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fractions of the original amounts of N, P and K appeared to be well explainable by a decreasing exponential relation with a non-zero asymptote. The average remaining fraction after 4 weeks amounted to roughly 67% for nitrogen, 50% for phosphorus and 25% for potassium, the latter further decreasing to an average asymptotic value of 10%. The differences between the elements were already significant after 1 or 2 weeks.

Regression models showed that the differences between sites could be explained best by the chemical composition of the vegetation at the time of cutting. The remaining fractions of the original dry weight and N-amount were explained best by the C/N ratio at time of cutting, whereas the remaining fractions of P and K were explained best by the P-concentration of the vegetation at time of cutting.

With this knowledge, we were able to model the withdrawn amount of nutrients for 11 roadside communities for which data were available from the main research project. The amounts were modelled for different timelags, ranging from 0 to 6 weeks or more. It appeared that, for many communities, the yearly withdrawal of N is larger than the annual atmospheric deposition only when the cuttings are removed within the first 2 or 3 weeks. For some communities the atmospheric N deposition can never be withdrawn, not even by a direct removal of the cuttings. On the other hand, the withdrawal of K exceeds the atmospheric deposition in all communities when the cuttings are removed within the first week. However, the heavy losses for this element result in the withdrawal of K falling below the annual deposition in nearly all communities when the cuttings are left for longer periods.

Changes in the Vegetation of Meijendel Influenced by Grazing

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Meijendel is a calcareous coastal dune system near the city of The Hague, which is used as a water catchment area. A combination of a decreased intensity of grazing by rabbits together with a strongly increased load of nitrogen caused by the pollution of the precipitation has led to a dune vegetation with a less open character and an increasing dominance of *Calamagrostis epigejos* and *Carex arenaria*. To stop this process, grazing by cattle was introduced in some parts of Meijendel in 1990. After 5 years of grazing a first evaluation report was planned. This research is part of the evaluation and contains the development of the vegetation as influenced by grazing. It consists of three parts:

- Vegetation classification; the present vegetation types in three transects (both grazed and ungrazed) are described.
- Permanent plots; in the grazed area there are 19 permanent plots, from which development has been observed since 1960.
- Structure comparison; with the help of false-colour aerial photo-series, a comparison of the vegetation structure in the three transects has been made between 1990 and 1995.

It can be concluded that grazing does not result in a change in the vegetation types. The different types are present in both grazed and ungrazed areas. The cover of *Calamagrostis epigejos* and *Carex arenaria*, however, is significantly lower in the grazed area. The total number of plant species, decreasing since 1960, shows an increase after the introduction of cattle in 1990. With regard to the structure comparison it can be concluded that in grazed areas the amount of high grass vegetation has almost totally disappeared and the amounts of open sand, sand with moss and lichens and low grass vegetation have increased. After 5 years of grazing the pattern of the several structure types has become more small-scale.

Compensating for Water Shortage in Wet Grasslands: does sulphate-enriched water cause problems?

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Many wetlands in The Netherlands deal with serious water shortage, because of agricultural activities and water extraction. To compensate for the decrease in groundwater levels, allochthonous water, originating from the rivers Rhine and Meuse, is often used. The concomitant eutrophication was originally completely attributed to the external input of nutrients, especially of phosphates.

It was hypothesized that sulphate-enrichment, due to the use of this river water, is a major cause for the observed eutrophication in wet grasslands. Therefore, the effects of waterlogging with sulphate-enriched water (0, 2 and 4 mmol l⁻¹) on soil processes were tested in mesocosms. Humic soil cores including vegetation, from a mesotrophic wet grassland dominated by *Carex* species, were investigated in a laboratory flow-through system. Soil water chemistry was determined, using permanent moisture samplers, and the above-ground biomass was harvested several times during the experiment. In the soils treated with sulphate-enriched water, enhanced

sulphate reduction generated alkalinity and caused accumulation of free sulphide in soil pore water. Nutrient concentrations increased considerably within a few months, compared with the control treatment. Because of iron sulphide precipitation during sulphate enrichment, less free iron was available for the binding of phosphates, resulting in a rapid increase of the phosphate concentration. The increase in alkalinity probably stimulated the decomposition and mineralization of organic matter, causing a significant increase of macronutrient concentrations. However, the vegetation regrowth was reduced in the sulphate-treated pots, indicating sulphide toxicity. During the subsequent desiccation of the sulphate-treated soils, soil pH dropped substantially due to proton production by iron sulphide oxidation. Moreover, heavy metal (e.g. aluminium) concentrations increased to potentially toxic levels.

The outcome of this experiment indicates major changes in soil chemistry due to sulphate enrichment, which might contribute to the observed deterioration of wetland vegetations affected by water, rich in sulphate. Future research will focus on the sensitivity of different soil types and plant species, in relation to the involved biogeochemical processes. The occurrence of internal eutrophication due to sulphate enriched water has important implications for the management of nature reserves, as a decrease of phosphorus and nitrogen levels in the inlet water may be insufficient to prevent eutrophication. It is suggested that the restoration of the original hydrology is the only way to conserve endangered wetlands.

Pollen Exchange in Small Populations of *Salvia pratensis*

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Recently, many plant populations have become fragmented, often due to habitat destruction, resulting in small and isolated populations. These populations not only face an increased probability of extinction by stochastic processes, but, in addition, may also experience a loss of genetic variation and fitness due to genetic drift and inbreeding. Gene flow can alleviate the deleterious genetic effects of small population size and isolation. In many plant species with limited seed dispersal gene flow largely depends on insect-mediated pollen flow.

In *Salvia pratensis* pollen flow depends on the behaviour of bumble bees, foraging for nectar. Since the number of open flowers per plant can have important consequences for their behaviour, we have investigated how pollinator movement and thus potential pollen exchange is affected by plant size

(measured as number of open flowers). Therefore, all plants and all bumble bees in a patch were marked individually, and we tracked the foraging paths of these numbered bumble bees and constructed the possible pollen flow between plants.

A positive correlation was found between the number of open flowers per plant and the percentage intra-plant movements. In other words larger plants experience more geitonogamous visitation, that can cause relatively higher selfing rates. On the other hand plants with many flowers attracted more bumble bees and were connected with a larger number of neighbouring plants. This promotes outcrossing and may result in a genetically more diverse progeny. As the balance between outcrossing (connections to other plants and gene flow) and selfing (and the possible occurrence of inbreeding depression: Ouborg & Van Treuren (1994): *Evolution* 48: 996–1008) depends on the foraging behaviour of bumble bees, changes in their behaviour in relation to population fragmentation can have important consequences for the persistence of plant populations.

A Landscape Ecology Survey of Edgeoya Svalbard

Presented by I.S. Zonneveld, based on the work of M. Lebouille, N. de Nies, A. van Dijk, H. Heinemeijer, P. Oosterveld and I.S. Zonneveld and various publications. Stichting Arctisch Wetenschappelijk onderzoek [Netherlands Foundation for Arctic Scientific Research], Zeist, The Netherlands

A land ecological survey was executed of the island of Edgeoya (Svalbard, Spitsbergen) during a Reindeer Environment Expedition (REES) summer 1977. For the methodology see I.S. Zonneveld (1995) *Land Ecology*, SPB Academic Publishing, Amsterdam. 199 pp. Sub-objectives were to describe the vegetation communities and their ecology and to assess the environment of the reindeer. This survey was carried out parallel to studies on the reindeer population. The result was expressed in a four-colour map, scale 1:200 000, cartographically treated and printed in 1995 using the newest techniques. The legend of the map is expressed in 25 land units, each described according to landform (geomorphology), soils and vegetation. The latter was expressed in (complexes of) seven floristically defined plant communities, structural data and (peak) standing crop of the vascular plants and (negligible) lichens. The communities distinguished (A, *Eriophorum*—*Carex subspathaca*; B, *Tomenthypnum*—*Saxifraga flagellaris*; C, *Tomenthypnum*—*Luzula arctica*; D, *Papaver*—*Cardamine bellidifolia*; E, *Phippsia algida*; F, *Papaver*—*Oxyria digyna*; G, *Papaver*—*Saxifraga cernua*) reflect temperature and moisture gradients.