in the Biebrza
125-137.

ologische Flora

d. Thieme,

ent of the

osition of fen
W.J. and R.A.

mit Selen als

halk grassland

Summary

Species-rich fen meadows in north-western Europe are seriously threatened. During the last decades, it appeared that nearly all fen meadows are severely disturbed or have even vanished due to more intensive land use and technological improvements in agricultural production. What is left are isolated patches of mostly disturbed fen meadows in an intensively used landscape. Nowadays, much effort is put in conservation and restoration of those fen meadow sites.

Studies of undisturbed or nearly undisturbed fen meadows show complex interactions between hydrology, soil and vegetation. Disturbance mainly involves moderate to very deep drainage and an increased artificial nutrient input (mainly N and P). Severe drainage of fen peat caused physical and chemical changes of the soil. An increased mineralisation rate due to a more aerobic soil environment as well as a larger nutrient input from outside the fen system resulted in eutrophication. This has favoured a few fast-growing plant species at the expense of several characteristic fen meadow species.

This thesis reports on a study aimed at improving the success rate of restoring disturbed fen meadow sites and characteristic fen meadow plant communities. Chapters 2 and 3 focus on the differences in the type and extent of nutrient limitation of undisturbed fen meadow communities and neighbouring communities disturbed by severe drainage. A comparative study of a relatively wet site, harbouring a species-rich *Calthion palustris,* and a neighbouring drained and degraded site assessed nutrient deficiency (concerning N, P and K) in the field as well as in a greenhouse experiment. Experimental rewetting of intact sods was applied to study the perspectives of rewetting for restoring this type of vegetation. The phytomass yield in the wet site was mainly limited by nitrogen while the yield in the drained site was only limited by potassium. Rewetting intact sods, taken from the drained site, did not change the phytomass yield or the type and extent of nutrient limitation. Rather similar results were found in a species-rich *Caricetum nigrae* and a nearby located species-poor drained fen meadow. It was concluded that those two plant communities, when relatively undisturbed, are characterised by N limitation. Hay cropping and leaching of potassium are thought to have led to a reduction of plant-available K in drained sites.

In each of the aforementioned study areas, soil was collected from the wet site and from the neighbouring drained site. *Holcus lanatus* was used as a phytometer for determining the nutrient supplying capacity of peat soils under wet conditions and drained peat soils when drained and rewetted. This experiment (Chapter 4) revealed that past drainage of peaty soils

caused a decrease in the K-availability for the vegetation. Rewetting did not entirely remove the K-deficiency but additionally established a more pronounced N-deficiency. Furthermore, comparing the results of the field fertilisation experiments at the community level with the phytometer test in the laboratory showed the general difficulty of linking results of laboratory experiments to field situations.

Chapter 6 deals with the type and extent of nutrient limitation that was assessed for three different plant communities occurring in one fen meadow. It was studied whether restoration practices in a disturbed site result in a type and extent of nutrient limitation comparable to a relatively undisturbed fen meadow site. A fertilisation experiment using intact sods showed co-limitation of N and P for a *Caricion davallianae* and a *Juncus subnodulosus* community. The phytomass production of the *Calthion palustris* was mainly limited by N. Recordings at the species level allowed assessment of the most responsive plant species or species groups in case of deficiency of a particular nutrient. Comparing phytomass measurements with the results of tissue analyses, it was concluded that N:P ratios should not be used as an indicator for nutrient limitation. The experiment also indicated that restoring disappeared plant communities requires more than redeveloping a similar type and extent of nutrient limitation as to be found in a reference community.

The final chapter of this thesis reviews the concept of nutrient limitation as well as its interaction with past drainage and future rewetting of those severely drained peat soils. Different methods of assessing nutrient limitation were compared and the type and extent of nutrient limitation were determined for several different wet grassland communities. It was concluded that a full-factorial field fertilisation experiment is the most preferable method. Plant tissue analyses and soil chemical analyses are considered less suitable although they may provide helpful additional information. Fertilisation experiments in the laboratory using sods or test plants appear proper means to study mechanisms or processes but have a restricted predictive value for field situations. Generalising the results, it seems that many relatively undisturbed grassland plant communities on peaty soils are characterised by N limitation. Phosphate limitation for vegetation on peat soils is mainly observed in specific circumstances such as extreme calcium richness high concentrations of ionogenic Fe or Al or as a result of drainage or long-term hay cropping. The latter two may also cause K-limitation.

An important issue in restoring disturbed sites is defining properly our goals. Without this, we cannot determine to what extent restoration attempts are successful. The next step is to choose an approach for a site-specific problem analysis, review the objective of the restoration, the selection of restoration measures and evaluation of the restoration. This is the focus of chapter 5, reviewing an integrated multidisciplinary approach that was used to evaluate an attempt to restore a *Cirsio-Molinietum,* a fen meadow community that has

become very rare in th
research of environme
caused by soil acidific
expert judgement and p
taken by the nature co
hydrological and soil fa
permanent plots, (iv) a
factorial fertilisation ex
and (vi) recording the
experiment. The result
study has shown that th
could not be countera
approach enabled draw
particular area and that t

Rewetting is regarded as
for further restoration
(developing a wet grass
individual site condition
parameters is involved ar
detail desired and on the
judgement, environmenta
to the most optimal resto
grassland communities on
reach our goals. It also
communities. Perhaps we
communities.

become very rare in the Netherlands. The approach included descriptive and experimental research of environmental and biotic factors. The degeneration of the fen meadow was caused by soil acidification due to drainage in the surrounding area as was indicated by expert judgement and preliminary research. A study was undertaken to evaluate measures, taken by the nature conservation authorities. The research comprised (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 limitation using a full factorial fertilisation experiment, (v) assessing the effect of liming on vegetation biomass, and (vi) recording the growth of three introduced fen meadow species in a liming experiment. The results of the different experiments and field measurements from this study has shown that the restoration measures failed so far, probably because acidification could not be counteracted satisfactorily. It was concluded that the multidisciplinary approach enabled drawing adequately conclusions about the restoration prospects of a particular area and that this approach is suitable for other restoration attempts as well.

Rewetting is regarded as a prerequisite in restoring wet grassland communities. The choice for further restoration measures depends on the aims of the management authorities (developing a wet grassland or developing a specific wet grassland community) and the individual site conditions. But, one must realise that a whole set of abiotic and biotic parameters is involved and should be considered at the same time. Depending on the level of detail desired and on the financial budget available for the restoration, a combination of expert judgement, environmental measurements, monitoring and experiments may be applied to come to the most optimal restoration measures. The success rate of attempts to restore species-rich grassland communities on peat soils is still rather low. Possibly, we need a longer time span to reach our goals. It also may not be feasible yet to focus too much on target species and communities. Perhaps we should settle for the aim of relatively low-productive species-rich communities.