Chapter (non-refereed)

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# Development of the critical loads concept and the UN-ECE mapping programme


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### INTRODUCTION AND THE DEFINITION OF CRITICAL LOADS

The critical loads approach to controlling acidic emissions has attracted increasing interest in recent years. International activities aimed at reducing sulphur and nitrogen emissions (especially those within the United Nations Economic Commission for Europe (UN-ECE)) are looking to critical loads as a practical means of linking emission controls with environmental benefits.

The basic concept of critical loads is a simple one - the threshold at which a pollutant load causes harm to the environment. However, much thought has been given to turning this simple idea into scientifically acceptable criteria. Bull (1991) has discussed the problem in detail in relation to the efforts made by various specialist groups to find acceptable definitions for different sensitive receptors. However, a starting point for many recent deliberations has been the definition which Nilsson and Grennfelt (1988) adopted for a UN-ECE workshop in 1988. They described the critical load as:

'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'.

For this definition, much discussion has focused upon specifying appropriate sensitive elements of the environment and defining the meaning of significant harmful effects. This has not always proved easy.

When sufficient is known of the spatial pattern of sensitivity, maps of critical loads may be drawn which provide an opportunity to assess potential areas of damage in relation to known sources of pollution. In this way, it may be possible to calculate if critical load values are exceeded in an area, and thus to identify the likelihood of damage. This assessment may be done using current (usually measured) or future (modelled) pollution deposition loads. Maps showing where critical loads are exceeded are usually called exceedance maps.

The critical loads concept may be used to consider the recovery of damaged areas of the environment following a reduction in pollutant levels. However, it is necessary to consider the recovery process in more detail and to take account of time-dependent processes which may inhibit immediate recovery. It should be stressed that the pattern of recovery may be very different from that when the damage occurs.

In addition to the term critical load, it is important to draw the reader's attention to the terms critical level and target load. A critical level is analogous to a critical load but refers to a threshold of damage for gaseous pollutants acting directly upon (usually) vegetation species. A target load has been defined by Henriksen and Brakke (1988) as the pollutant 'load determined by political agreement'. Such a target may take account of social, economic or other constraints. It may be greater than the critical load and thus allow a degree of damage, or it may incorporate a safety factor and be less than the critical load value.

### THE EVOLUTION OF THE CRITICAL LOADS CONCEPT

While the precise source of the origin of the term critical load is unknown, ideas regarding the response of aquatic ecosystems to certain loadings of pollutants were being considered in Scandinavia in the 1970s (Almer *et al.* 1978), and, towards the end of that decade, the concept of an acceptable pollutant load was discussed in Canada. The term critical load was first used at the Stockholm Conference in 1982, and the concept was promoted by the Scandinavian countries at workshops in the years that followed (Nilsson 1986; Nilsson & Grennfelt 1988).

Towards the end of the 1980s, the UN-ECE, under the Convention on Long Range Trans-boundary Air Pollution, adopted the critical loads concept as a potentially useful approach for future consideration of the abatement of nitrogen and sulphur. Following this adoption, a series of national and international activities were initiated which have worked towards applying the concept to future abatement strategies.

### THE UNITED KINGDOM CRITICAL LOADS ADVISORY GROUP (CLAG)

When it was becoming clear that international abatement was beginning to focus upon the critical loads approach, the UK Department of the

Environment set up a small advisory group to provide expert advice on the application of critical loads in the UK. This group has subsequently grown to include more than 20 scientists from a wide range of organisations and areas of expertise. Subgroups of the CLAG, in particular those for freshwater systems and soils, have been actively calculating values for critical loads for the UK and using these values to draw critical load maps in collaboration with the Mapping Centre at ITE Monks Wood. The results of the efforts of the CLAG are described elsewhere in this volume and have been outlined by Bull *et al.* (1991).

The UK government's commitment to the critical loads concept became clear with the publication of the White Paper *This common inheritance* (Department of the Environment 1990). In this Paper, critical loads are one of the essential building blocks in a strategy for pollution abatement (Figure 1). Following the development of critical load maps, an iterative process of monitoring, assessing damage, planning abatement (setting targets), implementing controls, and remonitoring is envisaged. In this way, pollution levels should continue to decrease with the objective of achieving reductions below the critical loads. A similar iterative process may also be expected in the generation of critical load values and critical load maps. Current maps can only be based upon the knowledge available at present. This situation may change in the future and may result in changed critical load values for areas of Britain.

## THE UN-ECE PROGRAMME

International activities within the UN-ECE have focused upon the revision of protocols for sulphur and, more recently, nitrogen under the Convention on Long Range Trans-boundary Air Pollution. The existing sulphur protocol (the so-called '30% Club' which has aimed at reductions of sulphur emissions by 30%) is due for revision in 1993, and most critical loads activities have been directed towards this timetable.

Under the Convention, a series of Working Groups and Task Forces have been set up to deal with specific aspects of international negotiations (Table 1). In addition to the European Monitoring and Evaluation Programme (EMEP), which is responsible for drawing up emission inventories and mapping pollutant levels for Europe, there are two other groups of significance.

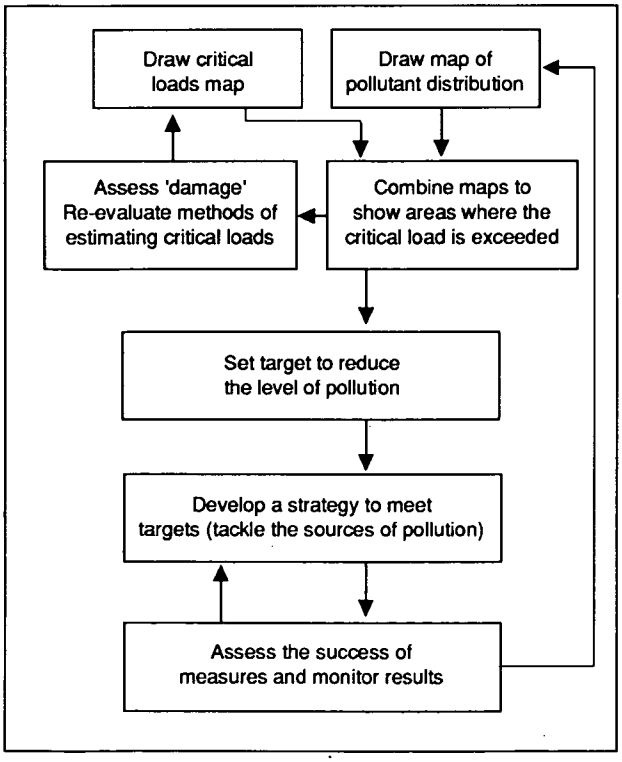


*Figure 1.* Flow diagram showing iterative re-assessment of critical loads, targets and strategies (based on Figure in Department of the Environment 1990)

*Table 1.* Structure of the relevant bodies of the UN-ECE Convention on Long Range Trans-boundary Air Pollution

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| Executive body of the Convention |
| European Monitoring and Evaluation Programme (EMEP) |
| Working Group on Effects |
| - Task Force on Mapping |
| - International co-operative programmes |
| Working Group on Strategies |
| - Task Force on Integrated Assessment Modelling |

The Working Group on Effects (WGE) is responsible for considering the environmental impacts of pollutants and, in this role, has promoted a Task Force on Mapping which has the objective of drawing critical load maps for the whole of Europe. The WGE (which is chaired by the UK) is also responsible for the organisation of a number of international co-operative programmes which are considering impacts on specific parts of the environment, such as crops, forests, freshwaters.

The Working Group on Strategies (WGS), formerly the Working Group on Abatement Strategies, is responsible for developing strategies for pollution abatement. It is considerating economic instruments and the application of emission/deposition models which incorporate cost functions and environmental impact assessment using critical load maps. These integrated assessment models are being developed by the Task Force on Integrated Assessment Modelling (TFIAM), which reports to the WGS.

## EUROPEAN CRITICAL LOAD MAPS

The development of methods for mapping critical loads and levels at the European scale has been the remit of the Task Force on Mapping. This Task Force has built upon a series of UN-ECE workshops at which methods for the calculation and mapping of critical loads and levels for different sensitive environmental receptors were discussed and agreed.

The approach adopted by the Task Force on Mapping for mapping critical loads and areas of exceedance has been discussed by Bull (1992) and Hettelingh, Downing and de Smet (1991). In general, it is dependent upon using known biological effects to derive 'critical chemical criteria' which can then be equated with pollution load in a numerical way, usually by some form of equilibrium model.

The responsibility for generating national critical load maps rests with the individual countries concerned, but it is recommended that they use agreed methods and procedures. To co-ordinate activities and collate national data sets for the European map, an international Coordination Centre for Effects (CCE) has been set up in The Netherlands. This Centre is responsible for generating European data for the Task Forces and Working Groups. To ensure that a complete map of critical loads for Europe is available, the CCE is responsible for filling the gaps in the map with appropriate data where there are no national submissions.

European maps of critical loads of acidity and of sulphur have now been compiled by the CCE and reported to the executive body of the Convention (Hettelingh *et al.* 1991). These maps are playing an important role in assessing environmental benefits arising from various deposition scenarios defined by TFIAM modelling activities. The work is aimed at the development of abatement strategies for a revised sulphur protocol in 1993.

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