Updates to UK critical loads and exceedances September 2009

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Executive Summary

This report summarises updates made to (a) acidity critical loads for the bog broad habitat; (b) the calculation of area-weighted deposition for freshwater catchments, and (c) the impact of both of these on critical load exceedances.

The analysis shows the impacts of these updates are relatively small at the national scale. An additional 346 km^2 (6.4%) of the bog habitat is exceeded using the updated critical loads; the largest increase is seen in Scotland (270 km^2).

The use of area-weighted habitat-specific deposition for the freshwater catchments increases the total number of sites exceeding critical loads from 652 (37%) to 675 (39%). In terms of area an additional 44 km^2 is exceeded using the updated deposition calculations.

However, together, these updates increase the total area of all sensitive habitats exceeded in the UK by 0.5% (390 km^2). The differences in exceedances resulting from these updates are relatively small and have little impact on maps of exceedance; differences are difficult to see on the national-scale maps.

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1 Introduction

The last major update to the national critical loads was carried out in 2003 (Hall et al, 2003); further minor updates were made in 2004 (Hall et al, 2004) and in 2008 (Hall et al, 2008).

This update involves a minor change to the calculation of acidity critical loads for the bog broad habitat. The consequences of this change on critical load exceedances are also considered.

In addition, the deposition data used for calculating exceedances of UK freshwaters have been updated from the application of area-weighted grid-average deposition, to the use of habitat-specific deposition appropriate to the land cover within each catchment. The impact of this on critical load exceedances is reported.

2 Updates to acidity critical loads for the bog broad habitat and impacts on exceedances

2.1 Critical load updates

The bog broad habitat distribution is defined using the CEH Land Cover Map 2000 (LCM2000) and bog species distribution data (Hall et al, 2003). Acidity critical loads for the terrestrial non-woodland habitats have been based upon the soil acidity critical loads map for the UK; this consists of critical load values based on the dominant soil type in each 1x1 km grid square. For squares dominated by non-peat soils the critical loads are based on the mineralogy and weathering rate of the soil type (Hornung et al 1995). For squares dominated by peat soils the critical loads are based on the amount of acid deposition that would prevent the soil solution pH falling below the pre-defined pH threshold of 4.4 (Calver, 2003; Skiba & Cresser, 1989; Calver et al, 2004).

The definition of the bog habitat from LCM2000 is: "Bogs include ericaceous, herbaceous and mossy vegetation in areas with peat >0.5m deep"[1]. This update is based upon the premise that bog habitat should only occur on peat soils and hence critical loads should be based on methods appropriate for peat soils. The following updates have been performed:

(i) Updates to the soil acidity critical loads for the bog habitat.
The soil acidity critical loads for the area of the bog broad habitat have been updated to values based on the peat soil method:
$CLA = Q * [H^+]$
Where:
Q = runoff in metres
$[H^+]$ = critical hydrogen ion concentration equivalent to pH 4.4

The only exception to this are bog habitat squares mapped in areas dominated by arable land; these are assumed to be lowland/arable fen peats, less sensitive to acidification, and assigned a critical load value of 4.0 keq ha^{-1} $year^{-1}$. This approach is consistent with the national maps of soil acidity critical loads (Hall et al, 2004). Critical loads are calculated for 40 fewer 1x1 km bog habitat grid squares (12 in the Shetland Isles and 28 in Northern Ireland) using this approach; this is due to missing data for the critical load calculations.

Maps of soil acidity critical loads for the bog habitat based on (a) dominant soil type, and (b) peat soils, are presented for comparison in Figure 1. In some areas (eg, Skye, NW Scotland) the update has resulted in lower critical loads; and in other areas (eg, SW Scotland, Cumbria, Wales) the new critical loads are higher than previously.

(ii) Updates to the maximum critical load of sulphur (CLmaxS)
CLmaxS is calculated as: CLA + (BCdep – Cldep) – Bcu
Where:
CLA = acidity critical loads; here updated with the data from (i) above
BCdep = non-marine base cation deposition
Cldep = non-marine chloride deposition

[1] http://www.ceh.ac.uk/sections/seo/documents/leaflet3.pdf

BCu = base cation uptake by vegetation. For the bog habitat BCu is assumed to be zero (Hall et al, 2003).

(iii) Updates to the minimum critical load of nitrogen (CLminN)
CLminN is calculated as: Nu + Ni + Nde
Where:
Nu = nitrogen uptake by vegetation. For the bog habitat this has been set at 0.5 kg N ha^{-1} $year^{-1}$ (Hall et al, 2003).
Ni = nitrogen immobilisation
Nde = denitrification

Both Ni and Nde are assigned from default values by soil type (Hall et al, 1998 & 2003); values for Ni are either 1 or 3 kg N ha^{-1} $year^{-1}$ and values for Nde 1, 2 or 4 kg N ha^{-1} $year^{-1}$. These were previously assigned according to the dominant soil type in each 1km grid square. In this update the values for Ni and Nde for the bog habitat have been set for peat soils (Ni = 3 kg N ha^{-1} $year^{-1}$ and Nde = 1 kg N ha^{-1} $year^{-1}$). This results in a value for CLminN of 4.5 kg N ha^{-1} $year^{-1}$ for all bog habitat squares.

(iv) Updates to the maximum critical load of nitrogen (CLmaxN)
CLmaxN is the sum of CLminN plus CLmaxS and has therefore been re-calculated for the bog habitat using the updated values.

2.2 Impacts on exceedances

Exceedances of the previous and updated critical loads (CLmaxS, CLminN, CLmaxN) for the bog habitat are compared in Figure 2 and Table 1 below.

Table 1. Area and percentage of bog habitat critical loads exceeded by CBED acid deposition for 2004-2006 using (a) previous critical loads based on dominant soil type; (b) updated critical loads assuming all habitat on peat soils.

Country	Bog habitat area (km^2) [#]	Previous exceeded area (km^2)	Updated exceeded area (km^2)	Previous % habitat exceeded	Updated % habitat exceeded
England	1006	995	1004	98.9%	99.8%
Wales	56	55	56	97.6%	100%
Scotland	3955 (3959)	2257	2527	57.0%	63.9%
NI	437 (441)	356	421	80.7%	96.5%
UK	5454 (5462)	3663	4009	67.1%	73.5%

[#] The area of bog habitat for which acidity critical loads can be mapped has been reduced by 8 km^2 in this update due to missing data for calculating peat acidity critical loads in some parts of the Shetland Isles and Northern Ireland. Values in brackets are the habitat areas prior to this update.

The results show the greatest increases in the area of bog exceeded to be in Scotland and Northern Ireland. The magnitude of exceedance has also increased in some areas; this is evident in Figure 2 across parts of southern Scotland (more areas mapped in yellow).

3 Updates to the calculation of catchment-weighted deposition for freshwaters and the impacts on exceedances

Unlike the data for the terrestrial habitats that are mapped at 1x1 km resolution for the UK, the critical loads for freshwaters are only available for the 1752 sites sampled across the UK. Originally exceedances of these critical loads were calculated using the deposition values extracted from the national deposition maps for each site sampling point. At that time information on the land cover within the catchments was not documented and so the grid-average deposition values (ie, average values for all vegetation types) were used. As methods developed with the use of Geographic Information Systems (GIS), and with available digital catchment boundaries for each site, it became possible to calculate catchment area-weighted deposition values for each site. The grid-average values of deposition were used for this exercise until earlier this year (2009).

For this update, information on the land cover (LCM 2000) within each catchment has enabled us to calculate ecosystem-specific area-weighted deposition for each site. Deposition values can now be based on the area of woodland and non-woodland habitats in each site catchment, using the moorland and woodland CBED or FRAME deposition values. Table 2 shows a comparison of the exceedance results using area-weighted grid-average deposition and habitat-specific deposition. In total an additional 23 sites (44km^2) are exceeded using the habitat-specific deposition. Exceedance maps are shown in Figure 2; due to the scale and resolution of the maps, and the fact that differences between the two data sets are relatively small, differences between the maps are not easy to see.

Table 2: Comparison of the number of freshwater sites exceeding critical loads using (a) catchment area-weighted grid average acid deposition for 2004-06, and (b) catchment area-weighted habitat-specific acid deposition for 2004-06.

Country	Number of sites	Area (km^2)	Number & percentage sites exceeded by:		Area (km^2) & percentage area sites exceeded by:	
			Grid average deposition	Habitat specific deposition	Grid average deposition	Habitat specific deposition
England	425	1109	230 (54%)	240 (56%)	557 (50%)	570 (51%)
Wales	344	1225	168 (49%)	173 (50%)	407 (33%)	429 (35%)
Scotland	856	5338	232 (27%)	240 (28%)	725 (14%)	735 (14%)
NI	127	186	22 (17%)	22 (17%)	33 (18%)	32 (18%)
UK	1752	7857	652 (37%)	675 (39%)	1722 (22%)	1766 (23%)

4 Updates to UK summary exceedance statistics

The effect of the changes described in sections 2 and 3 above on the UK summary exceedance statistics and maps have also been considered. Table 3 below compares the exceedance statistics for the UK prior to this update and including the modifications described. For the UK the total area of habitats exceeded increases by 390 km^2 (0.5%) using the new data sets. The full results for each country are given in Annex 1.

Table 3. Acidity exceedance statistics by habitat for the UK based on incorporating the updated bog critical loads and updated catchment deposition. All deposition is CBED data for 2004-06. Results prior to this update are given in brackets for "Bog", "Freshwaters" and "All habitats".

Broad habitat	Habitat area (km^2)	Exceeded area (km^2)	Percentage area exceeded	Accumulated Exceedance (keq $year^{-1}$)
Acid grassland	15336	12749	83.1	1093590
Calcareous grassland	1808	0	0	0
Dwarf shrub heath	24705	11490	46.5	595731
Bog	5454	(3663) 4009	(67.1) 73.5	(237922) 253034
Montane	3054	2957	96.8	215174
Coniferous woodland (managed)	8374	5712	68.2	589994
Broadleaved woodland (managed)	7452	4983	66.9	608762
Unmanaged woods	4011	2262	56.4	225175
Freshwaters	7857	(1722) 1766	(21.9) 22.5	(140048) 148797
All habitats	78051	(45538) 45928	(58.3) 58.8	(3706396) 3730257

Exceedance maps can be generated for individual habitats as seen in Figures 1 and 2. One way of summarising the results in map form is to calculate the 5^{th}-percentile critical load values for CLmaxS, CLminN and CLmaxN from the 1km data for all the terrestrial habitats. The 5^{th}-percentile critical load in each 1km grid square is then the critical load that will protect 95% of the total sensitive habitat area within each square. Exceedances are calculated for these critical loads using grid-average deposition values; habitat specific deposition is not used in this instance, since different habitat types contribute to defining the 5^{th}-percentile values. Figure 3 compares the exceedance maps based on the 5^{th}-percentile values before and after the updates. As for the other maps, the differences are small and hence difficult to see at this scale and resolution.

References

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Annex 1: Acidity exceedance statistics by habitat and country based on updated bog habitat critical loads and updated catchment deposition for freshwaters; all other data unchanged. Results for "bog", "freshwaters" and "all habitats" include the results prior to this update in brackets. The habitat areas for bog are the updated areas. All exceedance calculations use CBED deposition for 2004-06.

(a) Results for England

Broad habitat	Habitat area (km^2)	Exceeded area (km^2)	Percentage area exceeded	Accumulated Exceedance (keq $year^{-1}$)
Acid grassland	2669	2532	94.9	331921
Calcareous grassland	1714	0	0	0
Dwarf shrub heath	2462	2278	92.5	216287
Bog	1006	(995) 1004	(98.9) 99.8	(139473) 141012
Montane	2	2	99.8	306
Coniferous woodland (managed)	1716	1496	87.2	239283
Broadleaved woodland (managed)	5565	3814	68.5	500978
Unmanaged woods	2392	1421	59.4	152872
Freshwaters	1109	(557) 570	(50.2) 51.4	(72949) 76309
All habitats	18635	(13095) 13117	(70.3) 70.4	(1654069) 1658968

(b) Results for Wales

Broad habitat	Habitat area (km^2)	Exceeded area (km^2)	Percentage area exceeded	Accumulated Exceedance (keq $year^{-1}$)
Acid grassland	3143	3008	95.7	305451
Calcareous grassland	45	0	0	0
Dwarf shrub heath	1078	1001	92.8	78331
Bog	56	(55) 56	(97.6) 100	(5927) 4921
Montane	18	18	100	2664
Coniferous woodland (managed)	1048	1008	96.2	122716
Broadleaved woodland (managed)	790	605	76.6	71621
Unmanaged woods	395	306	77.5	34838
Freshwaters	1225	(407) 429	(33.2) 35.0	(23365) 27604
All habitats	7798	(6408) 6431	(82.2) 82.5	(644913) 648146

(c) Results for Scotland

Broad habitat	Habitat area (km^2)	Exceeded area (km^2)	Percentage area exceeded	Accumulated Exceedance (keq $year^{-1}$)
Acid grassland	8336	6264	75.1	396407
Calcareous grassland	7	0	0	0
Dwarf shrub heath	20190	7560	37.4	272061
Bog	3955	(2257) 2527	(57.0) 63.9	(71978) 80263
Montane	3034	2937	96.8	212203
Coniferous woodland (managed)	5111	2912	57.0	203070
Broadleaved woodland (managed)	1096	563	51.4	36162
Unmanaged woods	1016	440	43.3	25020
Freshwaters	5338	(725) 735	(13.6) 13.8	(40729) 41887
All habitats	48083	(23658) 23938	(49.2) 49.8	(1257630) 1267073

(d) Results for Northern Ireland

Broad habitat	Habitat area (km^2)	Exceeded area (km^2)	Percentage area exceeded	Accumulated Exceedance (keq $year^{-1}$)
Acid grassland	1189	945	79.5	59811
Calcareous grassland	43	0	0	0
Dwarf shrub heath	974	651	66.9	29053
Bog	437	(356) 421	(80.7) 96.5	(20544) 26838
Montane	0	0	0	0
Coniferous woodland (managed)	500	295	59.0	24926
Broadleaved woodland (managed)	0	0	0	0
Unmanaged woods	208	95	45.4	12445
Freshwaters	186	(33) 32	(17.6) 17.5	(3005) 2997
All habitats	3537	(2375) 2439	(67.1) 69.0	(149784) 156070