Enhancing biodiversity through Nature-based Solutions: The use of wildflowers

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Result type: Methodologies / guidelines – Methodological framework for implementation

Summary

1. Aim of the document

This document aims at providing technical, legislative and practical guidance regarding the development of the wildflower supply chain and its value in safeguarding and promoting biodiversity as a Nature-based Solution. Starting from the case study of Castelluccio di Norcia, a Natura 2000 area, located in the Sibillini Mountains Park (Italy), the document addresses the main stages to be pursued, starting from the collection, selection and sorting of the seeds, up to their ex-situ use. These procedures can be reproposed, with possible adaptations, to other areas where a similar supply chain is to be started.

2. Ecosystem services and Nature-based Solutions

Global environmental challenges, such as climate change, biodiversity loss and land degradation, require an innovative and integrated approach to the sustainable management of natural resources. Nature Based Solutions (NBS) and Ecosystem Services (ES) are key concepts to address these challenges, offering solutions for mitigating and adapting to environmental changes.

NBS are nature-based interventions designed to address environmental, social and economic challenges. These solutions use natural processes or mimic biological systems to provide benefits to both humans and ecosystems. NBS can include ecosystem conservation and restoration, sustainable management of natural resources, the introduction of green infrastructure and the promotion of biodiversity. Ecosystem Services can be defined as the direct and indirect benefits that humans obtain from nature. These include provisioning services such as food and processing materials (e.g. timber), regulating services such as climate and air quality regulation, supporting services such as nutrient cycling, and cultural services such as aesthetic and recreational value.

NBS harness natural processes to provide a wide range of ecosystem services. For example, wetland restoration can improve water quality through natural filtration and provide habitat for biodiversity. Urban forests can mitigate urban warming by absorbing carbon and providing shade and habitat for urban wildlife. By integrating NBS into land use planning and management, benefits for society can be maximised. NBS have been shown to have a significant impact on ecosystem resilience and human well-being. Ecosystem restoration can contribute to disaster risk reduction, improve food and water security and promote social cohesion. Furthermore, implementing NBS can lead to long-term economic benefits, for example through eco-tourism and natural resource conservation. Nature Based Solutions therefore offer an innovative and sustainable approach to address current and future environmental challenges. By integrating NBS into land use planning and management, benefits of Ecosystem Services can be maximised in the long term, also thanks to innovative solutions.

3. Wildflowers: definitions and role as Nature-based Solutions

Wildflowers can be defined as natural or semi-natural areas characterized by a high variety of annual and/or perennial herbaceous species, in an open ecosystem. Wildflowers are often associated with agricultural lands, rural and pasture areas, but also with parks and gardens in urban areas.

The implementation in anthropized areas makes them important Nature-Based Solutions, thanks to their ability to offer a series of ecosystem services and practical benefits, such as:

- Wildflowers present a wide range of plant and animal species, including micro-fauna, thus contributing to the conservation of local biodiversity. This is even more true if we compare flowery meadows and traditional lawns (30-50 species per square meter, against 4-8 species). These habitats can provide nourishment and shelter for pollinating insects, birds, small mammals, usually lacking such oases in highly anthropized environments.
- Still in an urban/anthropized context, wildflowers can improve the aesthetic quality of green spaces, offering a pleasant natural environment richer in biodiversity, also useful for raising public awareness of the importance of biodiversity conservation. Furthermore, being areas with a higher level of wilderness than traditional lawns, wildflowers require less maintenance input: less frequent mowing, reduced need for fertilization and irrigation.

The spread of wildflower meadows as Nature-based Solutions is mainly due to Northern European countries and the United States and only later, in the last 15-20 years, also in South part of Europe (Italy). The use of wildflowers seeds originated around 1960 in the United States, then developed in

the 70s and 80s. In Europe, the first to introduce seed mixtures for wildflower meadows were the large French seed companies, whose products are still among the most widespread on a continental level.

In other part of Europe, including Italy, several test fields - also in collaboration with research institutes, universities and public bodies - were set up in different areas, in order to test the adaptation of different mixtures to the varied soil and climate conditions in Italy. These first pioneering tests revealed the great potential of wildflowers, so much so that over time different mixtures were introduced on the market to satisfy the growing and different demands of the market. The main target of these mixtures are all those entities that manage extensive greenery and that want on the one hand to ensure a valuable ornamental impact, on the other to contain the maintenance costs of the green areas. A considerable market has therefore been created, albeit a niche one. The main fields of use of these products are to be found essentially in the grassing of bare surfaces, in environmental restoration, but also above all in the field of landscape architecture, where they are very successful thanks to the value of the flowering, the ecological function and the containment of costs, which can be assessed in a ratio of 1:10 compared to the standard maintenance costs of a conventional lawn, given that the inputs (water, fertilization) and cultivation operations (mowing, weeding) are necessary to a much lesser extent in flowering meadows.

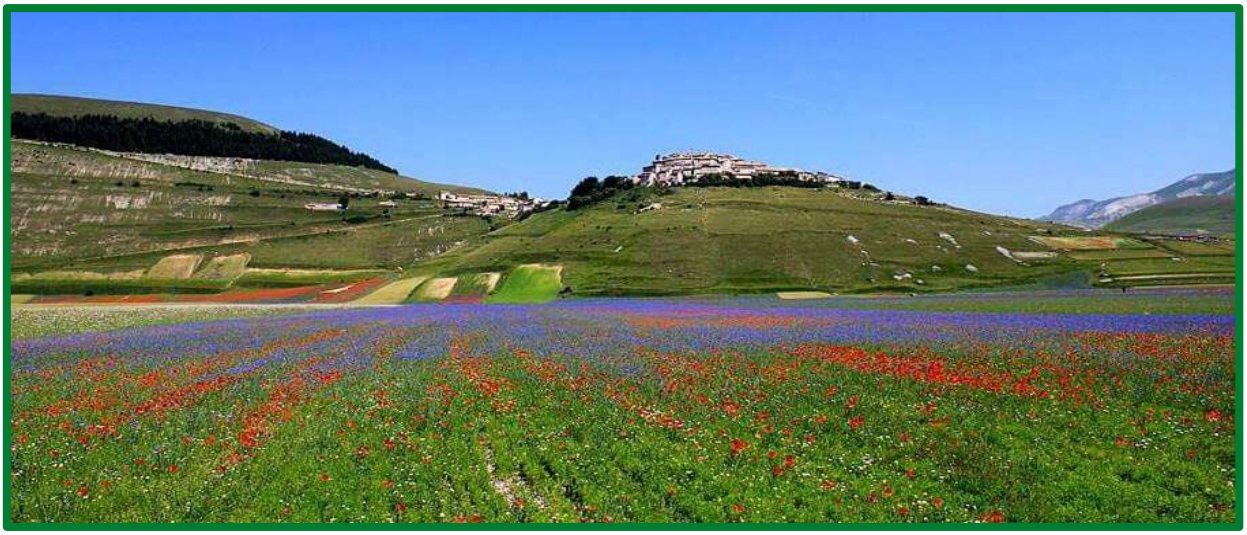
However, at present, there are no seed mixtures on the market that have a high guarantee of germination, purity, flowering quality and that are at the same time native, endemic and suited to local soil and climate conditions, thus able to satisfy both the requests and needs of a professional market dedicated to naturalistic engineering and landscape architecture interventions, and of a hobbyist market, dedicated to consuming a few grams of mixture per capita, but potentially very vast, and at the same time protecting local biodiversity.

4. Castelluccio di Norcia: a unique environment rich in biodiversity

The plateau of Castelluccio di Norcia has a great environmental and cultural value, based on the agricultural activity that takes place there without interruption. It is precisely this activity, together with the environmental and ecological characteristics of the place, that has led to the formation of a unique spectacle: the wild flowering.

This is essentially composed of annual and perennial herbaceous species that settle and develop in the fields cultivated mostly with lentils by the farmers of the local cooperative, in an organic regime - therefore without the use of agrochemicals that would hinder the presence of species other than those cultivated, i.e. weeds. Agronomically speaking, it is the flowering of various species: poppy, cornflower, sage, marigold, daisy, turnip, hemlock and vetch, as well as many others, therefore forming a spectacle that attracted (before the earthquake) about 250,000 visitors/year, but which - when the lentils were harvested - historically was totally destroyed.

In fact, weed seeds contaminate the lentil crop, and farmers are therefore forced to clean the crop before selling the lentil seeds – thus throwing away all the seeds useful for the formation of flower meadows. Flower meadows that can however have great value in many other situations: in urban areas, they can beautify green spaces, requiring less care than traditional lawns, and at the same time guaranteeing blooms useful to bees and pollinating insects; they can then be used in the food sector – being organic and edible; and finally they can enrich locally produced objects and artifacts.



These seeds, which have been eliminated up to now, have great ecological and environmental value and can be used again as ornamental seeds. The agricultural activity carried out here, and the regime with which it is conducted, create a real ecological niche, where the modern concepts of environmental sustainability, protection of biodiversity and the environment, which are widely used today, have always been applied here, avoiding considering this wealth of species as "weeds". The development of a wildflower meadow supply chain is therefore a priority, which can bring social and economic benefits and new work skills on site.

5. Vegetation-floristic analysis

The first step to be taken in view of the development of a flower meadow supply chain is a careful analysis of the vegetation on site, in the case under study the plain of Castelluccio di Norcia. The floristic vegetation analysis is used to frame the correspondence from a phytoclimatic and pedological point of view of the workplace. The investigation is carried out through the floristic vegetation analysis using the plant species as bioindicators, also according to the lines of analysis of Gerard Ducerf.

The Ducerf Method is based on phytosociological and phytoecological analysis:

- Phytosociology: phytosociology aims to study plant communities, their distribution and the whole set of physical and biological relationships that characterize their evolution in space and time.
- Phytoecology: study of the relationships between plants and their environment.

Finally, through the observation and survey of the plants present, bioindicator plants are identified - those easily recognizable species that, growing spontaneously in a place, give indications on the properties of the soil where they grow.

The framing of the area from a pedoclimatic and geobotanical point of view is carried out using regional maps: in this case, the Phytoclimatic Map of Umbria, Geobotanical Map of Umbria both published by the Umbria Region and created by the University of Perugia and the University of Camerino: from a geobotanical point of view all the areas investigated belong to the land use class "Cultivated or abandoned fields". From a phytoclimatic point of view, part of the areas investigated belong to the High-Mountain bioclimatic plan and part belong to the Hilly Subcontinental bioclimatic plan.

The second step consists in conducting specific surveys, in order to understand the actual floristic composition that can be used as a basis for the flower meadow mixtures. The Braun Blanquet statistical

floristic method provides for each species an index of coverage and sociability. The important aspect of the vegetational floristic analysis is that it provides incontrovertible data on the frequency of each species and consequently on the indicator plants present. Plants are bioindicators capable of providing very precise information regarding parameters that simple pedoclimatic analytical values can provide, above all they allow us to operate knowing the susceptibility of a site to host a certain crop, regardless of its current use. The survey is usually conducted on 12 plots each of about 10 m2, repeating three times for each plot at a distance of about 20 days each time: in this way it was possible to detect species flowering in different periods. The sequence that can be used is therefore the following:

A. delimitation of an area of approximately 10 m2;
B. visual estimate of the species present;
C. detection of the species present with coverage index using the following scale:
    - index 5 = coverage 75-100%
    - index 4 = coverage 50-75%
    - index 3 = coverage 25-50%
    - index 2 = coverage 5-25%
    - index 1 = coverage 1-5%
    - index + = coverage less than 1%
    - index r = plant with rare presence
D. detection of sociability index with the following scale:

    5 = pure populations

    4 = carpets or colonies extending over more than half the surface

    3 = small colonies

    2 = individuals gathered in groups

1 = isolated individuals

On the basis of the presences detected it is then possible to conduct the analysis of the bioindicator plants.

The analysis of the frequencies of some species and plant associations and of the correspondence to the parameters of the bioindicator plants tables has provided a very precise picture of the floristic vegetation situation of the investigated sites. This analysis is carried out according to the principles of Gerard Ducerf and allows, by examining the greater or lesser presence of some plants (which indicate certain characteristics of the soil but also of the environment in general) to obtain a judgment on the overall characteristics of a station for the purposes of its agronomic use for different purposes. Briefly, the phases of the analysis through the bioindicator plants are the following:

- A survey of the species present is carried out by referring to the list of known bioindicator species.
- For each species, the abundance is assessed through the use of an abundance coefficient between 1 and 4:

  1 = covers 0 to 25% of the land surface

  2 = covers 25 to 50% of the land surface

  3 = covers 50 to 75% of the land surface

  4 = covers 75 to 100% of the land surface

- A table is created (as per ref. Volume 1 and 2 of «L'encyclopédie des Plantes Bio-indicatrices» Ducerf, 2003) that attributes the main bioindicator characteristics to each species.

- The coefficient is reported, for each species and for each characteristic the coefficient is placed in the relative box.
- The coefficients obtained for each characteristic of the terrain are added together and the result is used for the vegetation analysis of the places (Diagnosis). The information taken into consideration is the following:
  - Indication relating to the organic plant substance, also due to past residues

    + = strong presence -= deficiency
  - Indication on the soil pH:

    A= acid, poor in bases, generally pH lower than 5

    B= soil rich in bases, generally pH between 5 and 7

    C= soil with high pH, with a lot of active limestone, generally pH higher than 7
  - Indication relating to organic or mineral nitrogen

    + = excess -= deficiency
  - Soil compaction

    L = formation of a crust of mud due to soil characteristics

    E = passage of machinery that is too heavy

    P = passage of machinery in the event of rain
  - Water stagnation

    + = temporary +++ = permanent
  - Blockage of the elements P and K

    YES/NO
  - Leaching

    YES/NO
  - Balance

    YES/NO

In the situation under analysis the main important characteristics were:

- Strong presence of total organic matter;
- Strong presence of organic matter of vegetal origin;
- Strong presence of organic matter of animal origin;
- Significant presence of nitrites and free aluminum (due to excess of nitrites);
- Strong indication of soluble bases (Ca, Mg and K) and good mineralization of organic matter;
- Unavailability of K and P elements due to high organic matter and high pH values.

6. Wildflowers seeds development

The case of Castelluccio di Norcia’s plateau allows us to identify a method of reproducing the seeds of wildflowers, after the vegetation analysis to be conducted as a first step. Indeed, if you want to set up a supply chain, legislative and technical aspects must be taken into consideration. Let's see which ones.

7. European legislation

At European level, the sale of seeds is strictly regulated, in order to protect the healthiness of production and farmers themselves, regarding the compliance of their production with certain standards. These regulations regarding seed quality and the registration of the varieties, initially conceived to improve productivity, have over time constituted an obstacle to the preservation and diversification of varieties suitable for different local agricultural contexts and to the growth of small supply chains in the agricultural sector. These considerations do not only apply to the purely agricultural sector - that is, the human/livestock food supply chain - but also to niche and non-food supply chains, such as wildflowers.

Several proposals have been put forward to address this issue and promote the use of diversity in agricultural systems. Among these, "conservation varieties" emerge as the most advanced solution from an institutional and legislative point of view to date. Directive 98/95/EC, issued on 14 December 1998, introduces a new type of agricultural variety that can be marketed in the European continent: "conservation varieties". The same directive states an important starting point: "*Whereas it is essential to ensure that plant genetic resources are conserved; whereas a legal basis for this purpose should be introduced to allow, within the framework of the legislation on the marketing of seeds, the conservation, through in situ use, of varieties threatened by genetic erosion*". This represents a significant step towards promoting the conservation of agricultural biodiversity.

At the national level of implementation of this directive, the path has not been entirely linear and fast. This has led to a certain discrepancy between territories, but also to greater attention to individual genotypes present in niche environments.

8. Developing wildflowers mixture: some practical steps

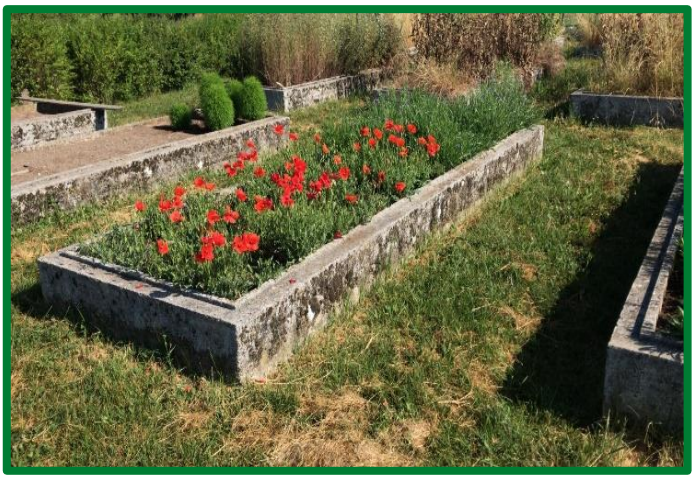
Therefore, by developing a seed mixture of species present on the Castelluccio plateau and exploiting the particular environmental characteristics of Castelluccio di Norcia, it is possible to obtain a case study of circular economy, which transforms waste into a resource and guarantees a potential source of income for the local socio-economic fabric. In order to obtain a similar mixture, the main steps to follow are reported, both in this environment and in other similar case studies:

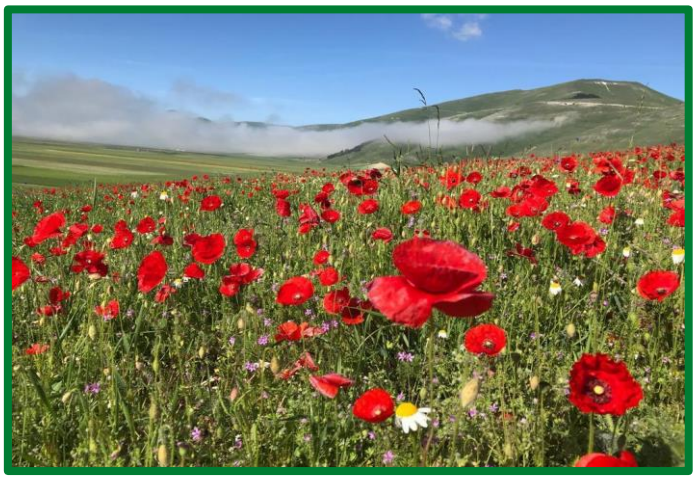
A. The first activity to be carried out is the collection of the seeds, in this case a lentil-weed seed mixture, with the subsequent normal cleaning of the crop, so as to obtain on the one hand the lentil ready for the usual marketing, and on the other the set of collected weeds from which to obtain the mixture.
B. Subsequently, it is a good idea to carry out some simple cultivation tests in order to understand the actual species present and the possible need for agronomic techniques (e.g. vernalization) necessary for germination. Often, a further screening of the species present is necessary: this is both to increase the value of the seed, thanks to a percentage increase in the composition of species with a marked ornamental use, and to improve the mixture from a technical point of view: for example, some species (such as some legumes and many grasses) tend to take over the others over time.
C. Some species of particular ornamental and/or ecological value (for example *Centaurea cyanus*, and Papaver sp.) are then to be isolated in purity. This is to further test their germination and overcome some technical problems: for example, the very small size of the poppy seed does not allow for machine harvesting.

D. Once a mixture has been obtained, it is advisable to proceed with some tests, both in situ and ex situ. This is to test the degree of adaptation of the seed to environmental conditions different from the original ones. Furthermore, thanks to tests in different environments, it is possible to test the different needs and inputs really necessary to obtain a good result. In particular, soil processing, preventive weeding, sowing methods and fertilization and maintenance needs are delicate aspects that must be evaluated in detail to provide potential future users with precise and useful indications for obtaining a satisfactory result.
E. Finally, it is important to underline that the final use of the mixture varies based on its composition: less refined mixtures may prove suitable for naturalistic engineering uses or for extensive grassing, and not for purely ornamental purposes.

The development of mixtures of flowery meadows in rural areas allows the farms involved to improve their economic performance, enhancing agronomic and agroecological assets that have been unexploited until now but are rich in potential. In particular, the creation of local supply chains allows for several advantages, not only environmental, but also socio-economic, such as:

- the diversification of products and activities,
- the optimization of the production cycle, converting production waste into an opportunity,
- the opportunity to introduce absolutely unique products onto the market that cannot be reproduced elsewhere, with high agronomic value.



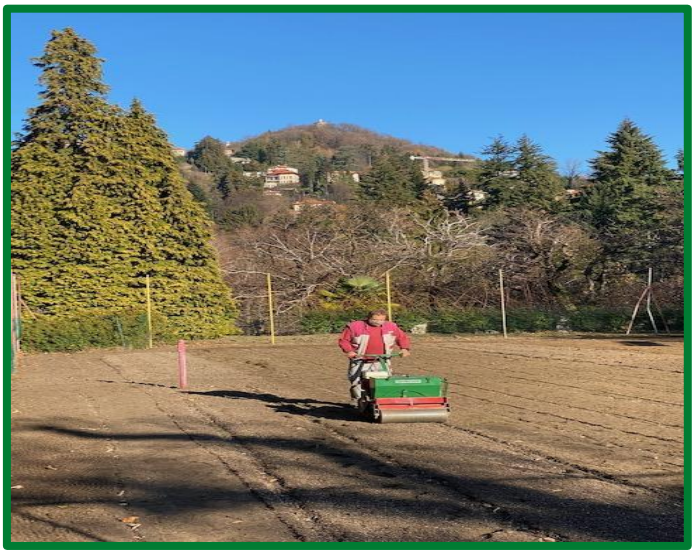


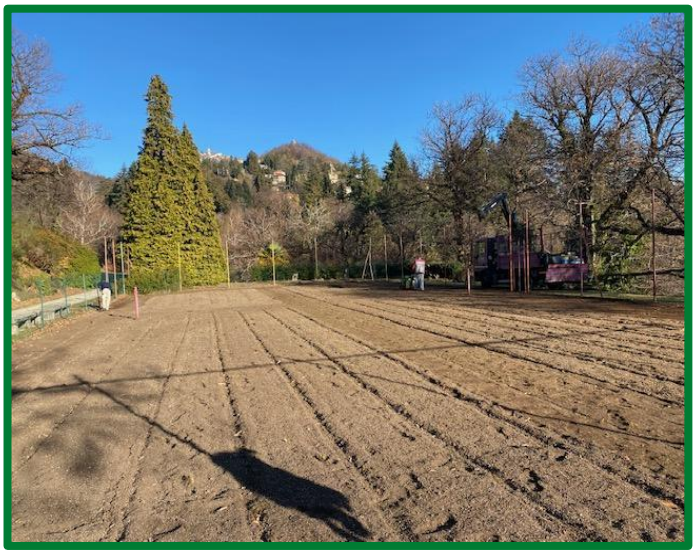
The multi-stage flowering during the growing season guarantees a notable aesthetic effect and the presence of blooms useful to pollinators in different periods of the year. Local farmers grow lentils without using herbicides, so the different plants that grow among the lentil plants flower, each with a different color and at different times (yellow=cruciferous; red=poppies; blue=cornflowers; white=lentils; lilac=roveja; violet=vetch;...and many other species and colors in a real explosion of colors).

9. Implementing wildflowers: practical steps

Usually, it is best to sow the mixture preferably in autumn, alternatively in early spring. Soil preparation is the fundamental step for the correct establishment of a flowery meadow. It is necessary to work the soil, avoiding sowing on surfaces that are already grass: the seed requires light burial and suffers from excessive competition from grasses. It is therefore necessary for the soil to be worked and bare, just like when we sow a traditional lawn.

A small trick can be to practice "false sowing": prepare the soil and let any weed species present germinate, then work the soil again and proceed with the actual sowing. On small surfaces, the recommended sowing technique is manual, by scattering: given the small size of the seeds, it is advisable to prepare a mixture with sand, so as to make the quantity and distribution uniform. On medium-large surfaces, the use of rotary trolleys or mechanical seeders is recommended, always mixing with sand. In any case, the mixture needs to be lightly buried and rolled, so as to ensure good adhesion between the seed and the substrate, and to allow the soil to settle.





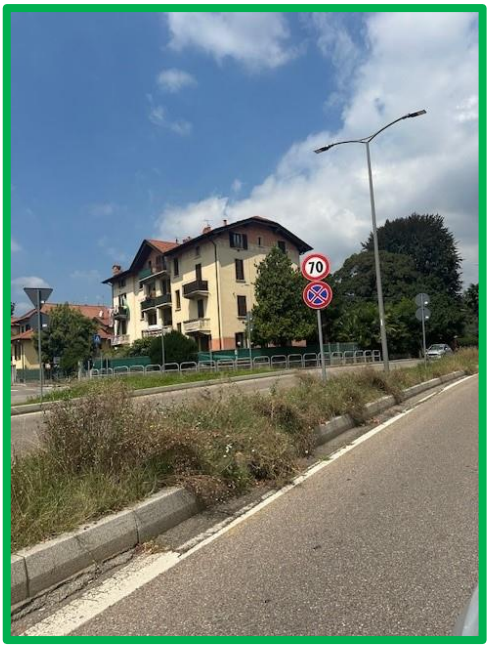
Sowing phases with disc seeder, with a mixture of seeds and sand. Note the soil processing performed a priori in order to eliminate competition and facilitate development.

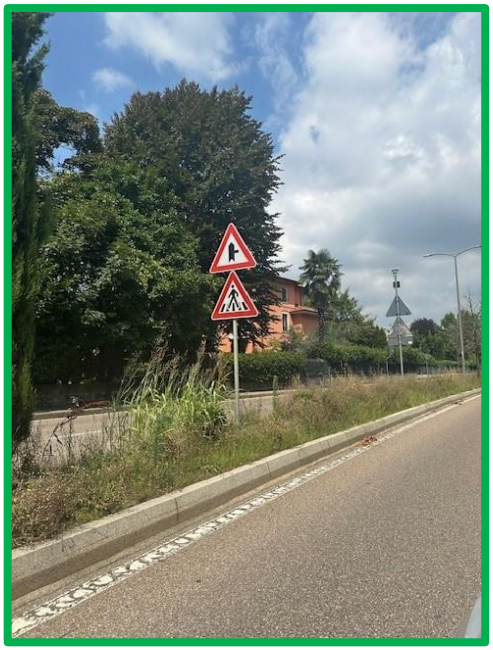
The sowing dose varies depending on the chosen mixture, environmental conditions and actual water availability. In general, it is advisable to sow at doses ranging from 5 to 15 gr./m2, increasing the dosage if temperatures are low, or competition is high.

The management of a flower meadow are different from those followed for a traditional lawn. The most delicate and important phase is soil preparation. Once sown, on small surfaces it is possible to weed any weeds present. Also depending on the characteristics of the soil, it is possible to carry out fertilization, avoiding however synthetic fertilizers with a high nitrogen content and favoring organic fertilizers with low titrations. During the growing season, the flower meadow should be watered according to needs, and should not be mowed frequently: a mowing after the end of the flowering of the last species to flower may be sufficient.

For a successful project, it is considered useful to follow the steps described above. Errors in the design and implementation phase lead to disappointing results over time, both from an aesthetic and environmental point of view - with many complications from a maintenance point of view. In particular, it should be avoided:

- sowing on unworked land, or where there is the presence of traditional turf: the grasses will tend to take over;
- sowing late: if the sowing period is wrong - e.g. late spring/early summer - the weeds will overwhelm the seed;
- not considering the specific needs of the species, in particular from a water point of view. The lack of water - in the early stages and then during flowering - is a depressing factor for many species, with serious effects. The failure to adapt the irrigation system is also a sore point: the use of high sprinklers, capable of overhanging the vegetation, allows for good results in this sense.





Negative examples in wildflowers implementation: weed overtaking the wildflowers meadow, due to poor soil preparation and water management - resulting in a failure.

10. Conclusions

This document aims at serving as an introductory basis for all those - technicians, agronomists, farmers - who at various levels deal with the concept of wildflower meadows, both by developing a new supply chain and by using mixtures.

The objective we set ourselves when writing the text is to represent the various steps to be faced in rural environments. These steps must however be calibrated and validated according to the contexts, both environmental and legislative, and are aimed at filling the gaps currently present in the supply chain in terms of knowledge about wildflower meadows and Nature-based Solutions, which can prove to be of fundamental importance for the conservation and protection of biodiversity in agricultural and urban contexts. The future hope is that all stakeholders in the sector will grasp this importance and act accordingly, embracing innovative supply chains that are able to provide multiple ecosystem services.

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