Mapping Manual 2004

Sections 5.1–5.4 are an update and extension of the relevant parts in the 1996 Mapping Manual. T. Spranger (Germany) has prepared the introductory section 5.1 and J. Hall (United Kingdom) section 5.2 on empirical critical loads. M. Posch has compiled sections 5.3 and 5.4 on terrestrial and aquatic critical load models for nitrogen and sulphur. B. Reynolds (United Kingdom), S. Augustin (Germany) and G.J. Reinds (The Netherlands) provided valuable comments. The careful reading and the many suggestions by J. Aherne (Canada) are greatly appreciated.

The new section 5.5 on critical loads for heavy metals has been prepared by G. Schuetze (Germany) in close cooperation with W. de Vries (The Netherlands), E. Tipping and St. Lofts (UK), M. Meili (Sweden) and B.J. Groenenberg (The Netherlands). Comments by other colleagues of the Expert Panel on Critical Loads of Heavy Metals are acknowledged.

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5.1 Introduction

The general definition of a critical load is "*a quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge*".

This definition applies to different receptors (e.g., terrestrial ecosystems, groundwater, aquatic ecosystems, and/or human health). 'Sensitive elements' can be part or whole of an ecosystem or of ecosystem development processes, such as their structure and function. Critical loads have been defined for several pollutants and effects resulting from their deposition.

Critical loads of sulphur and nitrogen acidity for an ecosystem have been specifically defined at the Skokloster Workshop as (Nilsson and Grennfelt 1988):
"*the highest deposition of acidifying compounds that will not cause chemical changes leading to long-term harmful effects on ecosystem structure and function.*"
Both sulphur and nitrogen compounds contribute to the total deposition of acidity. The acidity input has to be considered in this balance regardless whether it is due to S or N depositions. Thus, the ratio between sulphur and nitrogen may vary without change in the acidity load (see section 5.3.2 for details).

In addition to acidification, inputs of nitrogen may influence the eutrophication and nutrient balances of ecosystems. The critical load for nitrogen nutrition effects is defined as:
"*the highest deposition of nitrogen as NH_x and/or NO_y*[1] *below which harmful effects in ecosystem structure and function do not occur according to present knowledge.*"
Critical loads for heavy metals are defined accordingly.

The basic idea of the critical load concept is to balance the depositions which an ecosystem is exposed to with the capacity of this ecosystem to buffer the input (e.g. the acidity input buffered by the weathering rate), or to remove it from the system (e.g. nitrogen by harvest) without harmful effects within or outside the system.

In the context of a multi-pollutant multi-effects approach it is desirable to consider all effects simultaneously as far as possible. For eutrophication and acidification, this has been done using so-called critical load functions. These are described in detail in section 5.3.

Critical loads can be determined either by steady-state methods or by dynamic models with varying degree of complexity. Since critical loads are steady-state quantities, the use of dynamic models for the sole purpose of deriving critical loads is somewhat inadequate. However, if dynamic models are used to simulate the transition to a steady state for the comparison with critical loads, care has to be taken that the steady-state version of the dynamic model is compatible with the critical load model. Dynamic models are dealt with in a separate chapter (Chapter 6).

[1] $NH_x = NH_3 + NH_4^+$; $NO_y = NO + NO_2 + NO_2^- + NO_3^-$