Belgium (Wallonia)

National Focal Centre	Collaborating Institutions
A. Fourmeaux Ministry of Walloon Region, DGRNE Avenue Prince de Liège 15 B-5100 Namur tel : +32 -81-325784 email: A.Fourmeaux@mrw.wallonie.be	V. Vanderheyden SITEREM S.A. Cour de la Taillette, 4 B-1348 Louvain-la-Neuve email: info@siterem.be S. Eloy Scientific Institute for Public Services (ISSEP) Rue du Chera, 200 B-4000 Liège email: s.eloy@issep.be

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 areas (>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 (0.50° x 0.25°) in order to load CCE database as requested.

Calculation methods & results Wallonia

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):

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

Where:

$[Al^{3+}]$ = 0.2 eq/m^3

$[H^+]$ = concentration of $[H^+]$ at critical pH (Table BE.2).

$[RCOO^-]$= 0.044 molc/molC x $DOC_{measured}$ (Table BE.2)

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.

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

Table BE.1 Aluminium equilibrium and weathering rates calculated for Walloon soils.

Sites	Soil types	K	BCwe(eq ha^{-1} yr^{-1})
Bande (1-2)	Podzol	140	610
Chimay (1)	Cambisol	414	1443
Eupen (1)	Cambisol	2438	2057
Eupen (2)	Cambisol	25	852
Hotton (1)	Cambisol	2736	4366
Louvain-la-Neuve (1)	Luvisol	656	638
Meix-dvt-Virton (1)	Cambisol	2329	467
Ruette (1)	Cambisol	5335	3531
Transinne (1)	Cambisol	3525	560
Willerzie (2)	Cambisol	2553	596

(1) deciduous or (2) coniferous forest

Table BE.2. Constants used in critical load 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)

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

In *Wallonia*, the **base cation weathering rates** (BC_{we}) were estimated for 10 different representative soil types (table BE-3) 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 were used to describe the input-output relationship. To estimate BC_{we}, a acid input was fixed at 900 $eqH^{+}\ ha^{-1}\ yr^{-1}$ in order to keep a long term balance of base content in soils.

$$\mathbf{N_{le} = Q_{le}\ \ cN_{(acc)}}$$

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 in Fig. BE.1.

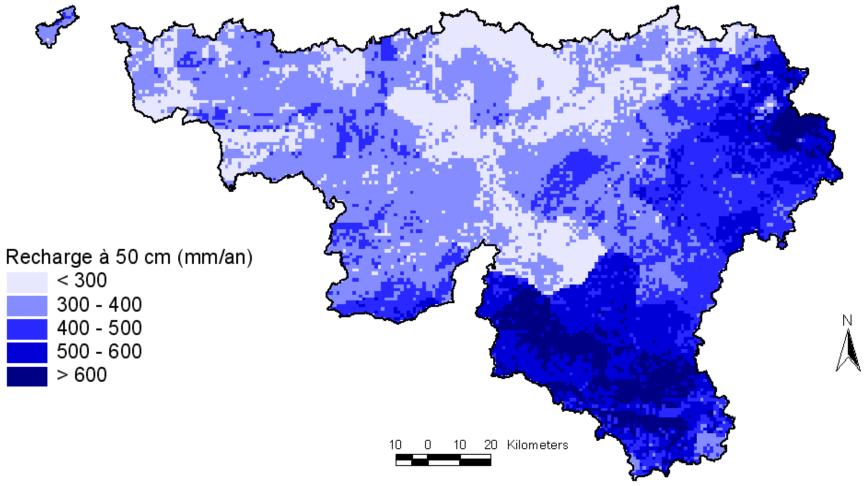

Figure BE.1 Flux of drainage at 50 cm depth in Wallonia for the 2001-2005 period.

The **critical (acceptable) N concentration, $cN_{(acc)}$,** comes from the CCE/Alterra Report (De Vries et al. 2007):

Coniferous forest	2.5-4 $mgN\ L^{-1}$
Deciduous forest	3.5-6.5 $mgN\ L^{-1}$

The minimum recommended values are applied for the calculation of CLnutN (Table BE.2).

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 robus*, *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, May 2001; Frédéric André et al., 2010; Frédéric André, Quentin Ponette, 2003).
The net growth uptake of nitrogen ranges between 266 and 822 eq $ha^{-1}\ yr^{-1}$, while base cations uptake values vary between 545 and 1224 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 2002, were used to estimate BC_{dep} 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 BC_{dep} 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 for 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.

Natural vegetations
For Walloon ecosystems, considering the lack of accurate input data, we use critical values established in Flanders with SMB method (Meykens & Vereecken, MIRA/2001/04). The critical loads for N and S deposition to natural vegetations are reported in Table BE.3.

Table BE.3 Critical loads for natural vegetations in Wallonia

Ecosystem type	EUNIS code	CLmax N	CLmax S	CL nut
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

References
Bosman B., Remacle J. & Carnol M. (2001) Element removal in harvested tree biomass: scenarios for critical loads in Wallonia, south Belgium. Water, Air and Soil Pollution, in press.

De Vries W., Reinds G.J., Posch M. & Kämäri, J. (1994) Simulation of soil response to acidic deposition scenarios in Europe. Water, Air and Soil Pollution 78: 215-246.

De Vries W. (1994) Soil response to acid deposition at a different regional scale: field and laboratory data, critical loads and model predictions. Ph.D dissertation, Univ. Wageningen, The Netherlands. 487pp.

De Vries W. (1990) Methodologies for the assessment and mapping of critical acid loads and of the impact of abatement strategies on forest soils in the Netherlands and in Europe. Winand Staring Centre Rep., Wageningen, The Netherlands, 91pp.

Dupriez, Sneyers (1979) Les nouvelles cartes pluviométriques de la Belgique. Rapport a/103. Institut Météorologique de Belgique, Uccle, Bruxelles.

Duvigneaud P., Kestemont & Ambroes P. (1969) Productivité primaire des forêts tempérées d'essences feuillues caducifoliées en Europe occidentale. Unescco. 1971, Productivité des écosystèmes forestiers, Actes du Colloque de Bruxelles, 1969 (écologie et conservation). p. 259-270.

Eloy S. (2000) Modeling, mapping, and managing critical loads for forest ecosystems using a geographic information system: approach of Wallonia, Belgium, to study of long-range transboundary air pollution effects on ecosystems in Europe. Environmental Toxicology and Chemistry 19, 4(2): 1161-1166.

Fevrier (1996) Charges critiques d'acidité pour les eaux de surface dans le massif des Ardennes. DEA Physique et chimie de la Terre, ULP STRASBOURG, 38 pp.

Maréchal R., Tavernier R. (1970). Association des sols, pédologie 1/500 000. Atlas de Belgique, Bruxelles, Belgium.

UBA (1996) Manual on Methodologies and Criteria for Mapping Critical Levels/Loads and geographical areas where they are exceeded. UN/ECE Convention on Long-range Transboundary Air Pollution. Federal Environmental Agency (Umweltbundesamt), Texte 71/96, Berlin

Unité des Eaux et Forêts (May 2001), Exportation de minéraliomasse par l'exploitation forestière. Université Catholique de Louvain, Belgique.

Siterem (2001) Estimation des charges critiques et des excès en polluants acidifiants pour les ecosystèmes forestiers et aquatiques wallons. Editor : Siterem s.a, Autors : Vanderheyden V. and Kreit J-F, Co-Autors : Bosman B., Brahy V., Carnol M., Delvaux B., Demuth C., Eloy S., Everbecq E., Halleux I., Jonard M., Marneffe Y., Masset F., Remacle J., Thome J.P. Published for Ministère de la Région wallonne, DGRNE, Belgique.

Siterem (2006) Analyse spatio-temporelle du dépassement des charges critiques en polluants acidifiants en région wallonne. Analyse selon le type d'écosystème et mise en relation avec les quantités émises de substances acidifiantes. Editor : Siterem s.a, Autors : Vanderheyden V with collaboration of ISSEP and CELINE. Published for Ministère de la Région wallonne, DGRNE, Belgique.

Weissen F., Hambuckers A., Van Praag H.J., & Remacle, J. (1990) A decennial control of N-cycle in the Belgian Ardenne forest ecosystems. Plant and Soil 128: 59-66.

Frédéric André et al. (2010) Biomass and nutrient content of sessile oak (Quercus petraea (Matt.) Liebl.) and beech (Fagus sylvatica L.) stem and branches in a mixed stand in southern Belgium. Science of the Total Environment 408: 2285–2294

Frédéric André, Quentin Ponette (2003) Comparison of biomass and nutrient content between oak (Quercus petraea) and hornbeam (Carpinus betulus) trees in a coppice-with-standards stand in Chimay (Belgium). Ann. For. Sci. 60: 489–502

Meykens & Vereecken, MIRA/2001/04. Ontwikkeling en integratie van gevoeligheidskaarten voor verzuring en vermesting van ecosystemen in Vlaanderen

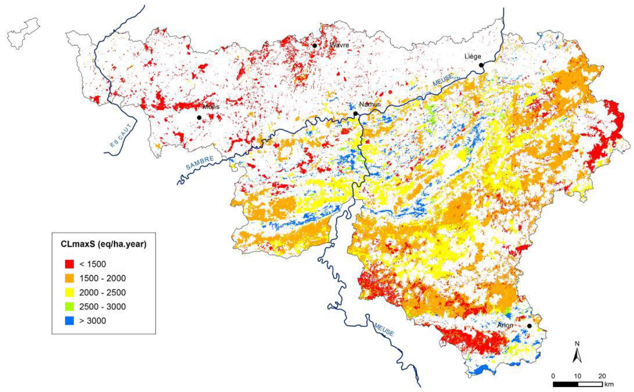

Figure BE.2 Maximum critical loads of sulphur for forests, CLmax(S)

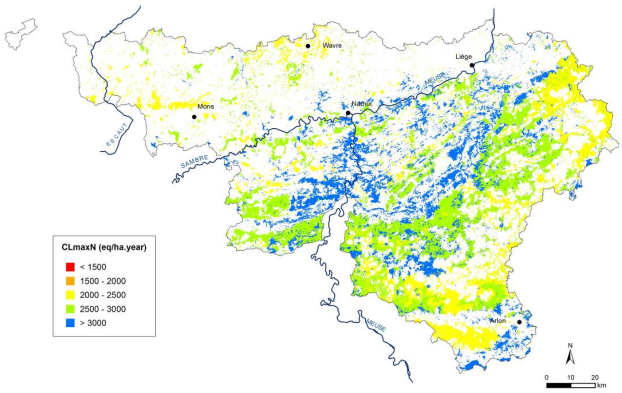

Figure BE.3 Maximum critical loads of nitrogen for forests, CLmax(N)

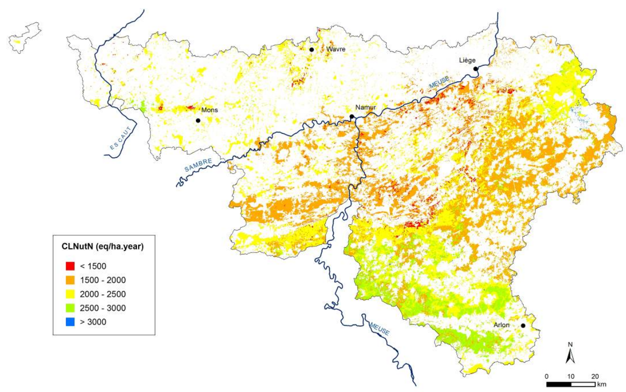

Figure BE.4 Critical loads of nutrient nitrogen for forests, CLNut(N)