Chapter 2
Reassessment of Critical Levels for Atmospheric Ammonia

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2.1 Summary

- The existing Critical Levels (CLEs) for NH$_3$ require revision in the light of new experimental evidence from field-based experiments and surveys.
- The existing annual CLE (8 $\mu$g NH$_3$ m$^{-3}$), when expressed as an equivalent deposition of N to an ecosystem, is less protective than the current Critical Load for most, if not all, European ecosystems and habitats.
- Field-based evidence relating effects on vegetation to NH$_3$ concentrations measured over one year or longer show that the current annual CLE is set too high.
- A new long-term CLE for the most sensitive vegetation type (lichens and bryophytes) is proposed, based on observed changes to species composition in the field.
- Most of the evidence comes from studies in the UK, but there is corroborative evidence from Switzerland, Italy and Portugal.
- The proposed long-term CLE for NH$_3$ for ecosystems in which lichens and bryophytes are important is 1 $\mu$g NH$_3$ m$^{-3}$.
- There is less evidence for long-term effects of NH$_3$ on species changes in communities of higher plants; on the basis of expert judgement we propose a long-term CLE for higher plants of 3 $\mu$g NH$_3$ m$^{-3}$.
No assumptions have been made on the mechanism by which NH$_3$ exposure leads to changes in species composition.

Several recommendations are made, to address uncertainties relating to the lack of observational data and long-term NH$_3$ concentration measurement, particularly in southern and eastern Europe.

There is also need for better understanding of the mechanisms whereby NH$_3$ affects plants, so that predictive models can be constructed for extrapolation to other types of vegetation and land use in different climatic zones.

### 2.2 Introduction

The process of arriving at generally accepted, scientifically reliable quality standards for pollutants follows a pathway that covers several decades. The derivation of a Critical Level (CLE) for NH$_3$ is no exception. A Critical Level is defined as "the concentration in the atmosphere above which direct adverse effects on receptors, such as plants, ecosystems or materials, may occur according to present knowledge" (Posthumus 1988).

In the first phase of the process, quality standards are largely based on the “No observable effect concentration” (NOEC) of the most sensitive species tested. This NOEC will tend to decrease over time as the result of discovering receptors with greater sensitivities. In the second phase of the process, with continued investigation, a set of effects data becomes available that allows evaluation of inter-species variability in sensitivity. Quantification of the protection level (e.g. confidence limits or percentage of species protected) becomes possible. In the third phase, models at the ecosystem level based on causal analytical relations become available. The focus on protecting species is then broadened to protecting the functioning of the full system. Up to now, the CLE for NH$_3$ has been in its first phase, but recent developments mean that it can begin to move into the second phase.

Critical Loads (CLO) are defined as “a quantitative estimate of deposition of one or more pollutants below which significant harmful effects on specified elements of the environment do not occur according to present knowledge” (Posthumus 1988). There is a subtle, but important distinction in the phraseology – the CLE marks a lower threshold (above which effects are known to occur), while the CLO marks an upper threshold (below which no effects are known). There are other differences: CLO are usually considered as representing a long-term deposition (10–100 years) whereas CLE are usually defined for periods of up to a year. This distinction is related to the pathways by which deposition and concentration may have effects; deposition (CLO) is usually considered as operating through changing soil or water chemistry, whereas concentrations (CLE) are usually seen as having direct effects on above-ground vegetation, in addition to any effect mediated through dry deposition and subsequent effects through soils and waters. Mathematically, multiplying a CLE with deposition velocity results in a deposition rate which can be compared directly with a CLO. Thus, it might seem superfluous to set both CLEs and CLOs. Current practice is different, however (Table 2.1).