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Nature Management Experiments in a Derelict Reedmarsh. II: Effects of Summer Mowing

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ABSTRACT

Lowering of the summer water table, eutrophication and dereliction have caused severe ruderalisation of the marsh vegetation of the Belgian wetland site, The Blankaart. Management experiments, based on an annual summer mowing regime, have shown that the ruderalised mixed-fen vegetation with dominance of competitive species such as Calamagrostis canescens *and* Glyceria maxima, *which has completely lost its reedland character, can develop into a more diverse hayfield vegetation. However, the high nutrient status of the marsh and difficulties with the invasion of seed of hayfield species, due to the changed environment, discourages further distinct changes of the vegetation.*

INTRODUCTION

The beneficial effects of winter cutting on the ruderalised marsh and fen vegetation of the derelict reedmarsh of 'The Blankaart' (Belgium), have been discussed in Part I of this paper (Gryseels, 1989), which also contains a description of the environmental and ecological characteristics of the study site.

Parallel to research on the effects of winter cutting, experiments were also carried out to examine the evolution of the vegetation when it is mown in summer, particularly the effect on *Calamagrostis canescens*, which has

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greatly increased (Gryseels, 1985) due to drainage and consequent lowering of the water table during spring and summer, and dereliction of the marsh. *Calamagrostis* has suppressed the reed and mixed-fen vegetation, in which *Phragmites australis* is the normal dominant. This can even be considered as a relatively stabilized vegetation, which has developed instead of the normal carr. The seeds of shrubs cannot germinate due to the enormous mat of litter (Gryseels, 1985). Dominance of *C. canescens* after disturbance and drying out of an organic, peaty soil has been reported by several other authors (Segal, 1966; Hejny & Husak, 1978; Boedeltje & Bakker, 1980).

From a floristic and structural point of view, *C. canescens* forms a transition between fen and hayfield vegetation. It was therefore interesting to study how this vegetation would respond to a typical summer hayfield mowing regime. Would this provide opportunities for hayfield species, many of which have disappeared or declined as a result of intensive agriculture and drainage of the valley? Similar questions arose with the *Glyceria maxima* vegetation, which is only locally present near ditches at the edge of the marsh, but always bordering hayfields.

METHODS

Sampling

In the reedmarsh, four experimental plots (200–300 m^2) were chosen, each divided into a variable number of permanent quadrats, representing different vegetation types (Table 1)—*C. canescens* and *G. maxima* community, and, for comparison, a typical *P. australis* community. No plots were chosen near the shore, since this area is too wet to permit possible succession to a hayfield vegetation.

In early July 1978 the vegetation of these quadrats was described by relevés, according to the Braun-Blanquet method with the Londo-scale (see Gryseels, 1989). The plots were then mown and the litter was carefully removed. In 1979, 1980, 1981 and 1982, the plots were mown twice each summer, once at the beginning of July, and once at the end of August or the beginning of September. Relevés of the quadrats were made before the first mowing in July. After 1982, the plots were mown only once each summer (end July–early August). Relevés were made again only in July 1986.

Analysis

The same techniques were used as for the analysis of the data in the case of the winter cutting experiments, i.e. comparison of the yearly relevés,

TABLE 1
Description of the Plots

	Plot I	*Plot II*	*Plot III*	*Plot IV*
Area (m^2)	225	300	300	225
Number of quadrats	12	19	3	5
Position in the zonation	Middle of the succession: between the pondside and the shrubs	Along a ditch at the edge of the marsh	At the end of the succession, by the edge of the marsh	
Vegetation type	Vegetation dominated by *Phragmites*, *Calystegia*, *Urtica*, with other marsh plants and, locally, transition to *Calamagrostis* mixed-fen	Mixed-fen with *Glyceria* and *Rumex hydrolapathum*	*Calamagrostis*-dominated fen	
Ecological conditions	Peaty underground	Much silt and very nutrient-rich: irregularly flooded	Peat	Peat

All plots have been mown twice in summer from 1978 to 1982; as from 1983, they were mown only once in summer.

TWINSPAN and Detrended Correspondence Analysis (DCA). Data were summarized by using frequency and mean cover value of the species (see Gryseels (1989) for further explanation).

These data were used to illustrate species evolution (Figs 1–6). Only one Detrended Correspondence Analysis of the relevés is presented here (Fig. 7).

RESULTS

The vegetation of the mown plots was shown to change markedly: typical smaller grasses (e.g. *Poa trivialis*) increased, taller marsh grasses (*P. australis*, *C. canescens*, *G. maxima*) and tall marsh plants declined. Species density also increased.

Effect on dominant species

Mowing in summer had a negative influence on cover, density, height, vitality and flowering of *P. australis*. Two seasons of summer mowing resulted in a different vegetation structure, no longer dominated by *Phragmites*, although it remained an important species (Fig. 1). This effect was also linked with the decrease of the originally codominant, competitive species such as *Urtica dioica* and *Calystegia sepium*. Where *C. canescens* or *G. maxima* were codominant, *Phragmites* degenerated much more rapidly. The effect of competition is also well illustrated by *P. trivialis*: once this species was well established, it became more difficult for the reed to persist. Nevertheless, *Phragmites* kept a cover value of 10 to 20%, and this hardly changed when there was only one mowing a summer.

There was a rapid decline in the cover of *C. sepium* (Fig. 2); the high frequency evident in the figure is due to seedlings and juvenile plants, developed from small pieces of rhizome. Regeneration of *C. sepium*, when mowing only once a year, can therefore take place easily (e.g. plots II and III).

U. dioica also declined (Fig. 3). Nevertheless, some disturbance effect was noticed in the first year after mowing: a mass invasion of *Urtica* seedlings, which, however, remained in a juvenile state. After some years, the species still persisted, but with very low cover values.

C. canescens did not change much (Fig. 4), although at first there seemed to be a small increase, probably a disturbance reaction, just as with *U. dioica*.

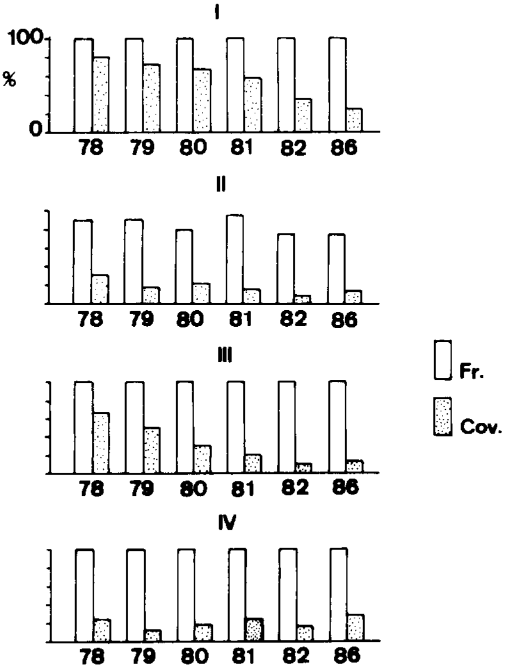

Fig. 1. *Phragmites australis*: frequency (Fr.) and mean cover value (Cov.).

After a few years of cutting, the species tended to be well represented (except for plot III), but in a different manner: more shoots were produced, giving a more homogeneous grass mat, while the patchy structure, with tall and large tussocks, disappeared, so the grass mat became more open.

G. maxima is favoured by summer mowing (Fig. 5): this species spread over all the plot, which explains the rise in frequency. The mixed *Glyceria–Phragmites* vegetation changed towards a pure *G. maxima* stand (see also Fig. 1, plot II: decrease of *Phragmites*), which was very dense, tall (1·5–2 m), and productive. Nevertheless, after a few years of repeated summer mowing, the *Glyceria* stand became more depauperate and open, as the individual plants grew less tall and were not as vigorous or produced fewer flowers. Vegetative spread was intensive, however. When mowing was reduced to once a year in mid-summer, the species grew taller again, but vegetative spread was more or less debilitated, resulting in a decline of total cover.

Effect on species richness

In all plots there was a marked increase of species density which led to more diversity in the vegetation (Fig. 6). Several species groups (defined in Table 2)

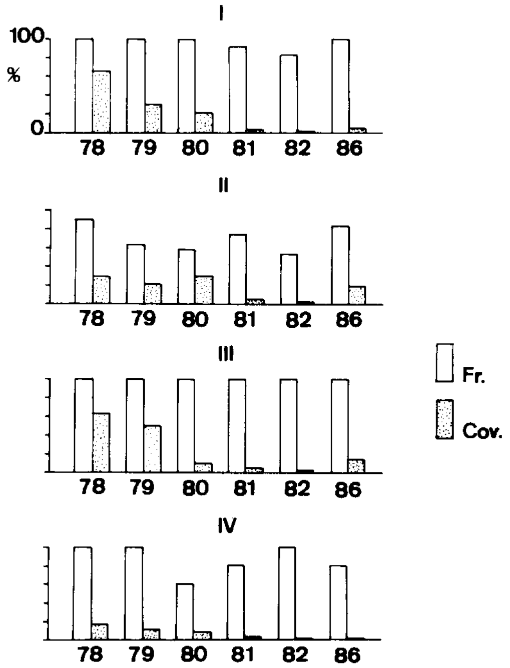

Fig. 2. *Calystegia sepium*: frequency (Fr.) and mean cover value (Cov.).

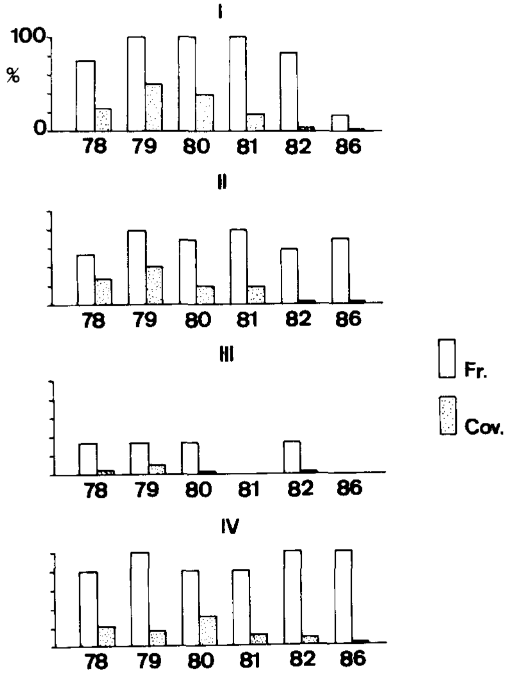

Fig. 3. *Urtica dioica*: frequency (Fr.) and mean cover value (Cov.).

could be recognised. 'Hygro-nitrophilous' species were poorly represented, in contrast to the plots which were cut during winter.

More important is the group of the typical 'marsh plants'. The smaller plants, represented only sparsely in the marsh, spread very fast in the plots, e.g. *Myosotis scorpioides*, *M. cespitosa*, *Galium palustre*, *Scutellaria galericulata*, *Epilobium parviflorum*, *E. ciliatum* and *Cardamine pratensis*. Some of these (*S. galericulata*, *M. cespitosa*) reached exceptionally high cover values during the first years of management. Nevertheless, most of these species remain rather slender, and not as tall as in the unmown vegetation.

The same observation can be made for the taller marsh plants, such as *Rumex hydrolapathum*, *Carex riparia*, *Iris pseudacorus*, *Mentha aquatica*. There was a slight increase of these species in the mown plots, but always of young individuals, either from seed of the plants originally present, or from vegetative spread. These new plants mostly remained juvenile or did not flower.

Some marsh plants disappeared altogether after summer mowing, e.g. *Solanum dulcamara* and *Typha latifolia*, and, when in a competitive position, also *Phalaris arundinacea*.

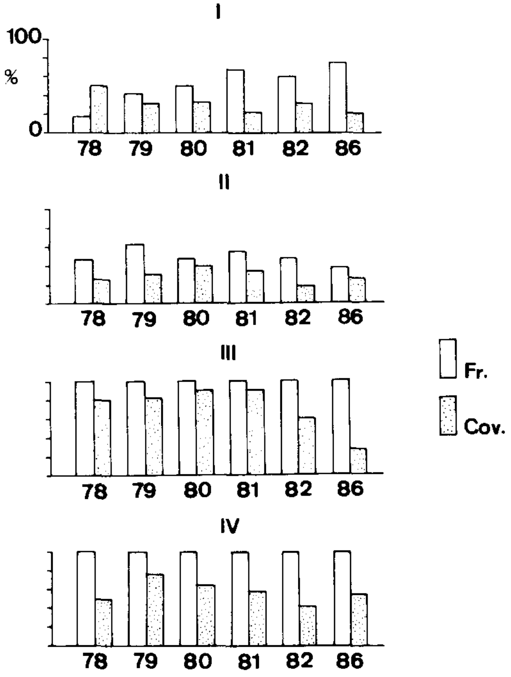

Fig. 4. *Calamagrostis canescens*: frequency (Fr.) and mean cover value (Cov.).

'Tall forbs' responded negatively to mowing, as also did the taller marsh plants. There was a 'qualitative' decrease: the plants were much less vigorous and flowered less. After several years of management, some individuals even disappeared. Nevertheless, there was usually an increase in the number of plants, but this was due to the presence of smaller or juvenile individuals. Only the tall forbs which flowered early in summer (e.g. *Filipendula ulmaria*) were more or less unaffected by this mowing regime.

Most important in this experiment was the appearance of a species group new to the marsh: 'hayfield plants' such as *Lychnis flos-cuculi*, *Poa trivialis*, *Carex disticha*, *Ranunculus flammula*, *Oenanthe fistulosa* and *Ranunculus acris*.

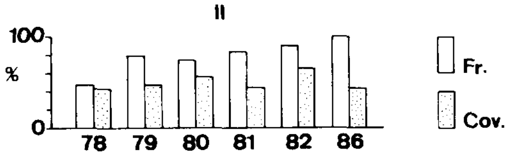

Fig. 5. *Glyceria maxima*: frequency (Fr.) and mean cover value (Cov.). Plot II only.

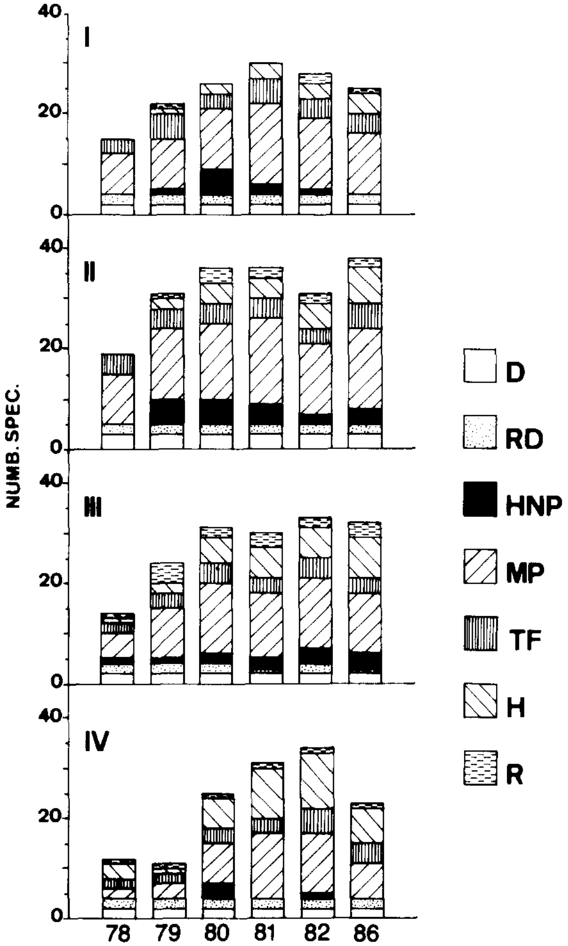

Fig. 6. Change in total species number and species diversity in plots I–IV. D, dominants; RD, ruderal dominants; HNP, hygro-nitrophilous plants; MP, marsh plants; TF, tall forbs; H, hayfield plants; R, rest. (For further explanation on the species groups, see Table 2.)

The expansion of *P. trivialis* was striking. After a few years of summer mowing the species developed a closed grass layer in all plots, while other hayfield grasses (*Holcus lanatus*, *Alopecurus pratensis* and *Anthoxanthum odoratum*) were only present as a few individuals. The hayfield dicotyledons invaded the vegetation only after 2 to 3 years of summer mowing but once established, they spread fast.

Bryophytes did not develop very well in the plots, in contrast to the observations made in the winter cut experiments. Only after a few years did

TABLE 2
Recognised Species Groups and Their Strategies

Species group	*Strategy*	*Species*
Dominants (D)	Competitor Stress-tolerant competitor	*Phragmites australis, Glyceria maxima* *Calamagrostis canescens*
Ruderal dominants (RD)	Competitor (ruderal character)	*Urtica dioica, Calystegia sepium*
Hygro-nitrophilous plants (HNP)	Ruderal Stress-tolerant	*Ranunculus sceleratus, Rorippa islandica, Atriplex prostrata, Rumex maritimus, Oenanthe aquatica, Alisma plantago-aquatica, Bidens tripartitus, Polygonum hydropiper, P. persicaria*
Marsh plants (MP)	Different strategies	*Cardamine pratensis, Galium palustre, Scutellaria galericulata, Myosotis cespitosa, M. scorpioides, Rorippa amphibia, Epilobium ciliatum, E. parviflorum, E. palustre, Carex pseudocyperus, Rumex hydrolapathum, Lycopus europaeus, Rumex sanguineus, R. conglomeratus, Carex riparia, Iris pseudacorus, Mentha aquatica, Sium latifolium, Lathyrus palustris, Ranunculus lingua, Polygonum amphibium, Typha latifolia, Solanum dulcamara*
Tall forbs (TF)	Competitor	*Lythrum salicaria, Lysimachia vulgaris, Filipendula ulmaria, Valeriana repens, Thalictrum flavum, Epilobium hirsutum, Symphytum officinale*
Hayfield plants (HP)	Different strategies	*Poa trivialis, Rumex acetosa, Carex disticha, Ranunculus repens, R. acris, R. flammula, Lychnis flos-cuculi, Oenanthe fistulosa, Vicia cracca, Taraxacum* sp., *Phleum pratense, Alopecurus pratensis, A. geniculatus, Agrostis stolonifera, Lotus uliginosus, Stellaria palustris, Angelica sylvestris, Cirsium palustre*
Bryophytes	Stress-tolerator	*Brachythecium rutabulum, Eurhynchium praelongum, Leptodictyum kochii, L. riparium, Amblystegium serpens, Calliergonella cuspidata, Drepanocladus aduncus*

mosses appear (including some less common species, e.g. *Drepanocladus aduncus* in plot I).

The impact of management is well illustrated in Fig. 7. It is clear that the longest managed plots are situated at the top of the figure, which suggests the strong impact of management on changes in the vegetation. Zonation effects have the greatest influence, however, due to the heterogeneity between the 4 plots (except for plots III and IV).

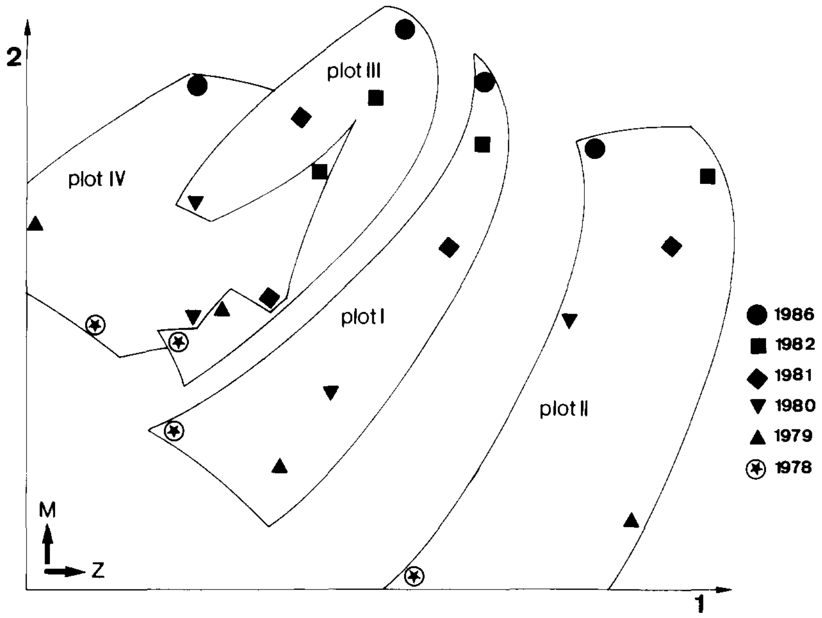

Fig. 7. Detrended Correspondence Analysis (DCA) relevés ordination of the summarised data per plot per year. Arrows indicate 2 ecological gradients: M, management; Z, zonation.

DISCUSSION

Changing vegetation structure and increased species diversity: the role of storage organs, vegetative expansion and litter removal

Dominant species

The decline of *P. australis* as a result of summer mowing has been discussed by several authors (Haslam, 1969*a*, *b*, 1970*a*, *b*, 1971, 1972; Allen & Pearshall, 1963; Fiala, 1976; Husak, 1978; Krisch *et al.*, 1979). At the end of the summer, nutrients are transported from the leaves to the rhizomes, where the new buds for the next season are formed. The amount of available nutrients determines bud width, which in turn determines the potential final height of the reed (Haslam, 1969*a*,*b*; Mook & Van der Toorn, 1982). Cutting in July limits the amount of nutrients, by inhibiting growth and photosynthesis for half the growing season.

There was no evidence of a decline in reed performance, as reported by Haslam and most other authors. Dykyjova & Husak (1973) suggested that controlling reed growth by cutting at the peak of the summer season was not sufficient unless the cutting was repeated during the same growing season. But even the double mowing regime which was undertaken since 1979 did not prevent the reed from recovering. Haslam (1969*a*) suggests that a reed population can persist under regular cutting in July, but only when there is no competition from other species. In this experiment, *C. canescens* and, at a later stage, *P. trivialis* were effective competitor species.

The effect of summer mowing on reed is thus not always as destructive as reported in the literature. This must be attributed to the high nutrient status of the Blankaart marsh, which allows the reed to recover quickly from cutting (new growth from sleeping buds). In such a nutrient-rich area, cutting twice in summer is necessary to cause reed to decline and to enable other species to enter the sward. Once competition with other species becomes possible, the structure of the dominant reedbed changes.

G. maxima is very tolerant of summer mowing. This is correlated with its high tillering power and ability to produce new shoots all year round (Lambert, 1947, 1948; Buttery & Lambert, 1965; Buttery *et al.*, 1965). As *G. maxima* increases, *P. australis* decreases, weakened by summer mowing. A similar evolution was also observed by Lambert (1947) and Buttery & Lambert (1965). The relative stabilisation which is noticed after some years is probably the result of the combined effects of three factors: (1) the ultimate weakening of the plant after mowing twice each summer; (2) removal of the litter mat, which, together with the high amount of deposited silt, provides an ideal nutrient layer; (3) the greater competition, e.g. from *P. trivialis*.

The decline of *U. dioica* was caused by the removal of its superficial roots with the litter, although, after the plot is mown, the plentiful seed can germinate freely in the favourable conditions of open surface, light, and high July temperature. However, as management prevented full development of the seedlings, an almost complete disappearance of *Urtica* was achieved within a few years.

The rapid regression of *C. sepium* can be explained by (1) mowing during the full vegetation period. The vegetative expansion of the root system takes place in late summer and autumn (Kopecky, 1965) and thus by mowing twice during the summer the competitive ability of the plants is reduced. (2) Removal of the litter mat, including removal of part of the roots. (3) The change in the vegetation to a lower, more open structure; *C. sepium* preferring a high, ruderal tall forb layer. Nevertheless, small pieces of rhizome, which are always present in the superficial soil layer, regenerate readily and explain the high frequency of small, juvenile plants.

Mowing of *C. canescens* prevents ‘ruderalisation’ and results in a more equal grass layer. Initially, mowing does not appear to operate through a reduction in frequency of this species. Rowell *et al.* (1985) noticed comparable effects with experimental July cutting in Wicken Fen, UK. During the later decline, competition with *P. trivialis* is especially important. The occasional summer floodings of 1980 and 1981 probably also depressed growth (see Gryseels, 1989).

Species diversity

The correlated effect of litter removal and regression of dominant species provides an open, illuminated space suitable for germination, and permits the spread of marsh plants. The rarity of hygro-nitrophilous species is linked with the lack of silty, open mud in the summer plots, where there is mostly a dense grass layer.

Although for most other marsh plants rapid spread is possible due to the lack of competition, optimal development is not guaranteed, reflected in the less vigorous growth of the taller forbs. The initially favoured vegetative spread or juvenile development is reversed by mowing in the full vegetation period because the storage organs become depleted. That is also why *Typha latifolia* disappears under a summer mowing regime, as has already been noticed by Hejny (1960), Fiala (1973) and Husak (1978). The process is caused by the same ecological factor which determines the regression of reed. In *T. latifolia*, nutrient transport from leaves to rhizomes takes place rather late, at the end of the summer (Husak, 1978), so is prevented by mowing in July. This explains the more severe regression of this species, in contrast to *P. australis*.

The quick expansion of *P. trivialis* is easily understood. There is a quantity of seed in the environment (fertilized hayfields) at the time of mowing, and, once established, the species tends to spread very quickly, with its high tillering power, behaving here as a 'ruderal-perennial' herb (Grime, 1979). Coexistence with other dominant grasses is possible through its complementary phenology. Other hayfield grasses enter the vegetation much more slowly. The lack of gaps in the closed grass layer of *P. trivialis*, suitable for seedling emergence, is not solely responsible for this. The limited invasion of seed is also an important factor.

The reason for the poor representation of bryophytes in the summer plots is unclear, as litter removal, open space, and a rather peaty soil, which seem to be the best conditions for good moss development (see Gryseels, 1989), also obtain here. One explanatory factor may be the timing of the management, which provides these open conditions in summer: best development of mosses takes place in spring. Another contributory factor may be the development of the closed grass layer. Moss development is thus only possible when some vegetation gaps become available.

The correlation between the effect of management and external, environmental factors: the influence on floristic diversity

It is important to note that the effects of mowing in relation to hayfield development are different in the 4 plots. As all are located at the edge of the marsh, direct zonation effects (e.g. inundation) cannot be responsible (as in the case of the winter cut plots, see Gryseels, 1989). The mowing effect is influenced by other factors, indirectly correlated with zonation: (1) the original dominant species, determined by the stage in the succession and the degree of ruderalisation; (2) the proximity of hayfields.

The evolution to a hayfield formation is most pronounced in plots III and IV: *C. canescens* vegetation most resembling it in structure and aspect.

In plot II, dominance of *G. maxima* restricts the evolution to a more open and richer hayfield vegetation.

In plot I, a particular type of vegetation is developing: a flower-rich, but depauperate, reedbed persists, as there is little competition from other grasses.

In contrast to the winter cut plots, there is a different trend in floristic diversity. After stabilisation of the smaller marsh plants, which reach full development here, more 'new plants' appear. The management has created a new biotope, where other species find more favourable ecological conditions. Environmental factors such as winter flooding provide normal circumstances for nutrient-rich hayfields. Mowing prevents the full development of competitive marsh dominants, and, by litter removal, enables smaller marsh and hayfield species to establish and grow together.

Implications for future management: limitations to the increase in species diversity

Although the experimental management has resulted in clear differentiation in the vegetation, it remains species-poor. There are two main reasons for this:

(1) The environment is still too nutrient-rich. Although the mowing regime results in a reduction of the standing crop and in a certain depletion of nutrient reserves in the soil, there are still inundations of nutrient-rich, silty water. Although this is a normal ecological factor, the water quality has given this a very ruderalised 'dimension'. Some plants are scarcely suppressed (e.g. *G. maxima*), while new competitive dominants (e.g. *P. trivialis*) invade the vegetation and in turn prevent the invasion of new plants.

(2) Although the experiment was situated in a wetland environment, it concerns mostly very highly fertilized, species-poor hayfields. Many typical hayfield 'flowers' have become very rare. The invasion of seed is thus difficult.

It is clear that, for a real development to hayfield, the experiment must be continued, and deliberate introduction of seed of former usual hayfield species should be considered. Nevertheless, as long as the water quality remains unchanged, the impact of a summer mowing management will be limited.

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