The ecology of soil seed banks in grassland ecosystems

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Summary

In the second half of this century the area of natural and semi-natural ecosystems has decreased drastically in the West European countries. In the Netherlands more than 400 plant species with reference to the beginning of the century have become endangered or even have become extinct. The decline of systems and plant species with nature conservation interest initiated the counteracting process of restoration and re-creation of endangered plant communities. The latter has become an important aim of nature conservation authorities all over Europe. During this process not only difficulties appear recreating the proper abiotic site conditions and restoring the biotic processes. Most often the availability of dispersules appears to be a serious bottleneck for the re-establishment of plant species. When species have been growing at a site in the past the possibility of re-establishment from a long-lived seed bank exists. The information on seed bank development and seed longevity of wild flower species at the start of this research, however, was scattered, incomplete and often inaccessible to the management authorities. Therefore, research on soil seed banks and seed ecology needed to be done with a special focus on the applicability in and the perspectives for restoration management.

This thesis aims at contributing to a better understanding of processes that influence changes in seed bank composition and seed longevity of grassland ecosystems. Instead of studying seed bank dynamics of a few model species, a broad spectrum of species and seed banks of intact plant communities were the object of study. This community based approach was adopted to enable translation of the results into perspectives for restoration management. A precondition to compare results on a community basis is the application of a standardized method of seed bank sampling which was elaborated at the start of the project. This method was used throughout the field studies presented in this thesis.

The first main question addressed in this thesis focuses on the relation between the species composition of the established vegetation and the seed bank. For this purpose sites differing in successional age were sampled in the Drentse A brook valley Anloërdiepje (Chapter 4) and in the dune slack Koegelwieck at the Dutch Waddensea island of Terschelling (Chapter 5). The sites of the Drentse A series are part of a secondary succession ranging from fertilized grassland towards low productive species-rich meadows. The sites of the dune slack series developed after removal of the top soil layer down to the mineral sand. Very few seeds were left in the soil after this measurement and, hence

the sites can be regarded part of a primary successional series. Seed bank development during the time of succession has been shown at both series, which revealed also an indication of seed longevity of the species involved. It has been shown in chapters 2, 4 and 5 that about 50% of the species in the established vegetation can be found present as seeds in the soil seed bank beneath the studied grassland communities. The majority of other species in the seed bank are ruderal or weedy species which are absent from the vegetation. This holds for a wide range of grassland communities. Research in sites that are part of chronosequences has shown that the similarity in species between the above-ground vegetation and the seed bank improves over time but it never exceeded 60 %. Not even in an ancient flood meadow that had not been used differently than cut for hay since the 13th century (Chapter 4). Together this already indicates that the soil seed bank under intact species-rich grassland communities cannot fully replace the above-ground vegetation, regardless the possible seed longevity of the species involved.

Chapter 3 mainly deals with the compilation of the data assembled in the database of Thompson, Bakker & Bekker (1997) into one figure of seed longevity, the seed longevity index, for individual species. Moreover, this chapter investigates with a large set of field data which species specific traits, seed size and shape, actually correlate with this independent measure of seed longevity. It has been shown that small and round seeds indeed tend to live longer in the soil than big and/or elongated seeds.

After having determined the possible seed longevity of species it is of importance to know the relative effects of site conditions on seed longevity. Can site conditions affect seed longevity? Nutrient conditions and water availability are regarded the main factors determining the soil environment at a site. The effects of nutrients and sites conditions on seed survival has been investigated by means of an extensive burial experiment (Chapter 6). Seeds of more than 15 species were buried in nylon mesh bags at five field sites. The seeds were buried in plots that were fertilized by means of macro-nutrient addition. After two years the experiment provided no evidence of any effect of nutrient conditions on seed survival when direct effects are considered. The indirect effects through population changes and possible changes in seed survival probabilities, however, may still be considerable and can be assessed in the running experiment during the coming years. This experiment did show, however, that the survival of seeds of the same origin can be affected in response to different site conditions.

In a mesocosm experiment the effects of a continuous high water level on the seed bank composition of a moist grassland community were assessed (Chapter 7). High water level and hence a low oxygen availability have been shown to affect the survival of seeds of individual species in the studied community differently. Species of wet habitats which are likely to have adaptations to cope with anoxic conditions, survived better under waterlogged conditions, whereas species of dry habitats suffered from decreased seed survival under high water level conditions.

Finally, in the light of restoration perspectives, it was important to determine the regeneration potential of grassland communities from the seed bank. A comparison between the composition of the soil seed bank of well-developed communities and degraded communities (Chapter 2) gave already a first indication of this potential. When only 50% of the species of a well-developed grassland community can be found in the seed bank and even less species of a reference community were detected in the soil seed bank of degraded communities, the regeneration potential could not be regarded very high.

In Chapter 8 a combined figure for seed longevity for a few plant communities was presented. The database on vegetation recordings of the Dutch plant communities was linked to the seed longevity indices of individual plant species. In this way the frequency distribution of seed longevity within a community could be calculated. It could be shown that the majority of the plant species in the two grassland communities studied produce short-term persistent seeds. The two communities, however, differed in mean seed longevity. The chalk grassland community tends to produce even less long-term persistent seeds than the fen meadow community. Altogether it was concluded that with respect to grassland communities the restoration potential from the seed bank is low. This research has pointed out that conservation and management of the remaining area of species-rich grassland requires the highest priority.