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METHODS

Additional costs of nature management caused by deposition

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Abstract

Effects of atmospheric deposition on natural areas can be mitigated by management. For example, the effects of excessive nitrogen deposition can partly be overcome by intensifying measures like mowing or sod cutting. The costs of this extra management may, in the future, no longer be required when deposition rates decrease. We developed a method to calculate the costs of the intensified nature management that is required at increased deposition rates. We used a set of models that simulate the biomass development under different management regimes necessary to maintain a certain level of biodiversity. The costs were calculated for several vegetation types based on, among others, the biomass and litter that was removed. Preliminary results show that the models can be applied with some success to assess these costs. Model outcomes show a clear effect of management intensity on biomass growth in heathland and grassland although no differences were found in forest. The biodiversity in heathlands clearly increased when management was intensified. As an example, the extra costs in heathlands that are made to counteract the effects of atmospheric deposition were calculated for The Netherlands. The costs of maintaining heathlands with sods being removed from heathlands every 20 years (presently the usual rate) exceed those in a situation of sod cutting every 60 years (the expected rate without atmospheric deposition) by 1.4 m Euro per year.

Keywords: Management costs; Nitrogen; Deposition; Model; Vegetation; Heathland

1. Introduction

In Western Europe, a lot of money is spent on the maintenance or improvement of biodiversity in natural and seminatural and even agricultural areas (Pieterse et al., 2001; Kleijn et al., 2001). Nowadays, even new natural areas are developed by buying new ground and adequate management, for instance, as compensation when a nature reserve is sacrificed for industrial development (Beyen and Meire, 2003). Besides the trade-off on the local level between ecology and economy, biodiversity is also threatened on a regional to worldwide scale by acidifying and eutrophying deposition (Bobbink et al., 1998; Hungate et al., 2003). The effects of the deposition can be

Abbreviations: MSL, mean spring groundwater level; NTT, nature target type; FGR, physico-geographic regions; *F*, Ellenberg indicator value for moisture; *R*, Ellenberg indicator value for acidity; *N*, Ellenberg indicator value for nutrient availability.

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counteracted in two ways: (1) at the source, i.e., by installing desulphurizers in electric power plants, or (2) in the field by intensifying management. The decrease of acidifying deposition and lately also in eutrophying deposition (Kelly et al., 2002;Tarasón et al., 2003) are mainly the result of government policies from the local to the global level. Theoretically, when the deposition drops, the intensified management may cease, and only regular management will be necessary to maintain biodiversity. A national workshop on the ecological benefits of the current acidification policy was held in The Netherlands early 2002. It concluded that research should be undertaken to estimate possible savings on nature management costs resulting from abatement of atmospheric deposition. In the context of this paper, the term atmospheric deposition includes both acid and eutrophying deposition.

Several reports published by the Dutch National Institute of Public Health and Environmental Protection RIVM over the last few years (e.g., *Natuurbalans*, RIVM, 2001 and *Natuurverkenningen*, RIVM, 2002) have discussed the relation between atmospheric deposition and the feasibility of nature target types (NTTs). The NTTs are defined as an ecological objective in terms of biotic and abiotic components and consist of 132 units. They should be regarded as a toolbox for planning, management and policy evaluation (Bal et al., 1995). The relation between atmospheric deposition and the management costs associated with the achievement of nature target types has not yet been assessed although Carpenter et al. (1998) considered in a similar way the cost and benefit of the management of nonpoint pollution in lakes. Nuppenau (2002) modeled the relation between humans and nature in a broad sense; we will focus only on the modeling of the influence of deposition on the management costs.

Alterra was commissioned by the Dutch Ministry of Housing, Spatial Planning and the Environment (VROM) to design a method that could estimate the additional costs made by nature reserve managers to mitigate the effects of atmospheric deposition. This study represents a first step towards the development of a new perspective on acidification policy, which provides the government with information on savings resulting from atmospheric deposition abatement. In addition, the study could render reserve managers more fully aware of the adverse (financial) consequences of atmospheric deposition. Natural areas have an intrinsic and often also indirect economical value of itself (Wilson and Carpenter, 1999; Fromm, 2000; Macmillan et al., 2002). These values may also be influenced by atmospheric deposition, but these effects are not the subject of this paper.

The aim of the study was to describe and test a methodology to estimate the additional management costs required to counteract the adverse effects of atmospheric deposition at site level. At a later stage, this methodology should allow nationwide assessment of the relation between atmospheric deposition, ecological quality and management costs. This study also addresses the call of Armsworth and Roughgarden (2001) 'to ecologists to use economic tools and to participate in ecological economic debate.'

Estimating the additional management costs necessary to counteract the effects of atmospheric deposition requires large quantities of data, the most important of which relate to the ecological quality at current deposition levels and the target ecological quality at a particular site. These data were obtained by combining the Dutch NTT map with the deposition map. Information is also required on the additional management measures that have to be taken to remove the excess atmospheric deposition and on the costs of these measures. The "nature planner" set of modeling instruments (Latour et al., 1997) can be used to calculate what ecological quality can be achieved in a particular NTT at a particular level of atmospheric deposition with a particular type of management. It is possible to calculate ecological quality at the natural background level of atmospheric deposition and to use this as a reference value to be compared with the value in a situation of increased deposition or altered management.

It is known for each NTT what additional management measures can be used to reduce or eliminate the effects of deposition. At each deposition level, management options can be varied, and the resulting changes in ecological quality can be calculated. While the present study only used a constant (namely, the current) deposition level to test the method, follow-up studies can also use scenarios in which the deposition levels vary over time (e.g., decrease as a result of abatement policy). This would allow assessment of the relation between costs of management, deposition