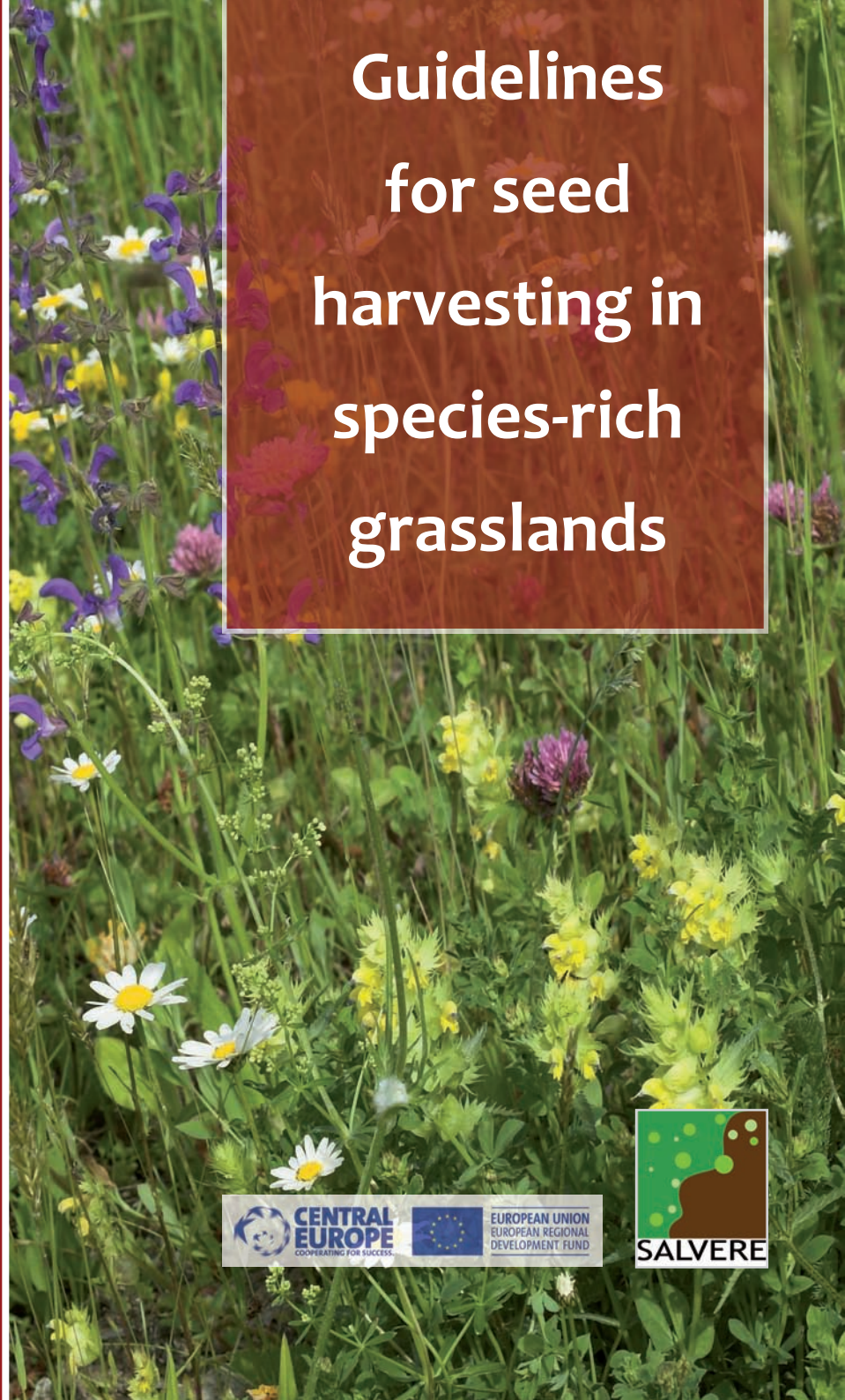
Guidelines for seed harvesting in species-rich grasslands



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EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

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Content

1. Why harvesting seed in species-rich grasslands

Species-rich semi-natural grasslands provide an essential contribution to the preservation of European biodiversity. They are ecosystems rich in native, often rare or endemic plants and habitats necessary for many animal species. such as birds and insects of great conservation importance. They are also highly beneficial to the water quality and present usually a very low risk of soil erosion. However, in the last few decades, abandonment of surfaces more difficult to cultivate and increased fertilization have considerably reduced their area. It is therefore important to conserve the still existing examples of such grasslands and promote restoration of new ones on areas with both farm and non-farm use.

Modern ecological restoration, as process of assisting the recovery of ecosystems which have been degraded, damaged or destroyed, is based on two main principles:

- native biodiversity must be protected through the use of only native seeds and plants;
- propagation material must come from donor sites with ecological characteristics similar to the receptor site.

To obtain seeds of native ecotypes consistent with the ecological and biological conditions of the receptor site, direct harvesting from semi-natural grasslands can be an excellent strategy especially in highly variable environments. To implement it in the best way, appropriate selection of the donor site and correct utilization of the harvesting techniques are important. For further information see Scotton et al. (2012) cited under Impressum.

2. Selection of the donor site

Selection of the donor site involves choosing the type of species-rich grassland and identifying the particular site where to harvest the seed.

2.1. Important types of species-rich semi-natural grasslands

Semi-natural grasslands are herbaceous vegetations composed of native species and managed by farmers for grazing or mowing. In Central Europe, the main types of semi-natural grasslands which can be used as potential donor sites for ecological restoration belong to the phytosociological orders *Arrhenatheretalia*, *Molinietalia*, *Festuco-Brometalia* and *Nardetalia*. Each grassland type is characterized by a particular combination of soil, climate and management.

The ***Arrhenatheretalia*** grasslands are usually more or less intensively fertilized and mown for forage production. When fertilization is moderate, they can be excellent donor sites of species-rich propagation material. The *Arrhenatherion* meadows are typical for low-medium altitude and mown 2-3 times per year. Important species are *Arrhenatherum elatius*, *Trisetum flavescens* (grasses), *Trifolium pratense*, *Medicago lupulina* (legumes), *Galium mollugo*, *Leucanthemum vulgare* and *Knautia arvensis* (forbs). The Trisetion meadows occur at higher altitude and are mown 1-2 times per year. The main species are *Trisetum flavescens*, *Festuca nigrescens*, *Alchemilla vulgaris*, *Silene dioica* and *Trollius europaeus* and other species typical of the hosting mountain chains.

The ***Molinietalia*** grasslands occupy moist soils on the alluvial areas of the rivers and are naturally manured by flooding. The *Molinon* litter meadows occupy acid to alkaline, relatively nutrients poor soils and were traditionally cut very late once per year to produce litter. The most frequent species are Molinia coerulea, Succisa pratensis and *Deschampsia caespitosa*. The *Cnidion* grasslands occupy lowland river floodplains with relatively nutrients richer mineral soils and summer drying out conditions. They are traditionally mown once or twice per year for forage production. Their botanical composition is very variable depending on the climate and soil water regime.

The ***Festuco-Brometalia*** grasslands are typical for low to medium altitude sites characterized by dry and alkaline soils on limestone substrates. Due to their extensive management (no fertilization and only one utilization per year) they are one of the more species-rich European vegetations, often housing rare and endangered plants and animals. They are characterized by *Bromus erectus*, *Brachypodium pinnatum*, *Koeleria pyramidata*, *Anthyllis vulneraria* and *Salvia pratensis* and often rare orchids. Among them, the *Mesobromion* communities occupy the relatively less dry sites, whereas the sites of more xeric soils and climates are occupied by the rare *Xerobromion* grasslands.

The ***Nardetalia*** grasslands develop on acid soils, mainly from siliceous rocks and are often species-rich grasslands characterized by *Nardus stricta*, *Arnica montana* and *Calluna vulgaris*. Usual management is no fertilization and mowing only once per year or grazing. The *Violion caninae* grasslands are typical of the lower and middle

altitude mountains and contain species such as *Festuca filiformis*, *Polygala vulgaris* and Viola canina. The *Nardo-Agrostion tenuis* vegetations occur at higher altitudes and include also species typical for natural grasslands above the timberline, such as *Campanula barbata* and *Geum montanum*.

The choice of the grassland type to be harvested is done after analysis of the characteristics of the site to be re-vegetated, which have to be consistent with those of the donor site. The main traits to be considered are climate (especially temperature and the correlated altitude), the soil (especially water and nutrients content and reaction) and the foreseen management (fertilization level and type and frequency of utilization).

2.2. Choice of the donor site and donor site registers

After deciding the grassland type to be considered for harvesting, the particular donor site has to be chosen based on these criteria to protect the local biodiversity and allow an easy harvesting:

- the donor site has to be geographically as close as possible to the receptor site and, in any case, in the same provenance region
- all donor site species and subspecies have to be present also in the geographical area where the seed will be used
- the donor site has not to have undergone sowing with mixtures of genetically selected cultivars and contain exotic or invasive species
- the donor site has to be accessible with the harvesting equipment used.

For an easier choice, reference to a donor site register for the geographical area can be very useful. Such geo-referenced data-bases of species-rich grasslands are usually accessible on-line and describe for the included surfaces some important characteristics such as: location, grassland type, botanical composition, natural value, accessibility and practicability. If such a register is not available, the restorationist has to refer to his own or other local experts knowledge and create a personal list of the potential donor sites available in the region.

IMPORTANT REMARK

If the establishment of a species-rich grassland is foreseen during planning of infrastructural works, it is opportune that also the donor site is identified during that stage. Instead, if the receptor site is not yet known and one wants to create provisions available for future market demands, it is important to research the probable future market requirements in different sectors, such as infrastructural works, agriculture etc. This allows for estimating the amount and quality of the needed seed and, therefore, to choose the more suitable donor sites.

3. How to harvest seed from species-rich grasslands

Depending on site and management, each type of semi-natural grassland is characterized by a specific amount, quality, botanical composition and development of seed production.

The total amount of seeds produced per m² and per year can vary between some thousands and more than one hundred thousands, with grasslands of more nutrient rich soils (*Arrhenatheretalia*) producing more fertile stems and more seeds than poor soil grasslands (*Molinietalia*, *Festuco-Brometalia* and *Nardetalia*).

As for forage, seed production is organized into one or more re-growths depending on soil fertility and length of the vegetation period. In fertile soil grasslands, where more than one re-growth is possible (*Arrhenatherion*), the seed produced at the first re-growth (June-July) is particularly abundant and rich in grasses. If a seed amount as high as possible is desired, harvesting in the final part of the re-growth at the maximum seed maturity stage (time when most species have matured their seeds) is the best solution. The seed produced during the following re-growths (August-September) are usually less abundant but richer in legumes and other forbs. If more seeds of the last species are desired, a further harvesting at the second re-growth or a late harvesting at the first re-growth can be implemented.

In poor soil grasslands, only one re-growth is usually possible and seed maturation occurs later than on fertile soils. The maximum seed maturity stage is reached in July on dry to fresh sites (*Festuco-Brometalia* and *Nardetalia*), while on wet soil (*Molinietalia*) seed maturation occurs over a long period with several species entering gamic reproduction very late, so that only by late August/September have all present species produced mature seed.

Due to different phenologies of the many grassland species, it is often impossible to obtain seed of all plants with only one harvesting. To collect more species, it is therefore necessary to harvest more times on the same grassland.

Based on the obtained material, harvesting techniques can be grouped as follows:

- Green hay and Dry hay harvesting
- On site-threshing, Dry hay threshing, Seed stripping and Vacuum harvesting
- Topsoil stripping and Turfing
- other methods: Raking and Hay flower

3.1 Green and Dry hay harvesting

With Green hay and Dry hay harvesting, the whole above ground grassland biomass, including seeds is harvested and used as propagation material.

Green hay harvesting

A seed mature grasslands is mown and the green hay obtained is spread on the receptor-site. Cutting can be done with a cutter bar or rotary mower, loading and transporting with a loader wagon, distribution on the receptor site with a manure spreader.

Advantages

- high harvesting efficiency (up to 100% of the standing seed yield)
- necessary equipment is available on most farms
- cheap harvesting method if agricultural machines can be used
- green hay is also propagation and mulching material

Disadvantages

- to avoid decay, green hay spreading on the receptor site has to be done immediately after harvesting
- large weight and volume of the green hay to be moved
- the biomass cannot be used as forage

Conclusion

Good for small scale receptor sites within a short distance of the donor site, when restoration can be done immediately after harvesting and equipment specific for seed harvesting is not available.

Dry hay harvesting (haymaking)

A seed mature grasslands is mown, the grass is dried with 1-3 turnings, swathed and loaded loose or baled. The hay can be used as propagation material immediately after harvesting or after a period of conservation.

Advantages

- necessary equipment is available on most farms
- harvesting can be done by the farmers managing the grasslands fro forage production
- Dry hay can be conserved and spread on the receptor site several months after harvesting
- Dry hay is also propagation and mulching material

Disadvantages

- medium-low harvesting efficiency (30-50% of the standing seed yield)
- large weight and volume of the green hay to be moved
- the hay cannot be used as forage
- hay is usually conserved at ambient conditions, so conservation of seed germinability is not long (use hay within one year)

Conclusion

Good for all types of donor and receptor sites when equipment specific for seed harvesting is not available and the harvested material can not be transported immediately to the receptor site.

3.2 On site-threshing, Dry hay threshing, Seed stripping and Vacuum harvesting

With On site-threshing, Dry hay threshing, Seed stripping and Vacuum harvesting the seed is harvested along with a small amount of fragments of vegetative plant parts.

On site-threshing

A seed mature grassland is harvested through a combine-harvester. Large grain threshers or small plot combines can be used. Most of the ripe seeds are separated from the vegetative plant parts and collected in the harvester bin. The cylinder should be set with a little space between rasp bars and concave, the air kept to a minimum to prevent seed from blowing out the back and screens adjusted to allow the most seed to pass through, while keeping most stems and leaves out. To avoid the machine from being blocked, in dense vegetation the cutting height can be set to more than 30 cm to reduce hay quantity. Another possibility is to cut the meadow early in the morning, when dew causes adhesion of the seeds to the plants, swath the material and thresh it after drying (1-2 days later).

Advantages

- medium-high harvesting efficiency (50-80% of the standing seed yield)
- low transport volumes (vegetative plant parts remain on the surface)
- hay remaining on the surface can be used as forage
- harvested material can be used immediately for re-vegetation (no need to be dried) or stored after drying
- due to the great reduced volume, storage is possible in refrigerator and seed can be used also some years after harvesting

Disadvantages

- a thresher is not available in all farms
- high cost of the equipment and its maintenance
- equipment settings and working (mesh size of the sieve, cleaning blowing, harvesting speed) has to be adjusted to the site conditions, so previous experience is important
- not suitable for steep or uneven grounds

Conclusion

Good for high efficiency harvesting on not too steep donor sites. The seed obtained, conserved under cool and dry conditions, can be used at least two years after harvesting.

Dry hay threshing

After haymaking (see above), the hay is threshed in the farm to extract the seed. For threshing a stationary thresher or a combine harvester can be used.

Advantages

- hay can be used as forage
- due to the great reduced volume, storage is possible under cool and dry conditions and seed can be used also some years after harvesting
- a stationary thresher is less expensive than a combine harvester
- the seed can be stored under cool and dry conditions and used some years after harvesting

Disadvantages

- very low harvesting efficiency (15-30% of the standing seed yield) due to seed loss in both haymaking and threshing

Conclusion

Good for supplying seed as a by-product of agricultural farms. The seed obtained can be stored at least two years under cool and dry conditions.

Seed stripping

Only the ripe seeds are detached off the plants with a brush rotating within the vegetation, while the other plant parts are left standing on the surface and can continue their growth, so that further harvesting is possible, after ripening of other seeds. The detached seeds are deposited in a hopper behind the brush.
Equipment used can be hand held portable, pull type or front end loader type.

The most frequent pull type equipment usually has an adjustable brush height and brush rotation upward (in some models also downward) at the leading edge.

Advantages

- medium harvesting efficiency of the pull type on low vegetations (55-75% of the standing seed yield)
- very low (hand held) or low (pull or front end types) equipment cost
- as the grass is not cut, several harvests on the same surface at different times during the same re-growth are possible
- the harvested seed can be stored under cool and dry conditions and used some years after harvesting

Disadvantages

- harvesting efficiency: low for the hand held type and medium-low for the pull type on tall grass vegetation (<30 and 20-50% of the standing seed yield respectively)

Conclusion

Good for not very expensive medium efficiency harvesting even on steep and uneven donor sites. The seed obtained, conserved under cool and dry conditions, can be used a long time after harvesting.

Vacuum harvesting

With vacuum harvesting the seeds are sucked through an air flow created by motor-driven blades and deposited in a fine mesh bag. The bag must be frequently emptied to maintain suction. Models available are light hand-held devices originally built for collecting fallen leaves, where the sucking unit is a 10-15 cm tube or heavier tractor mounted harvesters, where the tube is replaced by a hood up to more than 1 m wide.

Advantages

- steep and uneven grasslands can be harvested with hand held models
- can collect every type of seed but is especially useful for profuse and fine seeds which are easy to remove and close to the ground
- unwanted species present on the grasslands can be avoided
- after harvesting, grass can be cut for forage

- the harvested seed can be stored under cool and dry conditions and used some years after harvesting

Disadvantages

- only suitable for small areas
- low harvesting efficiency

Conclusion

Good for harvesting of small surfaces of every type and species with profuse and fine seeds, easy to remove and close to the ground.

3.3 Topsoil stripping and Turfing

With Topsoil stripping and Turfing, the topsoil including the seeds and the living plants is collected.

Topsoil stripping

The topsoil (up to 20 cm) containing also seeds and living plants is scraped with earth moving machines. If possible, to enrich the seed content in the harvested soil, stripping should be made just after seed maturation of most plants of the standing vegetation. On deep and stone free soils, equipments used are scrapers (hoppers endowed with a sharp horizontal edge in the lower frontal part pulled by a tractor), a combination of dozers, loaders and trucks and shovels/backhoes and trucks. On soil containing rocks and large stones, working with excavators (to remove the topsoil layer) and loaders (to stockpile the soil) is more effective. Storage is possible in mounds 1.5 m high (maximum 3 m).

Advantages

- suitable for sites with shallow soil, where topsoil salvage and redistribution is necessary for restoration success
- very useful for high altitude vegetation where re-utilization of the propagules of plants adapted to these difficult environments is an important condition for a successful restoration

Disadvantages

- expensive
- possible loss of seed and plant viability due to long term stockpiling
- vegetation obtained after topsoil re-distribution can be different than vegetation prior to soil stripping due to differences between standing vegetation and soil seed bank

Conclusion

Good for grasslands surfaces impacted by infrastructural works and which can be restored with the topsoil obtained from the same area before disturbance.

Turfing

Photo www.huckbody.com

Intact turves are removed and placed on a receptor site to be restored. Hand removal of turves up to 40 cm×40 cm and depth of 20 cm can be done with spades. Larger turves are removed with excavators and very large ones (up to rectangles with 1-2 m sides) (macroturfing) can be extracted with bulldozers or excavators equipped with special front-end excavating shovels. Turves can be stored in stacks (maximum 1 m wide and 0.6 m high) or on pallets. To avoid desiccation, storage in summer should not exceed two-three weeks.

Advantages

- very useful to conserve vegetation with very high ecological value or on grassland surfaces which are returned to their original use after infrastructural works
- low to medium disturbance of transferred vegetation

Disadvantages

- very expensive
- macroturfing needs non-standard earthmoving equipment

Conclusion

Good for the preservation of valuable plant communities to be destroyed due to infrastructural works.

3.4 Raking and Hay flower

Raking and Hay flower are additional methods useful in particular situations

Raking

Soil covered with low growing plants is raked to collect vegetative parts of mosses, lichens, and higher plants as well as seeds and parts of the soil seed bank. Tools used are rakes with rigid or elastic teeth. The method is good for sparsely vegetated dry grasslands rich in mosses and lichens, with propagules very close to the soil. However, large surfaces and quantities of propagation material are difficult to harvest.

Hay flower

Where the hay is stored loose in barns (not baled), the mixture of seeds and fragments of leaves and stems accumulated on the floor can be swept up and used as propagation material. In the past, this was the most frequently used material for sowing grassland. Hay flower should be salvaged from the hay loft every spring and, if not stored dry and cool, preferably used in the months after, otherwise germinability loss would become important. Further, all donor meadows where the hay comes from, have to be semi-natural grassland. The method is good for obtaining low cost seed but is only very rarely possible, as hay is currently conserved mostly after baling.

4. The main errors to be avoided

An effective seed harvesting in semi-natural grasslands implies knowledge of the main ecological aspects of the involved vegetations and, also, the technical aspects of the harvesting operations. Improper implementation of the necessary knowledge can lead to failures. The main errors to be avoided are as follows:

The involved surface is botanically unsuitable for seed harvesting

The main reason for unsuitability is that the grassland was more or less recently re-sown with a mixture of selected varieties of forage species and the species composition is not yet fully re-naturalized. Also species poor composition, high fertilization and the presence of weeds or invasive species can be important reasons for unsuitability.

Harvesting time was too early or too late

The many species present In semi-natural grasslands mature their seed according to different phenological rhythms. A wrong harvesting time can, therefore, significantly reduce the amount of seeds and species harvested. Harvesting should be done at the time of the maximum standing seed yield but can be anticipated, postponed or repeated in the same re-growth, depending on the species composition of the desired seed mixture.

Equipment settings were not appropriate

For an efficient harvesting, special seed harvesting equipment such as threshers, seed strippers etc. usually need to be set up according to the characteristics of the grassland to be harvested (grass height, seed maturity stage, species composition etc.). A wrong set up can result in a large amount of seed losses. Before harvesting the whole grassland, some trials should be done to decide the optimal equipment set-up.

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Impressum

Further informati on about restoration of species-rich grasslands as well as a comprehensive literature review about this topic can be found in: Scotton M., Kirmer A. and Krautzer B. (eds.) (2012) Practical handbook for seed harvest and ecological restorati on of species rich grasslands. ISBN 978 88 6129 800 2, published by Cleup Italy and printed by Wallig Austria, 116 p. The book and downloads are available at www.salvereproject.eu.

The Guidelines are an Output of SALVERE, a project implemented through the CENTRAL EUROPE Program and co-financed by the European Regional Development Funds.