2. Summary of National Data

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2.1 Introduction

The Working Groups on Effects (WGE) asked the Coordination Center for Effects (CCE) to issue a call for data for the heavy metals cadmium (Cd), lead (Pb) and mercury (Hg) in relation to the forthcoming review of the 1998 Heavy Metals protocol. This call was issued in October 2004 with the deadline of 31 December 2004. All the data of the Parties (National Focal Centres) that responded to the call have been merged into a European dataset, and are displayed and discussed in this chapter. Prior to this reporting the countries received a preview of the European compilation of their data, to enable feedback in an early stage.

2.2 Requested variables

The underlying methodology for calculating critical loads of heavy metals has changed significantly since the preliminary call for critical loads data (cadmium and lead) in 2001 (see De Vries et al., 2005; Hettelingh et al., 2002).
This led to the following changes to the call:
New pollutants, effects-based methodologies for mercury (Hg) are available for:

- ecotoxicological effects in forest humus layers
- human health effects: indicator is Hg in fish (surface waters)

New endpoints: Inclusion of human health aspects of Pb, Cd, Hg:

- Cd in wheat
- Hg in fish
- Pb, Cd, Hg in drinking water (protection of groundwater)

New critical limits (ecotoxicological) for Cd and Pb (application of the free ion approach for effects of Cd and Pb on biota in terrestrial systems.
Only effects based approach. The so-called "stand still", allowing no accumulation of the metals in the soil, has no longer been applied.

A description of the methodology can be found in chapter 5.5 of the recent update of the Mapping Manual (UBA, 2004). The instructions for submitting data, including the requested data structure, variable names and units, as send to all National Focal Centres, can be found in Appendix A.

2.3 National responses

The CCE has requested the 25 National Focal Centres (NFCs) for (an update of) the critical load data of heavy metals. A total of 17 NFCs have responded to the request and delivered data for one or more metals and for one or more effects (see Table 1-1). An overview of the national submissions is given in Table 2-1.

Table 2-1. Overview of the number of ecosystems per country submitted for critical loads of cadmium, lead and mercury and the 5 endpoint.

Country (Country Code)	Effect number (see Table 1-1)										
	Cadmium (Cd)				Lead (Pb)				Mercury (Hg)		
	1	2	3	4	1	2	3	4	1	3	5
Austria(AT)	2,953	1,154	2,953		2,953		2,953		2,953	455	
Belarus(BY)			9,503				9,503				
Belgium(BE)	1,833		1,833	10	1,833		1,833	10	1,833	1,833	10
Bulgaria(BG)	84				84						
Cyprus(CY)	31,893	8,274	31,893		31,893		31,893		31,893		
Finland(FI)											820
France(FR)			3,840				3,840				
Italy(IT)			881				881				
Germany(DE)	290,003	144,211	290,003		290,003		290,003		290,003	99,866	
Netherlands(NL)	12,627	10,180	30,484		12,627		30,484				
Poland(PL)			88,383				88,383			88,383	
Russia(RU)	6,616		22,828		9,992		20,206				
Slovakia(SK)			320,891				320,891			320,891	
Sweden(SE)		2450	2,070				2,070			5,396	2,977
Switzerland(CH)	57		220		56		221			277	
Ukraine(UA)		46				46					
United-Kingdom(GB)			234,654				234,654				
Total	**346,066**	**157,153**	**1,040,436**	**10**	**349,441**	**46**	**1,035,952**	**10**	**326,682**	**517,101**	**3,807**

Figure 2-1 shows the percentage of the total country area for which critical loads have been submitted of cadmium, lead and mercury by ecosystem type and by effect (see Table 1-1). Mostly critical loads of cadmium and lead, and for ecotoxicological effects for terrestrial ecosystems (effect 3) have been submitted. Finland, Sweden and Belgium have submitted data for the human health effects for aquatic ecosystems (food quality, effect 5). Belgium has also submitted the ecotoxicological effects for aquatic ecosystems (effect 4). Forest is the dominant ecosystem considered in most of Europe for submitting critical loads. Critical loads for agricultural areas were submitted by 6 countries.

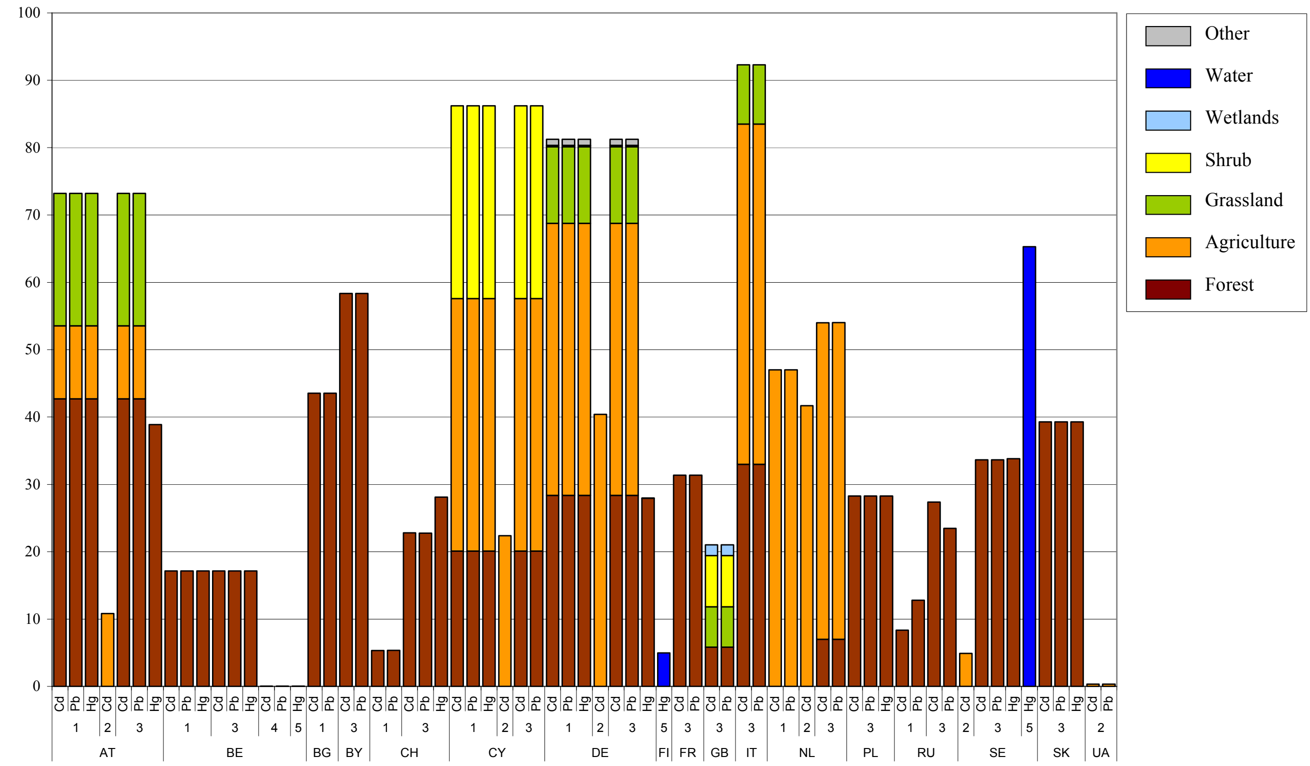

Figure 2-1. National distribution of ecosystem types (% of total country area) by effect (see Table 1-1) for critical loads of cadmium, lead and mercury.

All 17 submissions used the EUropean Nature Information System (EUNIS) to classify the ecosystem types, up to a very detailed level. These levels are truncated to a maximum of 2 characters. Table 2-2 lists the areas (in km^2) and the number of submitted ecosystems by heavy metal, indicating the resolution each country uses for its calculations.

Table 2-2. Number of ecosystems and areas per national contribution.

Country	Country area (km^2)	EUNIS lev. 1	Cd		Pb		Hg	
			#ecosyst	Area (km^2)	#ecosyst	Area (km^2)	#ecosyst	Area(km^2)
Austria	83,858	Forest	503	35,822	503	35,822	503	35,822
		Agriculture	1,154	9,073	1,154	9,073	1,154	9,073
		Grassland	1,296	16,491	1,296	16,491	1,296	16,491
		total	2,953	61,386	2,953	61,386	2,953	61,386
Belarus	207,595	Forest	9,503	121,128	9,503	121,128		
Belgium	30,528	Forest	1,833	5,237	1,833	5,237	1,833	5,237
		Water	10	9	10	9	10	9
		total	1,843	5,246	1,843	5,246	1,843	5,246
Bulgaria	110,994	Forest	84	48,330	84	48,330		
Cyprus	9,251	Forest	7,438	1,860	7,438	1,860	7,438	1,860
		Agriculture	13,869	3,467	13,869	3,467	13,869	3,467
		Shrub	10,586	2,647	10,586	2,647	10,586	2,647
		total	31,893	7,973	31,893	7,973	31,893	7,973
Finland	338,144	Water					820	16,856
France	543,965	Forest	3,840	170,657	3,840	170,657		
Germany	357,022	Forest	101,306	101,306	101,306	101,306	101,306	101,306
		Agriculture	144,211	144,211	144,211	144,211	144,211	144,211
		Grassland	40,529	40,529	40,529	40,529	40,529	40,529
		Shrub	3,205	3,205	3,205	3,205	3,205	3,205
		Wetlands	659	659	659	659	659	93
		Other	93	93	93	93	93	93
		total	290,003	290,003	290,003	290,003	290,003	290,003
Italy	301,336	Forest	436	99,327	436	99,327		
		Agriculture	230	152,285	230	152,285		
		Grassland	215	26,551	215	26,551		
		total	881	278,163	881	278,163		
Netherlands	41,526	Forest	17,857	2,900	17,857	2,907		
		Agriculture	12,627	19,522	12,627	19,522		
		total	30,484	22,422	30,484	22,429		
Poland	312,685	Forest	88,383	88,383	88,383	88,383	88,383	88,383
Russia*	5,090,400	Forest	29,444	1,818,725	30,198	1,844,700		
Slovakia	49,034	Forest	320,891	19,253	320,891	19,253	320,891	19,253
Sweden	449,964	Forest	2,070	151,441	2,070	151,441	5,396	152,098
		Agriculture	2,450	22,050				
		Water					2,977	293,749
		total	4,520	173,491	2,070	151,441	8,379	446,177
Switzerland	41,285	Forest	277	11,612	277	11,612	277	11,612
Ukraine	603,700	Agriculture	46	1,925	46	1,925		
United Kingdom	243,307	Forest	98,827	14,134	98,827	14,134		
		Grassland	73,816	14,637	73,816	14,637		
		Shrub	49,517	18,488	49,517	18,488		
		Wetlands	12,494	3,892	12,494	3,892		
		total	234,654	51,151	234,654	51,151		
All Countries	**8,814,594**	**Grand Total**	**1,049,699**	**3,169,849**	**1,048,003**	**3,173,780**	**745,442**	**946,889**

* European part.

All figures in this chapter show aggregated ecosystem types to EUNIS level 1, or grouped further into the main categories *forest, (other semi-natural) vegetation, agriculture* and *water*, as listed in Table 1 in Appendix B.

2.4 Critical loads

A critical load has been defined as *a quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge*. In this call different endpoints, and pathways towards these endpoints, have been considered, referred to as *effects*, see Table 1-1).

This section shows critical load maps and critical load distributions by country. Characteristic national features can often be explained by studying the national reports in Part II of this report.

Maps of the 5th percentile of the critical loads and critical concentrations are presented in Chapter 1 (Figure 1-1). Figure 2-2 shows median (50th percentile) values of these minimum critical loads for countries that submitted data. Percentiles have been calculated as follows. For each ecosystem the minimum critical load of effects 1 to 4 was taken. Then for each EMEP50 grid cell the 5th and 50th percentile of the distribution of minimum critical loads is calculated implying a critical load at which 95 and 50 percent of the ecosystems are protected respectively in that grid cell against any of the four effects. Effect 5 is treated separately because it is not associated with a critical deposition but with a critical concentration in precipitation (CC). For this effect the 50th percentile critical concentration is mapped in each EMEP50 grid cell, implying a value at which 50 percent of aquatic ecosystems will be protected from a health effect caused by the consumption of fish.

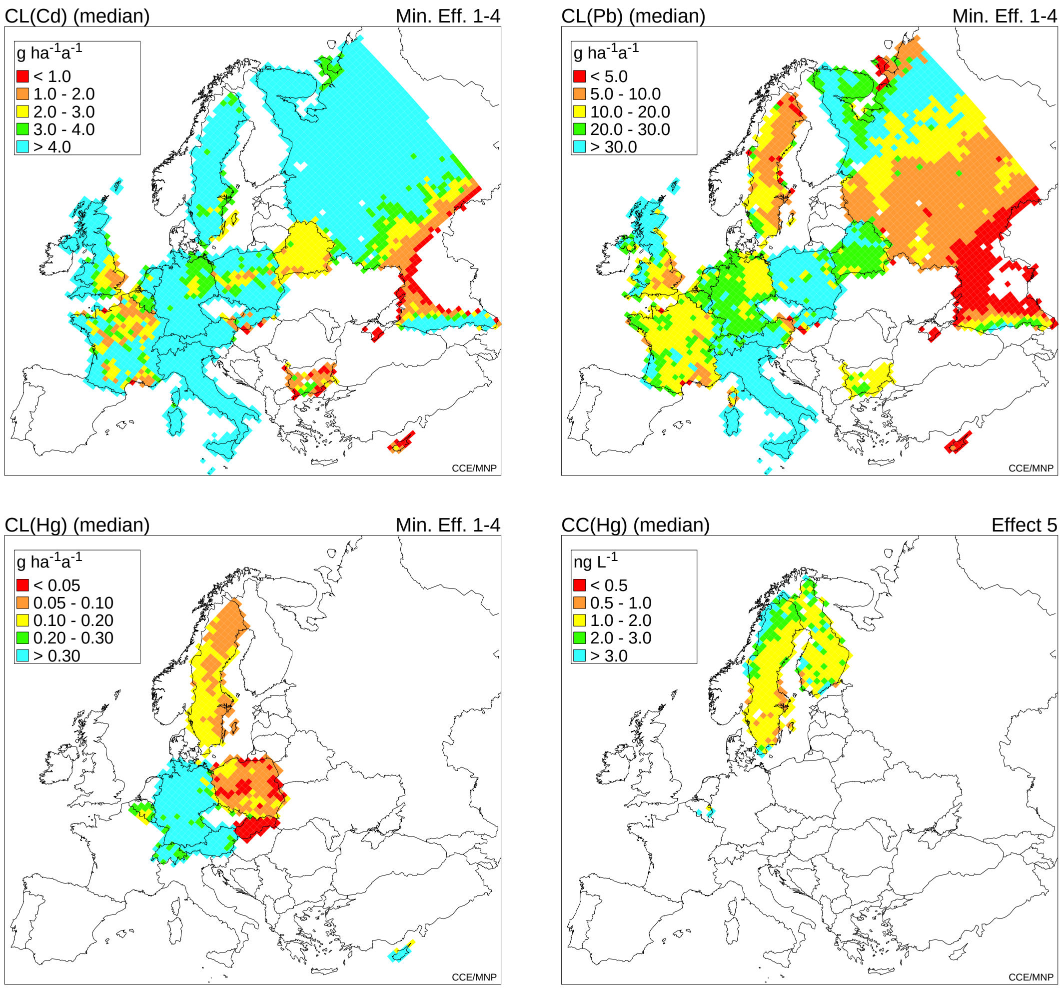

Figure 2-2. Median values of the critical loads of Cd (top left) Pb (top right) and Hg (bottom left), and the critical concentration of Hg in precipitation(bottom right) of countries that submitted data.

Critical load maps

Cadmium

Figure 2-3 shows the 5th percentile values of the critical loads of cadmium for each effect separately on the EMEP50 grid in countries that submitted data.

Most countries have submitted critical loads for effect 3 (ecotoxicological effects on terrestrial ecosystems). This map shows that the most sensitive areas are in Belarus, Cyprus, France, Poland, Slovakia and South-Russia. Comparison of the maps of the different effects shows that the effect with the lowest critical loads differs by country. For example, for the Netherlands effect 2 (human health effects – food quality) is the most sensitive, whereas effect 1 (human health effect – drinking water) turns out to be the most sensitive for Germany.

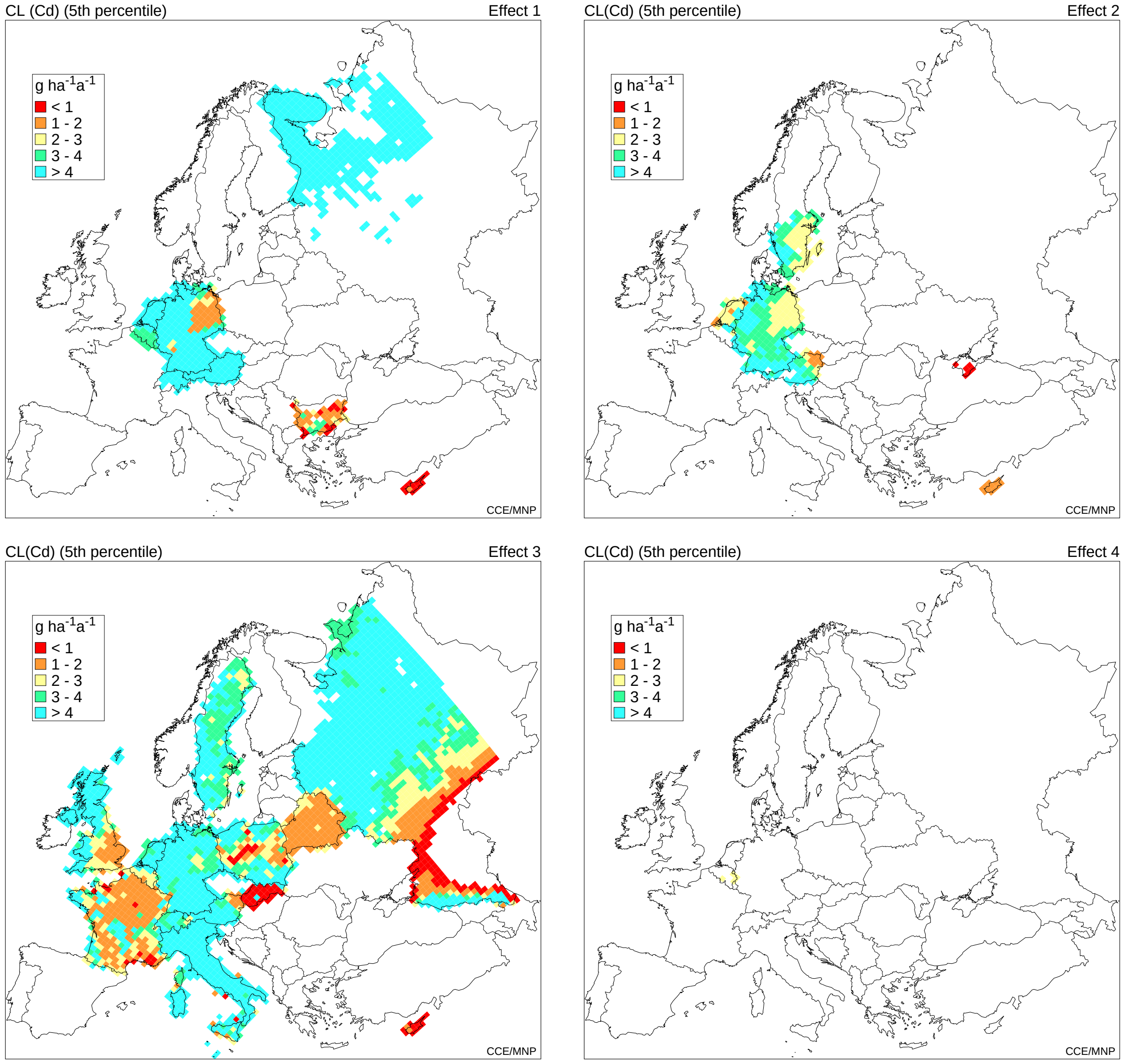

Figure 2-3. The 5th percentile EMEP50 grid values of the critical loads of cadmium for the different effects (1: human health effects – drinking water; 2: human health effects – food quality; 3: ecotoxicological effects on terrestrial ecosystems; 4: ecotoxicological effects on aquatic ecosystems).

Lead

Figure 2-4 shows the 5th percentile values for the critical loads of lead for effect 1 and 3 on the EMEP50 grid in countries that submitted data.

Ukraine has submitted critical loads for effect, which was mentioned in the Mapping Manual as a voluntary option. Belgium is the only country which also submitted critical loads for effect 4 (ecotoxicological effects on aquatic ecosystems). These two effects are not mapped here, since they show information for only three or four EMEP50 grid cells with 5th percentile values above 30 g ha^{-1} a^{-1}. For effect 3 (ecotoxicological effects on terrestrial ecosystems) the majority of countries has submitted critical loads. According to Figure 2-4 that the most sensitive areas are in Cyprus, Slovakia, Sweden, Russia and the United Kingdom.

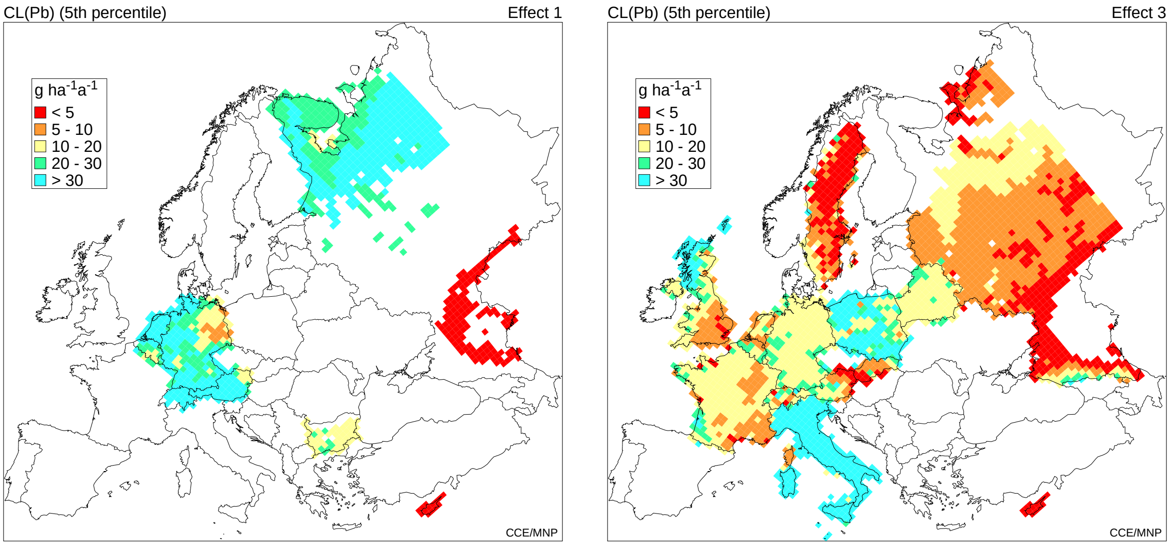

Figure 2-4. The 5th percentile EMEP50 grid values of the critical loads of lead for effect 1 and 3 (1: human health effects – drinking water; 3: ecotoxicological effects on terrestrial ecosystems).

Mercury

Figure 2-5 shows the 5th percentile values for the critical loads of mercury for effect 1 and 3. For effect 3 (ecotoxicological effects on terrestrial ecosystems) the most sensitive areas are in Poland, Slovakia and Sweden.

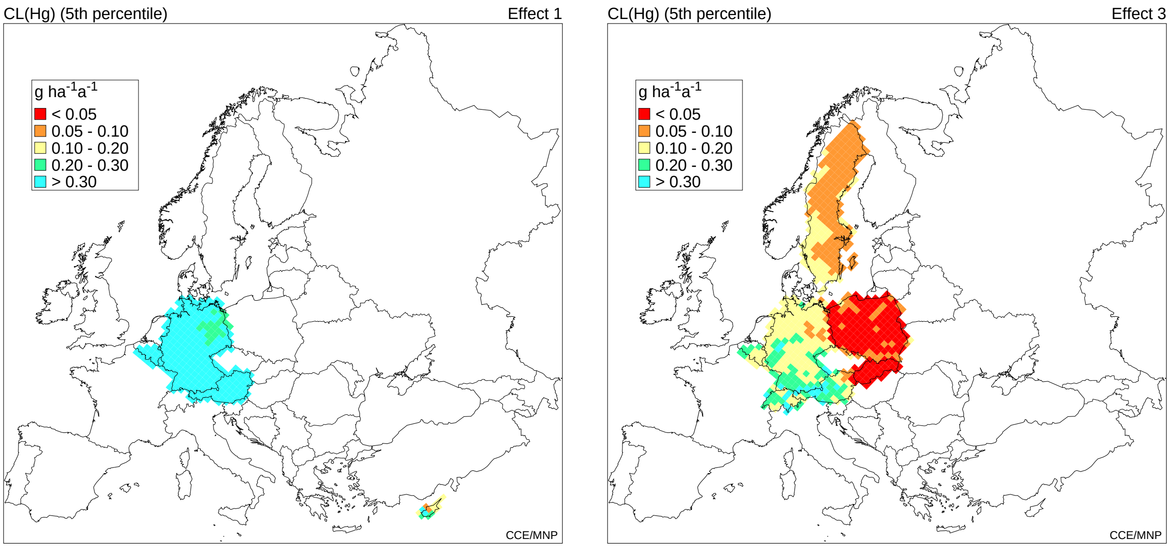

Figure 2-5. The 5th percentile EMEP50 grid values of the critical loads of mercury for effect 1 and 3 (1: human health effects – drinking water; 3: Ecotoxicological effects on terrestrial ecosystems).

Figure 2-6 shows the 5th percentile values for the critical concentration in rainfall of mercury for effect 5 on the EMEP50 grid. For effect 5 (human health effects on aquatic ecosystems) Belgium (Walloon), Sweden and Finland have submitted data. The most sensitive area is in the southern part of Sweden.

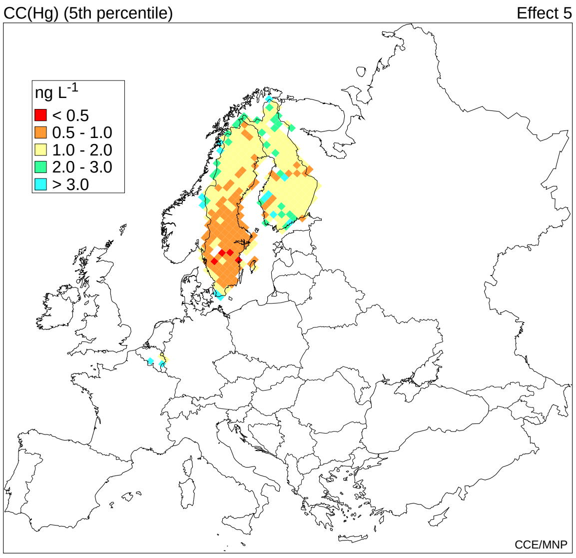

Figure 2-6. The 5th percentile EMEP50 grid values of the critical rainfall concentration of mercury for effect 5 (human health effects on aquatic ecosystems).

Critical load distributions

This section describes the cumulative distribution function (CDFs) of critical loads for each country that submitted data. A CDF of critical loads gives information on the percent of the ecosystem area (on the Y-axis) which has a critical load below or equal to specific values (on the X-axis). For reasons of graphical layout, no scale has been marked on the Y-axis of the CDFs shown in this section. Two kinds of distributions are inspected. The first focuses (plots on the left) on the distribution of critical load values for each of 4 ecosystems and the European background database (EU-DB; thin black dotted line) which only contains information on forest soils (see Chapter 3). There are no data (yet) for Cyprus in the background database. The ecosystem types which have been distinguished in the plots reflect the aggregation of classes given in the first column of Table 1 in Appendix B.

The second set of CDFs (plots on the right) looks distribution for each of the following 4 effects (except for Hg):

Drink	Effect 1	Human health effects – drinking water;
Food	Effect 2	Human health effects – food quality;
Eco-Terr	Effect 3	Ecotoxicological effects on Terrestrial ecosystems;
Eco-Aqua	Effect 4	Ecotoxicological effects on Aquatic ecosystems.

Cadmium

The CDFs of critical loads of cadmium are plotted in Figure 2-7. The submitted critical loads of cadmium are lower then those in the background database for the majority of the countries. The critical loads for agriculture ecosystems generally turn out to be lower than those for forests. Also note that 50th percentile critical loads of cadmium for forests (left plots) are between 4 and 6 g ha^{-1} yr^{-1} in France, the United Kingdom, Poland, Russia and Sweden, lower than 4 g ha^{-1} yr^{-1} in Belgium, Bulgaria and Belarus, and higher than 6 g ha^{-1} yr^{-1} in Austria, Germany, Italy, the Netherlands, Slovakia and Switzerland. Similarly we can see in the right-hand plots that the 50th percentile critical loads for effect 3 (*Eco-Terr;* Ecotoxicological effects on Terrestrial ecosystems) are between 4 and 6 g ha^{-1} yr^{-1} in the same countries.

Lead

The distributions of the national critical loads of lead are plotted in Figure 2-8. The CDF of submitted critical loads of lead for forest ecosystems are approximately comparable to the CDF of critical loads computed with the background database in e.g. Bulgaria and Switzerland. The minimum critical load for agriculture ecosystems is generally lower than that for forests in e.g. Austria and the Netherlands . The critical loads for effect 3 (Eco-Terr) are generally lower than for effect 1 (Drink).

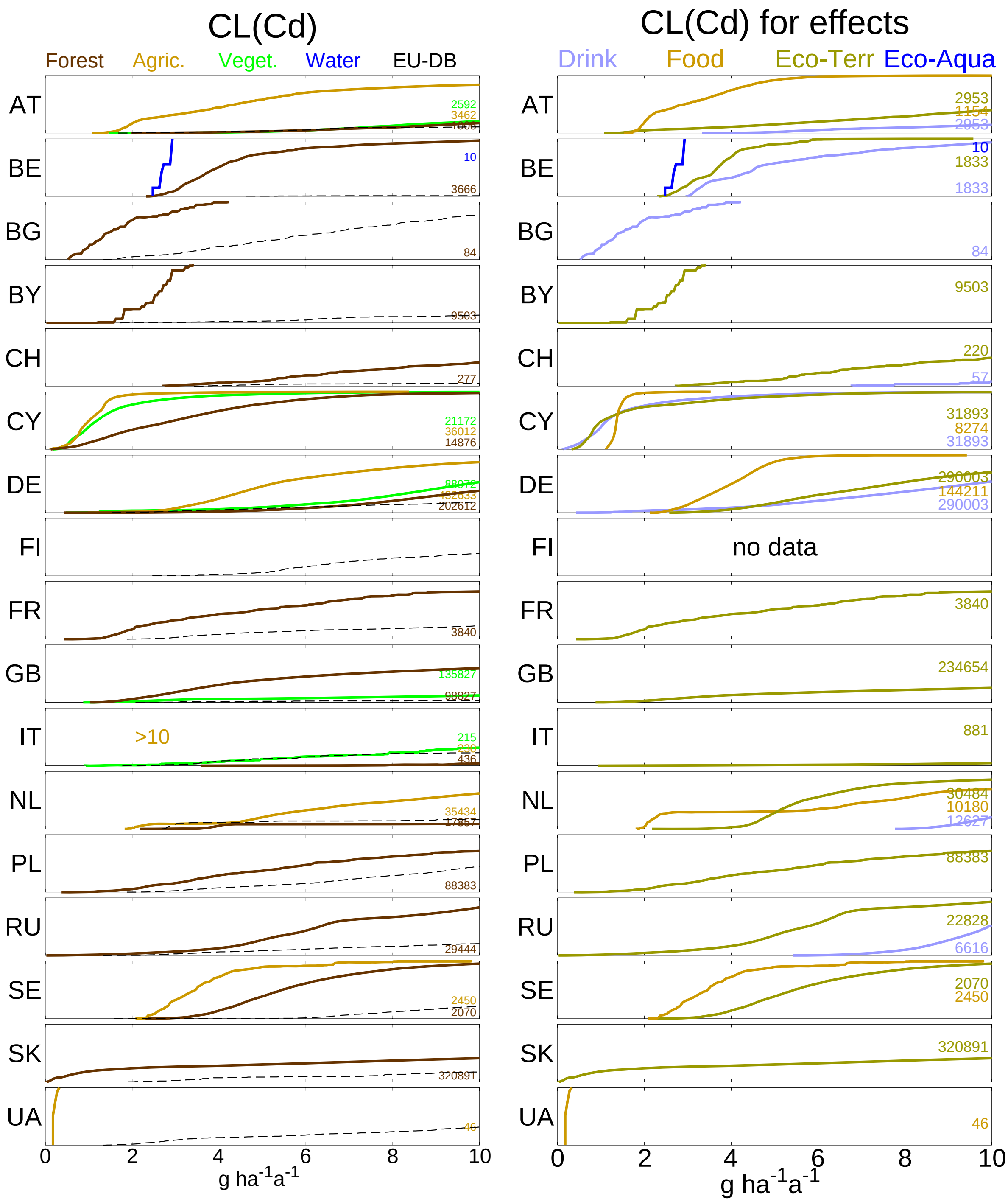

Figure 2-7. The cumulative distribution functions (CDFs) of critical load of cadmium for the different ecosystems and for the European background database ('EU-DB') (left) and for the different effects (right).

Mercury

The distributions of the national critical loads of mercury are plotted in Figure 2-9. The critical loads for Poland, Slovakia and Sweden are much lower than those for the other countries. The critical loads for effect 3 (Eco-Terr) are lower than for effect 1 (Drink).

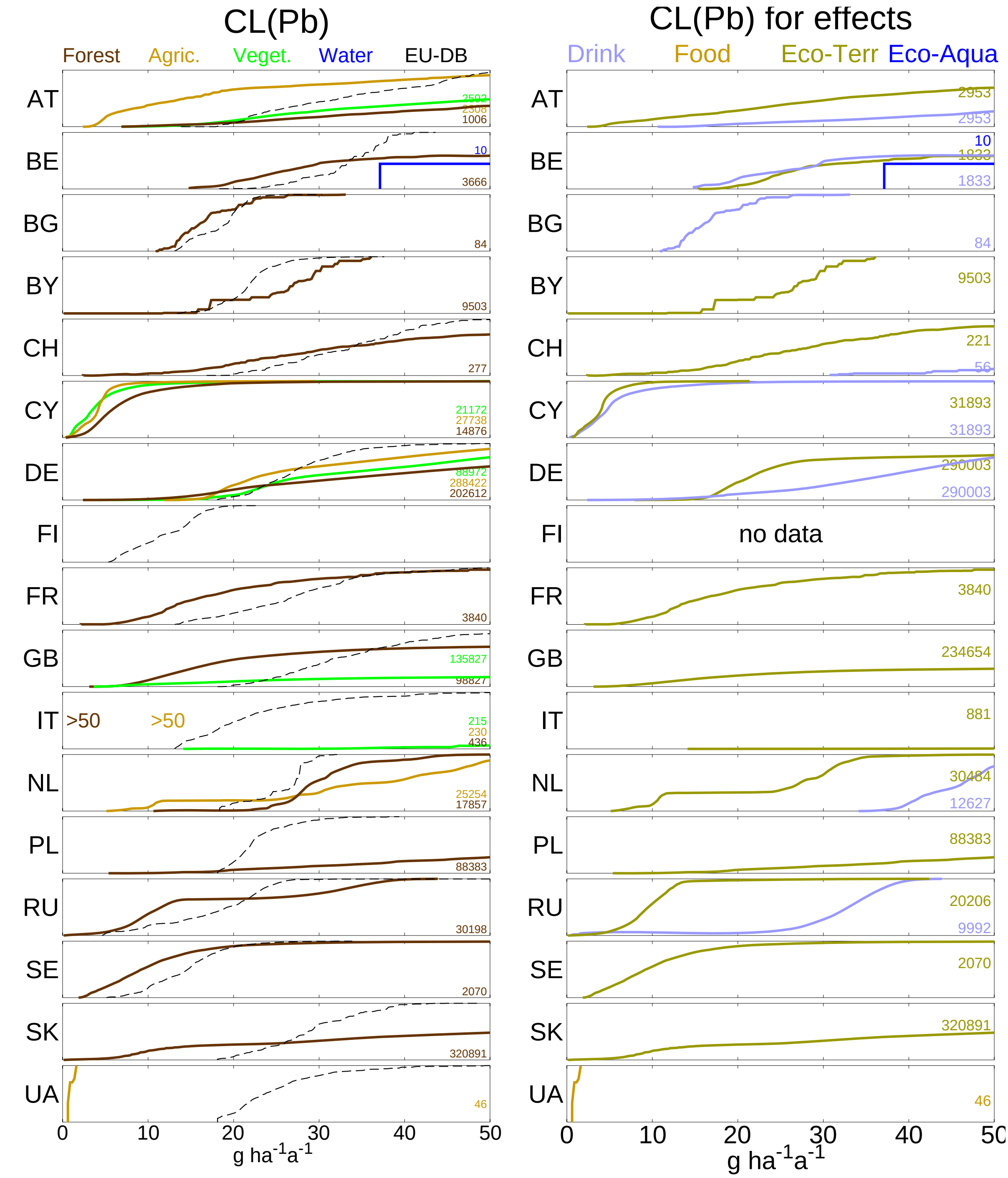

Figure 2-8. The cumulative distribution functions (CDFs) of critical load of lead for the different ecosystems (left) and for the different effects (right).

Figure 2-10 shows the critical concentrations for mercury for effect 5 (human Health effects through aquatic ecosystems). The CDF contains the cumulative area of the critical concentration by chosen fish species indicator.

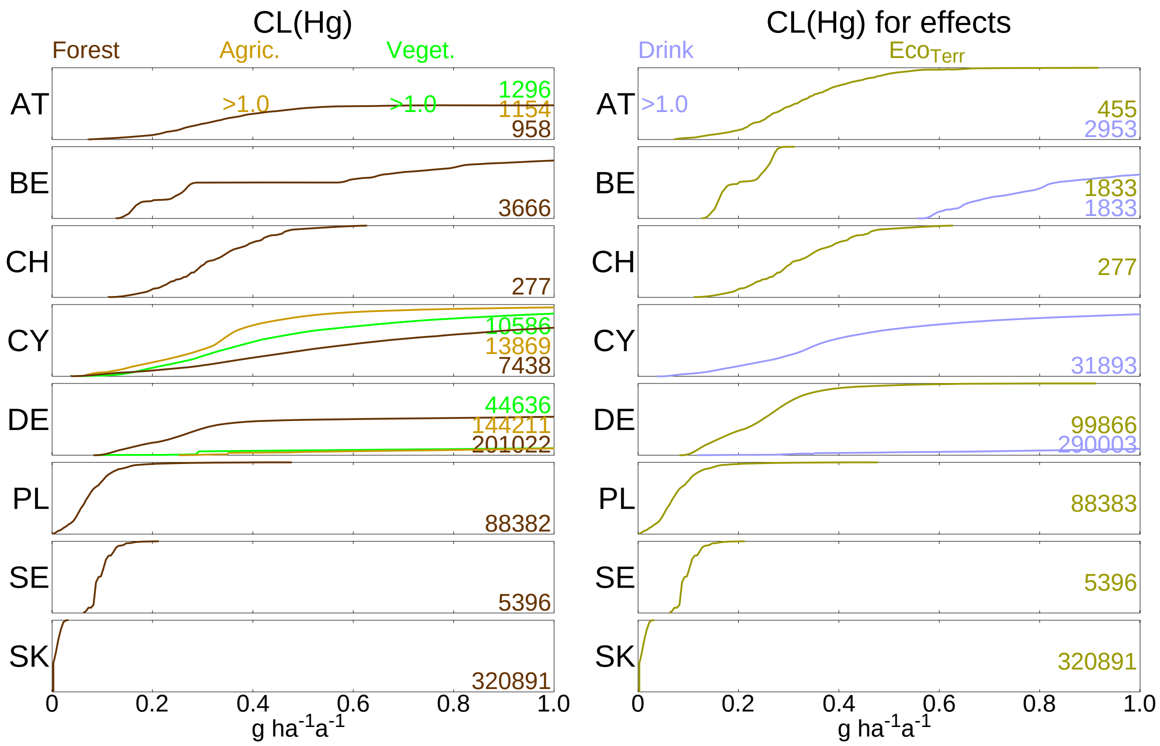

Figure 2-9. The cumulative distribution functions (CDFs) of critical load of mercury for the different ecosystems (left) and for the different effects (right).

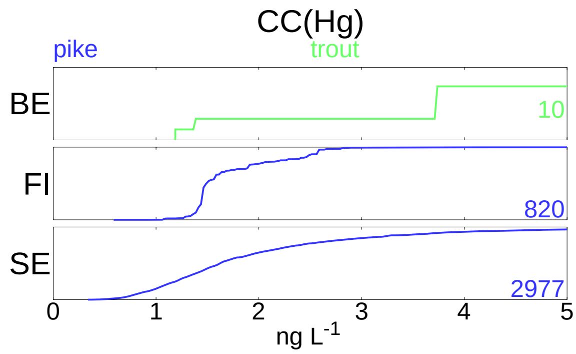

Figure 2-10. The cumulative distribution functions of critical concentration of mercury in rainfall for the different fish species.

2.5 Input variables

The CCE requested also the input variables needed to calculate the critical loads. These variables depend on the effect and receptor considered. A selection of the CDFs of these variables is plotted in the next graphs, to enable a comparison of national submissions. Details on the national data can be found in the national reports in Part II.

Cadmium

Figure 2-11 shows for cadmium the CDFs of the net uptake (Cd_u) the annual yield of biomass as dry weight (Y_{ha}), the content of Cd in the harvested part of the plant ($[Cd]_{ha}$), the critical leaching flux of Cd from the topsoil ($Cd_{le(crit)}$), critical limit ($[Cd]_{ss(crit)}$) and the flux of leaching water from the considered soil layer (Q_{le}). From these CDFs it can be observed that:

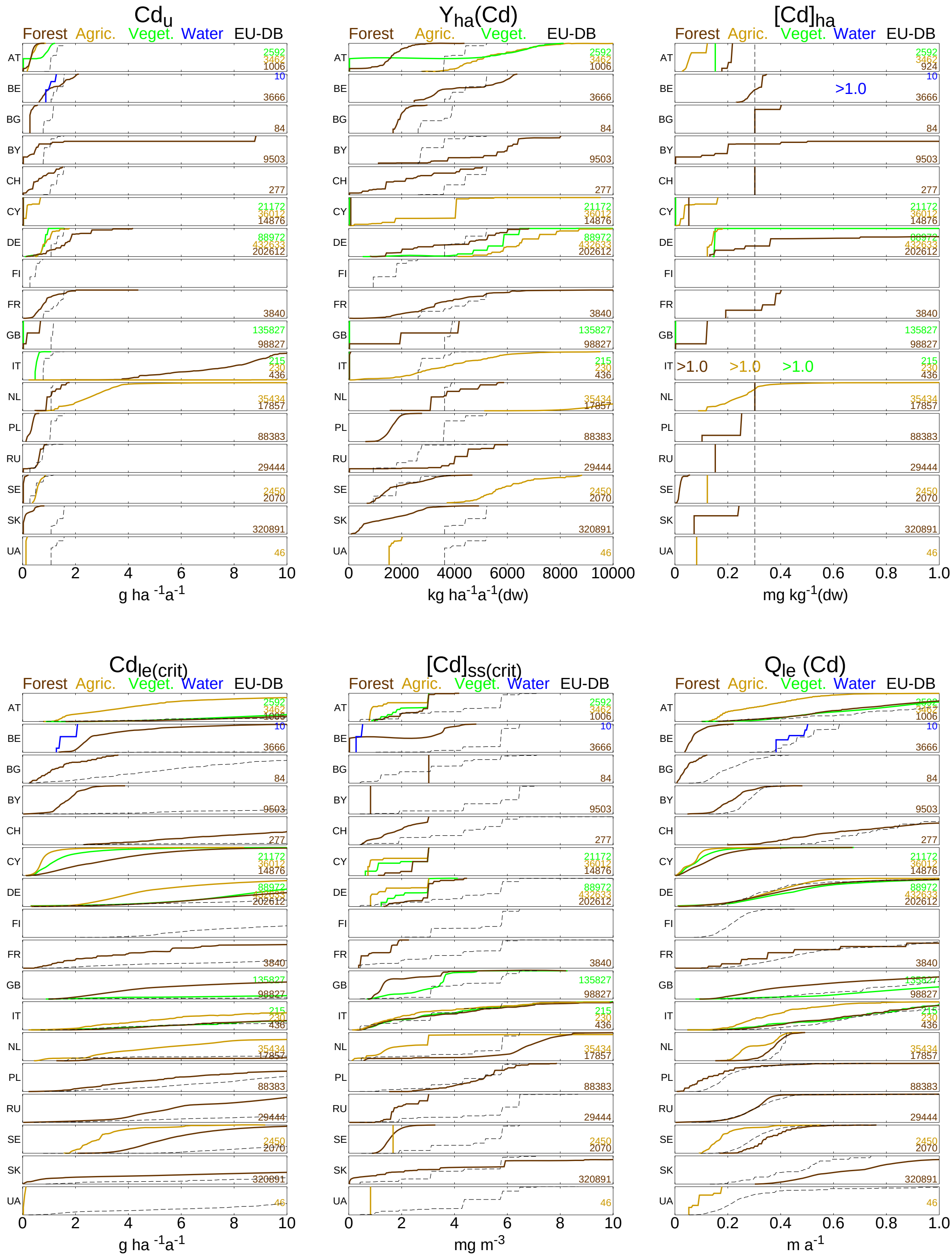

Figure 2-11. CDFs of the net uptake of cadmium (Cd_u), the annual yield of biomass, as dry weight (Y_{ha}), the content of cadmium in the harvested part of the plant ($[Cd]_{ha}$), the critical leaching flux of Cd from the topsoil ($Cd_{le(crit)}$)), the critical limit ($[Cd]_{ss(crit)}$) and the flux of leaching water from the considered soil layer (Q_{le}).

- Italy, Belarus and the Netherlands (agriculture) have broader ranges of net uptake values for cadmium than the other countries.
- National submissions of the annual yield of biomass cover a broader range than the values of the EU-background database.
- The submitted values for the content of cadmium in the harvested part of the plant turn out to vary while the EU-database applies a standard value of 0.3 mg/kg. The submitted values for Italy are higher than those for the other countries.
- Belarus has a fixed critical leaching concentration which is close to the minimum of the ranges used by many other countries. Bulgaria used the recommendation from the Mapping Manual for drinking water, 3 mg m^3. Ranges depend on the effects addressed by NFCs
- Agriculture ecosystems have lower critical leaching fluxes than forests.
- Values for the flux of leaching water in forest soils are approximately similar to the values from the EU-background database in many of the countries.

Figure 2-12 shows for each country a scatter plot of submitted soil-pH (X-axis) versus submitted uptake (Y-axis) within the considered soil depth (Cd_u) for forest, agriculture and vegetation. There does not seem to be an apparent correlation between pH and metal uptake. Uptake quantities for Italy and the Netherlands are much higher than those of the other countries.

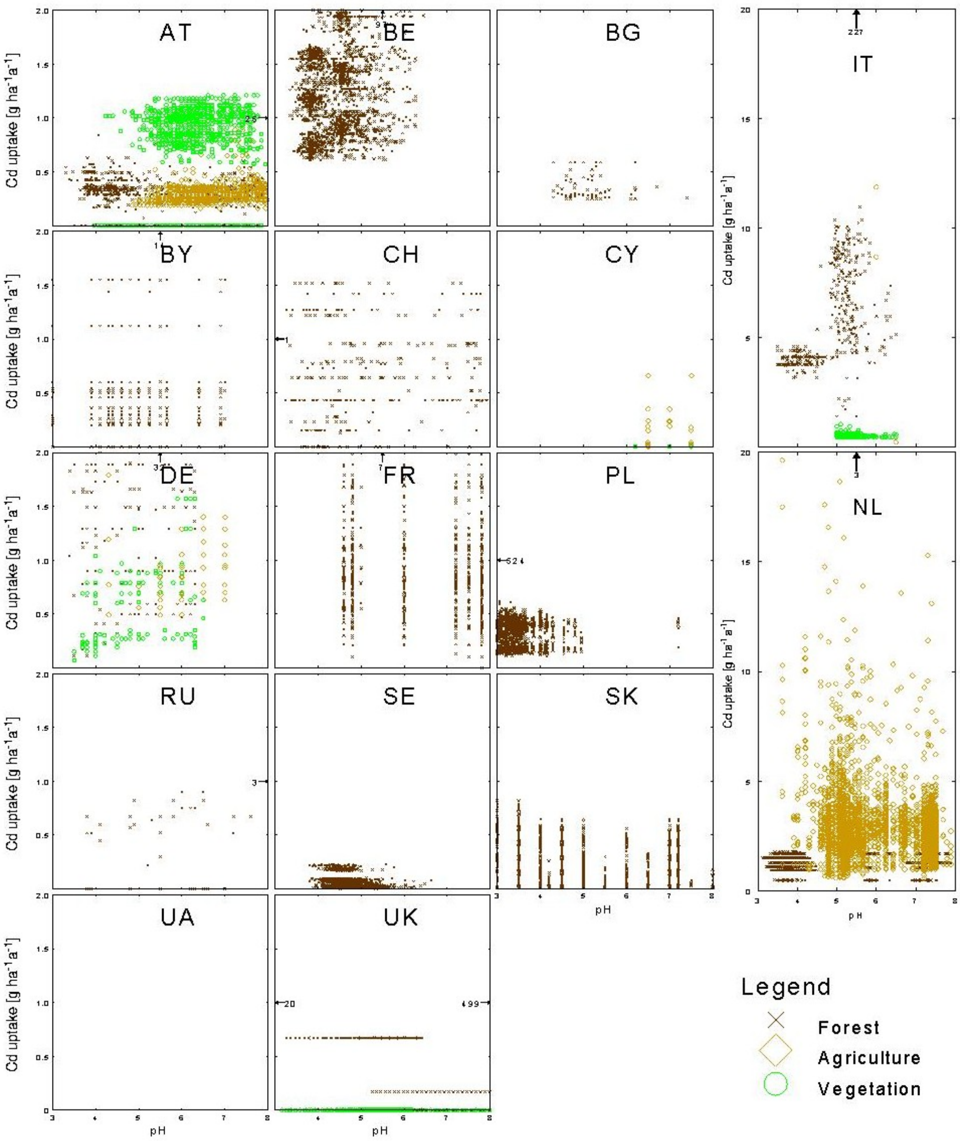

Figure 2-12. Soil-pH vs. metal uptake (Cd_u) for different ecosystem types.

The correlation between metal leaching and pH has been explored as well (see Figure 2-13). In some countries a lower leaching flux turns out to occur with higher pH values. However, for most countries no such correlation seems straightforward.

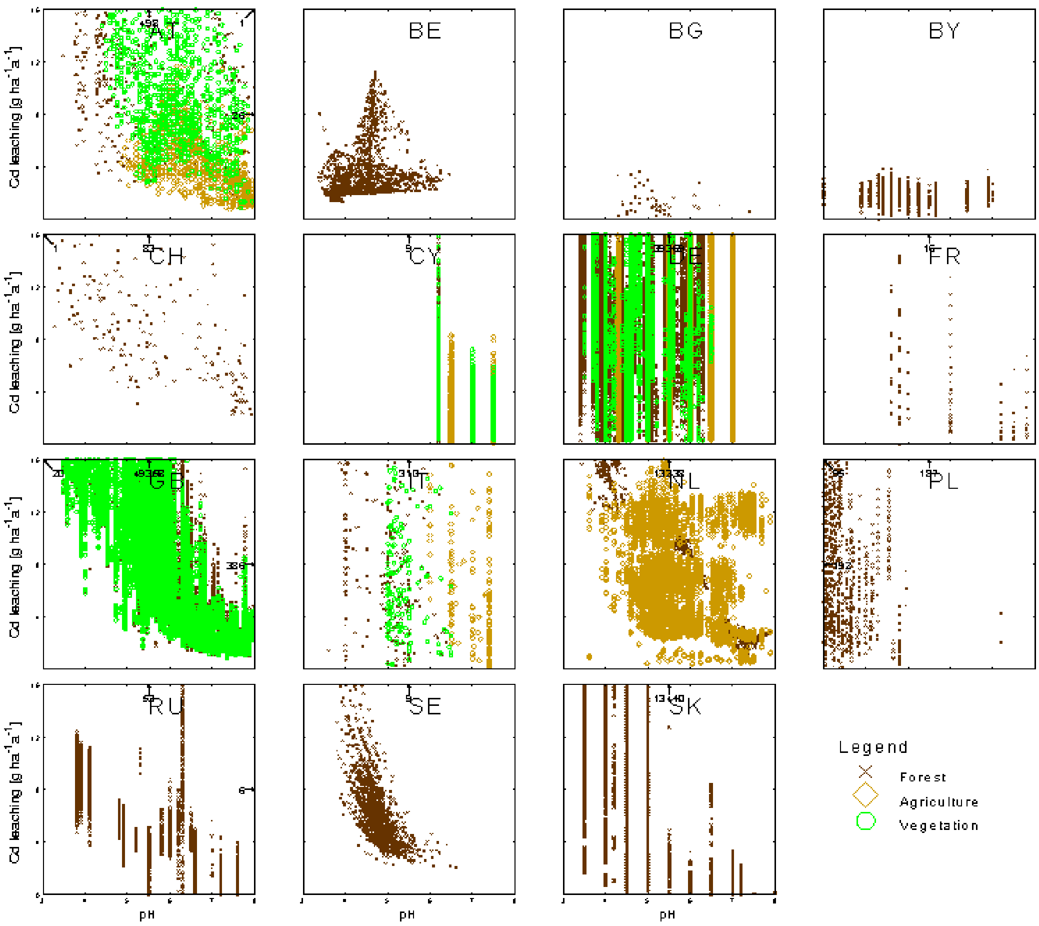

Figure 2-13. Soil-pH vs. metal leaching (Cd_{le}) for different ecosystem types.

Table 2-3 shows the used soil layer codes in the different countries. In the EU-database the critical loads have been calculated for the mineral layer. The submitted data shows that some of the NFCs have used different soil layers.

Table 2-3. The used layer codes (1 = humus layer only, 2 = mineral layer (A-horizon) only, 3 = humus layer + mineral layer, 4 = entire rooting depth).

Country code	Humus layer		Mineral layer (A-horizon)			Humus + mineral layer		Entire rooting zone			Unknown	
	effect		effect			effect		effect			effect	
	1	3	1	2	3	1	3	1	2	3	2	4
AT		85	2,450	1,154	2,868	503						
BE		1,833						1,833				10
BG	84											
BY		9,503										
CH							220	57				
CY				8,274	24,455		7,438	31,893				
DE				144,211	188,547		101,456	290,003				
FR					3,840							
GB							234,654					
IT		881										
NL					17,857			12,627	10,180	12,627		
PL							88,383					
RU						6,616	22,828					
SE							2,070				2,450	
SK					320,891							
UA											46	

Lead

The net uptake of lead (Pb_u), the annual yield of biomass as dry weight (Y_{ha}), the content of Pb in the harvested part of the plant ($[Pb]_{ha}$), the critical leaching flux of Pb from the topsoil ($Pb_{le(crit)}$), and the critical limit ($[Pb]_{ss(crit)}$) are displayed in CDFs of Figure 2-14.

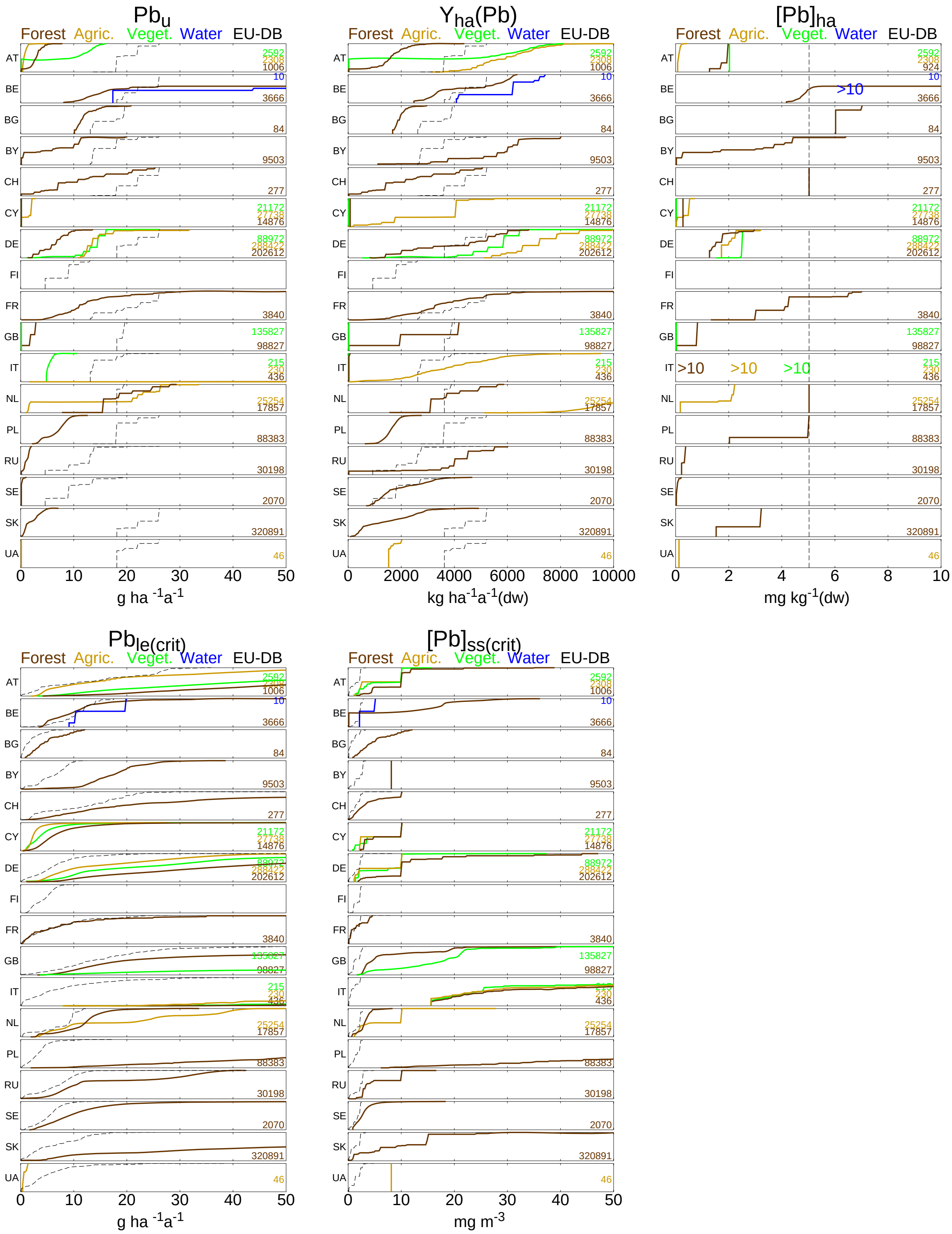

Figure 2-14. The CDFs of the net uptake of lead (Pb_u), the annual yield of biomass as dry weight (Y_{ha}), the content of Pb in the harvested part of the plant ($[Pb]_{ha}$), the critical leaching flux of Pb from the topsoil ($Pb_{le(crit)}$) and the critical limit ($[Pb]_{ss(crit)}$).

Inspection of the plots in Figure 2-14 can lead to the following remarks:

- The net uptake according to the background database is higher than the data submitted by NFCs. The net uptake for forests is generally lower than for other ecosystems.

- The range of values for the annual yield is broader for the submitted data than in the background database.
- Italy has very high values for the content of lead in the harvested part of the plant.
- The range of values covering the critical leaching flux in the background database is similar to the range of data submitted by many countries. For Austria the CDF of critical leaching in agricultural areas seems similar to the CDF in the background database between 5 and 25 g ha^{-1} a^{-1}.
- The CDF of the critical limit shows high values for Italy. The background database has lower values than the submitted data.

Mercury

Figure 2-15 shows the CDFs of the net uptake of mercury (Hg_u), the critical leaching flow of Hg from the topsoil ($Hg_{le(crit)}$), the critical limit ($[Hg]_{ss(crit)}$), the annual yield of biomass, as dry weight (Y_{ha}), the content of Hg in the harvested part of the plant ($[Hg]_{ha}$) and the concentration of dissolved organic matter in the soil solution ($[DOM]$).

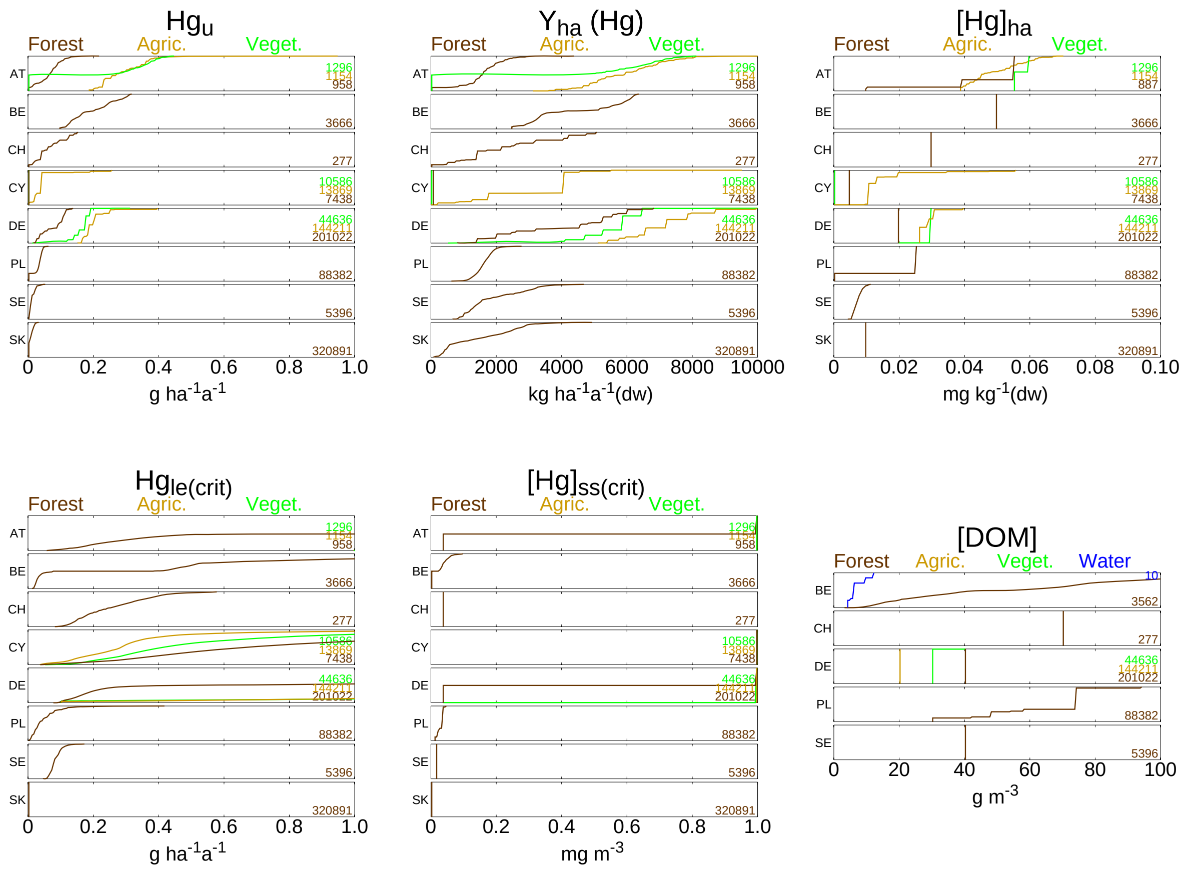

Figure 2-15. The CDFs of the net uptake of mercury (Hg_u), critical leaching flux of Hg from the topsoil ($Hg_{le(crit)}$), the critical limit ($[Hg]_{ss(crit)}$), the annual yield of biomass, as dry weight (Y_{ha}), the content of Hg in the harvested part of the plant ($[Hg]_{ha}$) and concentration of dissolved organic matter in the soil solution ($[DOM]$).

From Figure 2-15 we can mention:

- The net uptake by forests is lower than for other ecosystems.
- The critical leaching flux of mercury from the topsoil for Poland, Sweden and Slovakia are lower than for the other countries.
- The CDF of the critical limit shows that some countries have a fixed value for the forest ecosystems and other countries have a broader range of values.
- The annual yield of biomass in Cyprus for forests and vegetation is much lower than for agriculture. In general the values for this variable for forests are lower than for other ecosystems.
- The content of mercury in the harvested part of the plant has fixed values for some countries, although other counties have a broader range.
- The CDF of dissolved organic matter in the solution show the same characteristics.

Figure 2-16 shows for aquatic ecosystems the total organic carbon concentration in the water ([TOC]), the concentration of total phosphorus in the surface water ([*TP*]), the site specific transfer function (TF_{HgSite}) and the deviation from a standard fish (TF_{HgBio}). The concentration of total phosphorus in the water in Belgium is higher than in Sweden and Finland. Belgium uses the transfer function for trout while Sweden and Finland use pike.

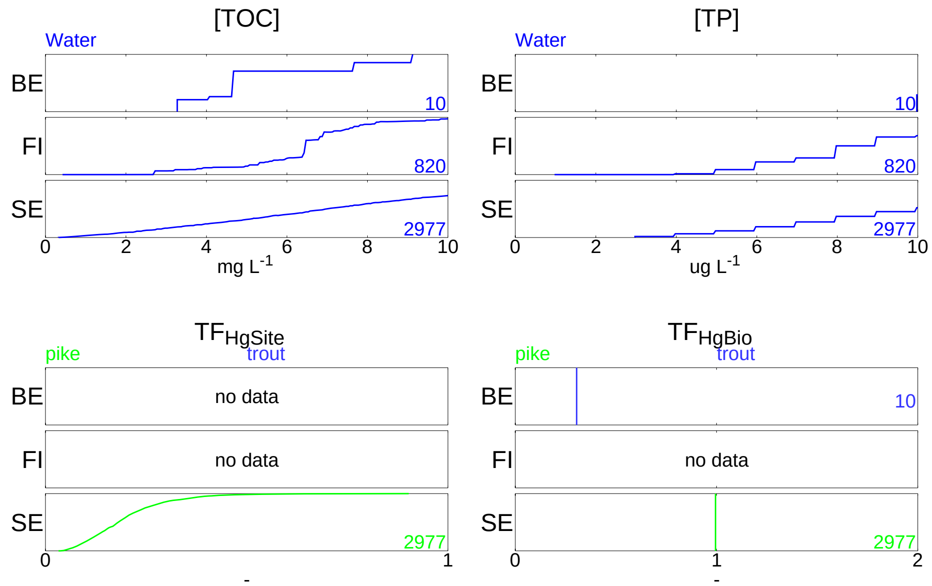

Figure 2-16. The CDFs of the total organic carbon in the water ([TOC]), the concentration of total phosphorus in the surface water ([TP]), the site specific transfer function (TF_{HgSite}) and the deviation from a standard fish (TF_{HgBio}).

2.6 Conclusions

Following the 2004 call for data, 17 National Focus Centres have submitted (updated) critical loads of heavy metals. Most countries have submitted data for cadmium and lead. Nine countries have submitted data for mercury. Most countries have submitted data for effects on terrestrial ecosystems (mainly ecotoxicological effects, effect 3). Sweden, Finland and Belgium have also submitted data for aquatic ecosystems.

The magnitude of the effects for the metals differs between the effects. The ecotoxicological effect on terrestrial ecosystems is the most sensitive effect for most of the countries which submitted more than one effect. A preliminary visual comparison of the submitted data with the calculated data in the EU-database shows that these datasets are more similar for lead than for cadmium.

Finally, the necessity to analyze different effects has emphasized the requirements of NFCs to use appropriate site identifications. The identification through site-IDs made it possible to correctly determine a minimum critical load over different effects for the same site.

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