use of underused Iberian and wild plant genetic resources to meet the new demands of agro-ecosystem sustainability and environmental restoration.
Semillas Silvestres has been involved in different research projects since the beginning of its activities, generating knowledge for the scientific community published in high impact journals, and for the users of these new resources.

In addition to research activities at the highest level, it has extensive experience in the practical application of native seeds in technical projects for the implantation of these resources by farmers, landscapers, and environmental restorers.

2.6 Beneficiary partners

- Diputación de Córdoba España
- Foro de Redes y Entidades de Custodia del Territorio España
- Subdirección General de Biodiversidad Terrestre y Marina. Ministerio para la Transición Ecológica España

- Generalitat de Valencia – Dirección General Desarrollo Rural – Consellería de Agricultura España
- Asociación Española de Municipios del Olivo España
- Conservatoire botanique national des Pyrénées et de Midi-Pyrénées France
- Conservatoire Botanique National Méditerranéen de Porquerolles France
- Conseil Départemental de l'Hérault France
- Conservatoire d'Espaces Naturels Auvergne France
- Agence Régionale de la Biodiversité Occitanie France
- Associação para o Desenvolvimento da Viticultura Duriense Portugal
- Fertiprado – Sementes e Nutrientes, Lda Portugal
- Associação Nacional dos Produtores e Comerciantes de Sementes Portugal

3. What do I want to restore? The restoration site

3.1 Why is it important to think about the restoration site?

The overall consideration of the site and objective of the intervention is the first step in any restoration initiative. Although any ecological restoration or nature-based solution is done for a particular reason, every single project will be different from the other. Financial possibilities, the maturity of the value chain and other aspects will vary each time and will have a clear impact on the project. However, in any restoration project, site characteristics will concentrate the most important decisions. When it comes to native seeds, due to their geographical specificity, analysing the restoration site in detail is a necessity. In this section, we will guide project managers through the different elements related to the restoration site which must be addressed.

3.2 What should be considered regarding your restoration site?

In this section the most interesting aspects that should be considered from the early stage of the project are described in a few ideas, as well as the design by the restoration promoter and all the actors involved.

3.2.1 Characteristics of the site

Interventions can happen in vastly different types of degraded habitats. In some cases, the areas to be restored will have a low natural value, with no or extremely low environmental protection, and interventions will be focused on delivering a solution with native seeds (a nature-based solution), such as preventing soil erosion, improving the aesthetic value, favouring the establishment of mature ecosystems, etc. Interventions in agricultural areas (including grasslands), urban areas, gardens, etc. fall into this category, as there will be no limitation to be considered in terms of land protection and the plant communities to be restored will probably not be very specific.

In other cases, restoration will take place in endangered habitats, protected areas or in areas of high natural value, and some regulations will probably have to be taken into consideration. In these areas, the interventions will probably be more specific in terms of plant communities. The collection of native seeds may also have limitations if this includes endangered species intended for reintroduction.

However, project managers will find plenty of situations that will not strictly fit into this classification. For example, some managed grasslands are protected (Natura 2000) and interventions do have legal limitations. In an urban intervention for recovering a degraded area, protected species can be used on condition that official authorisations be obtained. For this reason, exploring the characteristics of the restoration site, its legal situation, the typical plant communities and so forth are the first steps in restoring the site.

	Useful links about natural protected areas
Europe	https://natura2000.eea.europa.eu Portal of the European Natura 2000 network. Each site has a document called the 'Standard Data Form' which includes information about species, habitat, and site management.
Spain	https://www.miteco.gob.es/es/biodiversidad/temas/espacios-protegidos/red-natura-2000/ Website of the national environmental administration with detailed information on the Natura 2000 sites in Spain.
Portugal	
France	

It is also useful to know the characteristics of the surrounding area: common issues, if it is an area dedicated to farming or agriculture, if irrigation is used, and the climatic conditions such as average temperature and precipitation as this type of information will give a better idea regarding the restoration target and feasible final outcomes.

3.2.2 Ecoregion

An ecoregion is a relatively large ecologically and geographically defined area with similar characteristics, patterns, and composition of biotic and abiotic elements. The differences in the type, quantity, or quality of the environmental elements determine the differences in ecosystems quality and the integrity of the site, and, concerning the restoration of sites, will establish the differences in the potential vegetation that may be present and which could be adapted.

To any project manager, it will be clear that, for example, alpine species are not suitable for restoration projects at sea level, because they simply do not belong to the same ecoregion and habitat. However, there are more complex situations than this one. For example, some species with a wide geographical distribution may have different genotypes within its distribution area, probably as an adaptation to local soils, climate, etc. In such cases, especially if project managers have to buy seeds from third parties, they will have to carefully consider these ecological specificities, if known.

The EU is divided in 9 different bioregions, extensive terrestrial areas delimited basically by the natural vegetation, which share distinctive ecological characteristics (MITECO). Not all EU countries have defined the ecoregions for native seeds. This is an added difficulty for project managers that will have to get informed through local specialists and be as conservative as possible in their decisions. It is important to check case by case for those ecoregion subdivisions within the country. Spain does not have a delimitation of areas for the origin of native seeds. Here, phytogeographical divisions exist only for forestry species in which the territory is divided in 57 regions applicable to 39 species. Although it is not the ideal, this data can be consulted on the ministry website and can be used as a guideline within the country for the purpose of this project.

3.2.4 Ownership and land management

Describe the state of the property of the land to be restored, as well as who the owners are and who manages and uses the site, considering if these are public authorities, private owners, associations, etc. Assess the long-term situation as well, to ensure post-restoration maintenance, allowing continuous access for evaluation and monitoring of the site, but also to avoid a regression to the degraded situation. Share your plans with the above-mentioned actors from the start and reach agreements with them on anything you consider necessary for ensuring correct management in the future.

3.2.5 Current management of the degraded area

A description and assessment of the management of the area to be restored are important elements which will help the project manager to know not only the situation to be addressed in the early stages of the project, but also to anticipate corrective actions to maximise the ecological potential of the site.

Areas for restoration can be abandoned, with no or minimal maintenance, or may be actively managed such as a garden, a vineyard, or a heavily grazed pasture. None of these situations are more or less favourable for the success of the project. This is simply information that will help provide a better understanding of the current situation, the limitations that may be encountered and, therefore, any necessary adjustments in the restoration plan.

To prepare this information it is necessary to complete a baseline inventory which documents the causes, intensity, and extent of the degradation, and to describe the effects of this degradation on the biota and physical environment. Interview local people and specialists, ask yourself if the current impacts will disappear once the originating causes have been eliminated or if there will be long-term effects that may have an impact upon your restoration project. Explore the causes that led this habitat to have a degraded status and if this can happen again once you have restored it. Make sure to inform and agree with future users as to how the site will be managed or used.

3.2.2 Soil characteristics

Soil is the substrate for native seeds and the plant communities which are to be restored. Therefore, the biological, chemical, and physical conditions will have to be assessed. Soil is a mix of organic and inorganic elements, so one of the important things to evaluate is the organic matter content, as well as the nutrients present. Chemical characteristics such as the pH, cation exchange capacity, salinity, and information on other specific conditions can be obtained by a soil analysis. In terms of physical conditions, it is important to know the soil classification (sand-silt-clay) and the soil composition (amount and proportion of inorganic soil content). The biota of the soil can also be studied so as to have an understanding of the situation in terms of insects, bacteria, and fungi. All these aspects are of interest as they will help, in conjunction with observations of the surroundings, to identify vegetation that may be found at the site and the potential restoration capacity.

Soil diagnosis can be as complex as we want. For any of the variables mentioned, there are different analyses that can be performed, from quite simple studies to complex and expensive ones. However, there is no need to have highly detailed reports, or at least this should not be a limitation. In some cases, the observation of the soil, of the plant communities established and simple readings can be enough to determine the initial situation. Is the soil compacted? Is it contaminated with foreign materials? Are the plant communities mainly nitrophilous species? Is the soil the same that you can find in other areas? Just compile as much information as you can, the best way you can.

3.2.6 Species in the area and the soil seed bank

Almost any soil contains millions of seeds that will sprout when they find an opportunity. This could be some rain at the right time, a slight disturbance of the soil, the number of light hours in this season, or other changes. This seed stock is the natural seed bank. The species that will grow first will be opportunists in ecological terms, and they will be perfectly prepared to grow fast, occupy a lot of surface area, and produce as many seeds as possible. In some cases, they may limit the growth of other species, including the native seeds you sowed.

As the manager of the restoration project, it would be of interest to know the situation of the soil seed bank of the area to be restored. It might be necessary to ask botanical experts to identify what is on site, and to understand, for example, the maturity of the plant community. Are you seeing opportunist plants or a mature community that has been present for years? Are they nitrophilous species, thus indicating that the soil has been recently disturbed? **At a minimum, project managers should follow the two following steps:**

1. Identify species that are still living on the site, either native, ruderal or non-native, other more threatened species, plus the invasive species present. Basically, project managers ought to understand the ecological conditions of the habitat.
2. Identify the capacity of the seed bank to recover with or without assistance: native and non-native species presumed absent, those subsisting as propagules or others within colonisation distance that could return to the site. Although it is not easy and may only be partially possible, having an understanding of which seeds are already present in the soil and of these which are of interest for your objectives and therefore will not require extra effort from the restoration perspective will provide important additional information.

3.2.7 Limitations to the project

All the above-mentioned aspects will help project managers to anticipate limitations in restoration projects. However, there may be additional constraints not related to the ecological traits of the restoration site. Make sure to describe any restrictions that should be taken into consideration for the completion of your project, such as legislative measures or limitations on management which may affect your restoration site (river sites, Natura 2000, etc.).

Compile all such limitations and complete a full risk assessment, identify a risk-management strategy for the project: contingency arrangements for unexpected changes in environmental conditions, dependencies on third parties, financial expectations, changes in labour resourcing, providers, and so on.

Obtain all the permissions and permits for the current restoration activities, but also think ahead for the post-restoration conservation, evaluation and monitoring of the site. Consider any legal constraints which may apply to the site and the project. Aim to achieve full compliance with legislation (work, health, and safety) and other regulations related to additional environmental aspects (air, soil, water, heritage, etc.).

3.3 How should you proceed?

In this section, you will find a proposal sheet template for creating a description of the area that can be used to compile all the information. Add more information if needed. **The more information you have, the better prepared you will be for your restoration project.**

Name of the site		
Location		
Type of area	Grassland	✓
	Pemanent crops	
	Urban area	
	Natural areas	
	Other	
Ecoregion	Describe the main patterns of your area	
Current management and use	Describe the current uses	
	Examples: a) olive grove using organic production with weed management by tillage. b) abandoned garden in an urban area used by neighborhood for leisure activities.	
Soil seed bank	List the species that is already in your site	

Soil characteristics	Value
Ph	
Organic matter content	
Sctructure	
..	
...	

Restrictions	Describe the posible restrictions
Ownership and management	Describe the situation of the site

3.4 Reference documents

Title	Description
https://www.miteco.gob.es/es/biodiversidad/temas/espacios-protegidos/red-natura-2000/rn_pres_const_reg_biogeo_y_marinas.aspx	Spanish Ministry website with description and information about bioregions
https://www.miteco.gob.es/es/biodiversidad/temas/espacios-protegidos/red-natura-2000/rn_pres_const_reg_biogeo_y_marinas.aspx	Spanish Ministry website with information about the divisions of ecoregions in Spain for forestry purposes
https://www.miteco.gob.es/es/biodiversidad/servicios/banco-datos-naturaleza/informacion-disponible/E	Spanish Ministry website with information about natural protected areas, their categorisation, and

NP.aspx	location
Anthos http://www.anthos.es	Database of Iberian flora
https://flora-on.pt	Interactive webpage of Portuguese flora
https://www.vegetal-local.fr/	Map of ‘régions écologiques’ in France

4. What do I want to achieve? The restoration targets

4.1 Why is it important to think about the final targets?

Clear measurable goals and objectives are needed for identifying the most appropriate and feasible actions, for selecting the most appropriate species, as well as for sharing a common understanding among all the stakeholders of the project. Defining the most important ecological, social, and economic targets of the project is therefore another critical step.

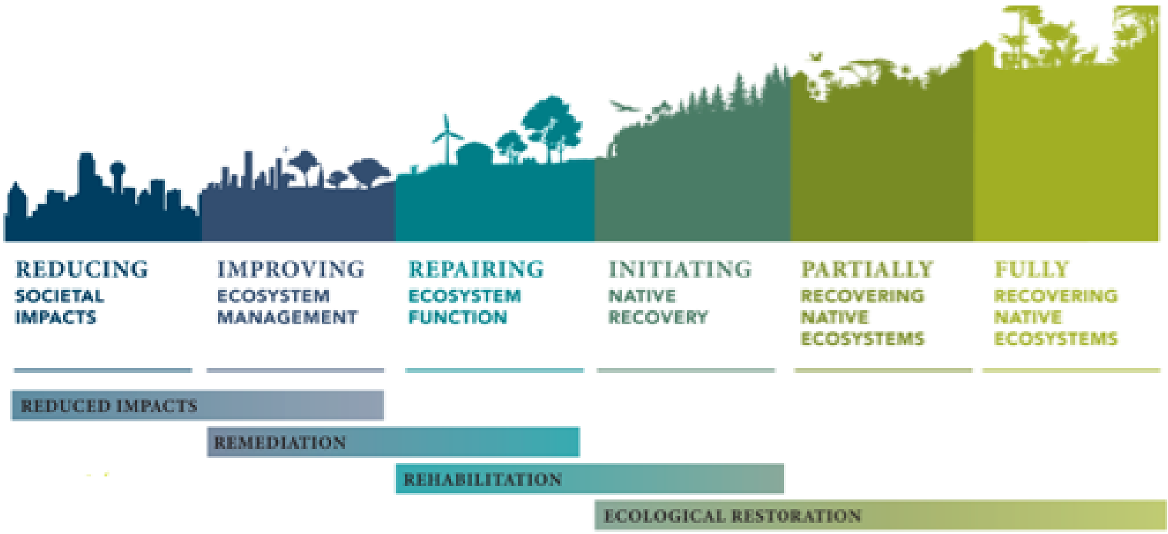
As described in the *International Principles and Standards for the Practice of Ecological Restoration* (Gann et al., 2019), the following elements should be addressed:

- The *Vision* is a general summary of the desired condition one is trying to achieve through the work of the project. A good vision is relatively general, visionary (inspiring), and brief.
- The *Targets* identify the native ecosystems to be restored at a site as informed by the reference model, along with any social outcomes or constraints expected of the project.
- *Goals* are formal statements of the medium to long-term desired ecological or social *condition*, including the level of recovery sought. Goals must be clearly linked to targets, measurable, time-limited, and specific.
- *Objectives* are formal statements of the interim outcomes along the trajectory of recovery. Objectives must be clearly linked to targets and goals, and be measurable, time-limited, and specific.’

4.2 What should be considered regarding targets?

The importance of transitional stages.

For setting the targets of a project, all the actors involved have to understand the difference between 3 elements: the ***current situation***, the ***transitional stages***, and the ***final outcomes***. Furthermore, it is important to highlight that the final outcome may not necessarily be a mature ecosystem, but probably a transitional stage that will evolve naturally to the mature ecosystem. For example, in the restoration from grassland to a woodland, and considering the woodland as the final ecosystem desired, there may be multiple intermediate states. This concept is well-explained in the above-mentioned document. In the figure, the progression from a degraded area to the full recovery of the native ecosystem is shown, and different transitional stages are identified. For example, the first action is to reduce the social impacts. Any of the stages in the middle could fit perfectly as a project target.



Source: *International Principles and Standards for the Practice of Ecological Restoration* (Gann et al., 2019)

Restoration and productive goals

One important step is to evaluate whether or not the desired final target includes an improvement on production, or beneficial aspects related to production, and not only for aesthetic or conservational reasons. Then special actions or selections of species should be made to meet the goals, such as an increase of the N availability in the soil, in the organic matter content or an increase of the quantity and quality of pastures. The list of the desirable species will directly depend on the desired outcomes.

4.3 How should you proceed?

The first step would be describing the current situation and identifying the causes that led to the degraded state. In this way, we will be able to assess the final condition of the restored area and to which extent we have the capacity of bringing the ecosystem to the final stage or to a transitional one.

The following table summarizes the initial and final stages, and also includes the transitional stages that could be the final ones for the purpose of a specific project. Additionally, reasons that explain each status (problems to be resolved, barriers to be overcome, etc.) can be included on the table in the row labelled 'limitations', which can state the reasons for the next stage not being achieved (budget, access, natural reasons, time, etc.).

Stages	Initial stage	Transitional stage 1	Transitional stage 2	Transitional stage 3	Transitional stage 4	Final stage
Description	Description 1	Description 2	Description 3	Description 4	Description 5	Description 6
Actions	Reducing social impacts	Improving ecosystem management	Repairing ecosystems functions	Initiating native recovery	Partially recovering native ecosystem	Fully recovered native ecosystem
Limitations						

The following is a template for a table in which the target or targets (as there could be more than one) of the restoration project can be checked. Obviously, there also could be others not listed on this table that can be added.

Target	Restoration project
Improve pollinators	
Increase biodiversity	
Conservation of species	
Improve soil characteristics	✓
Reduce erosion	✓

Improve auxiliary fauna	
Bioremediation	
Reduce weeds and invasive species	
Improve pasture quantity and quality	
Others	

4.4 Reference documents

Title	Description
International Principles and Standards for Native Seeds in Ecological Restoration.	Reference guidelines for restoration project design

5. What species would I like to have? The selection of species

5.1 Why is it important to choose the right species?

The Mediterranean phytogeographic region is a biodiversity hotspot. The terrestrial plant communities of this vast territory are multi-specific and frequently contain several codominant plants. Here, specific diversity has usually two maxima, one in open woodland and another in annual pioneer plant communities. This latter ecological group of plants is of particular interest in the recovery/improvement of natural ecosystems and agroecosystems.

Four principles for transition-to-restoration using native seeds

- Principle 1: Include as much appropriate biodiversity as possible in your ‘plant palette’.
- Principle 2: Establish the plant palette for your specific goal and for transitional change.
- Principle 3: Establish baseline species thresholds of your plant palette.

- Principle 4: Use appropriate sources of good quality seed.

De Vitis M., Mondoni A., Pritchard H. W., Laverack G., Bonomi C. (eds.). Native Seed Ecology, Production & Policy – Advancing knowledge and technology in Europe. MUSE, Trent, (2018).

5.2 What should be considered regarding species selection?

The introduction of native plant genetics is one of the strategies for the recovery/improvement of natural ecosystems and agroecosystems. For this approach to be efficient, it is essential to fully comprehend the ecology of the potential species of interest in order to anticipate their adaptation to the target environments. No two species have the same ecology (at least in germination) and soil heterogeneity with a complex array of micro-habitats is an intrinsic characteristic of Mediterranean landscapes. Thus, it is advantageous to use seed mixtures with a comprehensive assortment of plants having different ecologies. With this concept in mind, a practical approach to improve the success of seed mixtures includes the use of species from different botanical families or, at least, of different genera.

Different functional groups can be identified according to the project's needs, as a first approach to the different characteristics of interest of each of the species being considered for the restoration site. Traits such as growth form (perennial, annual), adult height, leaf area, leaf mass per area, nitrogen content per leaf unit mass, seed mass, seed length, seed shape, stem density, growth rate, clonal reproduction, flowering onset, flowering duration, seed dispersal timing, seed dispersal mode, seed yield, seed fecundity, seed dormancy, seed germination temperature can be used to define our list of species. The following is a description of two different traits.

Annual and perennial plants:

Annual species: annual species have short roots, and their establishment depends on the success of seed establishment. Due to this, annual species could be considered for:

- Restoration of areas where the soil is very superficial and deeper roots could not prosper in the first stages of a restoration plan.
- Green covers of perennial crops in which the grass is cut and water competition for crop production may be considered.
- A plant communities approach for restoration projects, where synergies among distinct species can be encouraged to establish a complete vegetation community.

Perennial species: herbaceous perennial plants have deep roots and a greater capacity for growth after the first rainfalls. They should be considered for:

- Soil restoration projects, because of their capacity to cover soil and generate a better structure and a good mineral and water cycle with their deeper roots.
- Restoration projects for grazing grasslands: because their longer vegetative period results in the presence of grassland for a greater period of time, which is very important in the Mediterranean context..

Legumes, grasses, and forbs

Legumes

Legumes can fix their own nitrogen, given suitable growth and conditions. Legume species have a low C/N ratio which is appropriate for microorganism growth and development. Many legume species have deep roots and indeterminate growth, so they are able to survive drought periods and respond to late rains. Legumes are also better at breaking through impermeable soil layers caused by the use of agricultural machines or trampling by cattle.

Grasses

Grasses can grow at lower temperatures and insolation than legumes and rapidly cover the soil, decreasing the amount of exposed soil vulnerable to erosion. The roots of grasses ameliorate soil aggregation and porosity which improves water permeability and soil aeration. The species of this plant family frequently produce masses of residues with a beneficial effect in soil carbon sequestration and creating regeneration niches for other seed propagated species.

Others (forbs)

Besides improving soil resources, the species from other botanical families are fundamental to enhancing the diversity of pollinators and to increase the populations of beneficial insects and mites.

Decades of experimentation have shown that diverse seed mixtures, when compared, for example, with monospecific or paucispecific sown stands, better address soil heterogeneity, are more resilient to interannual meteorological fluctuations and extreme weather conditions (which are common in the Mediterranean region), have a more efficient nutrient use, and are more diverse in insects and soil organisms.

The design of species mixtures should start with a clear documentation of the objectives of the recovery/improvement program and the identification/characterization of the target agrosystems/ecosystems as have been described in Chapters 3 and 4. In addition, the following table shows an example of the desirable characteristics of the species of potential interest in seed mixtures in two different contexts: cover crops in permanent crops and recovery of grasslands and other natural spaces and their provenance (biogeographic territory).

It is important to know the native species that we can use, which are many and which have quite different characteristics. The selected desirable characteristics must be listed, depending on the biogeographic region, natural or agrosystem environment and defined target objectives. In addition, the context of each region that will be worked in should be considered in order not to use undesirable species for that region or agrosystem (e.g., allochthonous or competitive species which consume water resources, and rare or endangered species, etc.). Therefore, the know-how of multidisciplinary teams, including farmers, landscape technicians and scientists will contribute to the best species selection.

Select the species according to the desirable characteristics and as proxy for the objective:

	Species for …	
	Cover Crops in permanent crops	Grassland recovering and other natural spaces
Indigenous	YES	YES
Annuals	Preferably	YES
Perennial	In small percentage	YES
Vegetative cycle	Short	Diversified
Indehiscent	YES	
Honeydew	YES	YES
Atmospheric nitrogen fixation (legumes)	YES	YES
Soil improvement	YES	YES
Self-sowing capacity	YES	YES
Plant height	Low	Diversified
Early growth	Fast	Fast
Weed control capacity	High	High
Root development	Superficial	Superficial and deep
Competitor for water resources	No	Not relevant
Capacity to capture and cycle nutrients (both macro and micro elements)	YES	YES
Production of biomass	Medium	Variable
Protection of soil from erosion	YES	YES
Runoff, capacity of structuring the soil in order to increase porosity, water retention and biological activity	YES	YES

Increase soil bearing capacity	YES	YES
Increase beneficial organisms and/or pollinators, easy to mow/cut down/tamp down	YES	YES
Morphology that allows for easy seed production	YES	YES
Persistence as dead matter on the ground.	YES	YES

As mentioned above, it is advantageous to use mixtures of different species in the recovery processes for degraded ecosystems. Thus, it is essential to know how to combine species with each other. To achieve this, the following general principles must be taken into account: The species to be used must be: (i) autochthonous (from the same or nearby phytogeographical territories); ii) characteristic of environments similar to the target agrosystems/ecosystems where they will be sown, (iii) have a capacity for quick installation in order to inhibit the establishment of weeds and undesirable species, (iv) have high versatility to obtain good soil cover despite some soil heterogeneity, (v) belong to different taxonomic groups.

When selecting species, it should also be considered that it may be advantageous to include legumes and grasses in a significant percentage in order to take advantage of their beneficial characteristics.

5.3 How should you proceed?

In order to be able to choose species in an appropriate and managed way in accordance with the environmental characteristics of the target environment and the defined objectives, the following elements are essential:

- Draw on the evaluation of the spontaneous flora (which species are present, their dispersion, phenology, capacity to fix atmospheric nitrogen, etc.) as this will provide useful indications about the characteristics/ecology of the site. More information about this is included in Chapter 3.
- List and prioritize the characteristics of the most interesting species, i.e., depending on the ecosystem, beneficial and trophic relationships, such as pollination, seed dispersal and herbivory.
- Among the species identified as the most interesting, choose those that show greater plasticity and with complementary vegetative cycles.
- Consider the availability of quality seed of the most interesting species. Detail description of this is included in section 7.2.2.
- Choose species that support efficient technical seed production protocols.

To be able to design an environmentally intelligent multi-species mixture, i.e., a nature-based, innovative, and competitive ('green economy') solution to recover degraded areas, not only is the number of species used important, but also the kind and proportions of the various species. Their arrangement within and among the parcel of land are critical features that must be considered:

- Define the amount of each species needed in your mixture. As a general recommendation, the species identified as the most interesting should represent a high percentage in the mixture.

- Regarding the seed density of each species in the mixture, studies show that herbage production of biodiverse mixtures increased as the proportion of the species in a mixture become more equal (i.e., seed mixtures with a more equivalent amount among the species contained therein). In order to have the ability to manifest the potential of legumes, their seeds should be inoculated with the specific rhizobia. A volume of 750-1500 germinable seeds per m^2 can be considered as a reference value for the sowing density of this type of mixture.

5.4 Reference documents

Title	Description

6. Restorative actions, including native seed use

6.1 Why is it important to think about other options?

The restoration of a degraded area can involve several synergic actions or even necessary and complementary ones.

Thinking about other actions helps in the evaluation of the real power of native seeds in isolation or with synergic and complementary actions, and also helps to evaluate the expectations, and to have an understanding of the influence of those native seeds in comparison with other restoration actions.

6.2 What should be considered regarding other options?

Think about the causes of the degradation and how those restorative actions could improve the situation. These causes could be quite different according to each context as the following table shows:

Type	Causes of degradation
Natural grasslands	Abandonment of traditional grazing or mowing Ploughing Use of herbicides

	Deposits/backfills Over frequentation by people/vehicles/animals Degradation by dominant invasive species Burnt grassland Previous crops
Grazed grassland	Continuous grazing Use of ivermectin for parasite prevention and treatment Regular tillage for shrub removal
Permanent crops	Regular tillage Use of insecticide Use of herbicides

Think about other actions that could be implemented to reach the goals of your project:

Goal	**Actions**
Improve pollinator/biodiversity	Sowing native seeds of herbaceous species Spontaneous green covers in permanent crops Implementation of hedgerows Beehives Insect hotels Water sources ...
Reduce soil erosion	Sowing native seeds of herbaceous species Spontaneous green covers in permanent crops Mulching Use of keyline design principles ...
Increase quality and quantity of pastures	Sowing native seeds of herbaceous species Rotational grazing Organic fertilization ...

6.3 How should you proceed?

Identify and assess the causes of the degradation of your site, as per the following example:

Type	Causes of degradation	Is it still occurring?	Can you reduce/avoid it?
Grazed grassland	Continuous grazing	Yes	Yes. A rotational grazing plan will be implemented with a plot-size reduction.
	Use of ivermectin for parasite prevention and treatment	Yes	Stool analysis for a re-evaluation for the need of treatment. In case of need, less toxic alternatives will be chosen.
	Regular tillage for shrubs removal	Yes	Yes. A rotational grazing plan will be designed and implemented to reduce the presence of shrubs.

Identify other actions that could be complementary to achieving the goals of your restoration project. The following is an example for a project to improve biodiversity in a permanent crop.

Goal	Possible actions	Is it possible in your real context?
Improve pollinator/biodiversity in a permanent crop	Sowing native seeds of herbaceous species	Yes.
	Spontaneous green covers in permanent crops	Not of interest because glyphosate has been used for decades and the actual seed bank is extremely poor.
	Implementation of hedgerows	Yes, there is a slope where production is not possible where a hedgerow with autochthonous species will be implemented.
	Beehives	No, there is no interest from local beekeepers.

6.4 Reference documents

Title	Description
‘MANUAL PARA PROYECTOS DE CONSERVACIÓN’	Description of conservation project design based on a Logical Framework approach. Particularly useful to contextualise the role of native seed in a conservation project.
Seed Sourcing for Grassland Restoration in the High Weald	An interesting example of native seed options assessment from commercial native seeds to different direct seed transfer actions.

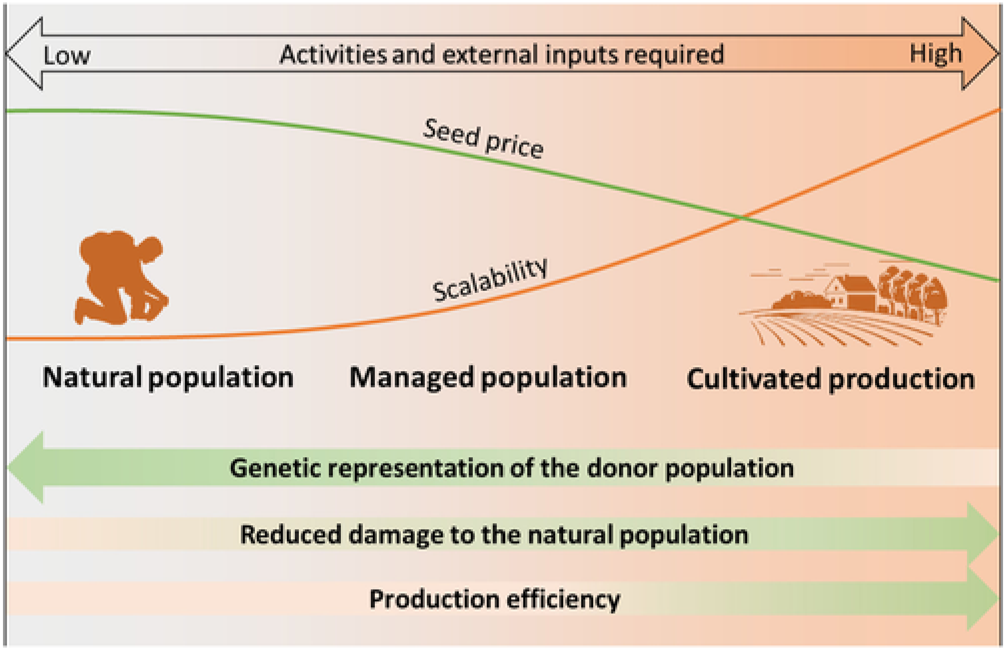
7. Native seed options

7.1 Why is it important to think about the seed options?

You need to think about the options available in your area and consider the different value chains. To make the project feasible and realistic, evaluate the most suitable option (buy, multiply, multiply by other means, without sowing).

An increased demand for native seeds to restore the natural ecosystems has pushed seed providers to use agricultural and horticultural methods to produce seeds of wild species. On one hand, these techniques have contributed to meet the demands for large-scale restoration and avoid depletion of native seed resources through overharvesting. On the other hand, seeds produced through these methods are not reflective of the genetic diversity of species in natural ecosystems.

Three approaches are commonly used to produce native seeds for ecological restoration purposes: collection from the natural population, management of the natural population, and cultivated production. These three approaches sit on a continuum of increasing intensity of management activities (e.g., weeding, fencing, ploughing, use of weed mats, sowing). They allow producers to increase seed supply while reducing seed price. As illustrated in the figure below, each approach has advantages and disadvantages and might not be always feasible for all species/ecosystems.



Source: *Collection and Production of Native Seeds for Ecological Restoration* (Image by Simone Pedrini)

It might be useful here to offer a reminder regarding the importance of collecting seeds from individuals originating within the same bioregion as the site to be restored. In fact, the introduction of seeds from a population with specific genetic characteristics could have a negative **impact on the genetic structure** of a local population via mechanisms such as outbreeding depression. This phenomenon could drive the local population to collapse and to the loss of genetic patrimony.

All the actors involved in the project should keep in mind the information listed above while selecting the source of supply of native seeds for use in experimental plots.

7.2 What should be considered regarding seed options?

Defining the options for the use of native seeds is one of the most important steps in your project. Assessing the different options according to their effectiveness is fundamental. As has been explained several times in this document, the collection of native seeds may affect natural populations, which is why this is an option in cases where the area is small or if there are research goals in the restoration project.

7.2.1. Buy native seeds

Native seed production has significant differences with agrarian commercial seeds. The latter type requires a series of precautions to guarantee the varietal character of the multiplied plant material, be it either by sexual means or by vegetative reproduction. The autogamous or allogamous character of the multiplied species and varieties require isolation distances to avoid unwanted crossovers. In short, the multiplication of seeds of agricultural varieties is based on the maintenance of the differential characteristics of each variety throughout the cycles of multiplication.

On the contrary, the multiplication of native seeds must always maintain the intraspecific variability of the natural populations, avoiding the use of production methods that imply the selection of some individuals for certain characteristics (height, precocity, dehiscence, etc.) over others. These precautions must be maintained not only during all crop phases (planting, vegetative development, and harvest), but also during the processing and selection of the seeds, by which we mean the cleaning of the seeds, not the selection of some seeds over others, by size, shape, etc.

These differences between both groups of species with regard to their multiplication mean that only multipliers who apply these procedures, maintain these precautions throughout the multiplication process and can demonstrate it, can be considered native seed producers.

Likewise, another aspect of vital importance is the traceability of the origins of the populations to be multiplied. Only seed lots with a guarantee of origin from a specific area can be considered native seeds. However, prior to allocating the populations, it is necessary to define the ‘seed zones’, which among the countries of the SUDOE zone has so far only been done in France.

The traceability of the seeds considered native must therefore include information on the areas or areas of the populations of origin, and on the cultivation cycles, in order to offer sufficient information to allow their use in the different destination areas with any guarantee of accuracy. The absence of this information to the client or user, the lack of transparency of the same or the importation of seeds of autochthonous species but of alien origin, should differentiate the producers of native seeds from those who are not.

In this sense, native seed producers must be characterized by exclusively offering species of autochthonous origin with a guarantee of geographic origin and multiplication methods according to the regulations that define ‘mixtures intended for the conservation of the natural environment’. Traceability, transparency and ethics in the production and supply of these seeds shall be innate characteristics of the native seed producer, avoiding as far as possible the transfer between geographically or ecologically distant populations.

7.2.2 Multiplying native seeds from a seed bank

The production of native seeds for practical purposes must be clearly differentiated from the collection of seeds from natural populations for use in research projects, conservation in genebanks or any other small-scale application. In the former, the applied use, whether commercial or not, is implicit, while in the latter, the conservation or prospecting of plant genetic resources takes precedence over production.

The production of native seeds entails a change of scale and therefore the use of production methods that do not allow scaling are limited only to the scientific use or conservation of germplasm, whether of catalogued species or not.

Current regulation only admits two methods of production of native seeds (Directive 2010/60 of the European Commission, of August 30, 2010, which establishes exceptions to the commercialization of mixtures of forage plant seeds destined to the conservation of the natural environment). The first is the direct collection of seed mixtures in natural populations that are representative of plant communities of special interest for the conservation of biodiversity. This method involves the collection of large amounts of biomass for the extraction of the seed fraction, the use of alternative methods such as 'seed strippers', or the use of harvesters, where the location allows it. In any case, all these methods are not very efficient in terms of the quantity of seed produced and require significant logistics to produce small quantities of seeds at high cost. The manual collections of seed mixtures, despite their romantic and communicative side, do not represent a real alternative for the production of native seeds in the increasing quantities demanded by restorers, landscapers, and farmers.

The second method for the production of native seeds contemplated in EU Directive 2010/60 is the collection of each species separately, their multiplication in cultivation fields, and preparation of the mixtures with the appropriate species and proportions. This method, known as 'seed farming', requires agronomic means and knowledge, innovation, and imagination to develop processes of cultivation, harvesting, processing, and so on, of species that have never been the object of multiplication before. In return, it allows the multiplication of seeds of native species in the quantities and qualities that the market demands at all times, and at reasonable cost, which does not limit the use of these resources in projects of the necessary scale.

The methods of production of native seeds for commercial use from natural populations are not contemplated in the regulations in force, and also present several important deficiencies from several perspectives. On the one hand, they do not allow, much less guarantee, the production of significant quantities of seeds, causing a deficit in the supply, mainly of the species with the greatest difficulty to collect (bias spices). On the other hand, the high cost of the seeds thus produced, compared to those produced by seed farming, makes it impossible for them to be competitive in the market. And thirdly, the consequences of collecting seeds in large numbers from natural populations can be the cause of destruction of natural populations, especially when it comes to annual or monocarpic species. The collection of seeds of forest species, which is to say, woody and therefore polycarpic species, is not comparable to the effects of damage to herbaceous plants

The collection of seeds in multiplication fields must consider several aspects of special importance. Sequential dehiscence, flowering and fruiting, and plant height diversity represent challenges to be solved in many crops. The ideation and implementation of non-discriminatory collection methods should be used for the maintenance of the intraspecific diversity of the seeds produced.

Aspects related to the processing of biomass or fruit batches in order to obtain clean seed batches represent a different system than that of the cultivation and collection of seeds. Machinery such as threshers, winnowers, sieves, air columns, densimetric tables and scarifiers, among other equipment, will allow for the production of quality seed lots at reasonable cost.

Controlling the quality of the seeds produced is an innate part of the production of native seeds. The basic analyses for the characterization of seed lots should at minimum include the evaluation of germination, viability, the weight notation of 1,000 seeds, and purity.

The presence of lethargy or parasitized or empty seeds may sometimes prevent conclusive germination analyses from being conducted, so the analysis laboratory must have the technical means and knowledge necessary to address these aspects with technical solvency.

In some cases, performing pre-treatment processes represents the best alternative to guarantee successful planting, so it will be necessary to have means to develop these. Chambers with humidity and temperature control, and equipment for pre-treatment (pelleting, scarification, etc.) of seeds may be recommended by the laboratory of the native seed producer to guarantee the supply of seeds in the best conditions for plant germination and establishment in restorations.

Perhaps the species that you need are not available from seed producers, but possibly a seed bank from your region has seeds that could be multiplied. This multiplication should be done following quality criteria in order to assure the conservation of the local variability of the species.

In some countries this multiplication is regulated but in others, such as Spain and Portugal, it is not. The following text provides a brief summary of the reference initiative ‘Vegetal Local’:

Mandatory rules for multipliers under the ‘Vegetal Local’ trademark:

a. The specific purity of the seeds for propagation must be inspected visually before use.
b. The multiplication is carried out on batches obtained by collection in the natural environment (or, in the case of messicole plants, obtained by collection from agricultural plots not sown in mixtures intended for ornamental flowers or flowering fallow) or on batches produced from cycles of multiplication.
c. Seed multiplication is limited to five (5) generations. The multiplication of C batches generates G1 batches, the multiplication of G1 batches generates G2 batches, the multiplication of G2 batches generates G3 batches, the multiplication of G3 batches generates G4 batches and the multiplication of G4 batches generates G5 batches. G5 lots cannot be used as the origin for a new multiplication cycle.
d. The harvest after multiplication of seeds intended for the production of a new generation must be done from a minimum of 50 individuals, with the goal of harvesting from the greatest possible number of individuals.
e. A rotation of the multiplication plots should be planned to avoid the succession of different lots of the same species in the same area.
f. Multiplication plots for perennial species may be conserved.

Recommended guidelines for multipliers under the ‘Vegetal Local’ trademark:

- The multiplier is encouraged to respect sufficient isolation distances between multiplication plots of the same species of different natural habitats or of different generations.
- Producers' recourse to vegetative propagation will be strictly reserved for species which cannot be multiplied sexually (certain helophytes, salicaceae, or other species on justification). Any request for vegetative propagation must be the subject of a detailed justification to the brand management committee, based on biological, ecological, and / or technical criteria.

7.2.3. Using hay bales for sowing native seeds

Spreading hay from dry hay bales has been successfully used to create and restore wildflower grassland. However, the seed content (quantity and diversity) of dry bales will however vary and may be low as seed will have dropped out while the hay was drying and when it was turned and baled. So, even if this is not the most successful option in terms of seed germination, it can be a very promising option for the restoration of grazing grasslands in which hay bales can be used at the same time as food for cattle and for seed to be sown by animals.

If hay bales from high quality natural grasslands are available from a region near your restoration site, this may be an option.

7.2.4. Collecting native seeds

This section will focus on the methodology for the collection of native seeds from a natural population while ensuring genetic diversity without affecting population reproductive capability.

First of all, it is important to underline that seed collecting is a well-defined scientific procedure, widely used for the *ex-situ* conservation of the genetic resources of plants. Therefore unauthorised, illegal and/or negligent seed collection and dissemination, may damage or threaten the populations of native species.

That said, the collection of native seeds remains one of the most reliable methods to create and reproduce effective and appropriate grasses and forb species mixtures for the restoration of small-scale natural landscapes and for establishing ecologically balanced agro-ecosystems.

This section offers a summary of the essential points to be considered when choosing a collection site of native seed for ecological landscape restoration.

Scientific advice and code of conduct

Before any collection of seeds, all collectors should contact the national institute responsible for native seed collection for scientific advice. It is possible to find the relevant institute in your country by visiting the ENSCONET website (http://www.ensconet.eu) or the national Convention on Biological Diversity focal points (see http://www.cbd.int/information/nfp.shtml). It may also be helpful to refer to the FAO International Code of Conduct for Plant Germplasm Collecting and Transfer (http://www.fao.org/ag/agp/agps/PGR/icc/icce.htm).

Permission and authorisation

Permission for collecting seeds should be obtained from the owner, manager or site/park authorities.
To determine if the target plants are listed under international agreements or directives that give them special status, it is possible to consult the following websites:

- CITES (http://www.cites.org)

- European Council Regulation (EC) No. 338/97 including annexes (http://www.ec.europa.eu/environment/cites/legis_wildlife_en.htm)
- The Bern Convention (http://conventions.coe.int/Treaty/EN/Treaties/Html/104.htm)
- Habitats Directive (http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm)
- The International Treaty on Plant Genetic Resources for Food and Agriculture – http://www.fao.org/plant-treaty/en/

Selection of the collection site to ensure appropriate ecological traits

In accordance with the project goals, ecological context and biological characteristics of targeted species, the characteristics of a preferred location for collection are:

- It must be situated in a specific ecoregion with very similar geographical and ecological characteristics to the site to be restored.
- The main habitat of the site should be known and classified.
- No sowing operations must have been conducted during the last 40 years.
- In the case of the collection of native seeds from an existing grassland in order to produce and trade them, you should refer to the European Directive 2010/60/EU and the relevant EU country members.

Every collecting site and population must be geolocated with GPS coordinates.

Sampling within the population and the site

- The quantity of the population to be sampled in order to ensure genetic diversity depends on the information available about the target species, the species itself and the needs of the collecting programme. The genetic diversity of a population depends on inherent factors such as the breeding system and on the size of the cohort; it is also conditioned by biotic and abiotic aspects of the environment.
- In many cases, due to lack of information concerning the distribution of a species, a good starting practice would be **to sample five populations from across the taxon's geographical range (see Falk & Holsinger, 1991)**. Data from four globally rare taxa (Neel & Cummings, 2003) indicated that five populations would include, on average, 67-83% of all alleles.
- As a general rule, collectors should aim to **sample from as many individuals as possible, without endangering the population**. There is a great deal of guidance in the literature on the collection of plant genetic resources . As a rule of thumb, try to **collect from at least 50 and preferably 200 plants per population.** However, you may modify these quantities on the basis of local circumstances (such as exceedingly small populations, annual or long-lived perennial, accessibility, time, and eventual use).

- In order to minimise risks to the future survival of plant populations, and particularly in the case of small populations of endangered species, **collect no more than 20% of the total mature seeds available.** Also, avoid repeat collections of a species from the same site for two consecutive years unless you reduce the quantity of seed taken to a level well below the 20% limit in each year.

- The gathering of a minimum of 5,000 seeds per collection period is suggested in order to maintain a stockpile without the need for seed multiplication.

- **Sample randomly to ensure as even a contribution of seeds from maternal genotypes as possible.** Avoid the temptation to concentrate the collection from individuals bearing most seeds as this will bias the genetics of the sample. For large populations in a uniform landscape, it is often easier to collect in a more systematic way, sampling at regular intervals along a transect.
  Where the number of plants sampled is less than 20, store seeds from different plants separately. This will maximise the contribution of the maternal genotypes at regeneration.

7.2.5. Sowing native seeds

For the successful development of restoration projects based on native seeds, it is necessary to consider multiple aspects related to their biology, as well as other logistical issues more typical of the scale and the technical project addressed.
Even so, all these aspects could be summarized in the following general sentence: 'the right seeds, sown in the right way, at the right time'. In other words:

1) Only those species and origins compatible with the area of action should be used. The elaboration of balanced seed mixtures, with taxa present in the area and a guarantee of compatible genetic origin, should be the basis of performing any restoration or landscape integration project. In this way, two risks will be avoided: on the one hand, the sowing of species with little or no adaptation to the destination area, and on the other, the genetic contamination of autochthonous populations with non-native genotypes.
2) Seeds must receive the most appropriate treatments to increase their chances of germination and establishment after sowing. The possibilities of pre-treatments are highly varied, depending on the distinct types of lethargy present. Mechanical dormancies can be eliminated through scarification processes (mechanical or chemical), as can some of the external structures of the seeds that may hinder their correct distribution and sowing. Furthermore, biological dormancies can be eliminated, at least partially, through different specific pre-treatments. Knowledge of the type of dormancy present is necessary to be able to develop the appropriate pre-treatment. When it is necessary to develop stratifications (cold or warm), adjusting the periods to the sowing dates is vital. Stratifications shorter than recommended are not effective, while excessively long layers can cause secondary dormancies, which are difficult to remove later. Other important aspects during sowing are those related to logistics. Good coordination and the use of mechanical means are necessary to achieve an adequate sowing. In this sense, the preparation of the soil can be crucial depending upon the chosen sowing method (manual, seeder, fertilizer, aerosowing, hydroseeding, etc.), and whether or not it is necessary to bury the seeds, according to their size and the pre-treatment they have received.
3) The selection of the moment to sow must be considered equally important. As a general rule, sowing should be done in the most favourable period for the immediate germination of the seeds. This is to avoid extended periods in which due to environmental conditions (humidity or temperature) that are not suitable for germination, they are left for prolonged periods of time at the mercy of predators. such as insects, birds, or rodents. Under our prevailing Mediterranean conditions, early fall should be chosen as the priority date, versus spring dates. The study of the ombroclimate of the nearest station will be of help in choosing the best planting date. Under mountain environmental conditions, spring sowing can be an alternative, although seeds that need vernalization should receive it before being sown. Despite all these precautions, due to the randomness of environmental conditions under the present climate change scenario, it is necessary to consider the possibility of conducting

replacement plantings. Once the results of the sowings have been studied, in terms of nascence, establishment, and especially for the replenishment of the soil seed bank (BSS), when it comes to sowing with annual species, the need for replanting ought to be evaluated.

Therefore, the monitoring and sampling of the plantings during the first year is absolutely necessary. Future decision-making will depend on this, both in the floristic composition used, as well as densities, methods, and sowing dates.

7.3 How should you proceed?

Preliminary assessment of your different native seed options. The following is an example:

Actions	Is it possible?	Cost	% of desirable species	Expected success
Buy native seeds	Yes, but not for all species	High, in comparison with the cost of non-native seeds.	Medium	High (high quality is expected from seed producers)
Multiply from a germplasm bank	Yes, depending on the availability of economic resources	High	High	High (high quality is expected and allows availability of wild seed from a very near/similar region)
Collect native seed	No personnel available, insufficient botanical knowledge, it is necessary to collect a large quantity of seeds	Very high	Medium	Medium because the process of collecting, classifying, etc. is quite complex
Other native seed options	Yes. Hay bales will be used	Low	High	Low, because the amount of the seed could be low and there is no information about

				the number of species and their quality, etc.

7.3.1. Buy native seeds

Determine if you can buy the species that you need. Ask the seed producers regarding:
- The availability of the seeds of the species you need.
- Confirm that seeds come from wild populations.
- If the region of origin of the wild population is near/similar to your site area.
- The number of generations after the wild population was collected.

The following is a proposed guide for assessing a native seed producer:

Species you need	Seed supplier 1	Region of origin and years of multiplication.	Seed supplier 2	Region of origin and years of multiplication.

7.3.2 Multiply native seed from a seed bank

- Contact the germplasm bank of reference for your restoration site.
- Ask about the species you need. What kind of seed do they have? Where have they been collected? How many seeds are there? What is the procedure to obtain seed by multiplication? Are there at least 3 different populations of the region of origin? Is there enough quantity?
- Can a native seed producer multiply the seed from a germplasm bank? Can this seed producer do so following the criteria detailed in '7.2.2 Multiplying native seeds from a seed bank'?

7.3.3 Using hay bales for sowing native seed

- Locate a natural grassland which has a vegetative composition that is representative of an advanced stage of your restoration project.
- Schedule the best moment to mow when key species are fully mature.
- Spread in your restoration site at the right moment. There is specific machinery that could help you to cut and distribute the hay.

- If possible, animals may graze the area, which will favour fertilization and sowing. After this grazing period, cattle should not come back to this area until germination is totally finished. Only in cases where cattle are used to select the more desirable species, such as leguminous varieties, should they be allowed to graze the area. In this example, they would eat the gramineous and other species, thereby increasing the light available for the development of leguminous seed.

7.3.4 Collecting seeds

In this table are outlined the most relevant technical advice to take into consideration while collecting native seeds.

Seed collecting techniques	**Check for empty or immature seeds prior to collecting**, even though the seeds may look outwardly acceptable. Families such as Fabaceae often suffer from insect-damaged seeds, while Asteraceae and Poaceae regularly have empty seeds
	Check **seed quality** before collecting (insects, fungal and disease damage).
	Collect seeds into 'breathing bags' (cloth or non-glossy paper bags). Choose bags carefully. For instance, in the case of collecting dust-like seeds, a paper rather than a cloth bag may be advisable: subsequent cleaning of a cloth bag may be impossible. Similarly, extracting grass seeds with long awns from cloth bags may be a very time-consuming process.
	Avoid plastic bags (and other sealed containers) as sweating and moisture absorption may occur (particularly at night, when it gets cooler), leading to rapid deterioration. **An exception should be done for fleshy fruits:** place them into plastic bags, keeping the bags open and giving the fruit plenty of aeration.
	Bags and envelopes should be **labelled** inside (using tags) and out, possibly in the field.
	The seeds/fruits must be collected **dry and 'ready to fall'.** However, it may occasionally be possible (or necessary) to collect slightly immature fruit (still fairly green) and mature these in the laboratory. In such case, maintain the fruit under fairly humid, light conditions until mature. This approach has been found to be particularly useful for species with explosive seed capsules. In any case, dry the seeds in a **shady place** (no direct sunlight)
	Select appropriate harvesting techniques and tools. Refer to ENSCONET 'Seed Collecting Manual for Wild Species' to find out the most appropriate technique according to the species.

	There is a great deal of guidance on the collection of native seeds by mechanical means and hand-tools (seed grabbers) in the literature and in commercial brochures.
	If transportation back to the seed bank will take several days, it is advisable to **dry the seed over silica gel, dried rice, or charcoal** inside sealed plastic boxes. This is particularly important if the average outside relative humidity (or the equilibrium relative humidity of the seed as determined by a hygrometer) is greater than 50%.
Passport Data collection	**Seed without data is almost useless.** Therefore, complete information should be recorded on each instance of seed collection. **Use appendix 1 of ENSCONET 'Seed Collecting Manual for Wild Species'** as a reference (mandatory fields are shaded in grey).
	It is particularly important that the **data recorded are as objective as possible** and that it will be easy to comprehend several decades from now.
	It is important to **record the location of the collection using a map or a Geographical Positioning System (GPS) receiver**. If GPS receivers cannot be used (dense tree covering or in deep valleys) it is possible to pinpoint the collection site to latitude, longitude and altitude using Google Earth (http://earth.google.com/download-earth.html) or Google Maps (http://maps.google.com).
	In Europe use **Flora Europaea as far as possible for identification of the species** in order to adopt a common taxonomy. Only use national, regional, or local monographs or floras if the taxonomy has been recently revised and is more up-to-date than Flora Europaea (for example online reference https://www.gbif.org/). Collection of herbarium specimens before or during seed harvest allows for the verification of identifications made by the collector.

7.4 Reference documents

The documentation available seems to be lacking in guidelines on how to identify and delimit appropriate seed sources. In fact, strong small-scale population differentiation makes it difficult to geographically delineate seed source zones, even within the same bioregion. Additionally, there is a lack of knowledge regarding the risk of depletion of genetic patrimony by the introduction of seed from another population (outbreeding depression).

Title	Description
ENSCONET (2009) ENSCONET Seed Collecting Manual for Wild Species. Eds. Royal Botanic Gardens, Kew (UK) & Universidad Politécnica de Madrid (Spain).	European references for guidelines and procedures for the collection of native seeds. These protocols are a useful reference point for planning and collecting seeds for ecological restoration.
Bacchetta, G., Fenu, G., Mattana, E., Piotto & Virevaire, M. – eds – (2006). 'Manuale per la raccolta, studio, conservazione e gestione ex situ del germoplasma'. APAT, Agenzia per la Protezione dell'Ambiente. Roma.	This manual identifies and describes the most used and efficient techniques which respect international standards, from harvesting plant material in the field through to conservation. It is focused on all taxonomic units relating to the native flora of Mediterranean territories and, more generally, European regions.
Simone Petrini et al (2020). 'Collection and Production of Native Seeds for Ecological Restoration'.	This paper provides a complete overview and analysis of the most commonly used approaches to produce native seeds.
Kristine Vander Mijnsbrugge, Armin Bischoff, Barbara Smith, 'A Question of Origin: Where and How to Collect Seed for Ecological Restoration', *Basic and Applied Ecology*, Volume 11, Issue 4, (2010)	Article which examines the importance of using locally adapted seeds and the potential negative impact of the introduction of non-local genotypes (outbreeding depression).
Collecting Seed Materials and Plants Materials, technical note (2010). Natural Resources Conservation Service, USDA.	Technical note providing information on proper seed collection techniques.
Référentiel technique de la marque collective simple végétal local, (2014). Fédération des conservatoires botaniques nationaux.	Guidelines and requirements for obtaining the 'Végétal local' label in France.
E.M. Koch et al, 'Les semences locales dans la restauration écologique en montagne. Production et utilisation de mélanges pour la préservation' (2015). Institut Agricole Régional, Aoste.	Overview of the legal context, technical and economic aspects, and ecological issues related to mountain grassland restoration in the Italian and French Alps.
Restoring Species-rich Grassland Using Green Hay. Magnificent Meadows (2017)	A very practical approach on how to use hay bales for sowing native seed

8. The restoration project: let's be pragmatic

8.1 Why is it important to think about the overall project?

At this stage, you should have a fairly complete definition of your restoration project. You have analysed the site, the management limitations, what transitional stage is going to be your target, the species you want to use, and so forth. You have probably engaged different stakeholders and agreed on the main steps. However, you will probably realise that your project cannot be as perfect as you would like. Perhaps the species you want to use are just not available, some of them do not perfectly match with the definition of native species, your budget is quite limited, or you have some legal constraints that prevent certain measures from being implemented. Do not panic. Ask yourself if these issues that keep you from a perfect restoration project are going to have a strong impact on the achieved results. Unless your answer is 'yes', be pragmatic and work with the least bad option.

8.2 What should be considered regarding the overall project?

A 'least bad option' does not mean a bad restoration project. It is simply the best result you can achieve given the financial and technical limitations. Considering these gaps in advance is the best way to later on find good opportunities to deal with them, as project conditions may change during its implementation.

Once this has been done, there is an extensive list of aspects to take into consideration to design your final restoration project. Make a list of all the different actions and actors, assign to each the responsibilities for completion and management of the tasks. Put everything in a common document or file, such as actions, budget, dependencies, milestones, deliverables, etc. One key element is preparing a calendar in which the actions are listed in order of completion, with a given priority, management responsibilities and individual cost. Any of the available management tools which include all this information is valid (including self-made ones, and free or commercial software) and will become your reference document from now on.

The organization and implementation of all the different tasks of a restoration project need to be adaptable to size, ranging from a small garden in an urban area to a large, degraded grassland. Also, be flexible in terms of the complexity of the restoration itself due to restrictions, lack of desirable species, the level or degree of degradation. As mentioned previously, consider the regulatory status and necessary permissions; maintain control over the project budget at all times. Consider the possibilities of including in your management tool a section for delays, amendments, contingency plans, and responsibilities for implementing the corrective actions.

Following the *International Principles and Standards for the Practice of Ecological Restoration* (Gann et al., 2019), here is the list of aspects that should be considered for the overall organization, planning and implementation of a real restoration project:

1. Planning and design: stakeholder engagement; context assessment; assessment of security of site tenure and scheduling of post-treatment maintenance; baseline inventory; native reference ecosystems and reference models; vision, targets, goals and objectives; restoration treatment prescription; analysing logistics.
2. Implementation: protect the site from damage; engage appropriate participants; incorporate natural processes; respond to changes occurring on-site; ensure compliance; communicate with stakeholders.
3. Monitoring, documentation, evaluation, reporting: monitoring design; keeping records; evaluating outcomes; reporting to interested parties.
4. Post-implementation maintenance: ongoing management.

8.3 How should you proceed?

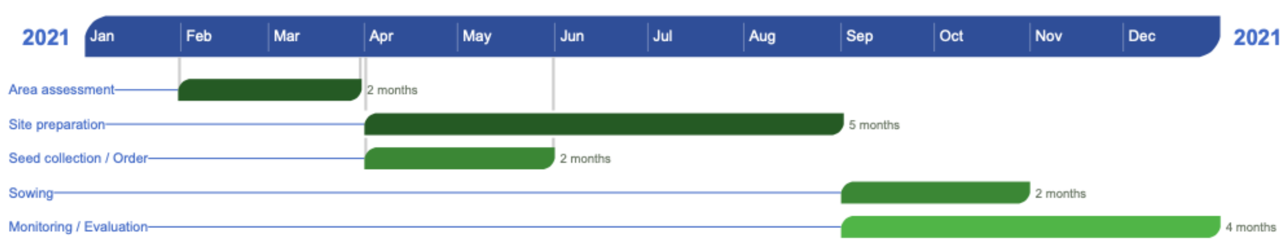
Planning the whole cycle of your restoration project. The following is a template to help you in this part:

Action	Responsible party and stakeholders involved	When	Resources needed
Description of your restoration site			
Target definition			
List of desirable species and mixture design			
Selection of the most suitable native seed option (buy, collect, multiply, etc.)			
Design of monitoring plan			
Implementation of native seed option: depending on the native seed option used, this point includes different sub actions. Here is an example of			

bought of native seed			
• Database of native seed producers			
• Consultation about the availability of species according to native seed criteria			
• Final mixture according to the availability			
• Bought			
• Land preparation and fertilization			
• Sowing			
• Maintenance actions			
Implementation of monitoring plan			
Evaluation. Lessons learnt to be considered in the future.			

Use a calendar to set all the specific dates for actions, meetings, payments, deadlines for paperwork or any other task. Being as organised as possible will enable the project manager to be ready for any changes or unexpected events and plan ahead all the activities for the completion of the project. See as well the following example of a roadmap that would be particularly useful for listing the main task schedule of the project.

Native seeds restoration project



8.4 Reference documents

Title	Description
Gann, George; McDonald, Tein; Walder, Bethanie; Aronson, James; Nelson, Cara; Johnson, Justin; Hallett, James; Eisenberg, Cristina; Guariguata, Manuel; Liu, Junguo; Hua, Fangyuan; Echeverria, Cristian; Gonzales, Emily; Shaw, Nancy; Decleer, Kris; Dixon, Kingsley. International principles and standards for the practice of ecological restoration. Second edition. *Restoration Ecology*. 27. (2019) S1-S46.	Extensive guide with descriptions and recommendations for implementing ecological restoration.

9. Monitoring the success of the project

9.1 Why is it important to think about monitoring?

Monitoring and evaluation helps with identifying the most valuable and efficient use of resources. It is critical for developing objective conclusions regarding the extent to which programmes can be judged to be a success. Monitoring and evaluation together provide the necessary data to guide strategic planning, to design and implement programmes and projects, and to allocate, and reallocate resources in better ways (adapted from Gage and Dunn 2009, and Frankel and Gage 2007).

In the context of a specific restoration project, monitoring is essential for making sure that native seed use is contributing to the restoration targets. You can consult the most relevant experts and studies, but the information you collect during your monitoring activities is the most valuable you can obtain for learning and improving.

9.2 What should be considered regarding the monitoring of project success?

Your restoration goals.

What do you want to achieve with a restoration project based on native seed? How can you measure success? Do you know the starting conditions of your project site? A definition could be done making the following scheme as an example:

Goals of a restoration project in a grassland.	**How can you measure the goal?**	**Do you know your baseline for this indicator?**
-Reduce the % of exposed soil	Visual inspection of % of bare soil in a square of 1x1 meter	Yes, around 40%
-Increase the biodiversity of species for this habitat	Botanical inspection. Number of distinct species.	Yes, at least 20 distinct species.
-Increase the quantity and quality	% of legumes per m2 % of perennial gramineous surface needed for daily ration	Yes, less than 15% Yes, 0% Yes, a square of 10x10 meters.

Implementation of your native seed actions.

The success of the project depends on native seed implementation. Monitoring can be done very lightly or be highly detailed depending on the context of the project, but a basic assessment can be done visually as it is written in the following example.

Native seed actions	**How can you assess the effectiveness of the implementation of native seed actions in your site?**
Native seed sown	Visual assessment of: a) which annual or perennial species were able to flower and produce seed. b) how many species in your seed mix did or did not survive the first year. c) how many species managed to establish resilient populations.

In addition, socioeconomic aspects could be critical for a wide implementation of native seed use. Some quantity and quality information could be monitored to assess the efficiency of the actions.

Native seed actions	**How can you assess the efficiency of the implementation of native seeds actions in your site?**
Native seed sown	Economic costs: Cost per hectare of seeds, fertilizers, and other inputs. Cost per ha. of machinery. Economic value of the restored site (in case of grazing grasslands, this could be calculated on the basis of reduction. Time needed to design the mixtures, to find (collect or buy) and mix the seeds, etc. Technical limitations to design the mixture, to prepare the soil, to sow, to manage, etc.

9.3 How should you proceed?

The following table is an example of how to easily define your monitoring activities.

Indicators	How?	When?	Who?	Time required
% of bare soil	Visual inspection of % of bare soil in the same square of 1x1 meter	twice a year: at the end of the two growing seasons (May and December)	Technician with basic training.	15 minutes
% of legumes per m2				
% of perennial				

gramineous surface needed for daily ration				
% of the sown species that germinated and succeeded in flowering	Each survey consists of a diagonal transect which is subdivided in three parts of equal length. In each third of the diagonal, dress the list of the vascular plants that are developed. You can pre-fill the list with the species that were sown/previously identified in the parcel.	Ideally, 3 surveys per/year should be made between March and July.	The person in charge of the survey should be able to recognize/identify each vascular plant that may occur in the restoration site	The survey of one transect should take approximately 1 hour. Thus, an experienced botanist may be able to survey about 8 parcels per day).
Cost/ha of inputs	Interview with the farmer and internal information: Sum of input costs (seeds, fertilizers, gasoil, etc.) Sum of the costs of external assistance (agronomic/botanical advisors, machinery, etc.)	At the end of the implementation.	Technician and farmer	1 hour
Time needed	Interview with the farmer and internal information: Time dedicated to implementation	At the end of the implementation	Technician and farmer	15 minutes

9.4 Reference documents

Title	Description
https://www.endvawnow.org/en/articles/331-why-is-monitoring-and-evaluation-important.html	
Standard floristic survey form	2-sided paper sheet providing all necessary information fields to complete for the floristic survey.
Observatorio de la Biodiversidad Agraria España	Pollinator monitoring https://oba.fundacionglobalnature.org/polinizadores/ Soil fauna https://oba.fundacionglobalnature.org/fauna-de-suelo/
Estándar de Pastoreo Regenerativo y Sustentable de Pastizales	https://escueladeregeneracion.com/wp-content/uploads/2019/07/Materiales-Modulo-evaluacion-1.pdf
Soil Montaña project.	http://www.soilmontana.com/?page_id=65

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