Hornung, M.. 1993 The provisional map of critical loads of acidity for the soils of Great Britain. In: Hornung, M.; Skeffington, R. A., (eds.) *Critical loads: concept and applications.* London, HMSO, 31-33. (ITE Symposium, 28).

Critical loads of acidity and sulphur for soils

The provisional map of critical loads of acidity for the soils of Great Britain

M Hornung

Institute of Terrestrial Ecology, Merlewood Research Station, Grange-over-Sands, Cumbria LA11 6JU

BACKGROUND

The provisional critical load map for the soils of Great Britain (Figure 1) has been developed using principles and proposals developed at two workshops, held in 1986 and 1988. The first workshop suggested that critical loads for soils should be set to prevent chemical changes which would lead to long-term harmful effects to the soil/plant system (Nilsson 1986). It also suggested that such chemical changes could be prevented, if acid inputs did not exceed internal (within the soil) alkalinity production, essentially the production of base cations by mineral weathering. The main factor determining the rates of weathering in soils is soil mineralogy. The 1988 workshop, at Skokloster in Sweden, divided soil materials into five classes, defined on the basis of their dominant weatherable minerals (Nilsson & Grennfelt 1988). Critical loads were then assigned to these classes, according to the amount of acidity which would be neutralised by base cation production, by weathering from the relevant minerals. It was also proposed that the critical load for a given soil could be adjusted, within the range of values suggested for each class of soil material, by applying modifying factors. Thus, if one of the 'decrease' factors applies, eg high precipitation, the value of the critical load is used which is at the lower limit of the values suggested for the given soil material class; if an 'increase' factor applies, then the upper value is used.

Given the excellent soil maps and accompanying data bases available for Britain, it was felt that sufficient information might be available for map units on existing, published, maps to be allocated to one of the soil material classes defined at the Skokloster workshop; the map units could then be assigned a critical load. If this allocation were possible, it would provide a relatively rapid method for producing a provisional critical load map for British soils. The approach was first tested in two exploratory studies.

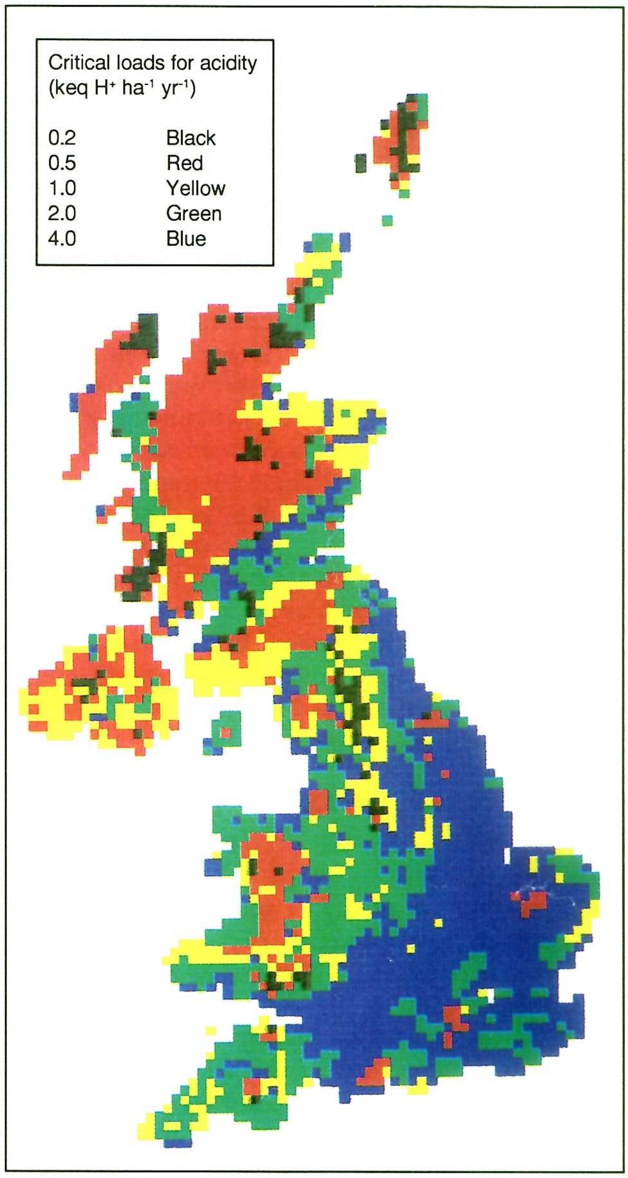

Figure 1. Critical loads of acidity for soils in Great Britain

EXPLORATORY STUDIES

In late 1988, an exploratory study was carried out in Wales to see if sufficient data were available to allow the soils of two test areas to be allocated to one of the five classes defined at Skokloster and then to produce a critical load map for soils. The two test areas were located in part of north-west Wales, including Snowdonia and the country around Llyn Brianne. The 1:250 000 soil map of Wales and its supporting memoirs and data bases were used as the basis for the exercise. The map units on this map are soil associations, which can contain a range of soil types with different chemical and mineralogical properties, and hence critical loads. In the trial, map units were allocated to one of the critical load classes proposed at Skokloster on the basis of the mineralogy of the dominant soil type (series) within each map unit, thus converting the soil maps to critical load maps. The resulting maps of critical loads were then overlaid with deposition data, derived from a national monitoring programme carried out by the Welsh Water Authority, to produce an exceedance map. The exercise showed that the approach based on the Skokloster classes was feasible but that some modification of the Skokloster classes would be necessary to include a wider range of minerals. It also highlighted the fact that organic soils could not be allocated to one of the Skokloster classes as they contain very few weatherable minerals.

The approach was tested further in 1989 using a test area stretching from the Cumbrian coast to the coast of County Durham and north Yorkshire. This area included a wider range of soils than the Welsh sites. The north of England study also considered (i) the possible impact of land use on critical loads of soils, in particular the addition of lime, and (ii) the importance of including total deposition when producing exceedance maps. As in the Welsh example, the study suggested that the approach based on the Skokloster classes could be adapted to encompass a wide range of soils, with suitable, relatively minor, modifications to the mineralogical criteria used to define the five classes. The land use-related work confirmed that, if allowance were made for the addition of lime, the critical load of large areas of soil would be increased, albeit in the short term. Inclusion of total deposition, as opposed to wet deposition only, greatly increased the area of exceedance, and underlined the need for comprehensive deposition data.

THE GREAT BRITAIN MAP

Beginning in late 1989, the approach developed in the two trial studies was built upon to provide a critical load map of acidity for soils for the whole of Great Britain; the work was carried out as a collaborative exercise by ITE, the Soil Survey and Land Research Centre, the Macaulay Land Use Research Institute and the University of Aberdeen. As in the trial studies, the 1:250 000 soil maps were used as the base, with the map units on them allocated to one of the five Skokloster classes, plus a class of peat soils, on the basis of the dominant soil series within the map unit.

In Scotland, the map units could be allocated to one of the classes using essentially the same approach as in the two exploratory studies. The soil associations used on the 1:250 000 scale soil maps of Scotland comprise groupings of soils developed on a given parent material. Information on the mineralogy of the parent materials could, therefore, be used to allocate the soils of a given association to a soil material class, and hence to assign a critical load. The initial, mineralogically based allocation was then modified, where necessary, using information on soil depth, texture and drainage, as suggested at the Skokloster workshop. Thus, where a map unit was dominated by shallow soils on steep slopes, the sensitivity class based on mineralogy was increased by one class. Conversely, in units dominated by deep soils or soils inundated regularly the class was decreased by one (Langan & Wilson, pp 40–47).

Many of the soils in England and Wales, but especially in south-east England, are developed on reworked materials. These soils seldom contain the primary minerals used in the definition of the soil material classes at Skokloster; however, they commonly contain large amounts of clay minerals. A modified schema was, therefore, developed which incorporated texture and secondary minerals into the definition of the soil material classes (Loveland, pp 48-53).

The trial exercises had essentially converted the soil map to a critical load map using the actual boundaries on the map to delimit areas with differing critical loads. The magnitude of the GB exercise enforced a different approach based on machine-readable data. One km square cells of the Ordnance Survey's National Grid of Great Britain were used as the basic units to build the map. Each 1 km square grid was allocated to one of the six classes on the basis of the dominant soil unit within the square. The resultant data bases for England and Wales, and for Scotland, were then forwarded to the UK Mapping Centre where they were merged to produce a critical load map for Britain, based on 1 km square cells.

As noted above, a major weakness with the Skokloster classification from the GB point of view was that it did not consider peats. As a result, the exploratory study in the north of England and the initial GB map had large areas of land in a sixth class of 'peat soils', to which no critical load values were assigned. An approach for assigning critical loads for dystrophic peats was eventually developed based on work at the University of Aberdeen. It began with an examination of the relationship between peat acidity in Scotland, or base cation depletion, and current inputs of acidic deposition. The study showed a broad relationship between current peat pH and current rainfall pH. Later laboratory studies assessed the impact of acidic inputs on peat pH by equilibrating peat samples with solutions representing a spectrum of rainfall chemistries. The work demonstrated that both H^+ and Ca^{++} inputs had to be taken into account when calculating critical loads for dystrophic peats.

The resultant method of calculating the critical load uses the relationships derived from the equilibration studies plus data on H^+ and Ca^+ deposition at pristine conditions and the concept of an acceptable pH shift. This latter was set at 0.2 pH units and the critical load was calculated as that input of H^+ and Ca^{++} which would not result in a maximum reduction in the pH of the given area of peat of 0.2 pH units. Using this approach, a critical load was calculated for each 1 km square in GB in which dystrophic peat was the dominant soil (Cresser, Smith & Sanger, pp 34–39). Eutrophic peats were assigned to a critical load class primarily on the basis of data for lowland peats presented by Burton and Hodgson (1987), and taking into account land use and management practices and, for soligenous mires, the surrounding geology.

The GB map was further modified to make allowance for the impact of land use (liming). It was assumed that lime would be added, if necessary in all areas where arable or intensive grassland farmland dominated. The ITE land classification was used to predict those 1 km squares where these forms of agriculture dominated. In those squares, the critical load was increased by one class.

The resultant map (Figure 1) shows that soils with small critical loads are widespread in the west and north of Britain, areas which are dominated by relatively shallow soils derived from acid, base-poor rocks. In contrast, the soils of much of the south and east of England have large critical loads; many of these soils are formed in thick calcareous and/or clay-rich glacial deposits or in materials derived from calcareous rocks. The more acidic soils in the south and east which are under intensive agriculture are also limed regularly.

REFERENCES

Burton, R.G.O. & Hodgson, J.M., eds. 1987. *Lowland peat in England and Wales.* Harpenden: Soil Survey of England and Wales.

Nilsson, J., ed. 1986. *Critical loads for nitrogen and sulphur.* (Report 1986: 11.) Copenhagen: Nordic Council of Ministers.

Nilsson, J. & Grennfelt, P., eds. 1988. *Critical loads for sulphur and nitrogen.* (Report 1988: 15.) Copenhagen: Nordic Council of Ministers.