Reintroduction of plant species

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Summary

The aim of this thesis is to contribute to the knowledge about several temporal and spatial community processes related to the reintroduction of plant species in nature reserves. Such knowledge is necessary to answer questions about the necessity or the feasibility of reintroduction.

In the **preamble** an overview is given of the historical developments in the approach of reintroduction in the Netherlands. The attitude of nature conservation authorities towards reintroduction has changed in the course of the last century. In the early 1900s it was regarded acceptable. In the 1940s and 1950s manipulation of species composition by sowing or planting was rejected, although human interference in itself was accepted to maintain semi-natural landscapes. In the last decades reintroduction has become more accepted again, but under restrictions. It is in defining and evaluating the restrictions that science may play an important role.

In **chapter 1** an overview is given of general questions asked in relation to reintroduction. The importance of a number of biological paradigms is discussed in this framework. In this chapter, the aim and the outline of the thesis are given.

The **chapters 2** to **5** of this thesis deal with seed dispersal, a biotic aspect of ecosystem dynamics that influences thinking about necessity of reintroduction. Three studies are given on spatial dispersal, and a fourth on both spatial and temporal dispersal, all relating to the question: Can rare species disperse in the modern landscape in a way that would make reintroduction unnecessary? **Chapter 6** deals with the applicability of knowledge about seed dispersal and seed banks. The **chapters 7** and **8** relate directly to the feasibility question: Can we judge the possible success of reintroduction of single species or communities in advance? Finally, chapter 9 is meant to reflect on the results in view of restoration ecology.

In **chapter 2**, the dispersal capability of wind-dispersed seeds of the rare plant species *Arnica montana* is discussed in relation to the chance that populations will establish naturally in restoration areas. Plumed Asteraceae achenes are often considered to disperse over large distances. The flying capability of plumed achenes of *A.montana* is investigated in a wind tunnel experiment. It was shown that *A.montana* achenes disperse rather inefficiently. Heavier achenes drop closer to the point of release than lighter ones. There was a positive correlation between achene weight and both germination and seedling quality. Consequently, germination and seedling quality declined considerably with increasing flying capability of the achenes. It seems that *A.montana* is adapted to an environment where moderate dispersal distances are required, up to several meters. It appears that re-establishment of this species on isolated sites in the Dutch landscape will depend on transport by human activity.

In **chapter 3**, the results of an experiment on human-induced seed dispersal leading to establishment of *Rhinanthus angustifolius* are presented. In August 1994 a hayfield from which *R.angustifolius* was removed was divided into three parts. Under fair weather conditions two of these parts were mown by a clean tractor disk mower combination and a tractor disk mower combination previously contaminated with *R.angustifolius* seeds respectively. The third part was mown under rainy conditions by a contaminated caterpillar mower. In both parts mown by contaminated machinery more plants of *R.angustifolius* were found as compared to the part mown with clean machinery. Especially within the part mown under wet weather conditions by the caterpillar mower many established plants of *R.angustifolius* were found. The conclusion of the experiment is that mowing machinery acted as an effective dispersal agent of *R.angustifolius* seeds.

In **chapter 4**, a study on the importance of seed dispersal by hay-making machinery in a restoration area is presented. Seeds of 26 species were found on the machinery in large amounts in late June. Species were found which play an important role in succession during vegetation restoration (*Holcus lanatus*, *Rhinanthus angustifolius*, *Anthoxanthum odoratum*). Their occurrence on the machinery and seed amounts were related to their field abundancy. Several abundant species were not found because they had no seeds at the cutting date (*Caltha palustris*, *Juncus acutiflorus*). There was a difference in species composition between material accumulating at two machinery parts. This was related to plant height. It was concluded that dispersal by mowing machinery is moderately selective towards and against certain species. Seeds were transported from species-rich fields and deposited into species-poor fields and vice versa. Dispersal by machinery may have a larger impact on the speed of succession in the hayfields of the Drentse A reserve than any other form of dispersal and establishment from the seed bank. Therefore it is an important process from a community restoration perspective.

In **chapter 5** a theoretical framework was constructed to use the level of specialization of plant species in terms of dispersal in space and time, and life span of the individual plant, to define the safe site dynamics within communities' habitats. According to a few simple rules the predictability in space and time were defined. After that, the predictability of the habitat was linked to the best fitting combination of trait specialization level. Having defined this link, communities could be characterized by their level of predictability in space and time. For this purpose, the most frequent species of five different communities were ranked in two classes according to their level of seed dispersal capability, their seed bank formation (dispersal in space and time, respectively) and their life span. In this way a 'trait combination fingerprint' could be made for each of the communities. Communities were very different in the distribution of the species over the classes of trait combinations. The meaning of the coexistence of many trait combinations in one community was discussed in terms of spatial system hierarchy, succession, and species traits. Finally, the meaning of predictability in space and time for the restoration of communities was discussed.

In **chapter 6** an analysis is presented of the way results of fundamental seed bank- and seed dispersal research can be used in practical management. Knowledge about seed dispersal and seed survival of species with nature conservation interest is necessary to anticipate measures to enhance their establishment. The interpretation of the results from seed bank and seed dispersal research for conservation purposes is not always easy. In this chapter, an overview is given of methods used to estimate the importance of seed bank and seed dispersal during vegetation restoration. The consequences of the methodology of seed bank and seed dispersal research for decision making in nature management are discussed. Qualitative as well as quantitative methods only provide rough estimations of seed availability. However, such rough estimations could still prove to be very useful in restoration management.

Chapter 7 deals with the choice of reference information for reintroduction. In this chapter, historical relevés with *Arnica montana* and *Phyteuma nigrum* are used to demonstrate changes in the characteristic vegetation in which these species occur, and the implication for their use as a reference is discussed. Also in this chapter, a reintroduction experiment involving *Fritillaria meleagris* is used to illustrate what difficulties may arise when reference relevés are used. In the historical relevé dataset with *A.montana*, a major shift was found in species composition, linked to documented changes in environmental conditions in the course of 60 years. The same kind of changes was found in vegetation descriptions with *P.nigrum*, made in 1973 and 1991 in the Drentse A valley. It is concluded that historical data are hardly fit to use as reference for restoration and reintroduction in these specific cases, because the constellation resembling the historical situation may not exist or be restored any more. In the (unsuccessful) reintroduction experiment with *F.meleagris*, vegetation data from an area different from the introduction area were used in its evaluation. It is concluded that such vegetation data may be used as a relative measure only, in judging the suitability of sites for reintroduction.

In **chapter 8** a multidisciplinary study is presented designed to evaluate an attempt to restore a species-rich fen meadow (*Cirsio-Molinietum*). Soil acidification due to drainage in the surrounding area, was assumed to have caused the degeneration of the fen meadow. Flooding the meadow with surface water had been applied in order to stop the acidification. A small irrigated wetland (helophyte filter) was constructed to reduce nutrient availability in the surface water. Sod cutting was applied in a small area as an additional measure, to remove the acidified top soil. The two measures were evaluated in the framework of a research project including: (i) measurements of hydrological and soil factors, (ii) seed bank analysis, (iii) recording species composition in permanent plots, (iv) assessing the type and extent of nutrient limitations (v) assessing the effect of liming on vegetation biomass, and (vi) recording the growth of three introduced fen meadow species in the liming experiment. The research was carried out in a degraded site with intact vegetation, a degraded site where the top soil was removed by sod cutting and a reference site with intact *Cirsio-Molinietum* vegetation. After the integration of all results it was concluded that the restoration measures failed so far. The multidisciplinary approach enabled comprehensive conclusions about the restoration prospects and future measures in this particular area.

Chapter 9 gives an overview of general conclusions that can be drawn from the research presented in this thesis in the context of restoration ecology, with a focus on reintroduction. It is concluded that the theoretical framework necessary to formulate questions to be solved in relation to reintroduction becomes more and more sophisticated. The results of seed bank and dispersal research leaves little doubt about the necessity of reintroduction to re-establish many plant species during vegetation restoration. The feasibility question however still needs more answers. Some work on experimental reintroduction and the influence of genetic background on the success of reintroduction is discussed briefly. Suggestions for future research are made. Finally, it is concluded that the interface between theoretical science and the practice of nature conservation still presents a tremendous challenge to ecologists.