Fen communities

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Summary

Fens belong to the most threatened European ecosystems, being at the same time inhabited by a high number of rare plant species. Together with other types of wetlands, fens used to be widespread in lowland river valleys, but due to agricultural development, commonly accompanied by drainage, their area has decreased dramatically. In addition, fen biodiversity is declining today due to a cessation of traditional agricultural management, which has largely contributed to the development and stabilisation of species-rich plant communities. Today, fens are recognised amongst the main targets for nature conservation, but the effectiveness of this conservation is still unsatisfactory. This is related both to an insufficient ecological knowledge and to the complex socio-economical aspects of their conservation. In this thesis, ecology and nature conservation of fen systems are explored, as it is assumed that understanding the ecological mechanisms in fen communities will enhance their conservation planning and increase the effectiveness of the implementation.

The principles of fen conservation are largely based on the observed relationship between the occurrence of species or vegetation types and hydrological site characteristics. The ecological mechanisms that underlie these relationships remained however unclear, which hampers the interpretation of the processes occurring in fen communities and impedes the conservation planning. An analysis of these mechanisms is attempted in the first section of this thesis (**Chapters 2-5**). In particular, the presented studies aim at verifying the hypothesis that species assemblages along the hydrological and trophic gradients in fens are largely affected by the effects of interspecific competition for resources.

One of the reasons to expect a significant impact of competition on ecological tolerances of fen plants is that these tolerances differ between distinct but comparable areas. The existence of such differences was demonstrated by a comparison of hydrological parameters from habitats occupied by similar plant species in two European river valleys: the Drentse A Valley (The Netherlands) and the Peene Valley (eastern Germany) (**Chapter 2**). Most species had narrower ecological tolerances in the Peene valley and occupied wetter sites with a higher groundwater level fluctuation. Differences in intensity of competition in the two sites seem to be

a likely cause of the detected discrepancies. Especially competition for light might affect the species' habitats in the German site to a larger extent than in the Dutch site, because of a higher abundance of large herbs with broad shade-casting leaves in the former site.

A comparison between 13 fen and fen meadow communities indeed revealed a large variability in the light availability under the canopy (**Chapter 3**). The amount of sunlight reaching the ground ranges from values close to zero in reedbeds and productive wet meadows to c. 70% in open sedge-moss communities and small sedge dominated litter meadows. Using a CCA analysis, it is shown that light availability explains a large part of the variation in species occurrence in the Biebrza fens. The differences in light availability between the canopies of different plant communities are clearly reflected in the life strategies of the constituting species. In productive communities with very low light availability, plants develop morphological (big size) or phenological adaptations (early growth and flowering), which enable them to reach enough light. They tend to invest in vegetative propagation or in the production of large seeds, which are more likely to germinate in darkness and result in a larger seedling size. In low-productive communities, where light is in high supply, the number of strategies can be much higher.

To check whether the light intensity does, indeed, affect the response of fen species to groundwater levels, an experiment was conducted in controlled climate chamber conditions (**Chapter 4**). The growth of four species was studied in a factorial design of four water levels and three light levels, using sedge-moss peat as a substrate. Differences in water levels affected peat mineralisation rates producing a secondary gradient in nutrient availability, which is characteristic of peatland habitats. The results from this experiment confirmed the dominating role of light availability in regulating plant growth as compared to water level and nutrient availability. Moreover, it was shown that the physiological optima of species typical of low-productive fens may, indeed, be located in nutrient-rich sites, which are not accessible in nature because of the competition from species with a higher growth rate and a larger size. This interpretation was confirmed in a field transplantation experiment conducted in the Biebrza Valley (**Chapter 5**). Sod-blocks were replaced between a low-productive sedge-moss fen and a high-productive tall-sedge fen and both nutrient availability and light availability were manipulated thereafter. Once the competition for light was eliminated by vegetation clipping, species of the sedge-moss community were able to produce equal biomasses in the tall-sedge fen site and in their original site.

Species occurrence patterns in fen systems seem largely determined by the response to the gradients of moisture and light availability (see **Chapters 4 and 9**, figure 9.2). The presented studies focused on the role of competition for light.

There are some indications that there is no general trade-off between the intensity of competition for light and the intensity of competition for nutrients along the productivity gradients in fen systems. This is in concert with the concept that plant adaptations in nutrient-poor environments are towards optimising nutrient use efficiency, rather than nutrient uptake rates. The distribution of species along the moisture gradient is related to their tolerance of anoxia and traits important for the survival of flooding, whereas the light gradient filters species according to their competitive ability for this resource. Moreover, due to a trade-off between efficient use of light vs. nutrients and water (cf. **Chapter 4**), fen plants may be more flexible in their relation to the water level conditions if they have enough light. These results suggest that the major impact of low nutrient availability and regular mowing management on the biodiversity of fen systems lies in lowering the effects of light competition.

The second section of the thesis (**Chapters 6-8**) tackles practical aspects of fen conservation, focusing on the Polish scenery, where some fens and fen meadows are still preserved in remnants of traditional cultural landscapes. However, as it is outlined in **chapter 6**, as much as 86% of the fens have been agriculturally reclaimed, whereas the remaining ones are largely endangered. The main threats are related to the abandonment of management, an on-going drainage by old amelioration systems and conflicts between fen conservation and other land-use types (e.g. intensive agriculture, forest plantations). Until now, the national system of nature conservation did not include instruments of active conservation, in terms of management or ecological restoration. As a result, the processes of secondary succession cause a decline of fen biodiversity within protected areas, as well as outside them. New hopes to change this situation are linked to the perspective of Poland's accession to the European Union and a proper application of agri-environmental programmes and the Natura 2000 network of protected areas. On the other hand, however, the accession may also impose a threat to fen biodiversity, due to subsidising intensive agriculture and afforestation of marginal agricultural grounds.

An important aspect of fen conservation is the restoration of degraded sites, which is undertaken increasingly often by some nature conservation organisations in Poland. In **Chapter 7**, a conceptual scheme for the assessment of the restoration feasibility of sedge-moss fens is developed and tested on 6 case areas. The criteria proposed include the hydrological regime, a degree of soil transformation, changes in plant communities and the socio-economical prospects of project continuation. It is concluded that the restoration of fen vegetation should be attempted if it may contribute to a better protection of threatened species and if there are chances to apply a management scheme to the restored plant communities.

In a strategic approach to nature conservation, it is necessary to include a spatial analysis of the resources. The Econet system (a pan-European ecological network) from the beginning gave special value to wetlands of major river valleys, which formed the ecological corridors. In **chapter 8**, an analysis of the actual extent and state of wetlands in the Polish part of this network is presented. The Econet-Poland covers 46% of the country area and incorporates 66% of all fen peat deposits in Poland. Their condition is better than outside the network, which is apparent from a larger percentage of wetland vegetation types. Although Econet will not be implemented in practice, it can function as a reference for the implementation of other nature conservation systems, e.g. the Natura 2000 network.

In the final, discussion **chapter 9**, a multi-approach analysis of fen conservation perspectives is presented, leading to the conclusion that a closer integration of scientific research, active nature conservation and agricultural policy is necessary to protect the biodiversity of these ecosystems. Fundamental ecological research can facilitate conservation practice by more accurate predictions about ecological processes, including developments which have not yet been observed and described in nature and allowing in this way for a better conservation planning. On the other hand, the scientific understanding of fen communities could largely benefit from a proper monitoring of the applied conservation measures.