Belgium (Wallonia)

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Regional Data Produced
Critical loads data have been produced for forests (coniferous, deciduous, mixed forests) and natural vegetation in Wallonia.

Mapping procedure Wallonia
From Walloon Land Cover Map, 27.344 forest ecosystems area (>1 ha) were extracted and overlaid with thematic maps in order to calculate critical loads parameters. From Corine Land Cover 2005, four natural ecosystem types (representing 136 ecosystems area) were extracted and assigned to a theoretical value according to ecosystem type. Next, critical loads maps were overlaid with new EMEP grid (0.10° x 0.05° Longitude-Latitude grid) as requested.

Calculation methods & results Wallonia
A. Forest Soils
Calculation methods

Critical loads for forest soils were calculated according to the method as described in UBA (1996) and Manual for Dynamic Modelling of Soil Response to Atmospheric Deposition (2003):

$CL_{max}(S) = BCwe + BC_{dep} – BC_u – ANC_{le(crit)}$
$CL_{max}(N) = N_i + N_u + CL_{max}(S)$
$CL_{nut}(N) = N_i + N_u + N_{le} + N_{de}$
$ANC_{le(crit)} = -Q_{le} ([Al^{3+}] + [H^+] - [RCOO^-])$

Where :
$[Al^{3+}] = 0.2\ eq/m^3$
$[H^+]$ = concentration of $[H^+]$ at the pH critique (Table BE-1).

$[RCOO^-]$ = 0.044 molc/molC x $DOC_{measured}$ (Table BE-1)

The equilibrium K = $[Al^{3+}]/[H^+]^3$ criterion: The Al^{3+} concentration was estimated by 1) experimental speciation of soil solutions to measure rapidly reacting aluminium, Alqr (Clarke et al.,1992) ; 2) calculation of Al^{3+} concentration from Alqr using the SPECIES speciation software. The K values established for 10 representative Walloon forest soils (Table BE-1) were more relevant than the gibbsite equilibrium constant recommended in the manual (UBA, 1996). The difference between the estimated Al^{3+} concentrations and concentration that causes damage to root system (0.2 eq Al^{3+}/m^3; de Vries et al., 1994) gives the remaining capacity of the soil to neutralise the acidity. For the majority of Walloon soils, the range of critical pH is 4.3-4.4.

The Tables BE-1 and BE-2 summarise the values given to some of the parameters.

Table BE-1. Aluminium equilibrium constants, weathering rates and critical pH limit calculated for Walloon soils; and pH and DOC measured.

Site	**Soil type**	**K**	**BCwe** eq ha^{-1} yr^{-1}	**Critical pH limit calculated**	**pH measured**	**DOC** g/m^3
Bande (1-2)	Podzol	140	610	3.95	5.16	42.59
Chimay (1)	Cambisol	414	1443	4.10	5.61	64.81
Eupen (1)	Cambisol	2438	2057	4.36	4.81	29.6
Eupen (2)	Cambisol	25	852	3.70	3.5	26.47
Hotton (1)	Cambisol	2736	4366	4.38	8.19	45.47
Louvain-la-Neuve (1)	Luvisol	656	638	4.17	4.37	99.35
Meix-dvt-Virton (1)	Cambisol	2329	467	4.35	5.4	32.21
Ruette (1)	Cambisol	5335	3531	4.47	6.12	26.12
Transinne (1)	Cambisol	3525	560	4.41	4.61	26.38
Willerzie (2)	Cambisol	2553	596	4.37	4.67	29.91

(1) deciduous; (2) coniferous forest

Table BE-2. Constants used in critical loads calculations in Wallonia.

Parameter	Value
N_i	5.6 kg N ha^{-1} yr^{-1} coniferous forest 7.7 kg N ha^{-1} yr^{-1} deciduous forest 6.65 kg N ha^{-1} yr^{-1} mixed forest
$N_{le\ (acc)}$	2.5 mg N L^{-1} for coniferous forest 3.5 mg N L^{-1} for deciduous forest 3 mg N L^{-1} for mixed forest
N_{de}	fraction of (N_{dep} – Ni – Nu)

Soils: In *Wallonia*, 47 soil types were distinguished according to the soil associations map of the Walloon territory, established by Maréchal and Tavernier (1970). Each ecosystem is characterised by a soil type and a forest type.

Weathering rates: In *Wallonia*, the base cation weathering rates (BC_{we}) were estimated for 10 different representative soil types (Table BE-1) through leaching experiments. Increasing inputs of acid were added to soil columns and the cumulated outputs of lixiviated base cations (Ca, Mg, K, Na) were measured. Polynomial functions (Table BE-3) were used to describe the input-output relationship. To estimate BC_{we}, an acid input was fixed at 900 eqH^+ ha^{-1} yr^{-1} in order to keep a long-term balance of base content in soils.

Table BE-3. Polynomial functions used in critical loads calculations in Wallonia.

Site	Polynomial function y = BC (eq ha^{-1} yr^{-1}) ; x = input d'H^+ (eq ha^{-1} yr^{-1})	Depth considered to establish the function (m)
Bande (2)	$y = -5.509E-10x^3 + 7.023E-06x^2 + 0.6721x$ $R^2 = 0.9999$	0.50
Chimay (1)	$y = -1.075E-09x^3 + 2.510E-05x^2 + 1.261x$ $R^2 = 0.9991$	0.40
Eupen (1)	$y = -3.294E-10x^3 - 4.338E-06x^2 + 1.147x$ $R^2 = 0.9998$	0.25
Eupen (2)	$y = 1.581E-10x^3 - 1.130E-05x^2 + 0.4835x$ $R^2 = 0.9989$	0.25
Hotton (1)	$y = 8.288E-10x^3 - 4.336E-05x^2 + 4.889x$ $R^2 = 0.9998$	0.50
Louvain-la-Neuve (1)	$y = 3.614E-10x^3 - 2.054E-05x^2 + 0.7267x$ $R^2 =0.9985$	0.50
Meix-dvt-Virton	$y = -3.545E-10x^3 + 1.675E-06x^2 + 0.5180x$ $R^2 = 0.9976$	0.50
Transinne (1)	$y = 3.729E-10x^3 - 2.627E-05x^2 + 0.6454x$ $R^2 = 0.9818$	0.50
Ruette (1)	$y = 1.111E-09x^3 - 5.334E-05x^2 + 3.970x$ $R^2 = 0.9995$	0.50
Willerzie (2)	$y = 6.326E-10x^3 - 3.396E-05x^2 + 0.6921x$ $R^2 = 0.9976$	0.50

(1) deciduous; (2) coniferous forest

The flux of drainage water leaching, Q_{le}, from the soil layer (entire rooting depth) was estimated from EPICgrid model (Faculté Universitaire des Sciences Agronomiques de Gembloux). The results of the EPICgrid model are illustrated at the Figure BE-1. The flux drainage of the 2009-2013 period was used.

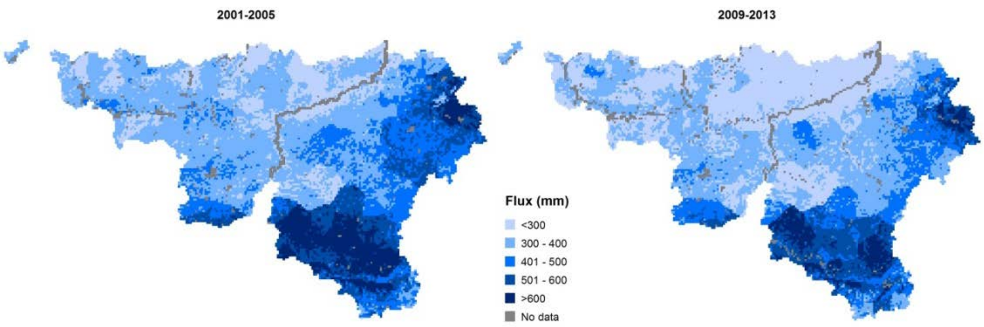

Figure BE-1. Flux of drainage at 50 cm depth in Wallonia for the 2001-2005 and 2009-2013 periods.

The critical (acceptable) N concentration was taken from the CCE/Alterra Report (De Vries et al., 2007):
Coniferous forest: 2.5-4.0 mgN L^{-1}
Deciduous forest: 3.5-6.5 mgN L^{-1}
The minimum recommended values (Table BE-2) are applied for the calculations of $CL_{nut}N$.

Net growth uptake of base cations and nitrogen: In *Wallonia*, the net nutrient uptake (equal to the removal in harvested biomass) was calculated using the average growth rates measured in 25 Walloon ecological territories and the chemical composition of coniferous and deciduous trees. The chemical composition of the trees (*Picea abies, fagus sylvatica, Quercus robur, Carpinus betulus*) appears to be linked to the soil type (acidic or calcareous) (Duvigneaud et al., 1969; Bosman et al., 2001; Unité des Eaux et Forêts, 2001; André et al., 2010; André and Ponette, 2003).

The net growth uptake of nitrogen ranges between 260 and 1090 eq ha^{-1} yr^{-1}, while base cations uptake values vary between 255 and 838 eq ha^{-1} yr^{-1} depending on trees species and location in Belgium.

Base cation deposition: In *Wallonia*, actual throughfall data collected in 8 sites, between 1997 and 2014, were used to estimate BCdep parameters. The marine contribution to Ca^{2+}, Mg^{2+} and K^{+} depositions was estimated using sodium deposition according to the method described in UBA (1996). The BCdep data of the 8 sites was extrapolated to all Walloon ecosystems depending on the location and the tree species.

Results
In *Wallonia*, the highest CL values were found in calcareous soils under deciduous or coniferous forests. The measured release rate of base cations from soil weathering processes is high in these areas, and thus provides a high long-term buffering capacity against soil acidification.

B. Natural vegetation
For Walloon ecosystems, considering the lack of accurate data, we use critical values established in Flanders with SMB method (Meykens and Vereecken, 2001). The critical loads for N and S deposition to natural vegetation are reported in Table BE-4.

Table BE-4. Critical loads for natural vegetation in Wallonia.

Ecosystem type	EUNIS code	CLmaxN	CLmaxS	CLnutN
Natural grassland	E1	4572	1893	1286
Moors and heathland	F4.2	2185	1645	643
Inland marshes	D5	2339	1655	786
Peat bogs-Fens	D2	2339	1655	786

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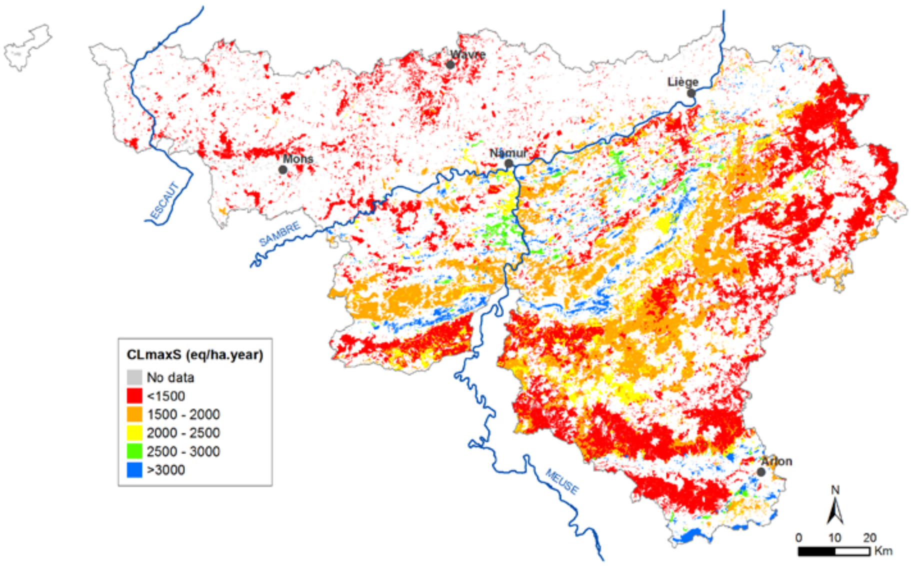

Figure BE-2. Maximum critical loads of sulphur for forests, CLmaxS.

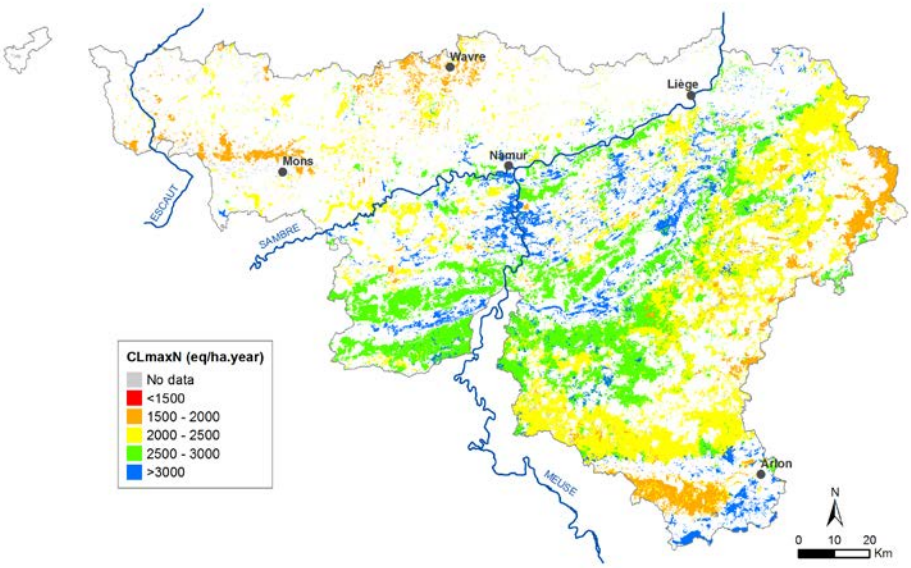

Figure BE-3. Maximum critical loads of nitrogen for forests, CLmaxN.

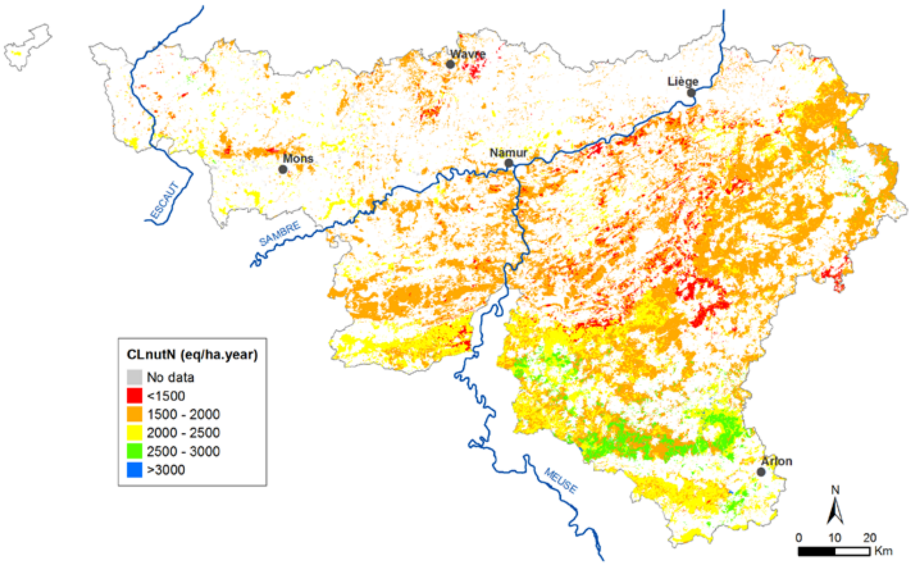

Figure BE-4. Critical loads of nutrient nitrogen for forests, CLnutN.