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Calculation methods and revisions made to UK critical loads data

The methods for calculating critical loads of acidity and nutrient nitrogen for ecosystems in the UK have been described previously (Hall *et al.* 1998, Posch *et al.* 1997). However, some revisions have been made to the UK critical loads data submitted to the CCE in February 2001. Reports on the methods used in the UK are provided on the UK NFC web site: <http://critloads.ceh.ac.uk>

The changes made to the UK calculations are listed below:

The Simple Mass Balance equation for woodland ecosystems:

- (i) Criteria: critical molar ratio of Ca:Al = 1 for mineral soils; critical pH 4.0 for organic soils; empirical critical loads for peat soils.
- (ii) Kgibb values: 950 m⁶/eq^w for mineral soils and 9.5 m⁶/eq² for organic soils.
- (iii) 1995-97 5km total (marine plus non-marine) calcium deposition, updated from 1992-94 20km data.
- (iv) New calcium uptake values for coniferous and deciduous trees.

The maximum critical load for sulphur

- (i) New acidity critical loads for woodland ecosystems.
- (ii) 5km non-marine base cation deposition values for 1986-91 as long-term mean values, instead of previous 1992-94 20km data.
- (iii) 5km non-marine chloride deposition values for 1986-91 as long-term mean values, instead of previous 20km estimates for 2010.
- (iv) New base cation uptake values for woodland ecosystems.

The minimum critical load for nitrogen

- (i) New nitrogen uptake values for woodland ecosystems.
- (ii) The inclusion of denitrification into the equation (not previously included).

The maximum critical load for nitrogen

Changes in values due to changes made to the maximum critical load for sulphur and the minimum critical load for nitrogen.

Critical loads for nutrient nitrogen

- (i) The minimum of empirical or mass balance critical loads applied to both coniferous and deciduous woodland ecosystems (previously only applied to conifers).
- (ii) New nitrogen uptake values for mass balance critical loads for woodland ecosystems.

Critical loads for freshwater ecosystems

- (i) The FAB critical loads now applied to 1470 sites in Great Britain and 140 sites in Northern Ireland.
- (ii) Runoff data for 1961-1990 for Northern Ireland (1941-1960 data still used for Great Britain).
- (iii) Forest areas in Northern Ireland defined from CORINE land cover (areas in Great Britain from the CEH Land Cover Map).

The justification for applying these values and/or methods in the UK are also given in Table 1.

References

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UBA, 1996. Manual on methodologies and criteria for mapping critical levels/loads and geographical areas where they are exceeded. UNECE Convention on Long-Range Transboundary Air Pollution. Federal Environmental Agency (Umweltbundesamt), Berlin.

Table 1 Summary of UK critical load values and the justification for their use

Critical loads parameter	Ecosystem code [#]	Minimum value	Maximum value	Data sources/methods used	Justification
$CL_{max}(S)$ Eq/ha/year	AG	130	5030	$= CLA + (BC_{dep}^* - Cl_{dep}^*) - BC_u$ See BCdep, Cldep and BCu comments below.	Mapping Manual (UBA, 1996)
	CG	598	4798		
	H	130	5010		
	C	10	11732		
	D	4	11108		
	W	0	36900		
$CL_{min}(N)$ Eq/ha/year	AG	213	570	$= N_u + N_i + N_{de}$ N_i & N_{de} values between 1 & 4 kg N/ha/year depending on soil type.	Mapping Manual.
	CG	857	1214		
	H	433	790		
	C	643	1000		
	D	643	1000		
	W	15	638		
$CL_{max}(N)$ Eq/ha/year	AG	363	5550	$= CL_{max}(S) + CL_{min}(N)$	Mapping Manual
	CG	1455	5972		
	H	583	5466		
	C	733	12651		
	D	647	11751		
	W	143	201500		
$CL_{nut}(N)$ Eq/ha/year	AG	714	1786	Empirical values applied: Acid grassland: 10, 12.5, 25 kg N/ha/year depending on species present.	Mapping Manual. Empirical values recommended by UK experts (Hall <i>et al.</i> 1998). However, the UK will review these after the UNECE workshop in 2002 to review empirical critical loads for nutrient nitrogen.
	CG	3571	3571	Empirical value applied: 50 kg N/ha/year	
	H	714	1214	Empirical values applied: 10, 15, 17 kg N/ha/year depending on species present.	

	C	928	928	Minimum of empirical value (13 kg N/ha/year) or mass balance value (where $CL_{nut}(N) = N_u + N_i + N_{le(acc)} + N_{de}$). N_i & N_{de} values between 1 & 4 kg N/ha/year depending on soil type. Previously only mass balance used for conifers.	Mass balance equation and empirical value as recommended in Mapping Manual. Input values recommended by UK experts (Hall <i>et al.</i> 1998). Empirical value lower everywhere.
	D	1071	1214	Minimum of empirical value (17kg N/ha/year) or mass balance value (where $CL_{nut}(N) = N_u + N_i + N_{le(acc)} + N_{de}$). N_i & N_{de} values between 1 & 4 kg N/ha/year depending on soil type.	Mapping Manual. Empirical values recommended by UK experts. Input values to mass balance equation recommended by UK experts (Hall <i>et al.</i> 1998).
	W	-	-	Not calculated.	
$BC_{dep}^* - Cl_{dep}^*$ Eq/ha/year	AG	0	1150	BC_{dep}^* and Cl_{dep}^* = changed to measured mean data 1986-91 for low vegetation.	Mapping Manual.
	CG	0	1150		
	H	0	1150		
	C	0	1850	BC_{dep}^* and Cl_{dep}^* = changed to measured mean data 1986-91 for woodland ecosystems.	
	D	0	1850		
	W	-	-	Not used.	
BC_u Eq/ha/year	AG	0	0	Set to zero - uptake negligible for acid grassland.	Based on published data by UK experts.
	CG	222	222	Includes removal via sheep.	Based on published data by UK experts.
	H	0	0	No uptake for heathland.	
	C	250	250	New values. Calculated from: average volume increment * basic wood density * concentration in wood and assuming potential yields achieved. Values based on data for Sitka Spruce.	Based on published data. Single value for UK for each of the following: coniferous woodland (all soils), deciduous woodland (Ca-poor soils), deciduous woodland (Ca-rich soils). Regional and species specific volume increment and concentration in wood to be incorporated in future. NB. These used in CLmaxS calculations only, estimates of calcium uptake only used in SMB for mineral soils.
	D	400	850	New values. Calculated from: average volume increment * basic wood density * concentration in wood and assuming potential yields achieved. Values based on data for Oak. Minimum value for Ca-poor soils and maximum value for Ca-rich soils.	
	W	-	-	Not used.	
ANC_w Eq/ha/year	AG	-	-	SMB not used: empirical critical loads of acidity for soils (Skokloster classification) applied, therefore ANC_w not assigned.	Methods agreed by UK experts (Hall <i>et al.</i> 1998). (SMB only applied to woodland ecosystems in UK).
	CG	-	-		
	H	-	-		
	C	0	4000	Set to zero for peat soils	Recommended in Mapping Manual. See Hornung <i>et al.</i> , 1995. Assigned values checked against application of PROFILE for limited number of sites.

	D	0	4000		
	W	-	-	Not used.	
$ANC_{le(crit)}$ Eq/ha/year	AG	-	-	SMB not used: empirical critical loads of acidity for soils applied, therefore $ANC_{le(crit)}$ not calculated.	Methods agreed by UK experts (Hall <i>et al.</i> 1998). (SMB only applied to woodland ecosystems in UK).
	CG	-	-		
	H	-	-		
	C	0.1	7734	Calculated via SMB equation with ratio of Ca:Al = 1 as chemical criterion for mineral soils and critical pH 4.0 for organic soils. Empirical acidity critical loads applied to peat soils.	SMB with BC:Al ratio and base cation deposition produced unrealistically high critical loads. Ca:Al ratio recommended in paper by Cronan & Grigel (1995).
	D	0	7067		
	W	-	-	For freshwaters the ANC_{limit} is set at zero $\mu\text{eq/l}$.	Value selected for 50% probability of damage to brown trout populations.
N_u Eq/ha/year	AG	70	70	Equivalent to 1kg N/ha/year	Based on published data by UK experts
	CG	714	714	Equivalent to 10kg N/ha/year	
	H	290	290	Equivalent to 4kg N/ha/year	
	C	500	500	New values. Methods as for BC_u .	Based on published data – one value for whole of UK: regional growth values to be incorporated in future.
	D	500	500		
	W	0	279	= fN_u . Uses N_u value of 279 eq/ha/year for all coniferous forest multiplied by percentage forest in catchment.	Based on published data. Curtis <i>et al</i> (1998).
N_i Eq/ha/year	AG	71	214	Dependant on soil type.	Based on published data for long term sustainability.
	CG	71	214		
	H	71	214		
	C	71	214		
	D	71	214		
	W	7	214	N_i values catchment-weighted according to area of different soils present in catchment.	
$N_{le(acc)}$ Eq/ha/year	AG	-	-	Empirical nutrient nitrogen critical loads used, therefore $N_{le(acc)}$ not assigned.	Values based on data from a limited number of detailed site studies for GB plantations.
	CG	-	-		
	H	-	-		
	C	428	428	Equivalent to 6kg N/ha/year.	
	D	428	428		
	W	-	-	Not used.	
N_{de} Eq/ha/year	AG	71	286	Used in CLminN only. (Empirical critical loads of nutrient nitrogen used). Values assigned according to soil type.	

	CG	71	286		
	H	71	286		
	C	71	286	Used in CLminN and mass balance of CLnutN.	
	D	71	286	Values assigned according to soil type.	
	W	7	285	Uses catchment-weighted N_{de} values (based on soil type) instead of f_{de} .	Use of f_{de} (0.1-0.8) as in Mapping Manual gives N_{de} values up to 25kg N/ha/year – much too high for UK (Curtis et al, 1998).
Precipitation surplus Q (m)	AG	-	-	SMB not used, therefore Q not assigned.	
	CG	-	-		
	H	-	-		
	C	0.057	3.876	1km runoff data based on 30-year (1941-1970) mean rainfall data.	Used in SMB equation for acidity critical loads.
	D	0.057	3.876		
	W	0.097	3.364	1km catchment-weighted runoff based on mean rainfall data for 1941-70 for GB and 1961-90 for NI.	Used in FAB.
k_{gibb} (m6/eq2)	AG	-	-	SMB not used (empirical acidity critical loads applied).	
	CG	-	-		
	H	-	-		
	C	9.5	950	Minimum value applied to organic soils and maximum value applied to mineral soils.	Mapping Manual.
	D	9.5	950		
	W	-	-	Not used.	

Ecosystem Codes:

AG = acid grassland

CG = calcareous grassland

H = heathland

C = coniferous forest

D = deciduous forest

W = waters