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Moving gradients

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Summary

Lowland brook valleys in northwestern Europe used to contain many rare plant species but their value has decreased sharply during the last decades. Regeneration of degraded valleys has, therefore, a high priority but prospects are often difficult to assess due to the complex interactions between hydrology, soil and vegetation. One way to improve such assessments would be to study the relation between site conditions and landscape processes and this approach is the focus of this thesis.

A study of undisturbed reference sites is not possible in the Netherlands because such areas no longer exist there. One way to overcome this problem is to make a reconstruction of landscape development on the basis of peat remains. Research in the Gorecht area showed that peat-building started in a floodplain mire along the river and spring mires and/or swamp mires along the valley flanks. During the Subatlantikum the groundwatertable rose and a groundwater-fed mire developed in the center of the area with only narrow bands of floodplain along the river and a small bog along the edge of the valley. During the most recent phase of peat-formation this groundwater-fed mire was replaced almost entirely by a eutrophic floodplain, only a very narrow zone close to the valley margin remained low-productive fen.

In the next chapter emphasis is placed upon the actual conditions in an existing mesotrophic fen. Measurements were carried out in the *Lieper Posse*, a presumably undisturbed fen in north-eastern Germany. It soon appeared, however, that the area was not undisturbed at all but instead was suffering from a prolonged low-intensity drainage. Hydrological investigations showed that the original mineral rich groundwater had become replaced almost entirely by acid rainwater. Base-rich conditions still occurred in a shallow top-layer but this buffer is probably diminishing very slowly and the ultimate fate of the area seems a development into a small bog.

In most Dutch brook valleys the hydrology has been affected to a high degree but some of these systems still contain rare species. *Ranunculus hederaceus* is such a species and is confined to running waters with a constant supply of mineral poor groundwater, originating from highly fertilized fields. Analysis of the relation between species performance and chemical composition of the water showed significant correlations for calcium, bicarbonate, sodium, chloride and sulphate-fluxes in the water. It seems unlikely that *Ranunculus hederaceus* actually prefers the relatively low nutrient availability in these systems. Instead competition for light with algae and large helophytes is more likely to be a major reason for its absence in stagnant, eutrophic waters.

The hydrological and ecological functioning of a cultivated river plain in the northern part of the Netherlands were studied in order to assess the feasibility of alternative restoration scenarios. There appeared to be large differences in patterns in the chemical composition of the groundwater and the actual water flows. It appeared that water flow was downward in most sites where very Ca-rich groundwater was present, contrary to the past when the direction of flow was upward. Since a constant supply of base-rich water is an essential condition for mesotrophic fen vegetation it was concluded that under the present conditions the regeneration prospects for these vegetation types are poor. It is suggested that the most definitive solution would be to reactivate the former seepage belt but at the same time it was realized that the socio-economic costs of this alternative are very high.

One way to increase the area with mesotrophic fen vegetation would be to start the terrestrialization of open water again. This process was studied in a former peat cutting area in the northern part of the Netherlands. It appeared that mesotrophic fens could develop also in an infiltration area if base-rich and nutrient-poor surface water was sufficiently available but this situation seems much less stable than under conditions of groundwater supply. Acidification does not occur as long as alkaline surface water can move freely underneath the floating mat but when a given site becomes disconnected from the surface water the depletion of bases by infiltrating rainwater is no longer compensated. A rough estimate of the acidification rate shows that three decades are sufficient for a floating mat of 40 cm to become completely decalcified and this corresponds well to the observed succession from rich fens to embryonic bogs in the same period. It is suggested that the best way to preserve rich fen vegetation is to start the succession over and over again by digging turf ponds every few decades.

Mesotrophic communities such as litter meadows can also survive in secondary gradients. One example in a narrow strip of land between a lake and a deeply drained polder was studied to understand which mechanisms allow for the survival of this vegetation type under seemingly unfavourable conditions. Water budget calculations showed that upward and downward water flow alternated during the year. Evapotranspiration losses generated an upward flow of base-rich groundwater during the summer but this was not sufficient to compensate for the infiltration of base-poor rainwater during the winter and on a yearly this resulted in a small but significant loss of bases. It was concluded that the life-expectancy of the litter meadow depends on soil conditions rather than hydrology. Combining the leaching rate with the total stock of Ca showed that it would take several decades before the upper 30 cm was completely decalcified. Obviously there is no immediate danger of acidification but in the long run measures have to be taken.

The last chapter sums up which measures have to be taken in order to successfully restore degraded brook valleys. A lowering of nutrient availability is the first necessary step to convert agriculturally used brook valleys into areas with higher biodiversity. Based on literature it is concluded that N- and P-availability will probably remain high during several decades but that K-availability is likely to

decrease when infiltrating rainwater is the main water source. However, this will also stimulate acidification of the site.

Once site conditions have been restored the vegetation composition depends on species availability. Estimations based on seed bank characteristics show that especially seeds of common meadow species are likely to have survived unfavourable conditions and are most likely to reappear in restored sites. Other species have to rely on dispersal to reach new sites and here, too, common species seem to have the best chances. The last step in the restoration process is the establishment of species. Species typical of highly productive vegetation types seem to have the best chances of invading existing communities.

It is concluded that in wetland restoration projects the rehabilitation of eutrophic floodplains has a much better chance of success than all other options. This implies that protection of the remaining sites with mesotrophic communities should be given the highest priority. Eutrophic communities should be the target only when mesotrophic communities have disappeared completely.