

3.3 Evaluation of ground vegetation with special respect to deposition effects

3.3.1 Introduction

Ground vegetation is a major component of forest ecosystems. It is linked to nutrient cycling and interacts directly with other biotic and abiotic components. Vegetation layers contain and determine large parts of the biological diversity of forest ecosystems.

Ground floor vegetation assessments are mandatory at all Level II plots. Repetitions are foreseen at least every five years. Data from a larger number of plots are available from 1994 onwards. First evaluations of these data were published by DE VRIES (2002 and 2003). These evaluations were focussing on the present state of the ground floor vegetation and its relation to environmental influences.

Hypothesis

The current evaluation of vegetation relevés from Level II plots is based on an enlarged data set including data up to the year 2003. The underlying hypothesis of this study is that nitrogen deposition is related to the species composition of the ground vegetation. In addition it was of specific interest to find out whether the repeated ground vegetation assessments allow for a detection of changes in vegetation composition that might be driven by changing environmental conditions.

Plots evaluated

For the current evaluation, information from vegetation relevés was available for a total of 720 sites for the years from 1994 to 2003. Vegetation assessments were carried out by national experts at one marked plot or on a series of marked subplots per monitoring site. In 2002, it was decided to use a common sampling area of 400 m². Prior to this year the use of deviating national standards was allowed within the monitoring programme. Therefore a wide variety of different plot sizes were used (Figure 3.3.1-1).

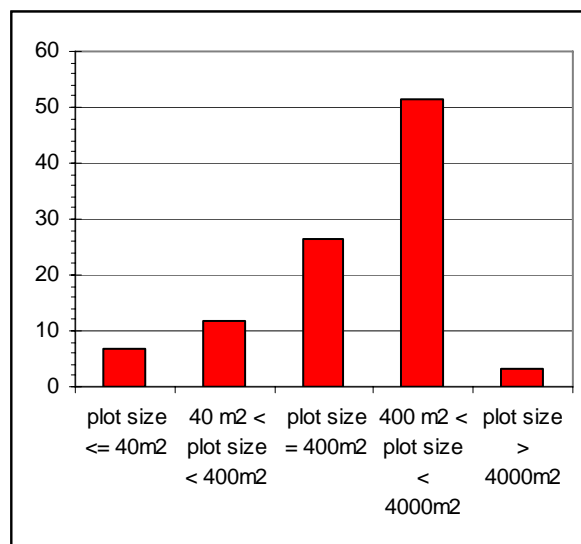


Figure 3.3.1-1: Percentage of plots with different plot sizes. $n = 720$ plots (in case of repeated surveys per plot, the last one was taken).

Due to repeated surveys at a number of plots, the total number of vegetation relevés was 1460. All intra-annual repetitions and all subplot information per plot were merged into

one composite relevé, resulting in maximally one relevé per plot and year. Among those were 243 plots respectively relevés which had been sampled only once, while other plots had been sampled up to five times (Table 3.3.1-1).

Table 3.3.1-1: Number of vegetation surveys per plot.

number of surveys per plot	number (percentage) of concerned Level II plots	number (percentage) of vegetation relevés
1	243 (34%)	243 (17%)
2	359 (50%)	718 (49%)
3	55 (8%)	165 (11%)
4	9 (1%)	36 (2%)
5	26 (4%)	130 (9%)
6	28 (4%)	168 (12%)
total	720 (100%)	1460 (100%)

Vegetation surveys are available for different years (Table 3.3.1-2). For 1994, there were data from 26 plots available. In 1995, a total number of 113 plots had been surveyed, however, 26 of them were repetitions of the previous year. A first peak is reached in 1998 with 283 relevés. The highest number of relevés was available for the year 2000.

Table 3.3.1-2: Number of relevés sampled at Level II monitoring plots per year.

year	number of relevés
1994	26
1995	113
1996	84
1997	43
1998	283
1999	157
2000	298
2001	137
2002	56
2003	263
total	1460

Fencing

38.4% of the plots were fenced and 61.6% were unfenced. A differentiated evaluation with respect to fencing was not conducted. DE VRIES et al. (2002 and 2003) showed that there was no significant effect of the fencing on ground vegetation composition at Level II plots at that time.

Cover estimates, layers and species numbers

Species abundance for ground floor vegetation was assessed using different scales like BRAUN-BLANQUET (1964), LONDO (1976), straight percentage cover, or others. The different scales were transformed into cover percentages following the ICP Forests manual (PCC 1998 and later updates).

Total percentage cover for moss, herb and shrub layer was assessed for each plot. The moss layer included terricolous bryophytes and lichens. The herb layer included all vascular plants below a height of 0.5 m. The height of the shrub layer was defined between 0.5 and 5 m. If individuals of herbaceous species or dwarf shrubs (e.g. *Pteridium aquilinum* or *Vaccinium myrtillus*) grew higher than 0.5 m, they were also assigned to the

herb layer. A comparable approach was chosen for slightly lignified shrubs like *Rubus mult. spec.*

Within the ground floor layer of the 1460 vegetation relevés, a total of 2003 vascular plant species was identified. Additionally, 91 unidentified taxa were registered. The frequency distribution of the species was typically J-shaped, with a few very abundant and many rare species. Table 3.3.1-3 presents the 25 most abundant species identified at the monitoring sites. The overall mean cover gives an estimate of the average abundance of each species. There are species that occur in many relevés, but have a low mean cover, like e.g. rowan (*Sorbus aucuparia*). Other species like blueberry (*Vaccinium myrtillus*) occur rather frequently and have a high mean cover.

Table 3.3.1-3: Frequency and over-all cover of the 25 most abundant vascular plant species on 720 Level II monitoring sites in Europe (in case of repeated surveys, only the last relevé was taken).

	species	frequency	mean cover [%]
1	<i>Vaccinium myrtillus</i>	504	17.7
2	<i>Deschampsia flexuosa</i>	420	11.3
3	<i>Sorbus aucuparia</i>	404	0.4
4	<i>Dryopteris carthusiana</i>	324	2.1
5	<i>Picea abies</i>	302	1.1
6	<i>Vaccinium vitis-idaea</i>	300	8.3
7	<i>Oxalis acetosella</i>	298	9.4
8	<i>Luzula pilosa</i>	261	0.5
9	<i>Maianthemum bifolium</i>	259	2.6
10	<i>Rubus idaeus</i>	257	6.5
11	<i>Quercus robur</i>	219	1.0
12	<i>Pinus sylvestris</i>	213	0.3
13	<i>Melampyrum pratense</i>	193	1.0
14	<i>Trientalis europaea</i>	193	1.0
15	<i>Calluna vulgaris</i>	191	2.0
16	<i>Fagus sylvatica</i>	191	2.2
17	<i>Calamagrostis arundinacea</i>	170	4.5
18	<i>Dryopteris filix-mas</i>	170	1.7
19	<i>Athyrium filix-femina</i>	162	2.5
20	<i>Solidago virgaurea</i>	150	0.5
21	<i>Betula pendula</i>	147	0.2
22	<i>Frangula alnus</i>	146	0.3
23	<i>Anemone nemorosa</i>	133	6.9
24	<i>Fragaria vesca</i>	128	1.8
25	<i>Dryopteris dilatata</i>	127	3.4

Most relevés had species numbers below 30 species. The highest frequency was recorded for the class of 10 – 20 species per plot (Figure 3.3.1-2); the recorded maximum is 128 species within one relevé.

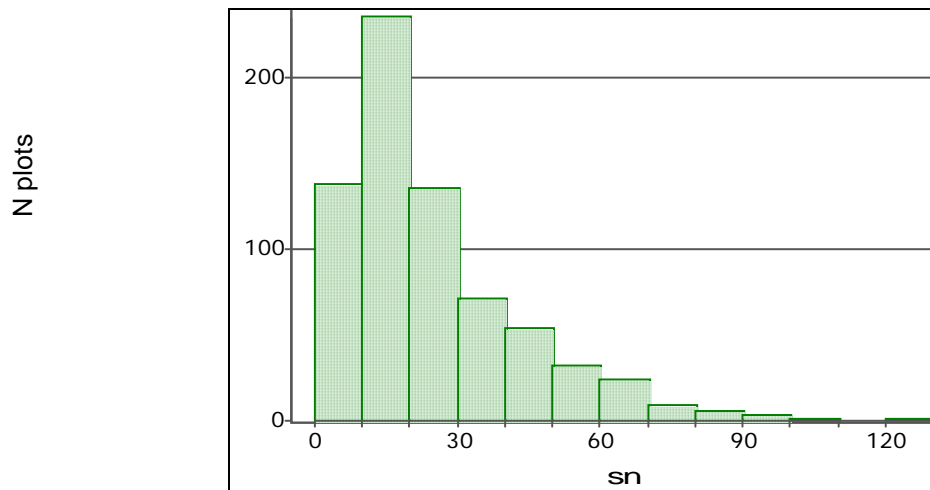


Figure 3.3.1-2: Frequency distribution of species numbers (sn) per plot (in case of repeated surveys, the last one was taken).

Soil and deposition data

Intensive Monitoring at Level II plots includes, among others, deposition measurements (LORENZ et. al 2005) as well as a soil survey (DE VRIES et. al 2000). The soil survey for most of the Level II plots was carried out in 1995. Deposition data were used for the years 1991 (6 plots) until 2001. Parameters used are listed in Tab. 3.3.3-4.

3.3.2 Diversity measures and vegetation structure at plot level

Since there is a narrow relationship between plot size and number of species growing on a plot, a simple comparison of species numbers per plot is heavily biased by differing plot sizes and is therefore not presented as map. In addition to species number, which is one of the major indicators for local (α) biodiversity, there are other more sophisticated estimates. A number of these indices, like Simpson index or Shannon-Wiener diversity are based on species number as a major component and thus, like species number itself, heavily depend on plot area and are therefore also not presented.

Only evenness (PIELOU 1969), which focuses at the relative abundance of all species at a plot, is almost unbiased by different sampling areas. Evenness was calculated for all Level II relevés at the basis of the cover percentages. Evenness values can vary between 0.01 (one species strongly predominating) and 1.0 (all species have the same share of cover). Evenness (J') was calculated as:

$$J' = D' / \ln(S)$$

$$D' = -\sum p_i * \ln(p_i) \text{ (= Shannon-Wiener diversity)}$$

$$p_i = \text{cov}_i / \sum \text{cov}_i$$

cov_i: cover of individual taxa

S: total species number

The mean evenness for 1492 relevés was 0.6 (Figure 3.3.2-1).

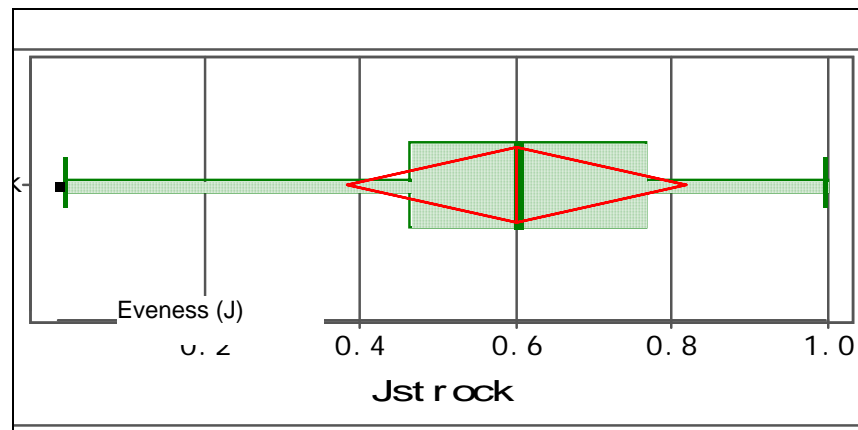


Figure 3.3.2-1: Box whisker plot for plot-wise evenness values (box: median, 25th, 75th percentile, whisker: mean plus/minus standard deviation, end of stalks: minimum, maximum); n = 1452 relevés (relevés with one species excluded).

The geographical distribution of evenness values (Figure 3.3.2-2) shows some small- to medium-scale clustering. This may originate from local, regional or country-specific forest management practices as well as from regional plant-sociological peculiarities. A general spatial trend over the whole of Europe cannot be observed.

The total herb layer cover is an important structural feature of forest ecosystems. High covers of the herb layer were observed on plots in eastern Germany, across Poland and in the Baltic states (Figure 3.3.2-3). The dense ground vegetation at these plots is mainly explained by a low coverage of the tree layer that mainly consists of *Pinus sylvestris*. *Pinus sylvestris* naturally has transparent crowns and enables rather dense undergrowth. Mean cover of the shrub layer (Figure 3.3.2-4) was as well high on plots in Eastern Europe, but as well in the south-west of Europe. The geographic distribution of moss abundance delivers a quite different picture (Figure 3.3.2-5): a distinct spatial trend can be observed from plots with sparse moss layers in the southern regions to dense moss layers on the plots in Scandinavia and north-eastern Europe.

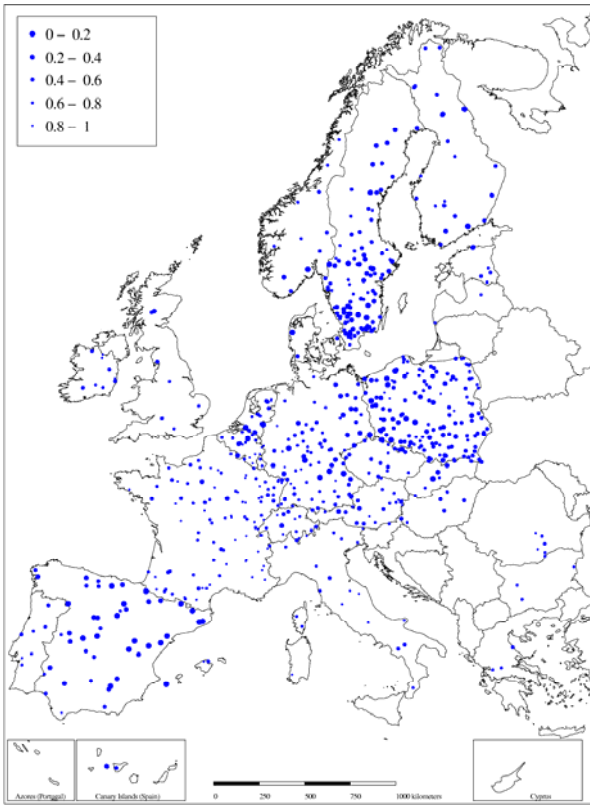


Figure 3.3.2-2: Evenness (J') of ground vegetation at Level II plots in Europe.

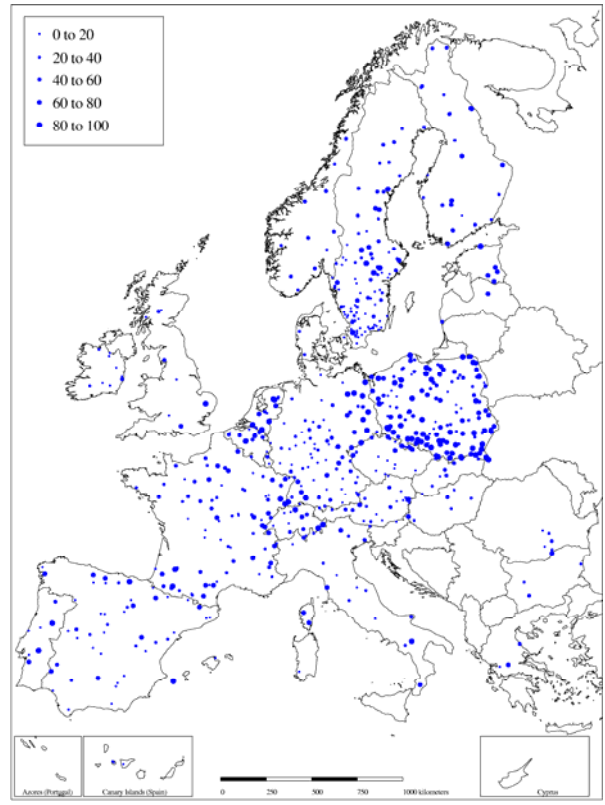


Figure 3.3.2-3: Mean % cover of the herb layer.

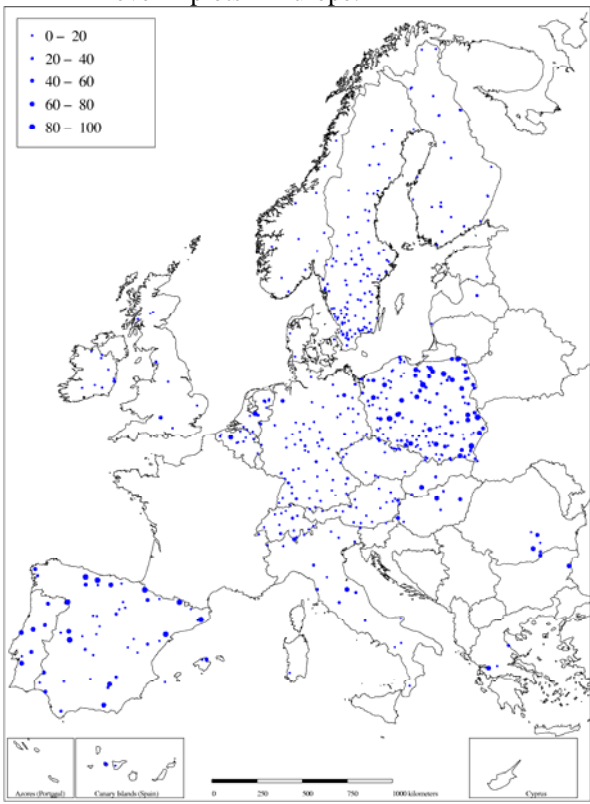


Figure 3.3.2-4: Mean % cover of the shrub layer.

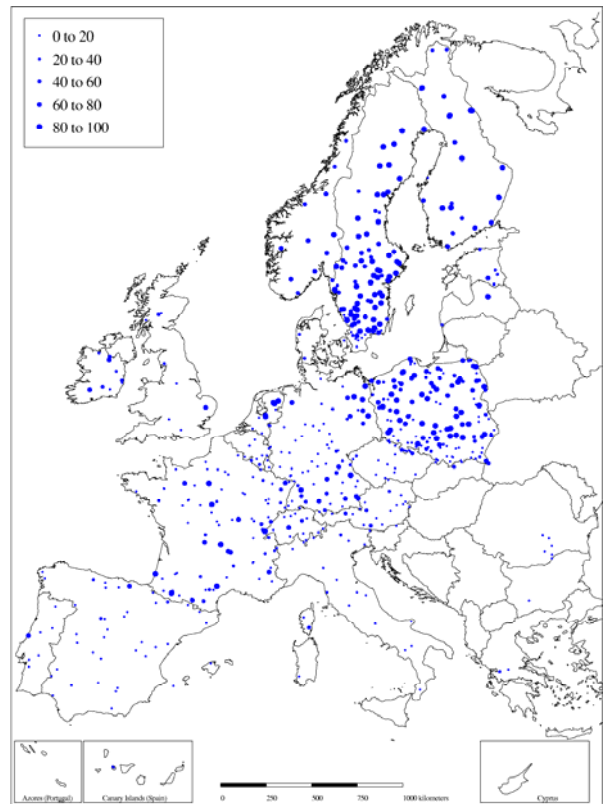


Figure 3.3.2-5: Mean % cover of the moss layer.

3.3.3 Floristic composition of ground floor vegetation and its relation to soil condition and deposition

The complete trans-national data set

Similarities of the floristic composition can be classified e.g. by cluster analysis (cf. WILDI 1986) or treaded by ordination techniques (TER BRAAK 1987). Both approaches aim to reduce the high dimensionality of the floristic space (here in total over 2000 species, each representing an axis in a multidimensional space). Within this study, ordination techniques were applied, because plot-related scores derived from an ordination can directly be used as predictors (explanatory variables) in interference models like multiple regression analyses. These analyses were applied in order to find main determinants for the floristic composition. Since the vegetation relevés from across Europe cover extremely wide biogeographical and ecological gradients, detrended correspondence analysis (DCA, detrended by segments), which is a unimodal response model, was used. CANOCO (TER BRAAK and ŠMILAUER 1998) in combination with EXCEL and SAS was used for the multivariate analysis and for subsequent evaluations. Species' cover values were square-root transformed for the DCA. Rare species that occurred in less than 5 relevés were excluded. To avoid bias from different numbers of repetitions, only the last relevé of each plot was used, resulting in a total number of 720 relevés and plots.

The DCA results in a first axis that explains 3.1% of the total variance (eigenvalue of 0.875 from a total sum of eigenvalues (inertia) = 28.3). The following three axes explain smaller proportions of the total variance: 2.6%, 2.3% and 2.0% respectively. The explained variance of the first four DCA axes sums up to 10%, which means that 90% of the total variance is not covered by the first four DCA axes. This is surely a result of a highly heterogeneous floristic composition of ground floor vegetation across the plots in Europe. Floristically, the first axis is on one side characterised by species dominating dry Mediterranean scrublands (maquis) represented e.g. by species of the *Cistaceae* family. On the other side shade tolerating undergrowth species of nemoral and boreal forests characterize the first axis (like *Deschampsia flexuosa* or *Vaccinium myrtillus* on acidic and *Anemone nemorosa* on calcareous soils). The spatial distribution of the scores of the first DCA axis (Figure 3.3.3-1) reveals distinctly higher scores for many plots on the Iberian Peninsula as compared to plots north of the Pyrenees. This can be interpreted as a border effect, which shows that a considerable number of plant taxa could not transcend the Pyrenees as a natural barrier after the last ice-age.

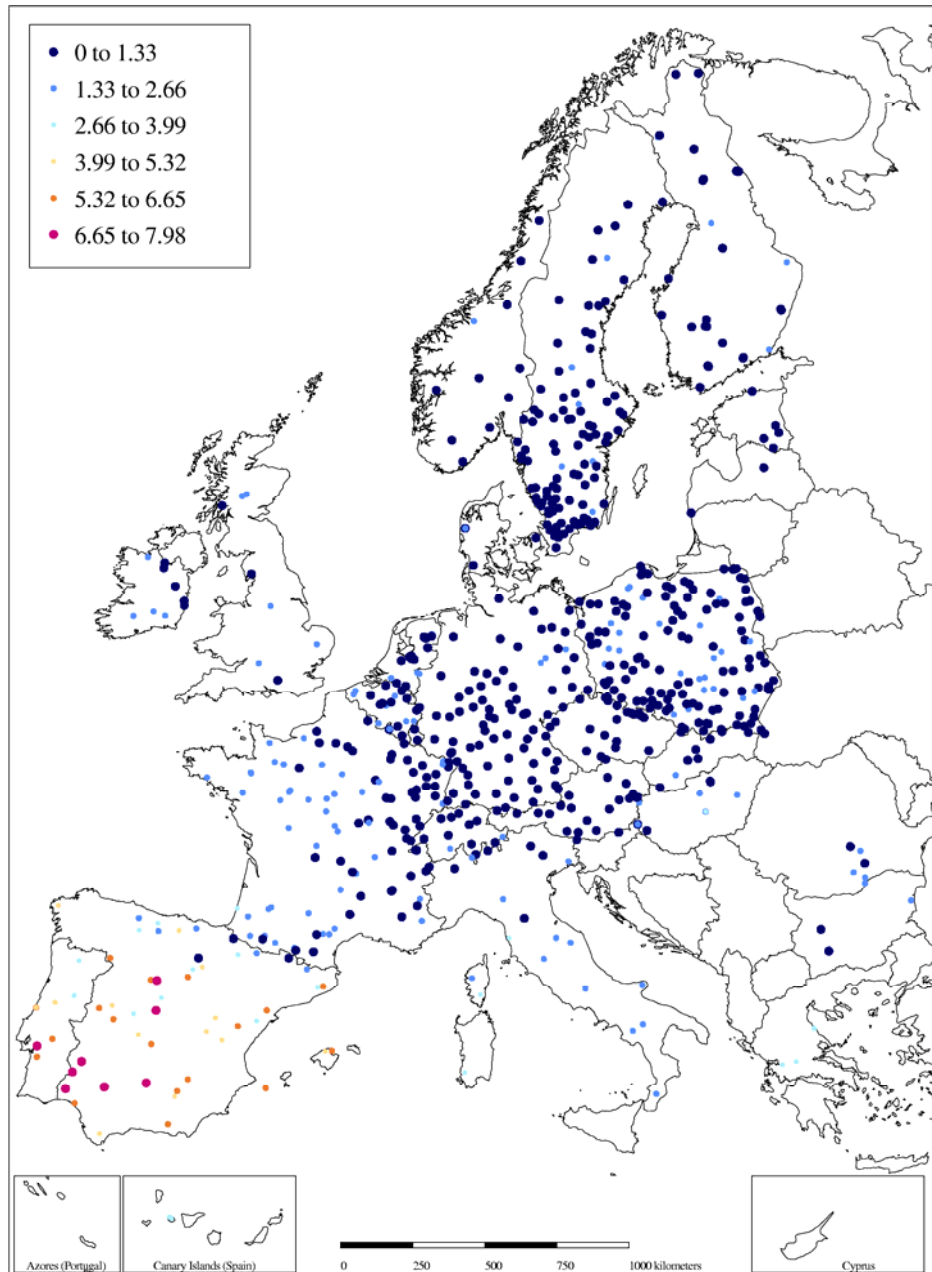


Figure 3.3.3-1: First DCA axis of an ordination with 720 Level II plots in Europe.

Plots in the nemoral forest zone of Europe

In the further evaluation a reduction of the high floristic variability within the data set was carried out as a first step as it was not the main objective to depict biogeographical aspects, but instead to search mainly for influences of nitrogen depositions onto the floristic composition of the ground vegetation. Therefore, all plots south of 46° latitude were excluded. In order to eliminate as well the floristically deviant influence of boreal and sub-alpine climates all plots north of 61° latitude and above 750 m a.s.l. were excluded from further analyses. It became clear that for detecting influences of environmental conditions on ground floor vegetation, the excluded plots need to be evaluated separately.

After this reduction a total of 488 plots remained for the application of a second DCA (sum of all eigenvalues = 15.02). The percentage of explained variance on the first axis now increased to 4.3%, the second to fourth axis explain decreasing shares of the total variance (2.5%, 2.2%, 1.8% respectively).

Table 3.3.3-1 provides an insight into the species with the highest loadings on the 1st DCA axis. Highest scores were reached by species typically occurring on acidic soils like some species from the blueberry genus (*Vaccinium mult. spec.*). At the other end of the axis species with the lowest scores like arum (*Arum maculatum*), dog's mercury (*Mercurialis perennis*), or oxlip (*Primula elatior*) are listed. These species typically grow on calcareous soils. These results show that the acidity status of the plots is the main factor that determines ground floor vegetation composition across the nemoral zone European forests (cf. EWALD 2003).

Table 3.3.3-1: Species of the ground floor vegetation with highest and lowest scores on the 1st DCA axis of 488 plots from the nemoral zone of Europe.

Species	DCA 1 score	Species	DCA 1 score
<i>Vaccinium vitis-idaea</i>	6.1609	<i>Vicia sepium</i>	-0.1651
<i>Vaccinium uliginosum</i>	6.1594	<i>Ranunculus ficaria</i>	-0.4019
<i>Empetrum nigrum</i>	5.9426	<i>Arum maculatum</i>	-0.4473
<i>Carex ericetorum</i>	5.5999	<i>Euonymus europaeus</i>	-0.5002
<i>Calluna vulgaris</i>	5.2408	<i>Acer campestre</i>	-0.5644
<i>Melampyrum sylvaticum</i>	4.9799	<i>Sonchus oleraceus</i>	-0.6393
<i>Carex nigra</i>	4.9359	<i>Quercus cerris</i>	-0.6479
<i>Linnaea borealis</i>	4.889	<i>Mercurialis perennis</i>	-0.6542
<i>Betula sp.</i>	4.8739	<i>Cardamine bulbifera</i>	-0.6761
<i>Hypericum perforatum</i>	4.7989	<i>Ranunculus auricomus</i>	-0.6962
<i>Sorbus intermedia</i>	4.798	<i>Cardamine pratensis</i>	-0.7195
<i>Festuca ovina</i>	4.776	<i>Alliaria petiolata</i>	-0.7346
<i>Monotropa hypopitys</i>	4.7315	<i>Primula elatior</i>	-0.7371
<i>Vaccinium myrtillus</i>	4.6717	<i>Cyclamen purpurascens</i>	-0.7441
<i>Amelanchier grandiflora</i>	4.6441	<i>Hypericum hirsutum</i>	-0.7716

For the species characterizing the second and third axis it was hardly possible to give any simple ecological interpretation. However, on the fourth axis species like climbing corydalis (*Ceratocapnos claviculata*), bifid hemp-nettle (*Galeopsis bifida*), or chickweed (*Stellaria media*) (Table 3.3.3-2) reached high scores. For these species there is considerable evidence from the literature (e.g. LETHMATE et al. 2002, DE VRIES et al. 2003) that they are favoured by high availability of soil nitrogen. Thus, it can be interpreted that plots with high scores on the fourth axis are characterized by the availability of soil nitrogen. On the fourth axis there are also species with high scores that are not specifically linked to nitrogen availability, but which might for other reasons occur in areas with elevated nitrogen deposition. Within the interpretation of the fourth axis, pseudo correlations have thus to be taken into account, related to species, like e.g. planted Douglas fir (*Pseudotsuga menziesii*) or black cherry (*Prunus serotina*) in The Netherlands or Flanders. Also crowberry (*Empetrum nigrum*) may more accidentally coincide with areas of high N deposition loads. Such pseudo correlations cannot be separated statistically, but have to be taken into account when interpreting the DCA results. Species with low scores on the 4th axis (Table 3.3.3-2) seem not to contain any specific common information with respect to nitrogen availability.

Table 3.3.3-2: Species of the ground floor vegetation best characterising (with highest and lowest scores) the 4th DCA axis of 488 plots from the nemoral part of Europe.

Species	DCA 4 scores	Species	DCA 4 scores
<i>Empetrum nigrum</i>	4.5847	<i>Orthilia secunda</i>	-0.4666
<i>Ceratocarpus claviculata</i>	4.424	<i>Sorbus aria</i>	-0.4961
<i>Pseudotsuga menziesii</i>	4.1899	<i>Pulmonaria obscura</i>	-0.5129
<i>Amelanchier grandiflora</i>	4.0857	<i>Gymnocarpium dryopteris</i>	-0.5533
<i>Senecio sylvaticus</i>	4.0665	<i>Galium boreale</i>	-0.6704
<i>Epilobium spec.</i>	3.8963	<i>Melampyrum sylvaticum</i>	-0.6858
<i>Galeopsis bifida</i>	3.7711	<i>Vicia cracca</i>	-0.6863
<i>Prunus serotina</i>	3.732	<i>Campanula rotundifolia</i>	-0.7114
<i>Equisetum arvense</i>	3.6021	<i>Polygonatum odoratum</i>	-0.7203
<i>Poa angustifolia</i>	3.6004	<i>Hypericum perforatum</i>	-0.7414
<i>Picea spec.</i>	3.5981	<i>Galium verum</i>	-0.793
<i>Calamagrostis canescens</i>	3.5689	<i>Linnaea borealis</i>	-0.8453
<i>Fallopia dumetorum</i>	3.5542	<i>Viola mirabilis</i>	-0.8502
<i>Conyza canadensis</i>	3.495	<i>Viola palustris</i>	-0.8535
<i>Rubus plicatus</i>	3.4527	<i>Hepatica nobilis</i>	-0.8814
<i>Impatiens noli-tangere</i>	3.4445	<i>Carex brizoides</i>	-0.938
<i>Stellaria media</i>	3.4398	<i>Geranium sylvaticum</i>	-0.9541
<i>Impatiens parviflora</i>	3.4118	<i>Equisetum sylvaticum</i>	-0.976

Due to its integrated sampling approach the Level II data set provides the opportunity to relate the scores on the different DCA axes to measured environmental parameters such as soil and deposition information. Correlation analyses were thus applied to statistically substantiate the ecological interpretation of the DCA scores. Results show that in spite of the low amount of the total variance explained by the first DCA axis, it reveals a significant relationship with $\text{pH}_{\text{CaCl}_2}$ values of the organic soil layer ($r = 0.789$, Table 3.3.3-3 and Figure 3.3.3-2). In addition, there are a number of soil parameters that provide significant relations like base saturation in the upper mineral layer (basesat, 0 to 10 cm depth), or the cation exchange capacity (CEC). It has to be taken into account that these soil parameters are significantly inter-correlated. The second and third axes show weaker relationships with the amount of organic carbon respectively carbon and nitrogen contents in mineral layers of the Level II sites. A weaker relationship between the 2nd DCA axis and ammonium deposition can be interpreted as a sign that NH_4 deposition may have effects on the floristic composition of the ground floor vegetation. This finding is underlined by the strong correlation between total nitrogen and ammonium deposition and the scores of the fourth axis (Table 3.3.3-3 and Figure 3.3.3-3) of the detrended correspondence analysis. This finding is based on a larger group of species with high scores on the 4th DCA axis. Even if pseudo correlations between geographical distributions of some species and anthropogenically caused deposition patterns are taken into account, the findings strongly suggest that there are a number of ground vegetation species that more specifically occur on plots due to higher nitrogen deposition. Thus, nitrogen deposition partly determines ground vegetation composition at the investigated plots. This interpretation is underpinned by the fact that there are hardly any other relationships of the 4th axis with any other soil related factors, except the C/N ratio within the organic layer. Just this parameter was also found to be correlated negatively with N deposition by AUGUSTIN et al. (2005).

Table 3.3.3-3: Correlation coefficients between DCA axes and key parameters of soil solid phase and deposition. For a detailed explanation of the key factors see Table 3.3.3-4.

All records from nemoral forest region; n = 488 plots. For plots with more than one record, the last record has been chosen in order to avoid pseudo-replication.

*: $(Prob > |r|) \leq 0.05$, **: $(Prob > |r|) \leq 0.01$, ***: $(Prob > |r|) < 0.0001$.

		DCA axis 1	DCA axis 2	DCA axis 3	DCA axis 4
Soil solid phase	C (n = 461)	-0.2462***	-0.0971*	-0.2481***	0.0174
	N (n = 471)	-0.4094***	0.0029	-0.2379***	0.0662
	BCE (n = 469)	-0.4659***	0.1004*	-0.0327	-0.0554
	CEC (n = 467)	-0.4357***	0.0709	-0.1883***	-0.034
	Basesat (n = 464)	-0.6439***	0.1692**	0.1205**	0.0171
	C _{org} (n = 465)	0.1516**	-0.2889***	-0.2115***	-0.0027
	C/N _{min} (n = 461)	0.3752***	-0.2479***	0.0342	-0.0560
	C/N _{org} (n = 465)	0.2199***	-0.0534	0.0421	-0.2205***
	pH _o (n = 472)	-0.7893***	-0.0022	0.0020	-0.0075
	pH _{m01} (n = 472)	-0.4661***	0.1736***	0.1481**	-0.0485
Annual throughfall deposition	xN _{depo} (n = 224)	-0.1228	-0.1969**	-0.0150	0.5204***
	xNH ₄ -N _{depo} (n = 224)	-0.0610	-0.2748***	0.0586	0.5140***
	xNO ₃ -N _{depo} (n = 224)	-0.2431**	-0.0031	-0.1105	0.4218***

Table 3.3.3-4: Parameters characterising the soil solid phase and throughfall nitrogen deposition.

domain	parameter	unit	explanation
soil solid phase	C	g kg ⁻¹	organic carbon concentration in the upper 10 cm of the mineral soil layer; different layers (0 – 5 cm, 5 – 10 cm, 0 – 20 cm) have been merged.
	N	g kg ⁻¹	total nitrogen concentration in the upper 10 cm of the mineral soil layer; different layers (0 – 5 cm, 5 – 10 cm, 0 – 20 cm) have been merged.
	BCE	cmol (+) kg ⁻¹	sum of basic exchangeable cations in the upper 10 cm of the mineral soil layer.
	CEC	cmol (+) kg ⁻¹	cation exchangeable capacity of the upper 10 cm of the mineral soil layer
	Basesat	%	base saturation of the upper 10 cm of the mineral soil layer
	C _{org}	g kg ⁻¹	organic carbon concentration of the organic layer.
	C/N _{min}		C/N ratio of the upper 10 cm of the mineral soil layer
	C/N _{org}		C/N ratio of the organic layer.
	pH _o		pH value in 0.01 molar CaCl ₂ of the organic layer; in cases where pH of the organic layer was missing, it was substituted according to the empirical relationship: $pH_o = -1.0145 + (1.5425 \cdot pH_{m0-10}) + (0.2068 \cdot pH_{m0-10}^2)$
	pH _{m01}		pH value in 0.01 molar CaCl ₂ of the upper 10 cm of the mineral soil layer; if only a value of the upper 5 cm are given, the respective value for 10 cm depth has been calculated according to empirical regressions: $pH_{m0-10} = 0.3449 + (0.9415 \cdot pH_{m0-5})$ or: $pH_{m0-10} = 0.0593 + (0.9769 \cdot pH_{m5-10})$; if only pH _{m0-20} is given, it has been equalled to pH ₀₋₁₀ ; if measurements in different years have been conducted, the latest datum was taken; in cases of moor soils pH of upper h-horizon was equalled to the upper mineral horizon; if only pH of the organic layer was given and value of the mineral layer was missing, the empirical relationship was used: $pH_{m0-10} = 4.6856 - (1.0375 \cdot pH_o) + (0.2068 \cdot pH_o^2)$.

domain	parameter	unit	explanation
annual throughfall deposition	xN_{depo}	$\text{kg ha}^{-1} \text{a}^{-1}$	mean annual N throughfall deposition as sum of $\text{NH}_4\text{-N}$ deposition and $\text{NO}_3\text{-N}$ deposition; calculated for all years available before 2001; only for plots with at least 273 days per year sampled; if sampling period was shorter than 365 days, missing periods were completed by mean values derived from the remaining days.
	$x\text{NH}_4\text{-N}_{\text{depo}}$	$\text{kg ha}^{-1} \text{a}^{-1}$	mean annual $\text{NH}_4\text{-N}$ throughfall deposition; calculated for all years available before 2001; only for plots with at least 273 days per year sampled; if sampling period was shorter than 365 days missing periods were completed by mean values derived from the remaining days.
	$x\text{NO}_3\text{-N}_{\text{depo}}$	$\text{kg ha}^{-1} \text{a}^{-1}$	mean annual $\text{NO}_3\text{-N}$ throughfall deposition; calculated for all years available before 2001; only for plots with at least 273 days per year sampled; if sampling period was shorter than 365 days missing periods were completed by mean values derived from the remaining days.

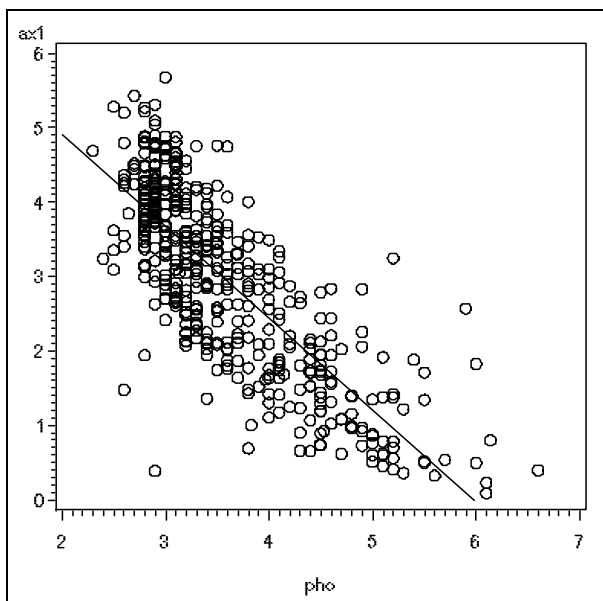


Figure 3.3.3-2: Relationship between the 1st DCA axis and $\text{pH}_{\text{CaCl}_2}$ in the organic layer; $R^2 = 0.623$, ($\text{Pr} > F$) < 0.0001 , $n = 472$ plots.

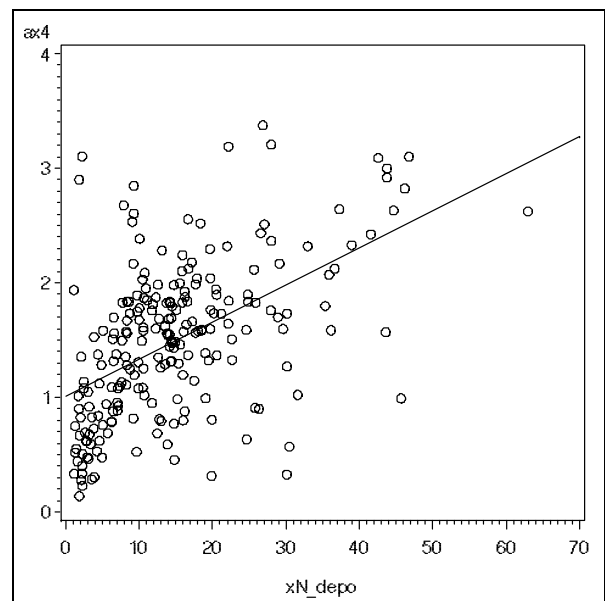


Figure 3.3.3-3: Relationship between the 4th DCA axis and annual N throughfall deposition; $R^2 = 0.271$, ($\text{Pr} > F$) < 0.0001 , $n = 224$ plots.

The plot related scores of the 4th DCA axis show spatial trends (Figure 3.3.3-4). High scores, indicating a vegetation composition that reflects high nitrogen availability occur mainly in regions that are known to receive high nitrogen deposition. This trend is particularly obvious for Western Europe and Southern Scandinavia. The high scores for the plots in Scotland and Ireland can probably not be explained by high N deposition rates, since some abundant species with a prevalence for the Atlantic climate (e.g. *Dryopteris dilatata*, *Galium saxatile*, *Galium palustre*) gain also higher scores on the 4th DCA axis.

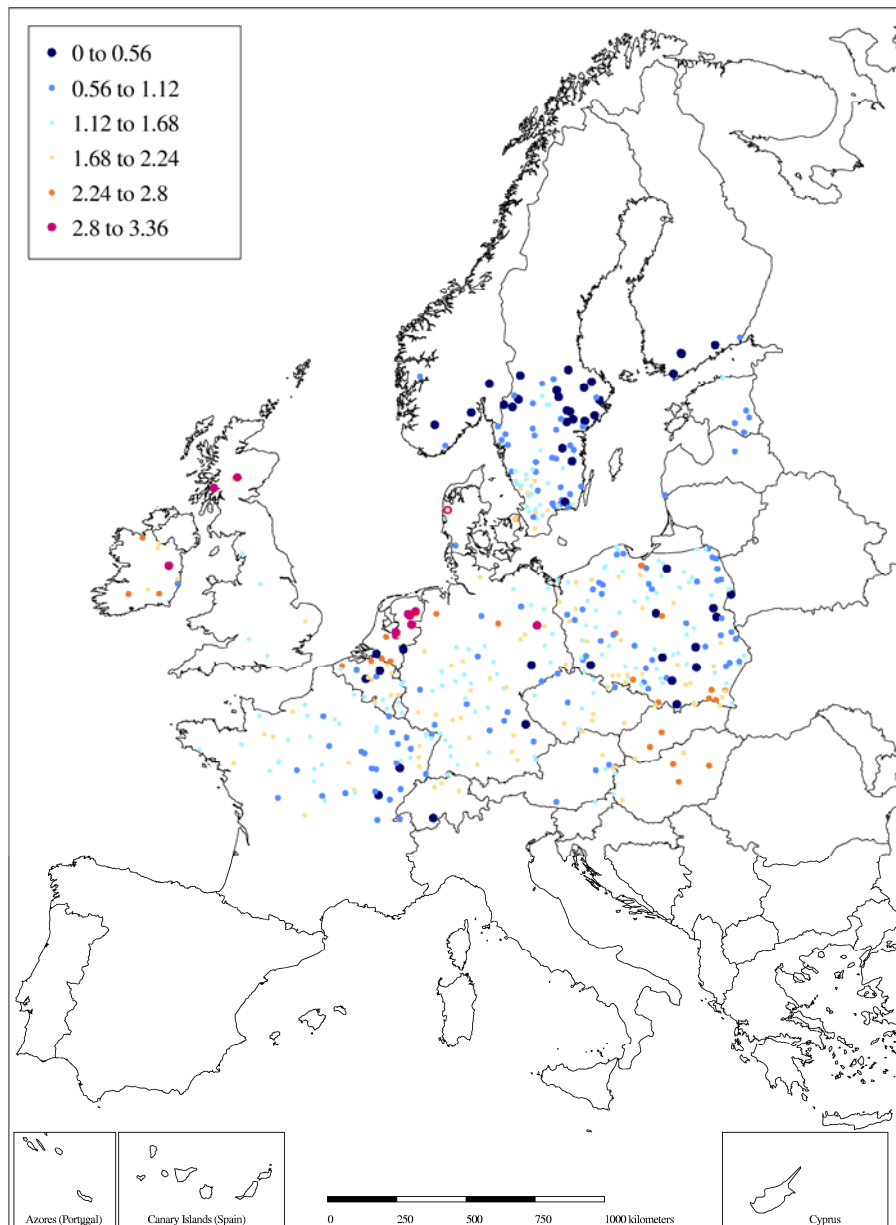


Figure 3.3.3-4: Scores of the 4th DCA axis at Level II plots within the nemoral zone of Europe.

3.3.4 Application of ecological indicator values

Indicator values according to ELLENBERG (1992) attributed to individual plant species deliver derived estimates for ecologically important site conditions. Of particular interest within the context of forest monitoring under the umbrella of ICP Forests are indicator values for soil reaction (R) and availability of soil nitrogen (N). Mean indicator values (mR, mN) per relevé were calculated from all plants species within a vegetation relevé. Weighting by cover degrees did not improve the results, thus unweighted means were used. Additionally, mean indicators for radiation (light, mL) and moisture (mF) were calculated.

There have been discussions about the applicability of the indicator values with respect to their geographical range. Also, modifications have been proposed (e.g. ERTSEN et al. 1998). For some parts of Europe alternative systems have been developed since long (ZOLYOMI et al. 1967, LANDOLT 1977, VEVLE 1985). Nonetheless, as shown for the

transnational Level II data set, the original Ellenberg indicator values for soil conditions are closely related to measured soil parameters (cf. Table 3.3.4-2). The Level II data are a unique basis for testing the applicability of these indicators on a European scale. Results show that they seem to work sufficiently accurate over wide geographical scales, which justifies their use for the whole of Europe (even including the Canary Islands, which do phytogeographically belong to the Macaronesian flora region). A map with mean indicator values for soil reaction of Level II plots (and one for temperature indicator values, which are not considered here) was already published by DE VRIES et al. (2002).

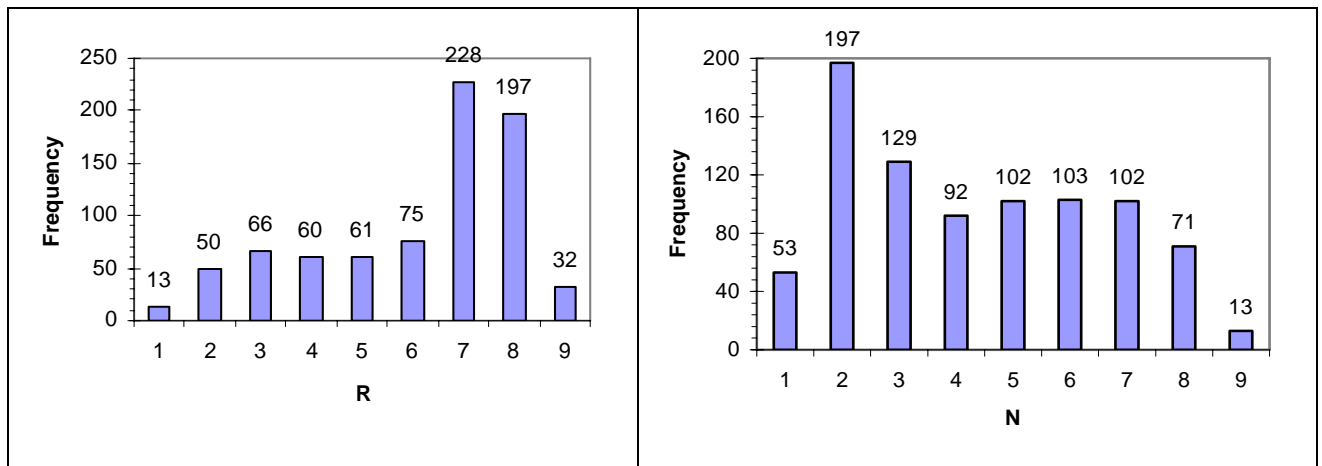


Figure 3.3.4-1: Frequency distribution for all R indicating plants found at the Level II monitoring sites irrespective of their local abundance or over-all frequency. Number of unranked and indifferent species: 1222.

Figure 3.3.4-2: Frequency distribution for all N indicating plants found at the Level II monitoring sites irrespective of their local abundance or over-all frequency. Number of unranked and indifferent species: 1142.

Figure 3.3.4-1 and Figure 3.3.4-2 reflect the frequency of all R and N indicators derived from all plants found at any site and point in time at any Level II permanent plot in Europe. Both distributions reflect almost exactly the frequency distribution of all 2726 species originally ranked by ELLENBERG (1992), even if there is a high amount of unranked and indifferent species. As stated by other authors (e.g. EWALD 2003) much more species grow on calcareous soils than on acidic soils (Figure 3.3.4-1). Within the N gradient from poor to rich soils more species occur on nitrogen poor soils. This has led to the hypotheses that N eutrophication might endanger biodiversity in the long run (e.g. ELLENBERG 1983).

When regarding the development of mean R and N indicator values per plot along the time scale the overwhelming majority of plots show no or only small changes (Figure 3.3.4-3). Extreme changes of the mean indicator values might be the results of heavy disturbances between two assessments or probably assessment errors (e.g. plots not identical at the assessments).

A comparison of differences between mean indicator values for available soil nitrogen for the first and the last assessment at all respective plots is given in Figure 3.3.4-4. The mN values of 50% of all plots remain almost constant. A slightly higher number of plots show increasing mean indicator values for nitrogen (98 plots corresponding to 27% of all plots) as compared to plots with decreasing mN values (84 plots corresponding to 22% of all plots). A t-test for paired data did however not reveal a significant difference between mN values of the first and the last assessment (mean increase: 0.02, $n = 475$, $(Pr > |t|) = 0.294$). A systematic statistical evaluation of changes with classical time series analysis and longitudinal approaches is to consider as soon as longer time series with more repetitions become available.

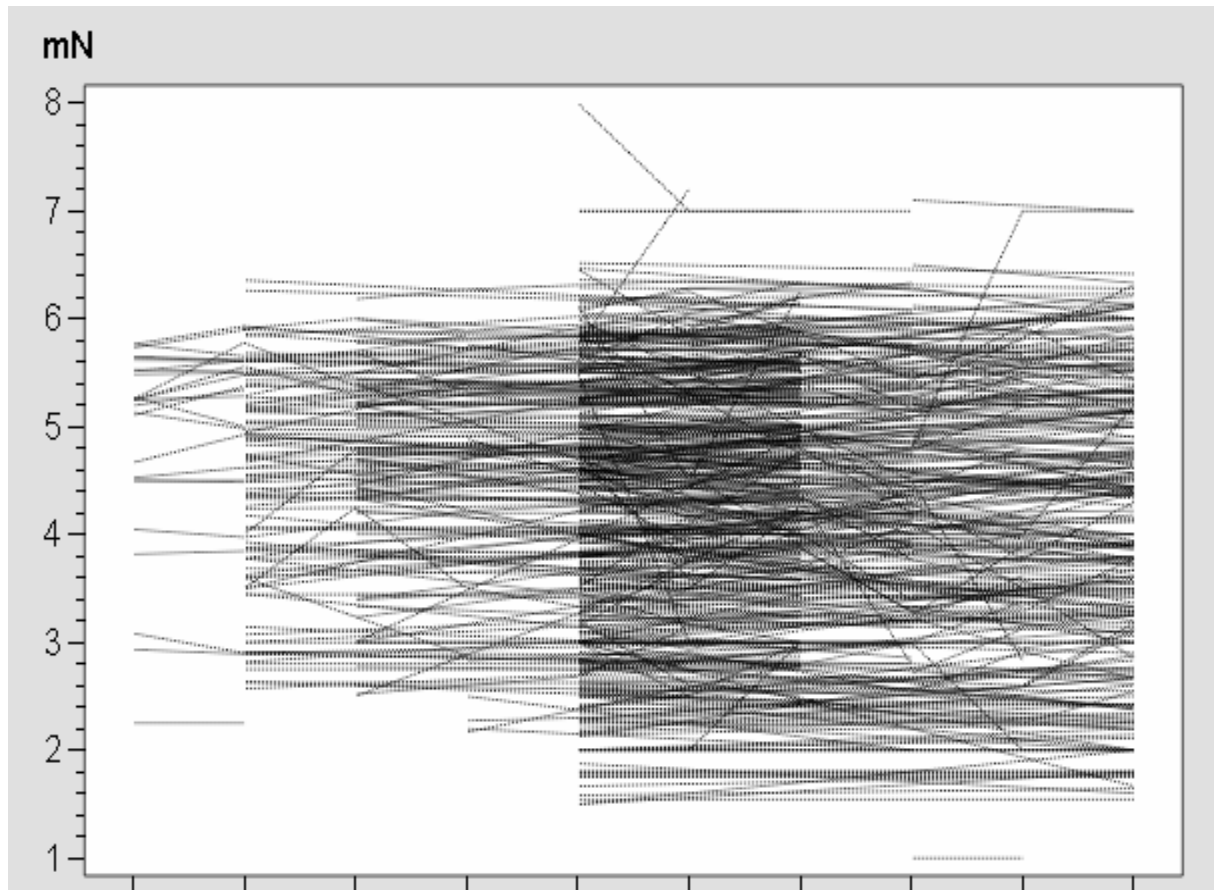


Figure 3.3.4-3: Development of mean N indicator values of the herb layer at each Level II plot in Europe with at least one repetition; n = 475 plots.

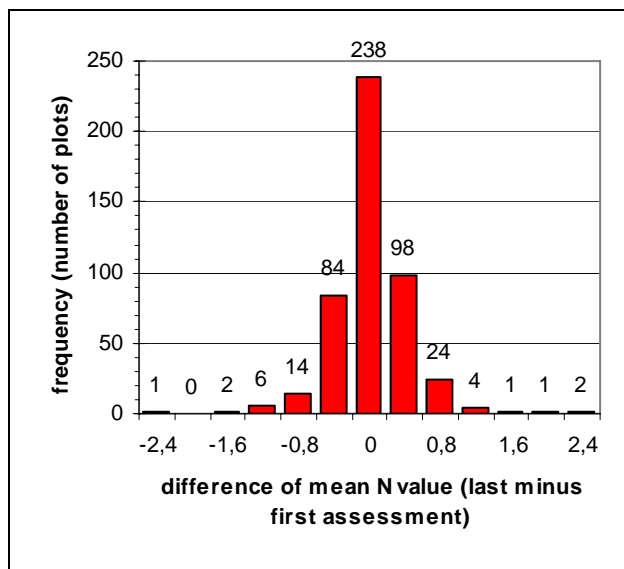


Figure 3.3.4-4: Summarised differences between the plot related mean indicator values for soil nitrogen (mN) at the respective first and at the last assessment; n = 475 plots.

Mean indicator values do not vary independently. Table 3.3.4-1 shows the intercorrelation structure of indicator values from 488 plots of the nemoral zone of Europe (numbers of intercorrelation pairs differ slightly due to plots, for which no specific mean indicator value could be calculated). The intercorrelations reflect the ecological ties between certain ecosystem features. For instance, in stands with better water supply a decrease of light on the forest floor is often observed, due to a denser crown layer (in case of wet and very wet soils this relationship is reversed, therefore the respective relationship is weak). The similar

relationship exists between mL and mR respectively mN values. On soils rich in basic cations or rich in available nitrogen tree crowns grow denser resulting in less light reaching the forest floor. A very strong relationship with a correlation coefficient of $r = 0.795$ exists between the mean indicator value of soil reaction and available nitrogen. This relationship, which exists over a wide range of the gradient from very acid to alkaline soils has often been found (e.g. ELLENBERG 1992, SEIDLING and ROHNER 1993) and was already described by SCHÖNHAR (1952). This relationship is physically based on a usually poor nitrogen supply on acidic soils due to impeded mineralization processes.

Table 3.3.4-1: Correlation coefficients of mean indicator values calculated from 488 plot form the nemoral zone of Europe; (): number of valid cases, $(Prob > |r|) \leq 0.05$, **: $(Prob > |r|) \leq 0.01$, ***: $(Prob > |r|) < 0.0001$.

	mF	mR	mN
mL	-0.1413** (475)	-0.3880*** (482)	-0.4759*** (484)
mF		0.0166 (470)	0.1843*** (473)
mR			0.7954*** (481)

The close correlation between mR and mN values can be corroborated by a correlation approach between measured soil and deposition parameters and indicator values (Table 3.3.4-2). Not only the negative relationship between light indicator values and all soil parameters closely related to soil acidity status, but also the mR and mN values reveal comparatively close relationships with these measured parameters. With an r of 0.765 the relationship between mR and the pH in the organic layer is specifically tight (Figure 3.3.4-5). This is interestingly in the same order of magnitude than the relationship between the 1st DCA axis and the same soil parameter (cf. Table 3.3.3-3).

Mean nitrate throughfall deposition shows a statistically significant relation with mean nitrogen indicator values (relationships with bulk N deposition are distinctively weaker and are not displayed here). Based on the evaluation of Ellenberg indicators, ground vegetation thus partly reflects atmospheric inputs. The higher mN values on plots with high nitrogen deposition might be due to a beneficial effect of nitrogen deposition on nitrogen indicating plant species.

Table 3.3.4-2: Correlation coefficients for mean indicator values calculated from 488 plots from the nemoral zone of Europe and measured environmental factors of the soil solid phase and mean annual throughfall deposition; $n = 488$ plots. $(Prob > |r|) \leq 0.05$, **: $(Prob > |r|) \leq 0.01$, ***: $(Prob > |r|) < 0.0001$.

		mL	mF	mR	mN
soil solid phase	C	-0.2411*** (461)	0.1324** (448)	0.1390** (456)	0.2254*** (457)
	N	-0.3308*** (471)	0.1329** (458)	0.3328*** (466)	0.3759*** (467)
	BCE	-0.2364*** (469)	-0.0345 (456)	0.5311*** (464)	0.3412*** (465)
	CEC	-0.2918*** (467)	0.0679 (454)	0.4250*** (462)	0.3619*** (463)
	base	-0.2246*** (464)	-0.0544 (451)	0.7555*** (459)	0.5028*** (460)
	C _{org}	-0.0959* (465)	0.1724** (452)	-0.2624*** (459)	-0.1525** (461)
	C/N _{min}	0.2201*** (461)	0.0077 (448)	-0.4249*** (456)	-0.3314*** (457)
	C/N _{org}	0.1100* (465)	-0.0586 (452)	-0.1708** (459)	-0.2338*** (461)
	pH _o	-0.3439*** (472)	-0.0249 (459)	0.7648*** (466)	0.5697*** (468)
	pH _{m01}	-0.2064*** (472)	-0.1660** (459)	0.5795*** (466)	0.3426*** (468)
mean annual throughfall deposition	xN _{depo}	0.2423** (224)	0.1740* (213)	0.0795 (219)	0.2402** (220)
	xNH ₄ -N _{depo}	0.2901*** (224)	0.1833** (213)	0.0384 (219)	0.1794** (220)
	xNO ₃ -N _{depo}	0.0970 (224)	0.1073 (213)	0.1776** (219)	0.3196*** (220)

The close correlation between mN values and the measured pH of the organic soil layer within the Level II data supports earlier findings by ELLENBERG (1992) and SEIDLING and ROHNER (1993). This relationship depends on a complex interplay between nitrification processes and availability of base cations within soils. Results for the Level II plots (Figure 3.3.4-6) show an almost linear increase from very acidic to slightly acidic soils and a more flat progression at higher pH values indicating decreasing nitrification rates at more calcareous soils which was also described earlier (e.g. RUNGE 1965, KRIEBITZSCH and BÜHMANN 1978).

The distribution of the plotwise values (Figure 3.3.4-6) shows a large variation and there is a large number of plots that deviate from the general mN-pH_O relationship. In the further evaluation it was of interest to explore reasons for these deviations and to find out whether additional nitrogen supply, e.g. through nitrogen deposition, was related to these deviations. The question of interest was whether nitrogen deposition could be related to plots with low pH but unexpected high mN values.

Therefore the residuals from the mN - pH_O relationship were regressed against soil and deposition parameters. The closest relationship in terms of the correlation coefficient was found for total N throughfall deposition. Results for a quadratic regression were slightly better as compared to a linear regression. Correlations for nitrate and ammonium were slightly weaker as compared to total deposition.

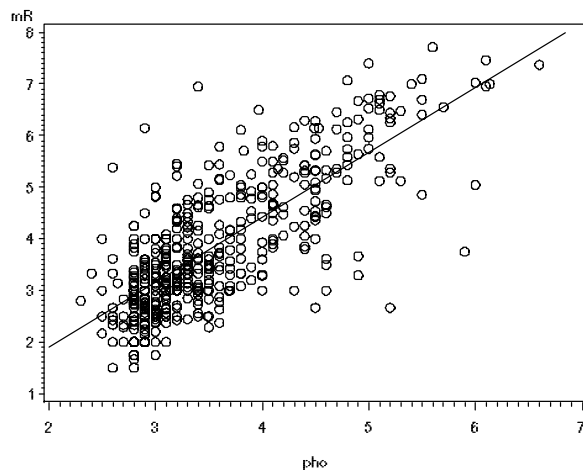


Figure 3.3.4-5: Relationship between mean indicator values for soil reaction and pH_{CaCl2} in the organic layer for n = 466 plots, R² = 0.5849, regression: $mR = -0.6260 + 1.2602 \text{ pH}_O$.

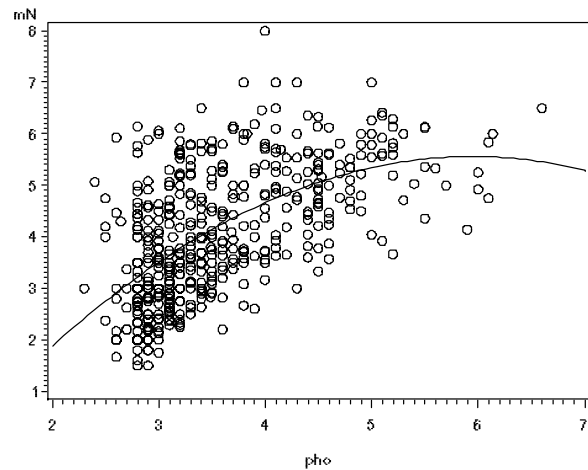


Figure 3.3.4-6: Relationship between mean indicator values for nitrogen and pH_{CaCl2} in the organic layer for n = 468 plots, R² = 0.3443, regression: $mN = -2.7799 + 2.8000 \text{ pH}_O + 0.2352 \text{ pH}_O^2$,

Figure 3.3.4-7 illustrates the relationship between the residuals from the quadratic regressions model mN on pH_O and atmospheric total N throughfall deposition. This relationship may still include a considerable amount of variation from different sources, like e.g. historical or recent mechanical disturbances, is however distinctively closer than the relationship between mean N indicator values and total N deposition (cf. Table 3.3.4-2).

The results show that on plots with acid soils nitrogen availability for ground vegetation is usually comparatively low. There are, however, a number of plots with acid soils where indicators of the ground vegetation suggest unexpected high nitrogen availability. These high mean indicators are correlated with higher nitrogen deposition.

Table 3.3.4-3: Correlation coefficients for residuals from the linear and quadratic regression models of mean N indicator values on pH_O on one side (indicator values are derived from the vegetation relevés; all records from nemoral forest region, if more than one record per plot is taken, the last record has been chosen) and key factors characterising the soil solid phase (organic layer and upper mineral layer) and mean throughfall deposition on the other side; *: (Prob > |r|) ≤ 0.05, **: (Prob > |r|) ≤ 0.01, ***: (Prob > |r|) < 0.0001.

ecological domains	environmental factors	residuals of mN on pH _O	
		from linear regression model	from quadratic regression model
soil solid phase	C	0.1310** (457)	0.1382** (457)
	N	0.2003*** (467)	0.2132*** (467)
	BCE	0.0081 (465)	0.0804 (465)
	CEC	0.1182* (463)	0.1763** (463)
	Basesat	0.1059* (460)	0.1132* (460)
	C _{org}	-0.0976* (461)	-0.0880 (461)
	C/N _{min}	-0.1704** (457)	-0.1590** (457)
	C/N _{org}	-0.2031*** (461)	-0.2107*** (461)
	pH _O	0.0000 (468)	-0.0000 (468)
	pH _{m01}	-0.0485 (468)	-0.0048 (468)
mean annual throughfall deposition	xN _{depo}	0.4000*** (210)	0.4310*** (210)
	xNH ₄ -N _{depo}	0.3644*** (210)	0.3899*** (210)
	xNO ₃ -N _{depo}	0.3860*** (210)	0.4194*** (210)

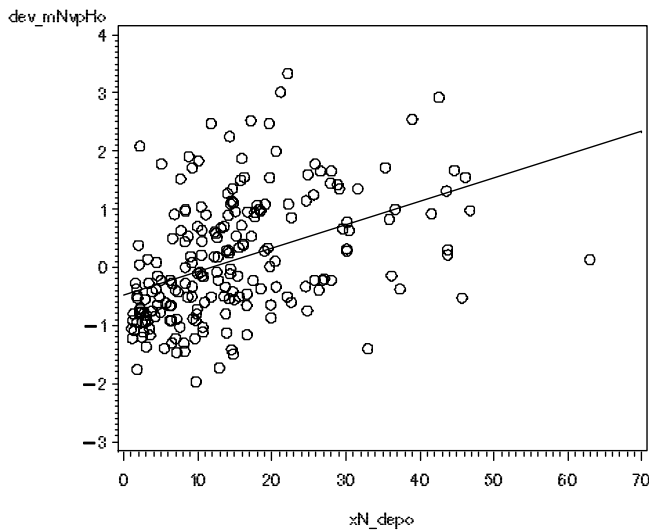


Figure 3.3.4-7: Residuals from the quadratic regression model between mean N indicator values and pH in the organic layer on the ordinate and mean annual total N throughfall deposition on the abscissa; R² = 0.186, n = 210.

3.3.5 Floristic changes along the time scale

Level II plots with repeated surveys of ground floor vegetation can be used to evaluate potential changes in ground vegetation composition. As the time series are of different length and as the starting points vary considerably, all repeatedly surveyed plots have been brought in sequences and analysed jointly by detrended correspondence analysis (DCA). Eventually triggering weather extremes can therefore not be considered. Anthropogenic and natural disturbances are not comprehensively acquired within the Level II data base;

these drivers for floristic dynamics can therefore as well not be differentiated from other influences like gradual changes of environmental factors.

For 106 plots at least three repetitions were available. Again, plots south of 46° latitude were excluded due to their strongly deviant floristic composition, leaving a total of 97 plots with 427 relevés. The eigenvalues of the DCA sum up to a total of 15.7, which is in the same order of magnitude than the approach covering 488 plots the nemoral zone (see subchapter above).

Results of the DCA reveal a 1st axis explaining 4.0% of the total floristic variance. Again this axis is loaded by species that are characteristic for the soil acidity status of the plots. The 2nd and 3rd axis explain 3.0% and 2.0 % respectively of the total floristic variance. Again, the 4th axis (explaining 1.8% of the total floristic variance) specifically lists species that show influences of nitrogen deposition on the ground floor vegetation. In general thus, this DCA based on plots with repeated surveys corroborates the findings of the DCA presented above showing that ground vegetation can be used to differentiate plots with more acidic or neutral acidity status and to differentiate plots with differing nitrogen availability.

The 1st and 4th axes of the DCA are the ones that carry the most relevant ecological information. Thus, all relevés were plotted in relation to their scores on these axes (Figure 3.3.5-1). Relevés belonging to the same plot were connected by lines. The resulting trajectories indicate whether the vegetation composition of the evaluated plots reflect changing acidity or nitrogen status of the plots over time. Results show that related to both axes there is hardly any general trend. This may be explained by the fact that either (i) time series are still rather short and start at times in which nitrogen deposition has already taken place for years and decades, so that a possible change of ground vegetation has already taken place before the assessments started, or (ii) the main determining factors for ground vegetation are site and stand specific (e.g. anthropogenic or natural disturbances) and did not change consistently over time.

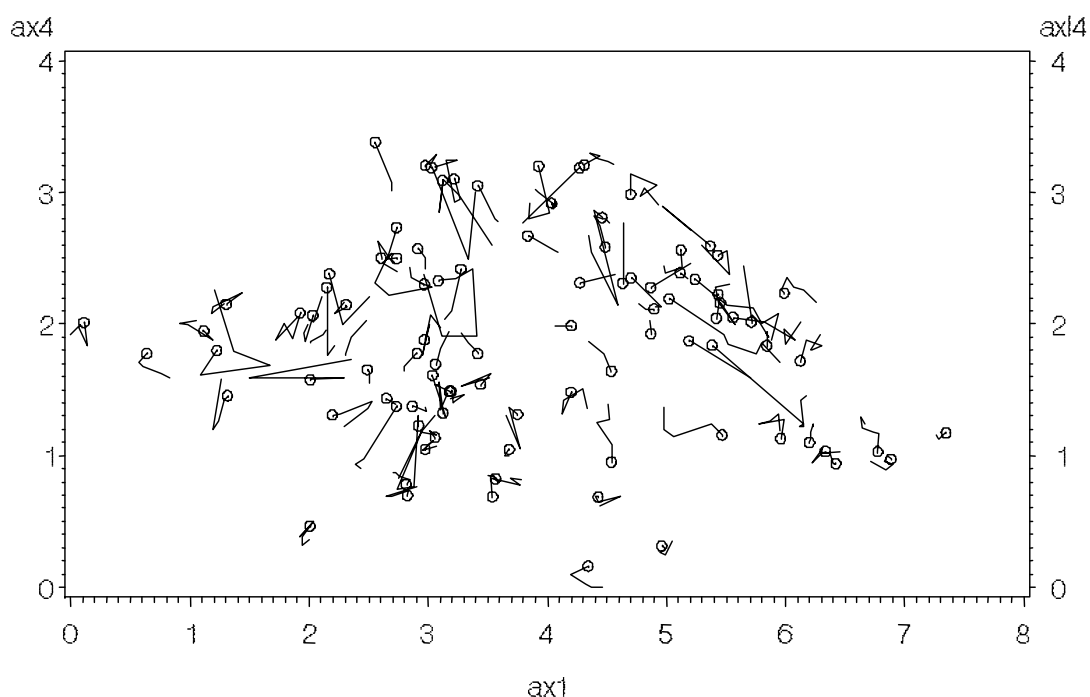


Figure 3.3.5-1: DCA-scores of the first and the fourth axes of serial vegetation relevés from permanent Level II plots. All relevés belonging to a series are successively interconnected by a trajectory; the temporally last point is marked by a circle.

3.3.6 Conclusions

Ground vegetation constitutes a considerable part of forest ecosystem diversity. Level II plots, albeit case studies, offer insight into cause effect relations of the most important forest ecosystems in Europe. The monitoring data offer detailed structural and species-specific information on the status and dynamic of this important ecosystem compartment at a European scale. Descriptive statistics of plain and derived parameters like cover degrees or diversity indices describe respective properties with a considerable broad geographical and ecological coverage, even if the results can statistically not be considered as area-representative. The measurement of a large amount of environmental parameters, both anthropogenic and natural, at identical sites, allows for interference studies, which may contribute to a better understanding of floristic and ecosystem processes.

Multivariate ordination (detrended correspondence analysis; DCA) of the floristic composition of vegetation relevés from all European Level II plots reveal a phytogeographical gradient which distinguishes relevés from the Iberian Peninsula as floristically most deviant.

A separate DCA with relevés from the nemoral zone of Europe, excluding Mediterranean, boreal and high-altitude forests reveals soil acidity on its first axis as the most differentiating ecological factor. The fourth DCA axis significantly correlates with nitrogen deposition in Europe indicating a fertilising effect of nitrogen deposition on the ground vegetation composition of the plots. This effect is corroborated by the fact that plots with high scores on the fourth axis are mostly located in regions with high nitrogen deposition.

Ellenberg indicator values for soil acidity and nitrogen support the results of the ordination as well. Soil parameters and nitrogen deposition are both significantly related to mean Ellenberg indicators per plot.

A strong correlation between soil pH and mean nitrogen indicators of the vegetation supports earlier findings whereas nitrogen availability is at least partly determined by the acidity status of the soil. Plotwise residuals from this general relation were significantly linked to nitrogen deposition showing that unexpected high nitrogen availability – mostly occurring at plots with low soil pH - is linked to atmospheric nitrogen inputs.

The analysis of changes in ground vegetation species composition over time was conducted by simple comparisons of mean Ellenberg indicators for nitrogen as well as with a DCA that aimed to check for changes in plotwise DCA scores over time. Both approaches did not reveal significant results, even though the number of plots with increasing mean nitrogen indicators was slightly higher compared to the number of plots with decreasing mean indicators. In general it is assumed that (i) the time interval was too short to detect changes and that (ii) the first assessments were made at times at which ground vegetation was already adapted to the nitrogen inputs. A systematic statistical evaluation of changes with classical time series analysis and longitudinal approaches is to consider as soon as longer time series with more repetitions become available.

3.4 Dynamic models for acidification and eutrophication

3.4.1 Introduction

All eight protocols to the Convention on Long-range Transboundary Air Pollution of the United Nations Economic Commission for Europe (UNECE) entered into force now. The most recent was on 17 May 2005 the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (Gothenburg Protocol). This Protocol aims to cut further emissions of sulphur, nitrogen oxides, volatile organic compounds (VOCs) and ammonia up to 2010. Reduction targets for all four pollutants are set for each country individual and nearly equal to the national emission ceilings (NEC) given by the NEC-Directive of the EU (2001/81/EG). In total by 2010, Europe's sulphur emissions should be cut by 63%, its NOx emissions by 41%, its VOC emissions by 40% and its ammonia emissions by 17% compared to their 1990 levels (Press Release UNECE/ENV/05/P04).

Since the first UNECE protocols on reducing emissions of sulphur (signed in 1985) and nitrogen (1988) have come into force, ever-increasing resources have been directed to develop effect-based approaches to control air pollution. With the implementation of the second Sulphur Protocol (1994) and, more recently, the Gothenburg-Protocol critical loads have been applied as guidelines for abatement strategies. Critical loads have been compared to actual deposition load values and an Average Accumulated Exceedance (AAE) of critical loads can be computed (see Mapping Manual 2004, Chapter 8).

In the last two decades, Europe observed the first results of the emission reduction but at the same time, critical loads of acidity and of nutrient nitrogen for forest, non forest vegetation and water ecosystems were still exceeded (Figure 3.4.1-1). The area of unprotected forest ecosystems amounts to only 10 percent by acidity but 50 percent due to nutrient Nitrogen (Figure 3.4.1-2). Results and methods are described in the CCE Report 2005 (POSCH et al. 2005).

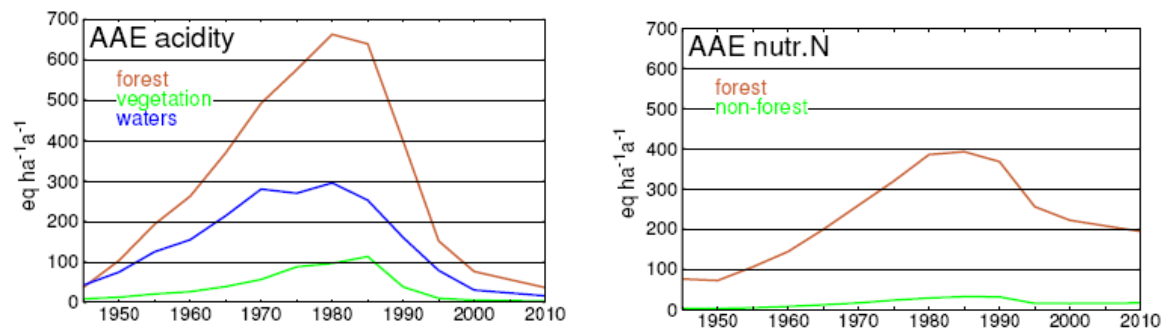


Figure 3.4.1-1: Average Accumulated Exceedance by acidity (left) and nutrient nitrogen (right).

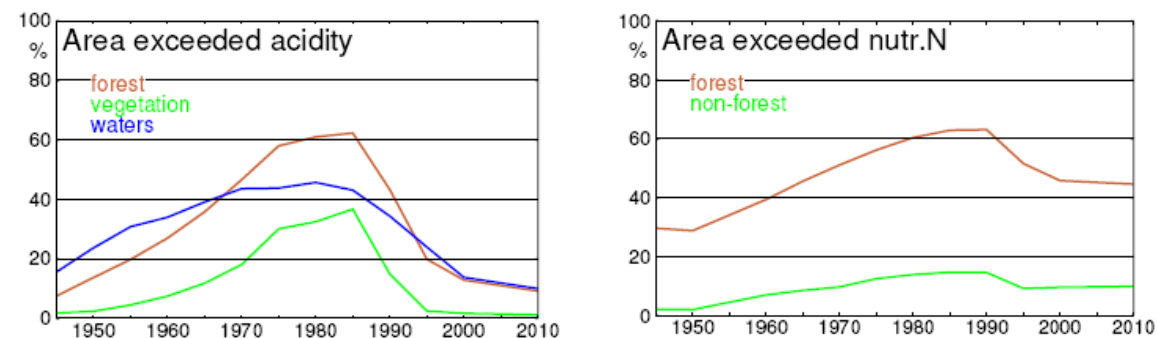


Figure 3.4.1-2: Ecosystem area exceeded by acidity (left) and nutrient nitrogen (right).

However, recently enacted measures are becoming effective. Additional commitments have brought about proof that the degree of acid critical load exceedance is falling. It is predicted to fall further in the future. To the contrary, the emission of nitrogen oxides and ammonia still remains on a high level and will be furthermore the main contributor of acidification and especially responsible for an unacceptable level of eutrophication.

3.4.2 Application of dynamic models at Level II plots

Air pollution is seen as an important factor for forest damage in several European countries. Long-term deposition of air pollutants is one of the main factors in processes linked to defoliation. It is monitored and assessed annually on a European scale. But will a decrease of deposition and reduced critical load exceedances result in forest ecosystem recovery? And if so, what's the time scale for coming under sustainable conditions?

To answer this dynamic modelling is necessary, because critical loads do not provide any information on time scales. Dynamic models are needed to assess time delays of recovery in regions cease being exceeded and time delays of damage in regions where critical loads continue to be exceeded (Mapping Manual 2004, Chapter 6). Studies based on mapping of critical loads of acidity and eutrophication and environmental monitoring supported by dynamic modelling show that recovery from pollutant stress will often be very slow and may sometimes even take decades or hundreds of years.

Therefore under the Convention in the ICP Modelling and Mapping as well as in other ICPs dynamic models have been developed and are applied to show the effects of acid deposition on soils and to derive targets for emission reduction with respect to acidification processes. The most common models are:

VSD

The Very Simple Dynamic (VSD) soil acidification model has been developed as the (minimal) extension of the Simple Mass Balance (SMB) steady-state model and is available for European use. In 2005, the Coordination Center on Effects (CCE) issued a call for dynamic modelling data and 14 countries submitted national results of applying the VSD model (POSCH et al. 2005).

SAFE

Soil Acidification in Forest Ecosystems (SAFE) is a dynamic soil chemistry model, developed with the objective of studying the effect of acid deposition on soil and ground water. It can be used to study the acidification and recovery processes and how they are affected by deposition rates, soil parameters and hydrological variations. SAFE includes process-oriented descriptions of cation exchange reactions, chemical weathering of minerals, leaching and accumulation of dissolved chemical components and solution equilibrium reactions.

Under development are also models focused on the biogeochemical modelling of nitrogen, and on modelling of acidification and eutrophication impacts on biodiversity for application in support of the Convention (e.g. BERN model).

Following the recommendations of the last year's Executive Report efforts were directed towards the application of the VSD and SAFE model to a larger number of Level II plots. In correspondence with this the Level II data were tested for generating inputs for dynamic models.

From these tests arose, that based on the ICP Forests data exclusively the SAFE model was not applicable and the VSD model could be used at a selected number of plots only. As minimum model input a complete set of mandatory and some optional data is required and

additional information on soil texture and mineral content should be available (Figure 3.4.2-1).

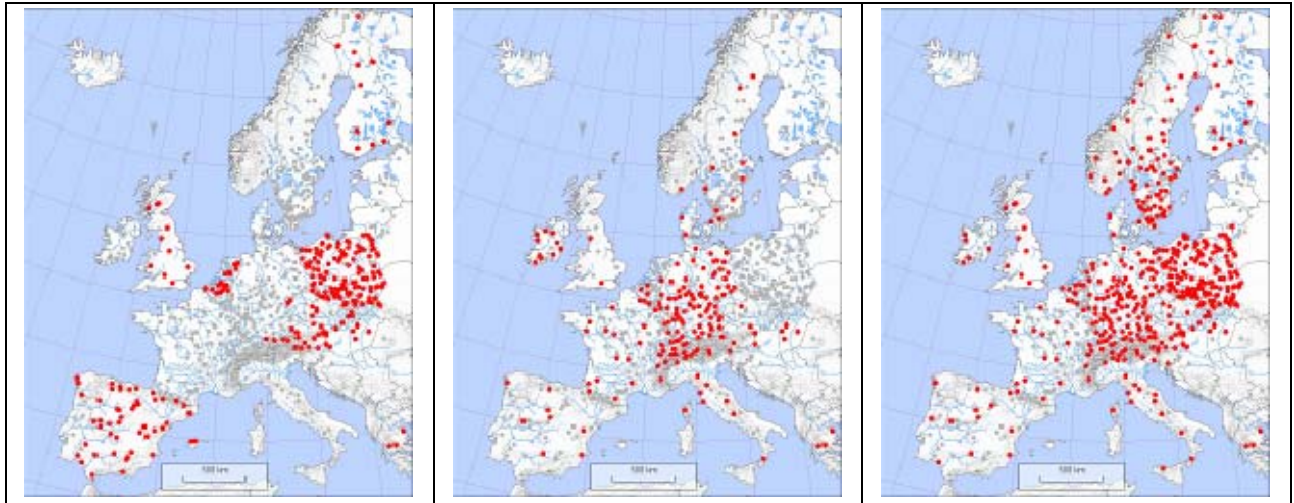


Figure 3.4.2-1: Availability of texture data (left), precipitation (centre) and bulk deposition (right) at Level II plots necessary for dynamic modelling, red dots show plots where data are present.

For dynamic modelling based on ICP Forests data 37 plots with sufficient input parameters were selected (Figure 3.4.2-2). Restrictions of model application on different Level II plots are mainly caused by missing input data, both mandatory and optional.

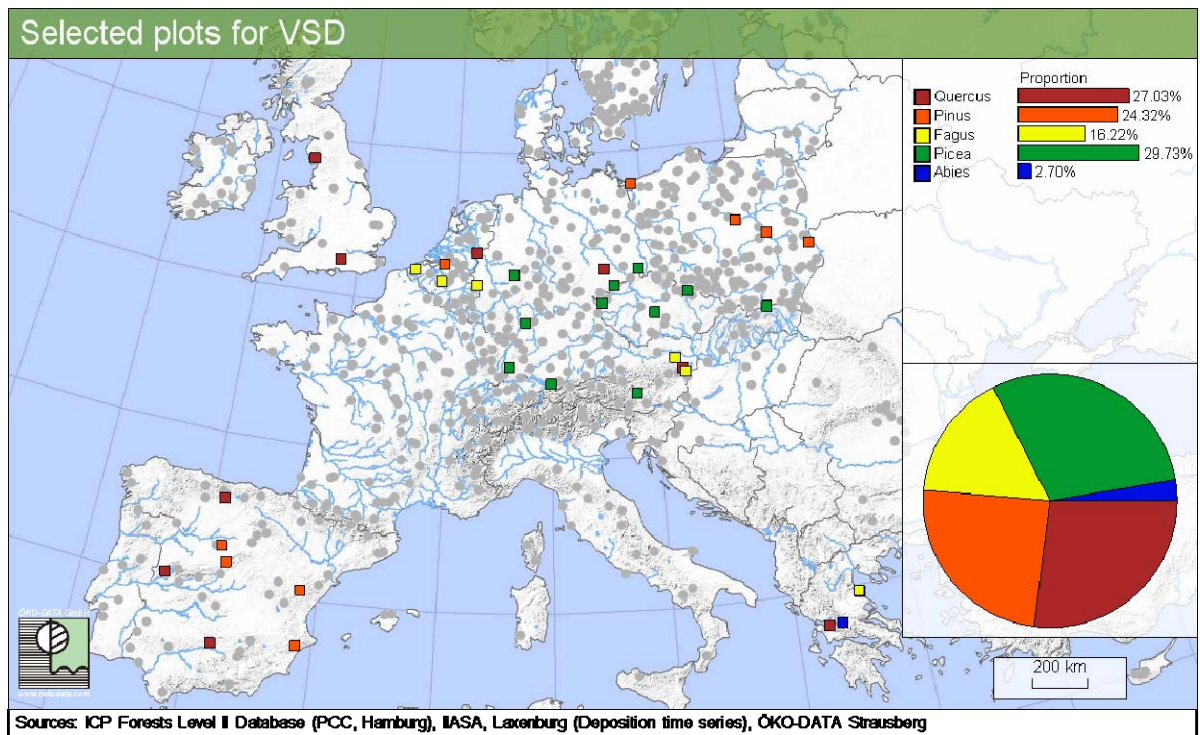


Figure 3.4.2-2: Level II plots selected for dynamic modelling with the VSD model.

Additional – as an example - a combination of ICP Forests data and specific forest research and monitoring studies in Germany were selected for running the SAFE model, resulting finally in 8 plots for SAFE applications (Figure 3.4.2-3).

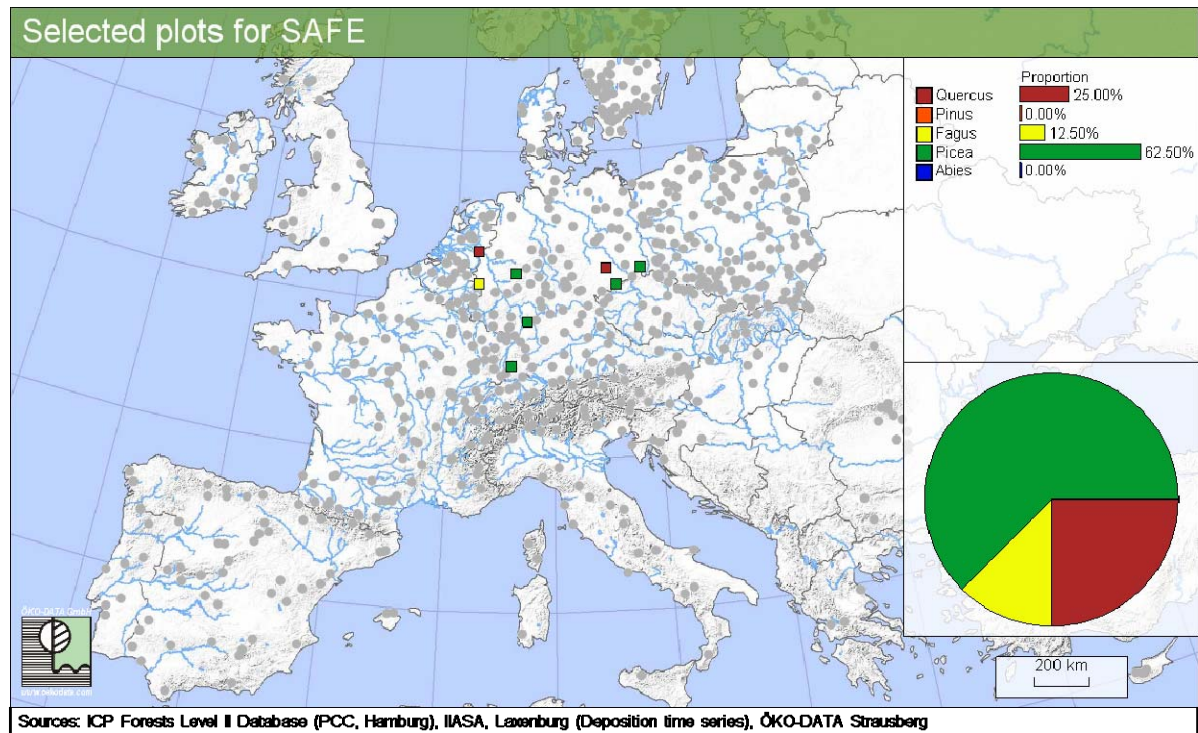


Figure 3.4.2-3: Level II plots selected for SAFE application.

3.4.3 Dynamic model results

Dynamic soil chemistry models such as VSD show the effects of acid deposition and forestry measures on the soil solution over time. The key processes included in the model are element fluxes in deposition, nutrient uptake by trees, nutrient cycling including mineralization, weathering processes for base cations and aluminium, and leaching of elements to groundwater. Also equilibrium reactions within the soil solution are taken into account. The calculations rely on Level II data and historical deposition rates available from literature. Future deposition scenarios based on the UNECE Gothenburg Protocol were applied as calculated by the International Institute for Applied Systems Analysis (IIASA). The depicted plots are not representative for Europe, but were selected for reasons of data availability. The application of dynamic models to a larger number of Level II plots is intended in the future.

The specific site and stand conditions on each plot have to be taken into account in order to assess the effects of measured deposition. Dynamic models have been applied to 37 Level II plots. These models specifically estimate the reaction of the soil solution based on soil, meteorological and deposition data.

Results of the dynamic model VSD are demonstrated in Figure 3.4.3-1 to 3.4.3-3. The pH value is chosen as accepted chemical indicator of acidification.

For the years 1900, 1990 and 2030 VSD results at the selected 37 Level II plots showing the change of pH, first an effect of acidification and then a recovery.

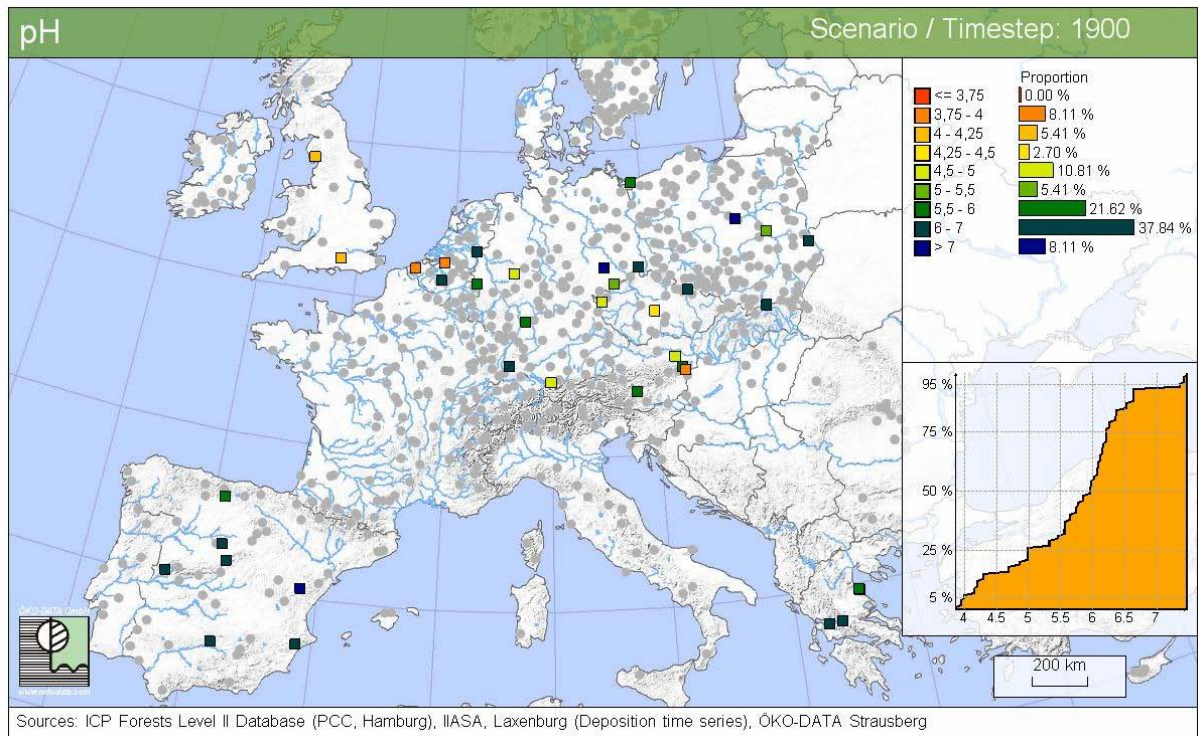


Figure 3.4.3-1: pH values at Level II plots for the year 1900. The pH value is a common chemical indicator for acidification, low values indicate acid conditions.

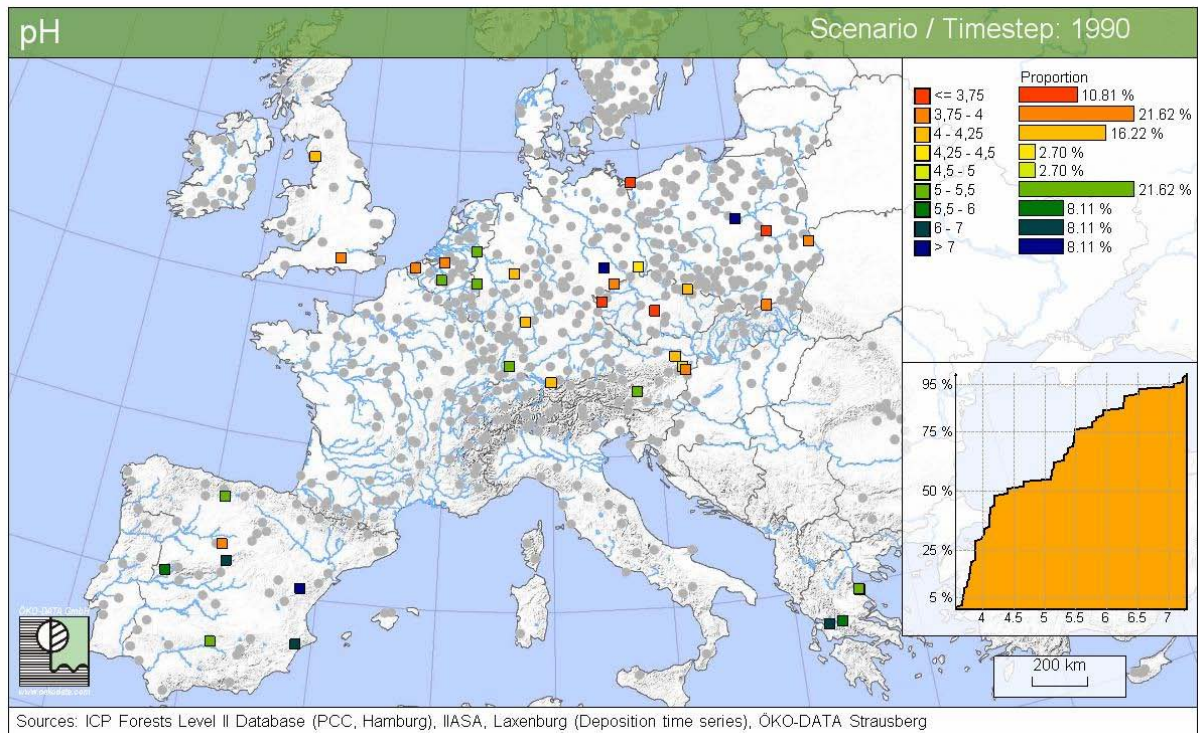


Figure 3.4.3-2: pH values at Level II plots for the year 1990. The pH value is a common chemical indicator for acidification, low values indicate acid conditions.

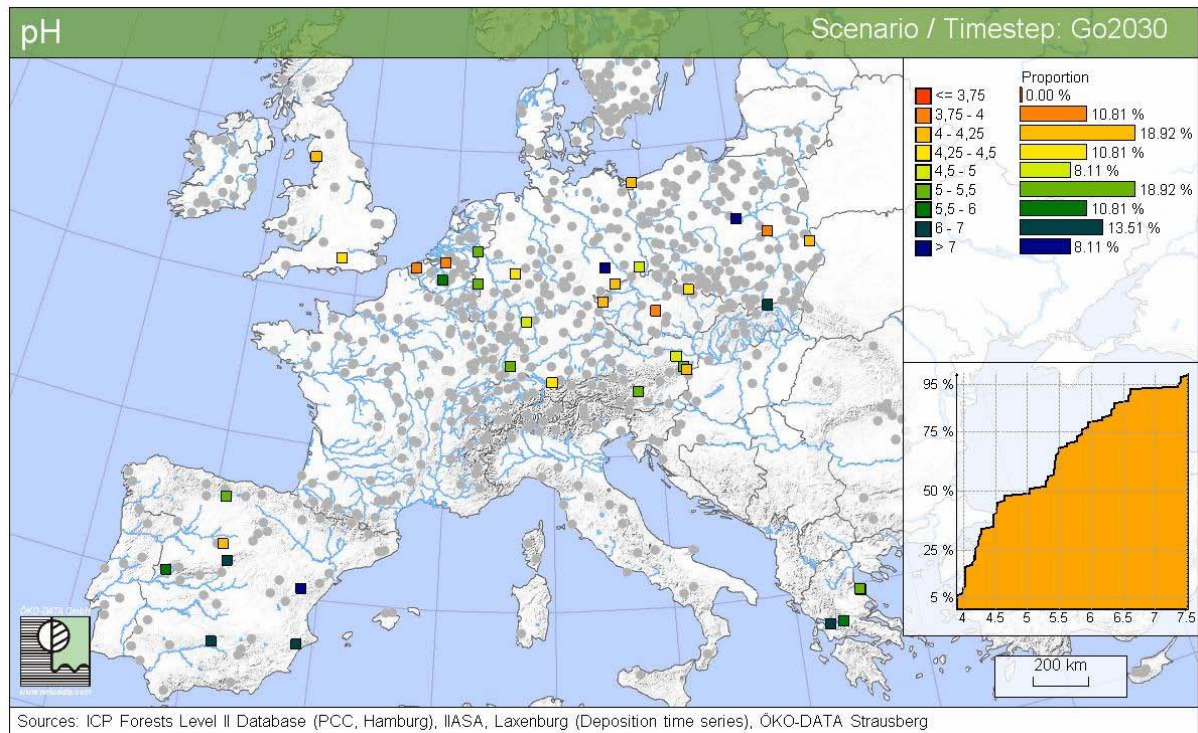


Figure 3.4.3-3: pH values at Level II plots for the year 2030. The pH value is a common chemical indicator for acidification, low values indicate acid conditions.

Many of the depicted plots show an increase of acidification between 1900 and 1990 and a subsequent slight recovery until 2030. Such a development is in general confirmed by measurements and has as well been reported from partner programmes of ICP Forests, showing that across Europe, the area with critical loads exceedances was largest in the 1990s.

The partial recovery that is observed since then is a success of emission reductions. The results presented are based on the assumption of further emission reductions following the UNECE Gothenburg Protocol. In 2050, soils with pH values below 4 can be expected for the examined plots nearly in the range of 1900, but above pH 5 are at this time just 50 percent of the calculated sites instead of about 70 percent in 1900 (Figure 3.4.3-4).

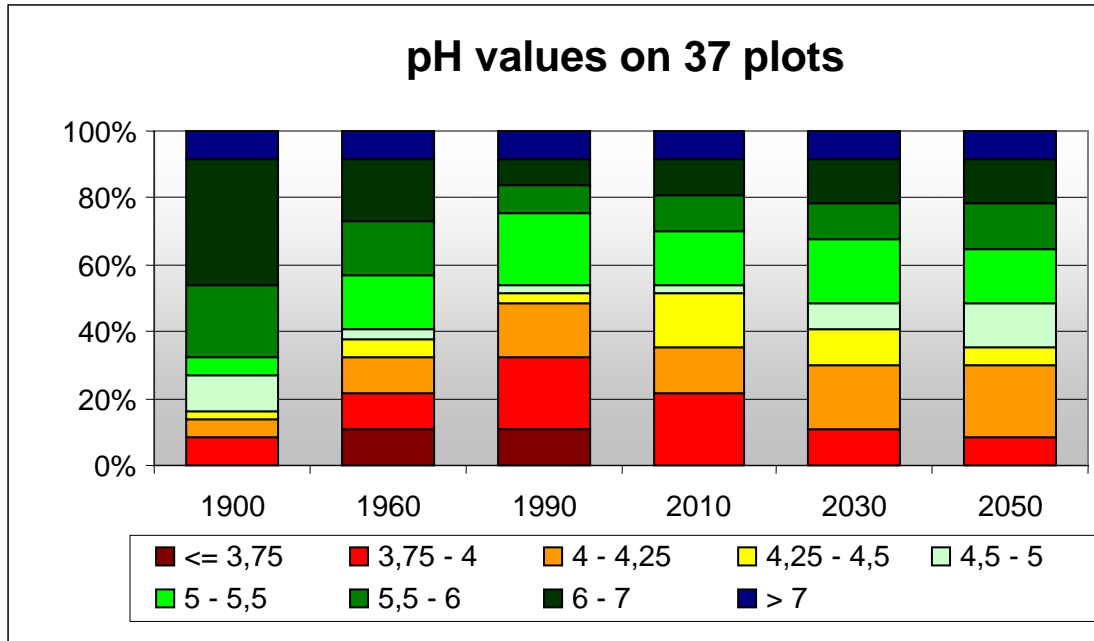


Figure 3.4.3-4: Frequency of pH values over time at 37 Level II plots, located in Spain (7), United Kingdom (2), Germany (8), Poland (6), Greece (4), Austria (4), Belgium (3) and Hungary (1).

The plot wise results show that the ecosystem reaction is not uniform, but instead depends on specific site and stand conditions (see Figure 3.4.3-5). Plots with a very constant pH value are mostly located on calcareous parent material which is a natural buffer for acidic inputs. Sensitive soils show a marked decrease in pH and only a partial recovery.

A full recovery is observed on plots where pH increases to historical levels after emission reductions have become effective. It has to be taken into account that dynamic models focus on the chemistry of soil solution which is closely linked to atmospheric deposition and thus reacts rather quickly to changing inputs. The recovery of the soil solid phase is much slower and can take many decades.

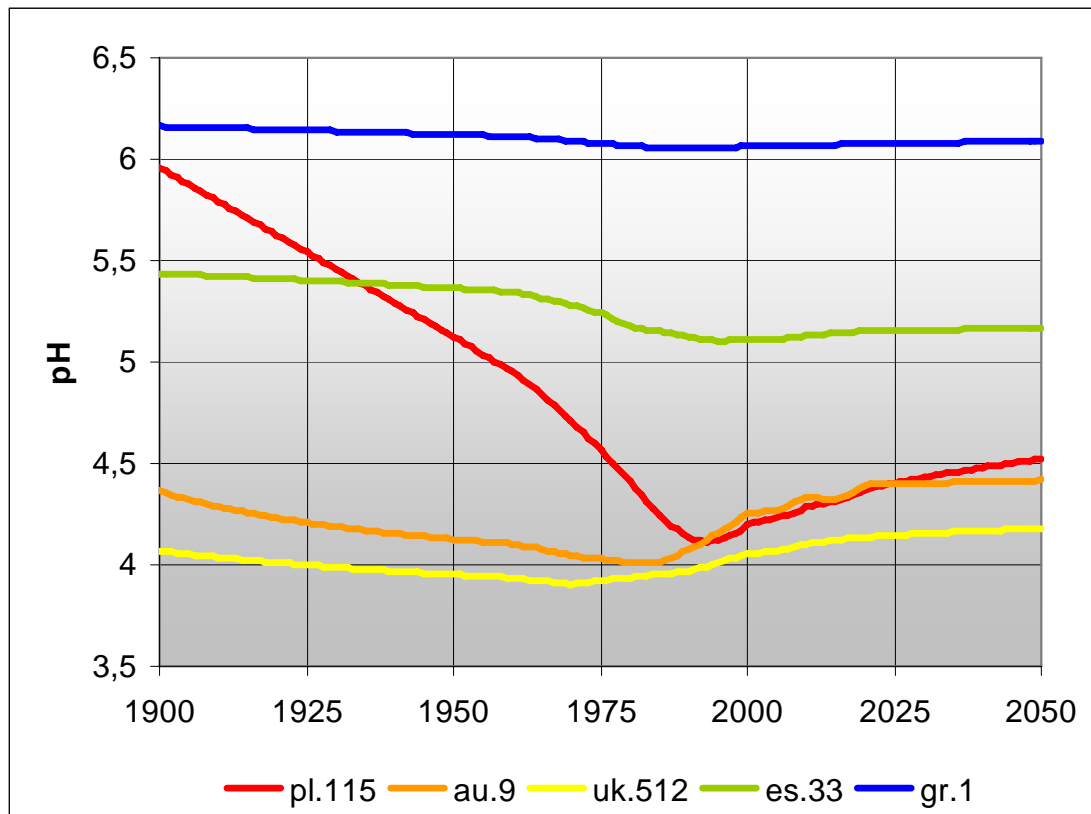


Figure 3.4.3-5: Time series of pH-value for selected Level II plots in Poland, Austria, United Kingdom, Spain and Greece.

The plots shown in Figure 3.4.3-5 are characterized by the following items.

- pl.115: Spruce, Texture: Medium, CEC 3.2 cmol_c/kg, Deposition 1760eq/(ha a) S, 800 eq/(ha a) ox. N, 890 eq/(ha a) red. N
- au.9: Beech, Texture: Medium, CEC: 12.8 cmol_c/kg, Deposition 264 eq/(ha a) S, 335 eq/(ha a) ox. N, 254 eq/(ha a) red. N
- uk.512: Oak, Texture: Fine, CEC: 11.2 cmol_c/kg, Deposition 550 eq/(ha a) S, 176 eq/(ha a) ox. N, 259 eq/(ha a) red. N
- es.33: Oak, Texture: Medium, Actual base saturation: 51%, CEC: 7.8 cmol_c/kg, Deposition 285 eq/(ha a) S, 200 eq/(ha a) ox. N, 130 eq/(ha a) red. N
- gr.1: Oak, Texture: Medium, CEC: 12.8 cmol_c/kg, Deposition 381 eq/(ha a) S, 121 eq/(ha a) ox. N, 175 eq/(ha a) red. N

Single layer models, like VSD, are neglecting the dependencies of the chemical status between different soil layers. Multilayer models as SAFE take care of these dependencies. For this reason, and also because of the much more sophisticated weathering module, results of SAFE are more reliable and comparable with measurements.

Model results applying SAFE demonstrate that due to reduced emissions after the implementation of the Gothenburg Protocol at some Level II plots a recovery can be expected, at other plots critical pH conditions will remain (Figure 3.4.3-5). The model application was funded by the forest departments of North Rhine-Westphalia and Saxony.

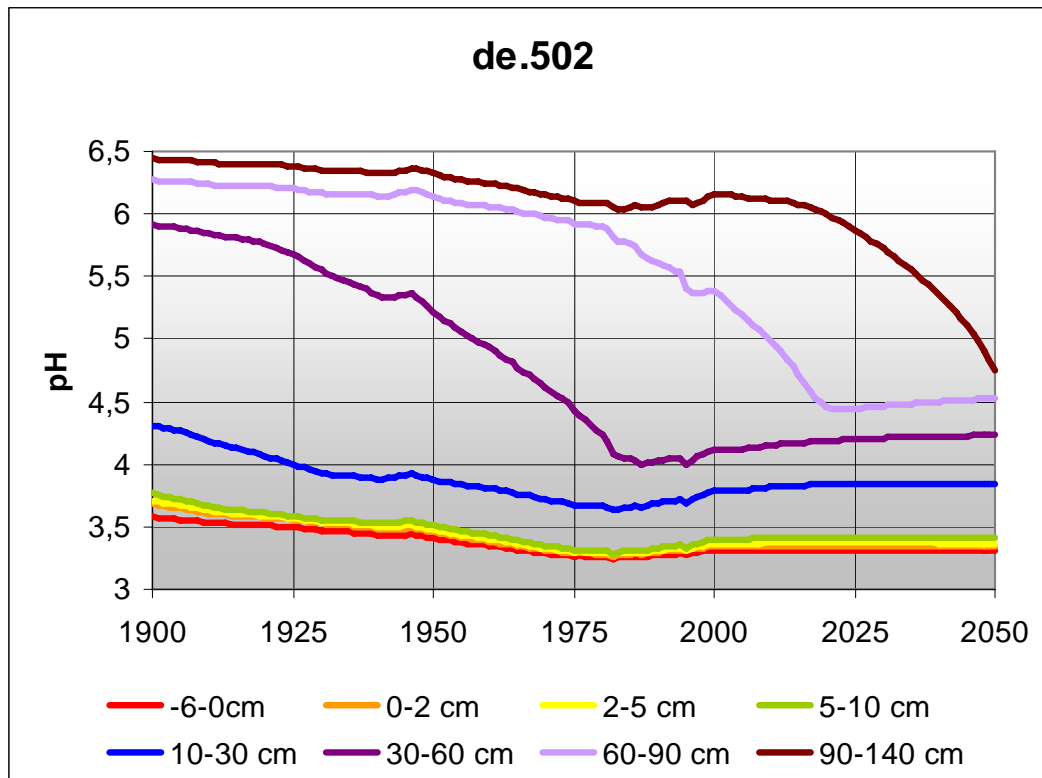


Figure 3.4.3-6: Dynamic acidification effects modelled with the multilayer model SAFE at the German Level II Plot 502: Tannenbusch, 130 year old oak with 25 % 75 year old beech, Gleyic Cambisol, sand (P=900mm, T=9°C), Deposition 900 eq/(ha a) S, 600 eq/(ha a) ox. N, 1570 eq/(ha a) red. N.

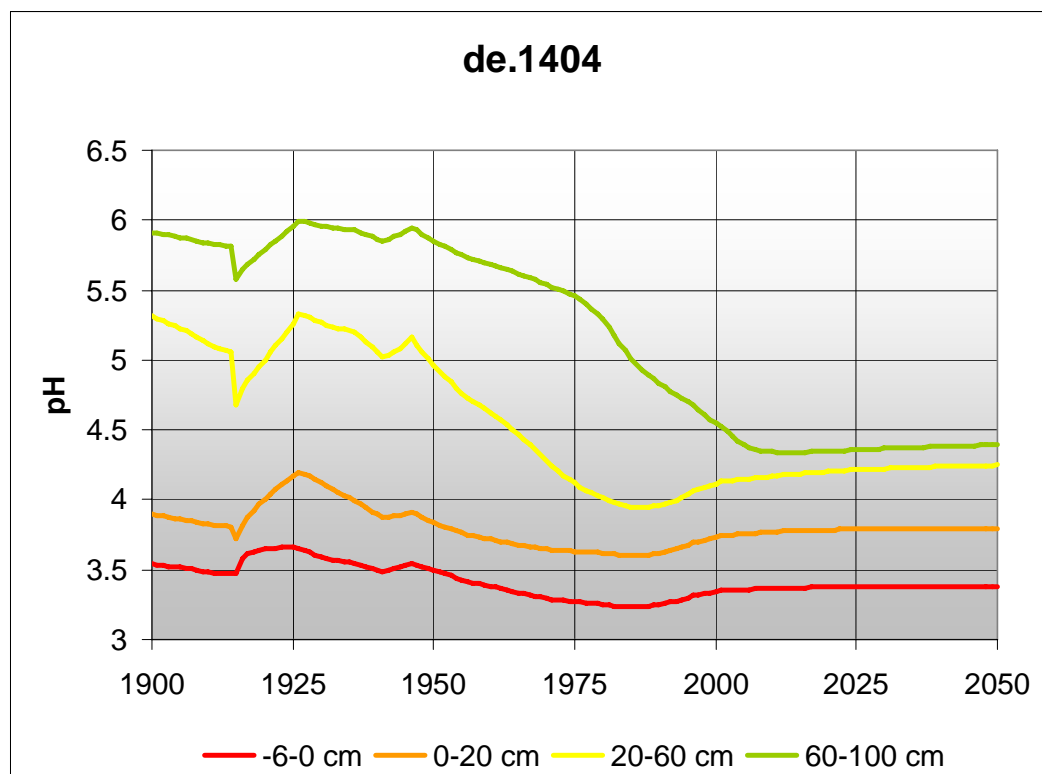


Figure 3.4.3-7: Dynamic acidification effects modelled with the multilayer model SAFE at the German Level II Plot 1404: Bautzen, 90 year spruce, Cambisol, silt, (P=900mm, T=8°C), Deposition 1280 eq/(ha a) S, 1070 eq/(ha a) ox. N, 1260 eq/(ha a) red. N.

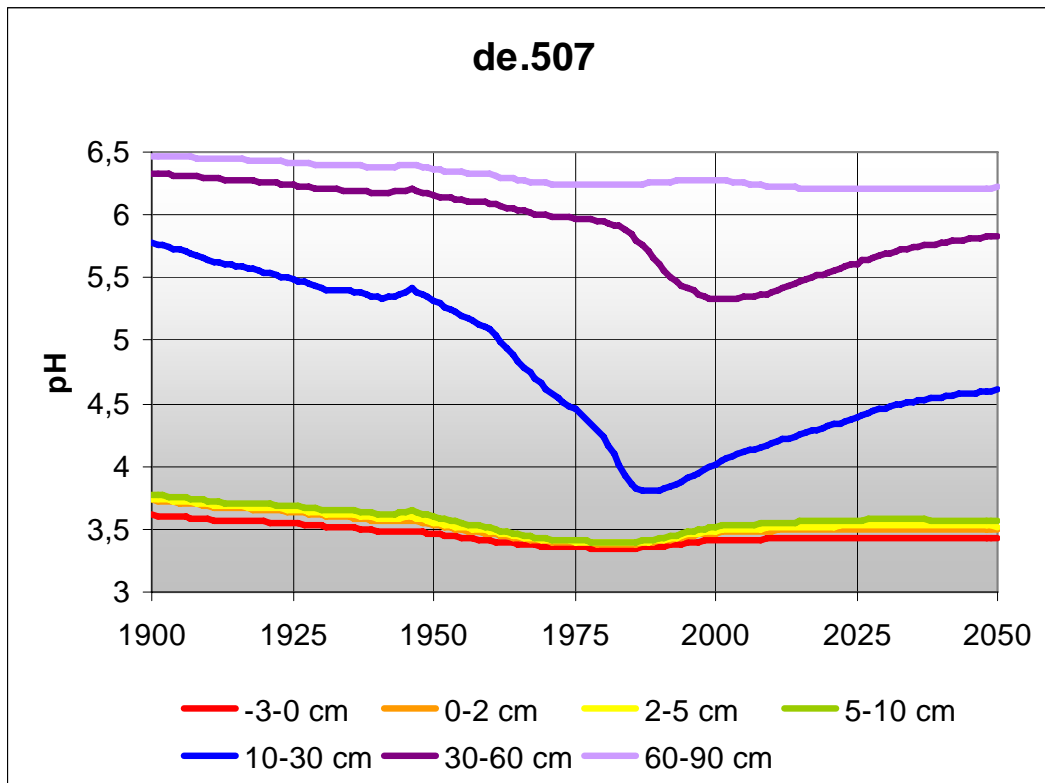


Figure 3.4.3-8: Dynamic acidification effects modelled with the multilayer model SAFE at the German Level II Plot 507: Monschau, 140 year beech, Gleysol, loam ($P=1050\text{mm}$, $T=8^\circ\text{C}$), Deposition $720\text{ eq}/(\text{ha a})$ S, $570\text{ eq}/(\text{ha a})$ ox. N, $590\text{ eq}/(\text{ha a})$ red. N.

The German Level II sites 502 and 1404 in Figure 3.4.3-6 and Figure 3.4.3-7 show the development of the acid frontier induced by acidic deposition. Plot 502 is a slow reacting site (a damage delay time is obvious) with high storage capabilities, while the Saxony site 1404 shows an extreme fast response to acid deposition. The third Level II plot 507 shows an expected recovery after implementation of the Gothenburg protocol (Figure 3.4.3-8).

3.4.4 Further development and tests for BERN-model application combining dynamic model results with vegetation changes

Level-II-data were selected for testing the biodiversity model “Bioindication for Ecosystem Regeneration towards Natural conditions” (BERN model, SCHLUTOW and HÜBENER 2005) in order to comprehend the vegetation changes in the past and future.

The BERN-model database contains the natural plant communities of middle Europe with their ecological niche widths of base saturation, pH, C/N-ratio in the soil and the climate conditions where their potential occurrence is possible. The BERN-model functions as an add-on-model to analyse and interpret biodiversity changes based on the results of modelled times series for base saturation and C/N-ratio.

Until now, BERN is a static model, which means that time lag effects are neglected. Due to the retardation of vegetation changes the observed vegetation effects may differ from the model outcome (not figured). Further evaluations and modelling based on a larger number of sites with an appropriate data basis are to be done in order to increase the experience with and the interpretability of biodiversity models.

4. NATIONAL SURVEY REPORTS IN 2005

Reports on the results of the national crown condition surveys at Level I of the year 2005 were received from 31 countries. For these countries, the present chapter presents summaries. Besides that, numerical data on crown condition in 2005 was received from 32 countries. These results are tabulated in Annex II. In Annex II-1 basic information on the forest area and survey design of the participatory countries is given. The distribution of the trees over the defoliation classes for all species is given in Annex II-2. Annexes II-3 and II-4 contain the data for conifers and for broadleaved trees, respectively. The annual changes in crown condition are presented for all species in Annex II-5, for the coniferous trees in Annex II-6, and for broadleaved trees in Annex II-7. Graphical presentations of the results are given in Annex II-8. It has to be noted, however, that it is not possible to directly compare the national survey results of individual countries. The sample sizes and survey designs may differ substantially and therefore conflict with comparisons. Gaps in the Annexes, both tabulated and plotted, may indicate that data for certain years are missing. Gaps also may occur if large differences in the samples were given e.g. due to changes in the grid, or the participation of a new country.

4.1 Northern Europe

4.1.1 Estonia

Forest condition in Estonia has been systematically assessed since 1988. In 2005, 2 167 trees, 573 *Picea abies*, 1478 *Pinus sylvestris* and 116 broadleaved trees were assessed on 92 permanent Level I sample plots in the period from July to October.

The most defoliated tree species in the past years has been *Pinus sylvestris*. An improvement of crown condition was observed in the period 1994–2000. Subsequently, a certain decline was observed until 2003. Since then decreasing defoliation has been observed for this tree species. In 2005, 49.3% of the *Pinus sylvestris* were not defoliated (defoliation class 0), 45.5% of the trees were slightly (defoliation class 1), 4.7% of the trees were moderately (defoliation class 2) and only 0.5% of the trees were severely defoliated or dead (defoliation classes 3 and 4). The reduced defoliation is a result of an ending outbreak of the shoot blight caused by *Ascocalyx abietina*.

Defoliation increased for *Picea abies* from 1996 to 2002 and remained on the same level since then. In 2005, 61.6% of the *Picea abies* were not defoliated (defoliation class 0), 31.8% of the trees were slightly (defoliation class 1), 4.4% of the trees were moderately (defoliation class 2) and only 2.2% of the trees were severely defoliated or dead (defoliation classes 3 and 4).

In general, the health status of deciduous species was markedly better than that of conifers.

Lophodermium pinastri (521 trees damaged) and *Ascocalyx abietina* (534 trees damaged) were the most important reasons for biotic damage of trees.

4.1.2 Finland

The 2005 forest condition survey was conducted on 609 sample plots arranged on 16 x 16 km and 24 x 32 km grids. During the summers 2004 and 2005, over 150 new plots were added to the survey. The present network also includes 110 peat land plots. No notable changes were observed in the average defoliation level of any tree species between the years 2004 and 2005.

Of the 11 535 trees assessed in 2005, 57% of the conifers and 62% of the broadleaves were not suffering from defoliation (leaf or needle loss 0-10%). The proportion of slightly defoliated (11 - 25%) conifers was 34%, and that of moderately defoliated (over 25% defoliation) 9 %. For broadleaves the corresponding proportions were 31% and 7%, respectively. In general, the average tree-specific degree of defoliation was 9.2% (9.1% in 2004) in *Pinus sylvestris*, 17.8% (18.0 in 2004) in *Picea abies* and 10.9% (11.5% in 2004) in broadleaves (mainly *Betula* spp.). On mineral soils, the average defoliation was 9.5% (9.3%) in *Pinus sylvestris*, 17.9% (18.1%) in *Picea abies* and 11.4% (12.0%) in broadleaves, and on peatlands 8.2% (8.2%), 16.8% (17.0%) and 9.4% (9.3%), respectively. A total of 13 trees (0.1%) died during 2004-2005 (0.1 % in 2003/2004).

In 2005 the most extensively reported disease was *Chrysomyxa ledi*. It was common in a belt running across central Finland. The most severe damage was caused by storms, even though there was no single storm but several local gales. Snow caused damage in many areas in winter 2004/2005. Moose remains a major threat for young plantations. Voles were abundant in 2005 and caused damage in plantations, too. In spring especially, brownish *Pinus sylvestris* were eye-catching along the roadsides where salt used for de-icing the roads had damaged the trees. *Juniper* spp. were again heavily infected by *Stigmina juniperina*. According to the inventories, *Gremmeniella abietina* and *Tomicus* species were the most abundant damaging agents in pines and *Chrysomyxa ledi* in spruces.

No correlation was found between the defoliation pattern of conifers or broadleaves and the modelled sulphur or nitrogen deposition at the national level in 2005 (the model calculation for 2005 is based on estimated deposition for the year 2002 by EMEP/Finnish Meteorological Institute).

4.1.3 Latvia

The forest condition survey of 2005 in Latvia was carried out on 349 permanent sample plots on the national 8 x 8 km grid net. Eight sample plots were completely destroyed during the hurricane of January 2005. The main species assessed were *Pinus sylvestris*, *Picea abies*, and *Betula* spp.

Of all tree species, 19.7% of the assessed trees were not defoliated, 67.2% were slightly defoliated and 13.1% moderately defoliated to dead (defoliation classes 2-4).

The mean defoliation of conifers was slightly higher (20.4%) than the defoliation of broadleaves (18.7%). For *Pinus sylvestris* a slight yet statistically significant increase in mean defoliation, reaching 20.5 %, was observed compared to 2004. 2005 was the first year with increasing pine defoliation after a long period of crown condition improvement since 1993. The deterioration in 2005 was due to a large-scale outburst of the European pine sawfly *Neodiprion sertifer* in the northwestern and northern regions of Latvia. The

total area affected by the pest was about 15 000 ha (in 2004 about 800 ha). In the most critical regions appropriate protection measures were taken.

The mean defoliation of *Picea abies* (20.2%) and *Betula* spp. (18.9%) was slightly lower than in 2004, although the changes were statistically insignificant. The percentage of damaged *Picea abies* (defoliation classes 2-4) decreased to 17.6% - the lowest value since 2000. However, since 2001 defoliation has been practically constant with annual variations below 1 percent point. For *Betula* spp., the proportion of trees in defoliation classes has varied periodically with no significant changes over the past four years.

In addition to the substantial storm damage from January 2005, visual observation revealed damage on 18.3% of the trees assessed. Compared to previous years, this index has increased by about 10 percent points. This increase is partly explained by a more thorough recording of the damage following the revised assessment methods. The proportion of damaged trees is similar for both conifers and broadleaved trees. For *Pinus sylvestris*, damage was recorded on 19.5% of the trees assessed, for *Picea abies* and *Betula* spp. the values were 14.7% and 16.1%, respectively. For *Pinus sylvestris* the most common damage causes were *Neodiprion sertifer* and the needle cast *Lophodermium pinastri*. *Picea abies* was most commonly damaged by deer and unfavourable abiotic factors. For *Betula* spp., foliar pests were the most commonly recorded damage types.

4.1.4 Lithuania

The 2005 forest condition survey was carried out on 262 sample plots of the transnational (16 × 16 km) and national (8 × 8 km) grid nets. In total, 6 315 sample trees representing 15 tree species were assessed. The main tree species were *Pinus sylvestris*, *Picea abies*, *Betula pendula*, *Betula pubescens*, *Populus tremula*, *Alnus glutinosa*, *Alnus incana*, *Fraxinus excelsior*, and *Quercus robur*.

Mean defoliation of all tree species was 20.3%, and thus 1.3 percent points lower than in 2004 (21.6%) and 0.9 percent points lower than in 2003 (21.2%). 14.1% of all sample trees were not defoliated (defoliation class 0), 74.9% were slightly defoliated and only 11.0% were assessed as moderately defoliated, severely defoliated or dead (defoliation classes 2-4). Mean defoliation of conifers was 19.6% (20.4% in 2004). The change in mean defoliation of broadleaves was statistically significant. It was 22.0% and by 2.1 percent points lower than in 2004 (24.1%).

Pinus sylvestris accounted for more than 50% of all sample trees and its condition thus significantly influences the overall mean values. Mean defoliation of *Pinus sylvestris* was 19.7% (20.2% in 2004). Since 1998, mean defoliation of *Pinus sylvestris* did not exceed 21.0%.

Mean defoliation of *Picea abies* was 19.3 (21.0% in 2004). In 2005, mean defoliation of *Quercus robur* was 31.4% (31.3% in 2004) and the share of trees in defoliation classes 2 -4 was 34.6% (47.6% in 2004). *Alnus incana*, *Alnus glutinosa* and *Populus tremula* had the lowest mean defoliation of all tree species. Mean defoliation of *Alnus incana* was 18.2% (24.2% in 2004), mean defoliation of *Alnus glutinosa* was 18.5% (19.1% in 2004) and *Populus tremula* had a mean defoliation of 18.6% (22.7% in 2004).

10.9% of all sample trees had some kind of identifiable damage symptoms. The most frequent damage was caused by insects (2.5%), abiotic agents (2.1%), fungi (1.8%) and

direct action of man (1.1%). The share of trees with insect damage was 4.2 percent points lower than in 2004 (6.7%). *Populus tremula* (48.9%) and *Quercus robur* (45.8%) were the tree species with the highest proportion of damaged trees. *Pinus sylvestris* (6.2%) and *Alnus glutinosa* (7.2%) were the tree species with the lowest share of damaged trees.

The condition of Lithuanian forests can be considered as relatively stable, as mean defoliation of all tree species has varied only slightly since 1996.

4.1.5 Norway

With respect to all tree species, 44.2% of the trees assessed in 2005 were not defoliated and 90.2% were not discoloured. This reflects a general improvement compared to the year before. The mortality remained at 0.3%. Average crown density was 82.6% showing a decrease by 0.7 percent points as compared to 2004.

For *Picea abies*, average crown defoliation increased from 15.1 % to 16.1 % in 2005 compared to 2004, and for *Pinus sylvestris* from 14.5 % to 16.0 % in 2005. The crown defoliation for *Betula* spp. was recorded to 21.3 %, representing a decrease by 1.3 percent points compared to the result in 2004.

Of the coniferous trees, 47% were rated not defoliated, representing the same level as in 2004. But, for *Picea abies* there was an increase in the share of not defoliated trees by 0.9 percent points and for *Pinus sylvestris* a decrease by 2.2 percent points compared to 2004. An increase for *Betula* spp. by 6.4 percent points to 34.8% in 2005 was observed in the class of not defoliated trees.

15% of *Picea abies* showed signs of discolouration, after 18% in 2004. For *Pinus sylvestris*, 4.7% were assessed as discoloured, reflecting the same level as compared to 2004. In *Betula* spp., a decrease in discoloured trees was observed from 9% in 2004 to 5.7% in 2005.

No serious attacks of pests or pathogens were recorded in 2005. In general, the observed crown condition results from an interaction between climate, pests, pathogens and general stress. The results of the 2005 assessments confirm the status of the crown condition recorded over the last few years.

4.1.6 Sweden

The national forest condition survey was carried out on 784 plots of the transnational Level I grid. In total, 11 443 conifers and broadleaved sample trees were assessed. Included in the calculations are also 7 386 sample trees (*Picea abies* and *Pinus sylvestris*) on 3 232 sample plots of the National Forest Inventory. The results from the national forest condition survey concern only forest of thinning age or older. The main tree species are *Picea abies*, *Pinus sylvestris*, *Betula pendula*, *Betula pubescens*, *Fraxinus excelsior*, and *Quercus robur*.

The proportion of trees with more than 25% defoliation is in *Picea abies* 27.9 % (25.6 % in 2004) and in *Pinus sylvestris* 11.4 % (10.0% in 2004). The increased defoliation is mainly seen as increased mortality rate, + 1.2 percent points, mainly due to wind thrown trees. In *Betula* spp. a slight increased defoliation was recorded and the proportion of trees with

more than 25% is 8.5% (7.0% in 2004). The share of discoloured *Picea abies* trees has in 2005 slightly decreased to 9.7%. In *Pinus sylvestris* discolouration is still rare, with less than 2%.

The severe storm in January 2005, which affected large parts of southern Sweden, has strongly influenced the forest condition in 2005. It will probably also have a significant affect on the condition in coming years due to the risk of increasing populations of bark beetles. About 75 million m³ timber, mainly *Picea abies* but also to a large part *Pinus sylvestris* trees were felled by the storm. In southern Sweden (Götaland) 6.8% of the *Picea abies* trees and 3.6% of the *Pinus sylvestris* trees were wind thrown. A relatively low rate (less than 5% for *Ips typographus*) of insect attacks on wind thrown trees indicated low populations in spring 2005. However, a large amount of suitable substrate has increased the populations in the meantime. Among defoliators no extensive outbreaks were found, and less than 1% of the broadleaved trees were moderately or severely affected by defoliators. Attacks of *Dendroctonus micans* were detected on 0.8% of *Picea abies* in southern Sweden (Götaland). Among fungi damage (root rot excluded) no indication of any outbreak was found. The excessive outbreak of *Gremmeniella abietina*, which arose in 2001, still influences the tree health on *Pinus sylvestris*. New infections are now however at a low level.

4.2. Central Europe

4.2.1 Austria

The crown condition assessment in Austria is restricted to the transnational grid of 16 x 16 km since 2003. The transnational grid in 2005 comprised 136 plots with about 3 500 sample trees.

In 2005, crown condition for all tree species, compared to results of the previous year, deteriorated. Around 15% of the sample trees, i.e. 1.7 percent points more than in 2004 were classified as damaged (defoliation classes 2-4). The share of coniferous species classified as damaged increased by approximately 2 percent points and the share of broadleaved species decreased by about 1 percent point. The mortality rate, calculated as the percentage of trees that died between two surveys, was 0.4%, and thus the highest value ever found in all years.

As regards the most common coniferous species, crown condition of *Picea abies* and *Larix decidua* deteriorated, and crown condition of *Pinus sylvestris* slightly improved. Reliable information on the development of broadleaved species, esp. *Quercus* sp., cannot be given due to the small sample size. The remarkable deterioration of crown condition of *Larix decidua* is probably due to strong infestation with *Coleophora laricella* and *Adelges geniculatus & laricis* in many parts of Austria. Because of the high amount of precipitation during the summer of 2005, several micro fungi, some of them leading to premature leaf shedding, were observed on broadleaved species. The swarming of bark beetles started very early this year. A surprisingly high activity of bark beetles occurred in alpine regions located higher than 1 000 m above sea level.

The impact of atmospheric sulphur deposition on forests has been assessed since 1983 on the Austrian Bio Indicator Grid comprising 760 sample plots. The main indicator tree species for foliar analysis is *Picea abies* (about 90%). The annual sampling allows a precise evaluation of the temporal and regional development of the impact of sulphur. Despite the reduction of SO₂ emissions in Austria since the 1980ies, the legal threshold value is still

exceeded on 8% of the plots. These plots are mainly located near large national emitters, but also in areas affected by transboundary sulphur emissions from neighbouring countries.

4.2.2 Croatia

86 sample plots on the 16 x 16 km grid network were included in the forest condition survey in 2005, and 87 plots in 2004. The percentage of trees of all species within defoliation classes 2-4 in 2005 (27.1%) was higher as compared to the year 2004 (25.2%). For broadleaves the share of trees in classes 2-4 was 17.8 % in 2004 and 19.2 in 2005. For conifers, the percentage of damaged trees shows an increase from 70.6 % in 2004 to 79.5% in 2005. Although the percentage of moderately to severely damaged conifers is high, it does not have a stronger impact on the overall percentage of trees of all species due to the low representation of coniferous trees in the sample (268 coniferous trees vs. 1778 broadleaves in the 2005 survey).

Abies alba remains the tree species with the highest share of damaged trees. The lowest value, 36.6% of moderately to severely damaged trees was recorded in 1988, whereas in 1993 the share was already 70.8%. In the year 2001 it reached 84.5 %, and after a slight decrease in 2002 (81.2%), the trend of increasing defoliation continued with 83.3% of moderately to severely damaged trees in 2003, 86.5% in 2004 and 88.5% in the year 2005.

The lowest damage of *Quercus robur* was recorded in 1988 (8.1%), the highest in 1994 (42.5%), and the share of damaged trees has been fairly constant in the following years with around 25-30% until the year 2000. Afterwards it decreased to values below 20% (15.4% in 2003, 18.5% in 2004). In 2005, an increase was recorded with 22.1% of moderately to severely damaged oak trees.

For *Fagus sylvatica*, the share of trees in defoliation classes 2-4 remained low since the start of the observations. The highest value was recorded in the year 2001 when it was 12.5%. Later it dropped to lower values: 5.1% in 2003, 7.5% in 2004 and 7.0% in 2005.

In Croatia, the last two years were wet years. According to the Meteorological and Hydrological Service of Croatia, the year 2004 was very warm (on 45% of the area) or warm (also 45% of the area) and rainy (50% of the area) or normal (45% of the area). These conditions did not seem to have a beneficial effect on the defoliation of trees in Croatia. Overall, despite a relatively high degree of damage, forest condition in Croatia has remained stable in the course of the last few years with a slightly increasing trend.

4.2.3 Czech Republic

No important changes in defoliation since 2001 have been observed for *Picea abies*, which is the main tree species in the 60 years old and older stands. For *Picea abies* trees younger than 60 years, the share of trees in defoliation class 1 slightly increased in 2005. Simultaneously, the share of trees in the higher defoliation classes 2-4 increased. A slight increase of the share of trees in defoliation class 2 was as well observed for *Pinus sylvestris* and *Larix decidua* of both age categories. The most distinct changes were observed for *Abies alba* up to an age of 59 years where, compared to the previous year, mean defoliation increased from below 10% to 35.0%. Just as in the preceding year, an improvement was observed for the older *Abies alba* stands. Here, the share of trees in defoliation class 1 increased at the expense of a decreasing share of trees in higher damage classes.

Compared to the previous year, no important changes occurred for the main deciduous species (*Quercus* spp. and *Fagus sylvatica*) of both age categories.

During the summer season 2005, forest stands in some forest regions, mainly in western and northern Bohemia, were sporadically damaged by strong winds and storms. Drought damage occurred for *Pinus sylvestris* and *Pinus nigra* on exposed sites of the central Bohemia.

In 2005, the continuing emission reductions of main pollutants like solid substances, SO₂, CO, VOCs, were less distinct as compared to the previous years. Emissions of solid substances and nitrogen oxides (NO_x) have slightly increased in the last years.

4.2.4 Germany

Since 1984, the crown condition of forest trees has been recorded on an annual basis. The survey provides information on the health status of trees. The results of the 2005 nationwide crown condition assessment show a slight recovery in the crown condition of forest trees compared to the previous year. The previous year was characterised by the most severe crown defoliation since the beginning of surveys. This can be attributed to the extreme drought situation and heat wave in 2003.

The proportion of forest areas with visible crown defoliation (defoliation classes 2–4) now amounts to 29% which is still a comparatively high level. Of all main tree species, *Quercus* spp. showed the largest share of visible crown defoliation (51%) which is a serious worsening as compared to the previous year (45%). This is as well the highest level of defoliation since the beginning of the survey. There are large regional differences. Compared with the previous year the crown condition of oak trees shows the most severe deterioration in Hesse, Saarland, Bavaria and Thuringia. The 75 % proportion of damaged oak area that was reported from Baden-Württemberg in 2005 marks a new peak in long-term as well as in supra-regional comparisons.

For *Fagus sylvatica* 44% of the area was rated as damaged. This is a substantial recovery since 2004 (55%). Yet, it is still one of the highest levels since the launch of the surveys in 1984. The current condition also constitutes a serious deterioration as compared to the condition in the early 1990s. 31% of the area covered by *Picea abies* showed visible crown defoliation. 19% of the *Pinus sylvestris* trees were classified as damaged or dead. These conifers showed comparatively small changes as compared to 2004.

In 2005, forest condition was still influenced by the after-effects of the dry summer in 2003. Whereas the weather in northern and central Germany was beneficial for a recovery of the trees, this was not the case throughout the South. The mass outbreak of bark beetles in the previous years receded nationwide, but bark beetles continued to inflict damage on spruce trees in the South-West. This development was fostered by the warm and dry weather that prevailed. The mass outbreak of insect pests on oak trees also continued in southern and in central Germany, as well as in Lower Saxony.

The fact that the forests have already suffered from persistently high deposition and acid inputs over years and decades increases their susceptibility to additional stress factors and

poses a long-term risk to the quality of soils and groundwater. Moreover, climate change poses new challenges to forests and forest management.

4.2.5 Poland

The 2005 forest condition survey was carried out on 1 298 permanent observation plots of the national gridnet, including 433 plots of the transnational 16 x 16 km grid. Each plot consists of 20 marked dominant trees.

Forest condition improved compared to the previous year. 12.2% of all sample trees were without any symptoms of defoliation, indicating an increase by 3.9 percent points as compared to 2004. The proportion of damaged trees (defoliation classes 2-4) decreased by 3.9 percent points to a current level of 30.7% of all trees. The share of damaged trees decreased by 3.7 percent points for conifers and by 4.5 percent points for broadleaves.

In 2005, improvements were specifically observed for *Abies alba* stands, where the share of trees with a defoliation above 25% decreased by 13.8 percent points. *Quercus* spp. also showed slight improvements. The share of trees with defoliation above 25% decreased by 6.6 percent points.

29.6% of the conifers were rated as damaged (defoliation classes 2-4). *Abies alba* remained the species with the highest defoliation (50.9% of the trees in defoliation classes 2-4).

For broadleaves, the proportion of trees in defoliation classes 2-4 amounted to 34.1%. As in the previous year, the highest defoliation amongst broadleaved trees was observed in *Quercus* spp. stands. In 2005, a share of 46.9% of all *Quercus* spp. trees was in damage classes 2-4.

In 2005, discolouration (classes 1-4) was observed on 3.6% of the conifers and 1.5% of the broadleaves.

4.2.6 Slovak Republic

The 2005 national crown condition survey was carried out on 108 Level I plots of the 16 x 6 km grid net. The assessments covered 4 993 trees, 4 111 of which being assessed as dominant or co-dominant trees according to Kraft. Of the 4 111 assessed trees, 22.9% were damaged or dead (defoliation classes 2-4). The respective figures were 35.3% for conifers and 13.6% for broadleaves. Compared to 2004, the share of trees defoliated more than 25% decreased by 3.8 percent points. Mean defoliation for all tree species together was 22.3%, with 26.2% for conifers and 19.2% for broadleaves. Compared to 2004, an improvement in mean defoliation was observed for *Carpinus betulus* only. Statistically significant improvements were not observed for any species.

Since 1987, the lowest damage was observed for *Fagus sylvatica* and *Carpinus betulus*, with exception of fructification years. The most severe damage has been observed for *Abies alba* and *Picea abies*.

From the beginning of the forest condition monitoring in 1987 until 1996 results show a significant decrease in defoliation and visible forest damage. Since 1996, the share of damaged trees (25-32%) and average defoliation (22-25%) has been relatively stable. The

recorded fluctuation of defoliation depends mostly on meteorological conditions.

As a part of the crown condition survey, damage types were assessed. 41.9 % of all sampling trees (4 993) had some kind of damage symptoms. The most frequent damage was caused by insects (18.8%) and fungi (15.1%) at tree stems. Additional damage causes were logging activities (13.3%), and abiotic agents (5.6%). Epiphytes had the most important influence on defoliation. 69% of trees damaged by epiphytes revealed defoliation above 25%. In addition, abiotic agents had a direct link to defoliation.

4.2.7 Slovenia

The 2005 national forest condition survey encompassed a total of 1056 trees on 44 sample plots. The sampling scheme and the assessment methods were the same as in the previous forest condition surveys. In 2005, the grid was revised for potential new sampling plots which might need to be included (e.g. afforestation). Eight locations were checked, but only two new plots were included.

The mean defoliation of all tree species was estimated to 23.3%, while the proportion of trees with more than 25% unexplained defoliation attained 30.6%. Despite the fact that, when compared to the previous assessment, the share of damaged trees has increased (in 2004 the mean defoliation was 23.3 % and the proportion of trees with more than 25% unexplained defoliation was 29.3%) the change has not been proven statistically significant ($p > 0.05$).

As already reported in the past years there are significant differences in defoliation between conifers and broadleaves. 28.1% of sampled coniferous trees were defoliated less than 10%, 38.1% of them between 10 and 25 %, 27.3% between 26 and 60%, and 6.5% of them were severely defoliated or dead. On the other hand, 30.1% of broadleaves were considered unaffected at all, 40.1% of them were damaged slightly, 23.7% of them were defoliated moderately and the defoliation of 4.8% trees was higher than 60%. To summarise, in comparison to the survey in 2004, the distribution of damage proportions has changed slightly, but the changes are not significant.

By considering only individual tree species, the following conclusions may be drawn. The mean defoliation of *Picea abies* remained almost the same as in 2004, while the share of damaged trees (defoliated more than 25%) decreased by 5.8 percent points. However, the change was not proven statistically significant ($p > 0.05$). In comparison to the situation of the last year, *Fagus sylvatica* remained almost unchanged. While its mean defoliation increased by 0.2 percent points, the share of damaged trees decreased by 0.7 percent points.

4.2.8 Switzerland

In 2005, the Swiss national forest health inventory was carried out on 48 plots of the 16 x 16 km grid using the same sampling and assessment methods as in the previous years.

Forest condition in 2005 was still affected by the drought of 2003. So far, the largest annual increase in defoliation had been recorded in 2004 as a delayed response to the drought. Crown condition in 2005 had only slightly (but not significantly) recovered in comparison to 2004. In 2005, 28.1% (2004: 29.1%, 2003: 14.9%) of the trees had more than 25% unexplained defoliation (i.e. subtracting the known causes such as insect

damage, or frost damage), and 39.2% (2004: 41.0%, 2003: 24.4%) of the trees had more than 25% total defoliation. It should be noted that the Swiss values also include all dead trees and that the proportion of dead trees is constantly rising in Swiss forests (2005: 8.4%, 2004: 7.5%, 2003: 6.7%). Although too few trees are assessed annually for a statistical analysis of tree mortality, it was striking that between 2003 and 2004 11 trees out of the roughly 1050 trees assessed had died and between 2004 and 2005 6 more trees died. These mortality trees were found on several plots and included various species (50% were deciduous trees). The mortality rates following the drought were higher than the 'normal' annual mortality rate of 0.3 to 0.4 percent.

On the Swiss Level II plots, the situation was similar. Following the large increase in defoliation on most plots in 2004 a slight decrease or stabilization was reported in 2005. Mortality rates for all plots combined were 1% between 2003 and 2004 and 0.55% between 2004 and 2005, but varied highly between plots. At one *Pinus sylvestris* plot, mortality since 2003 has surpassed 30%. In some parts of Switzerland, bark beetle induced mortality of *Picea abies* has continued in 2004 and to a lesser degree in 2005. On *Fagus sylvatica* few defoliators had been reported in the aftermath of the drought, but severe insect induced defoliation of *Quercus* spp., in particular *Operophtera brumata* species, has continuously increased since 2001.

4.3 Southern Europe

4.3.1 Cyprus

The annual assessment of crown condition was conducted on 15 Level I plots, during the period August - October 2005. The assessment covered the main forest ecosystems of Cyprus, and a total of 360 trees of *Pinus brutia*, *Pinus nigra* and *Cedrus brevifolia* were assessed. Defoliation, discolouration and the agents causing damage to the trees were recorded.

From the total number of trees assessed, 20% of them were not defoliated, 69.2% were slightly defoliated and 10.8% were moderately defoliated. A comparison with the survey results of the previous year shows a slight improvement with a decrease by 2.5 percent points of the trees being in class 0 (not defoliated) and by 1.4 percent points of the trees being in class 2 (moderately defoliated). On the other hand, an increase by 3.9 percent points in class 1 (slightly defoliated) has been observed. Among the years 2001 to 2005 there are no significant changes in the defoliation percentage in each class.

For the results of 2005 in *Pinus brutia*, 20% of the sample trees showed no defoliation, 67% were slightly defoliated and 13% were moderately defoliated. In *Pinus nigra*, 19.4% of the sample trees showed no defoliation while the rest 80.6% of them were slightly defoliated. In *Cedrus brevifolia*, 20.8% of the sample trees showed no defoliation and 79.2% of them were slightly defoliated.

From the total number of sample trees inspected, 42.5% showed signs of insect attack and 7.5% showed signs of attack by "other agents" (lichens and dead branches). Compared to the previous years' results, there is an increase by 0.5 percent points of sample trees showing signs of insect attack and an increase by 1.1 percent points for other agents. The preliminary analysis shows that sucking and defoliator insects are the major biotic factors causing defoliation during the year 2005. No damage was attributed to any of the known pollutants. However, the poor edaphic conditions on which the forests grow, and the

adverse drought conditions prevailing in Cyprus should be considered as additional factors contributing to the defoliation of trees.

Forest fires are a serious problem for the forests in Cyprus due to drought conditions, low precipitation and high temperatures prevailing in the island. However, due to the effective system and infrastructure in preventing and suppressing forest fires, the annual burnt area is kept small. During 2005, twenty-eight forest fires damaged 28.9 ha of State forests. 12.5 ha were coniferous forest, 13.5 ha were broadleaved forest and 2.9 ha were other forest cover types. The main causes of fires were: carelessness of forest visitors and farmers, malicious, unknown and natural causes. Forest fire did not cause any damage to the Level I plots in 2005.

4.3.2 Greece

When all tree species are taken together, 83.7% of the trees were not or slightly defoliated, 13.3% of the trees were moderately defoliated, 1.5% were severely defoliated and 1.5% were dead. For the conifers, 48.5% showed no defoliation, 36.5% were slightly, 12.2% were moderately and 0.8% and 1.9% were severely defoliated and dead, respectively. For the broadleaves, 38.7% showed no defoliation, 43.4% were slightly, 14.6% were moderately and 2.4% and 0.9% were severely defoliated or dead, respectively.

A comparison of defoliation results between 2005 and 2002 (year of the previous assessment) shows that for the sample of all species, the share of moderately and severely defoliated trees and dead trees decreased by 3.3, 0.8 and 0.5 percent points, respectively, whereas an increase by 2.1 and 2.5 percent points was observed for the share of not defoliated and slightly defoliated trees, respectively.

A comparison of the 2005 survey results with those of the 2002 shows a slight improvement in the condition of conifers and mainly of the broadleaved species. From the total number of trees assessed, about 25.5% showed signs of insect attack and 8.3%, 1.9%, and 19.5%, showed signs of adverse effects by abiotic, human and "other agents", respectively. No damages were attributed to any of the known pollutants. The insect damages registered in 2005 were mainly old damages of the previous years.

2003 and 2004 were rainy years with heavy winters and exceptionally wet and humid summers. 2005 was extremely rainy and a lot of floods occurred during winter and spring in widespread areas all over the country.

4.3.3 Italy

The number of Level I plots in Italy (6573 trees on 238 plots) was in 2005 slightly lower than in 2004 (17 plots less), because of assessment problems in some regions. Thereby, the main results as far as defoliation and discolouration are concerned, as well as the frequency of biotic and abiotic damage agents, according to the new assessment form are presented.

Defoliation data are reported according to the usual categorical system: most (74.4%) is included in the classes 1 to 4; the 32.9% is included in the classes 2 to 4. 41.0% of conifers and 20.1% of broadleaves are without any defoliation (class 0). The conifers falling in the defoliation classes 2 to 4 are 22.8%, for broadleaves 36.5%. Analyzing the sample by defoliation and by age class (<60 and ≥60 years) it can be observed that, among the young

conifers (< 60 years), the share of trees belonging to the classes 2-4 is highest for *Pinus sylvestris* (33.3%) and *Pinus halepensis* (29.7%). Among the old conifers (≥ 60 years) for *Pinus cembra* (40.4%) the highest share of trees in classes 2-4 was followed by *Larix decidua* (35.6%) and *Picea abies* (25.8%). The share of damaged trees (classes 2-4) was even higher among the young trees (<60 years) for *Castanea sativa* (56.3%), *Quercus pubescens* (53.3%), *Ostrya carpinifolia* (31.7%) and *Fagus sylvatica* (26.5%). Also among the old broadleaves the share of damaged trees was relatively high for some species (*Castanea sativa*, 61.0%; *Quercus petraea*, 44.4%; *Fagus sylvatica*, 31.1%). Discoloration is absent in 92.8% of conifers and 93.6% of broadleaves. Among the young conifers (< 60 years) 43.1% of the *Pinus halepensis* trees present discoloration in the classes 2-3, all other tree species showed lower discoloration.

Starting from 2005, the new methodology for a deeper assessment of damage factors (biotic and abiotic) was introduced. In conifers, most of the observed symptoms were attributed to insects (14.3% of the whole sample); the conifers affected to fungi are the 6.7% of the total. Abiotic agents are the 4.9% of the sample from which 17.3% of the trees with abiotic damage were affected by “snow/ice”.

For broadleaves, most symptoms are attributable to insects (39.9%), mostly “defoliators” (79.6%). Fungi infest 11.7% of the sample. They are especially: “decay and root rot fungi” (14.2%), and “blight” (10.6%). Abiotic agents infest 4.5% of the sample, of which “hail” (26.2%) and “heat/sun scald” (16.6%) were assessed most frequently.

4.3.4 Portugal

In 2005, the forest condition survey was conducted on 119 forest plots including 3 570 trees, of which 69% had an age less than 60 years. 97% of the trees assessed were broadleaves. Considering the results from 1988 to 2005, the share of both damaged broadleaves and conifers shows a peak in 1990, and decreases until 2002. However, since 2003 again a slight increase in the proportion of damaged trees has been observed.

With respect to the most important tree species in Portugal, *Quercus suber* shows the severest situation, reaching the peak of its share of damaged trees (52.7%) in 1991. In the same year, *Quercus ilex* L. showed its maximum of damaged trees (46.2%). The share of damaged trees was generally far lower for *Pinus pinaster* with a maximum of 26.3% in 1990, and in *Eucalyptus globulus* Labill. with 7.3% in 1991.

The bad crown condition of several tree species in the years 1990 and 1991, and recently in 2003, 2004 and 2005, has to be interpreted in connection with attacks by fungi and insects as well as by forest fires, triggered by a sequence of dry years, specially in 1989 until 1991, and 2003 until 2005. In fact, 2003 was the worst year on what concerns forest fires, since systematic data records exist. 423 276 ha were burned, 283 063 of which (67%) were forest stands (8% of the total Portuguese forest). 2005 was the driest year of the last 50 years. This had a negative impact on the condition of forest trees as well.

4.3.5 Spain

Results of the forest condition survey in 2005 showed that 21.5% of all assessed trees were rated as damaged or dead (defoliation classes 2-4). Compared to the previous year, the share of damaged trees increased significantly. For the class of undamaged trees, the lowest share of trees was observed since the beginning of the surveys in 1987. The worsening affected more strongly the broadleaves, but also conifers showed a worsening,

reaching the highest defoliation since 1987. The percentage of dead trees remained practically unchanged.

The four most important species in the survey are *Pinus sylvestris*, *Pinus halepensis*, *Quercus ilex* and *Quercus pyrenaica*. In 2005, *Quercus pyrenaica* was, out of the four species, the one which had the best results. For the first time since 2000, the share of undamaged trees increased for this tree species. *Pinus sylvestris* worsened slightly, with a reduction in the number of healthy trees and a corresponding increase in the share of damaged trees. These two species were hardly affected by the drought that occurred in 2005. In contrast, the two more xeric species *Quercus ilex* and in particular *Pinus halepensis* showed a more serious worsening. For the latter species, 25% of the trees were classified as damaged, which is the worst result since the beginning of the inventories in 1987.

The most frequently registered damaging factors were abiotic ones, specifically drought, followed by insects, mainly defoliators and fungi. Drought and water shortage specifically affected eastern, south-eastern and central regions and caused damage mainly at *Quercus* spp. and *Pinus halepensis* plots. As regards insects, the noticeable increase in spring defoliators at plots with broadleaves is remarkable. Most damages were caused by the combined action of several *Lepidoptera* species. Alder stands suffered defoliation by *Agelastica alni*. In mountain pine forests of central Spain damage by *Diprion pini* was again increasing. Among fungi, foliar fungi diseases in *Eucalyptus* stands, mainly in the eastern part of the Cantabric coast, and a frequent appearance of *Spaheropsis sapinea* in *Pinus radiata* stands are worth mentioning.

The importance of atmospheric pollution for forest condition is a factor which can not be quantified directly, as it is frequently disguised by other processes which are more apparent. However, its contribution to degradation processes in forests (in combination with other agents), can not be denied.

4.4 Western Europe

4.4.1 Belgium

Flanders

The crown condition survey in the northern part of Belgium was conducted on 72 plots in a 4 x 4 km grid in 2005. The main tree species are *Quercus robur* and *Pinus sylvestris*. *Fagus sylvatica*, *Quercus rubra*, *Pinus nigra subsp. Laricio* and *Populus* spp. are as well represented.

The share of damaged trees was 21.3%. Discolouration was observed on 6.2% of the sample trees. During the last 10 years, the mortality rate fluctuated between 0 and 0.5%. In 2004/2005, 0.2% of the trees died.

Compared to previous surveys, defoliation increased in coniferous stands while the crown condition of broadleaves remained stable. 22.6% of the broadleaves and 19.2% of the conifers were rated as damaged. Discolouration increased as well and was higher for broadleaves (7.0%) than for conifers (4.6%).

Pinus sylvestris remains the species with the lowest defoliation (15.0%). The most severely damaged species were *Populus* spp. with 46.3% of the trees in defoliation classes 2-4. The

crown condition of *Pinus nigra* is still high, with 35.0% of the trees being damaged. The crown condition of *Pinus nigra* and *Quercus rubra* showed a significant worsening.

Quercus robur (23.2%) has a higher share of damaged trees than *Q. rubra* (19.4%). Especially young *Q. rubra* trees revealed a lower defoliation.

One year after the mast year in 2004 there was hardly any seed production in *Fagus sylvatica* in 2005. The condition of the trees was significantly better than in the year before. 18.8% of the trees show moderate to severe leaf loss.

Especially in *Quercus rubra* stands there was more insect damage compared to the year before. In *Quercus robur*, insect damage remained constant but more trees suffered from *Microsphaera alphitoïdes* infection. In the north eastern part of Flanders, there was a high infestation of *Thaumetopoea processionea*, resulting in defoliation of oak trees.

Locally infection by the fungus *Discosporium populeum* in *Populus* was continuing, resulting in dying and dead trees for the third consecutive year. The infection by this weakening parasite started after several years of a severe *Melampsora larici-populina* infestation.

Wallonia

The 2005 survey comprised 1 398 trees (504 conifers and 894 broadleaves) on 60 plots, on the regional 8 x 8 km systematic grid.

Since 2002, mean defoliation of *Fagus sylvatica* increased continuously and was about 27% in 2005; sessile oak showed also an increase in 2005, while the defoliation of *Quercus robur* was lower as compared to the previous year.

The high defoliation for *Fagus sylvatica* is most likely a consequence of beetle damage during 2000-2002, of dry weather conditions and high temperatures in the period from June to October 2003, which induced an intensive fructification in 2004 with a consecutive lack of foliage in 2005. Such an intensive fructification in 2004 had the same impact on *Quercus petraea* defoliation. The other species showed minor changes, both for broadleaves and conifers.

Discolouration has decreased both for broadleaves and conifers since the high level of 2003, but about 13% of the trees showed more than 25% of discolouration in 2005, which was still higher than before 2003. Discolouration at conifers mostly occurred at old *Pinus sylvestris* and *Picea abies*.

Among broad-leaved species, young stands showed hardly any discolouration. At older stands, the high discolouration was most intensive for *Fagus sylvatica* and *Quercus petraea* with respectively 28% and 15 % of the trees moderately or severely discoloured.

4.4.2 Denmark

The Danish Level I forest condition survey in 2005 showed that most tree species had satisfactory health, based on both EU/ICP Forests plots (22) and national plots (26). In total, 1152 trees were assessed. In general, the average defoliation scores of *Picea abies*, *Fagus sylvatica* and *Quercus* spp. were slightly lower than in previous years. Most other

tree species were also in good health, although *Fraxinus excelsior* and *Picea sitchensis* showed elevated defoliation in some areas.

Within the crown condition survey in 2005, 78% of all coniferous trees and 67% of all deciduous trees were rated as undamaged. 17% of all conifers and 25% of all deciduous trees showed warning signs of damage, and 5% of all conifers and 8% of all deciduous trees were rated as damaged. The period of very good forest health in Denmark has now lasted for more than 5 years, in spite of storms and dry summers which have had some negative impact.

The mean defoliation of *Picea abies* was 6% in 2005, and the share of damaged trees remained at only 5%. As in the previous three years, more than 80% of the monitored spruces were in the lowest defoliation class. However, a storm in January 2005 did cause extensive damage to many spruce stands, including some observation plots.

The health condition for beech (*F. sylvatica*) continued to improve in 2005, with a mean defoliation of 9%, the lowest since monitoring began. The amount of damaged trees was only 5%. Since 2000 none of the monitored beech trees have been in the two highest damage classes.

In 2005 the mean defoliation of oak (*Q. robur* and *Q. petraea*) decreased to 17% after a couple of years with 20% average defoliation. The share of damaged trees fell to 16% in 2005 (from 21% in 2004). The health of oak is still significantly better than in the 1990's. Some damage due to the outbreak of defoliators in 1996-1997 can still be seen in oak forests in Denmark, mainly killing of trees by *Armillaria gallica*.

4.4.3 France

In 2005, the French forest condition survey included 10 129 trees on 509 permanent points. The growing season was characterized by the third consecutive dry summer, especially in the Southern part of the country. Nevertheless, temperatures were closer to the long term average as compared to summer 2003. At the national level, several species showed slight increases in defoliation. Broadleaves remained at a higher defoliation level than conifers. The amount of discoloured trees in general decreased, remaining at a relatively low level. Less than 10% of the trees were judged discoloured. The only exceptions were the Jura and the North-eastern Plaines with 26% and 13% of the broadleaved trees, respectively, being discoloured and the Pyreneans and Mediterranean regions with 19% and 16% of the conifers rated as discoloured. The 2005 growing season was marked by a mortality rate that remained relatively high.

Since 2002, the species that worsened most at the national level in terms of defoliation have been *Castanea sativa*, *Fagus sylvatica*, *Quercus ilex*, *Quercus petraea*, as well as *Picea abies*. Nevertheless, these tendencies mask a regional variability.

Identifiable damage was reported from one third of the trees. Among all reported damage types, insects were mostly mentioned (15% of the trees) with caterpillars, *Coroebus bisfasciatus* on *Quercus* spp. and *Orchestes fagi* on *Fagus sylvatica* affecting crown condition. As concerns fungi, an increase in *Microsphaera alphitoides* on *Quercus robur* was observed. *Cryphonectria parasitica* was reported from 14% of the *Castanea sativa*. *Melampsora* spp. affected *Populus* spp.. Drought and other abiotic damage were mentioned from 10-35% of the trees depending on the tree species, mainly from *Fagus*

sylvatica, *Quercus ilex*, *Quercus pubescens*, *Castanea sativa*, *Populus* spp. and *Betula* spp. and as well as from *Pinus halepensis* and *Pinus sylvestris*.

These results are considered as evidence for the importance of the European network for monitoring annual changes in forest crown condition.

4.4.4 Ireland

The annual assessment of crown condition was conducted on the Level I plots in Ireland between June 28th and September 19th 2005. Overall mean percent defoliation and discolouration was 16.0% and 6.5% respectively. This represents a slight disimprovement in crown condition of Irish forests between the 2004 and 2005 survey of approximately 1 percent point for defoliation and of 1.3 percent points for discolouration. Defoliation levels recorded in 2005 were similar to the long term average of 15.6% and discolouration in 2005 was also close but below the long term 16 year average of 8.0%. In terms of species, defoliation decreased in the order of *Picea abies* (24.5%) > *Pinus contorta* (16.7%) > *Picea sitchensis* (13.6%), while the trend in discolouration was in the order of *Pinus contorta* (12.2%) > *Picea sitchensis* (3.4%) > *Picea abies* (0%). These results do not vary significantly from those recorded in the 2004

The trends in crown density among species are similar to last year's survey. In 2004, *Picea abies* had the highest defoliation levels as was observed in 2003 and 2002 also. This was the result of a combination of defoliation levels decreasing in *Pinus contorta* and increasing somewhat in both spruce species since 2001. *Pinus contorta* had the highest discolouration levels of the three species in 2003, which was also the observation in the 2004 survey. There has been a recent increase in discolouration of *Pinus contorta* in the Irish crown condition survey.

The number of trees with absolutely no damage (i.e. 0% defoliation and 0% discolouration) increased in 2005 by 6 percent points to 22% of trees in the survey. An additional 27% of trees had such low levels of defoliation and discolouration that the causes of damage were indiscernible. These figures represent a slight decrease, some 5 percent points, in the number of trees recorded in this category in 2004. Of the remaining trees where causes of damage could be identified, approximately 33% of trees had less than 25% defoliation and less than 4% of trees had greater than 25% discolouration. Exposure continued to be the greatest single cause of damage to the sample trees in 2003 with over one third of sample trees showing some damage attributable to the abiotic environment. The instances of observed aphid damage however were much decreased since the 2002 outbreak, in particular for Sitka spruce, with only 5% of trees affected in 2005. The aphid responsible for damaging more than 20% of the sample trees in 2002 was *Elatobium abietinum* but this insect pest has a typically sporadic occurrence depending on the prevailing environmental conditions in a given year (Less than 3% of trees were affected by aphids in the 2001 survey.) Other damage types (shoot die-back, top-dying, nutritional problems, and grazing damage) accounted for damage in a very small percentage of the trees. Damage due to grazing was again apparent in 2005; recorded on the young spruce trees at Ballinglen on the east coast of Ireland. No instances of damage directly attributable to atmospheric deposition were recorded in the 2005 survey.

4.4.5 The Netherlands

Over the last three years, more than 75% of the conifers in the Netherlands showed a defoliation below 10%. This high percentage however mostly depends on *Pinus sylvestris* which constitutes the largest part of this sample. Defoliation of *Pseudotsuga menziesii* on the other hand has increased over the last three years. In this period, most trees moved from defoliation class 1 (10%-25%) to defoliation class 2 (25%-60%). In 2005, 92% of the trees were in class 2 compared to only 8% in 2003.

The defoliation of *Quercus* spp. in the Netherlands was considerably higher compared to the mean of all broadleaves. In 2003, 48% of the assessed trees were in defoliation class 1. In 2005 however, 49% of the *Quercus* were in defoliation class 2. This shift mainly occurred for the trees older than 60 years and was even more pronounced for the sample of trees older than 100 years.

4.4.6 United Kingdom

Climatic conditions during the 2005 growing season and the preceding winter were variable, being drier than average in the south of the UK and wetter than average in the north. In spite of this difference, tree growth across the entire country was generally good and there was an overall improvement in crown condition this year. Broadleaves and conifers displayed a similar pattern of change, with the percentage of trees in class 0 (0-10% defoliation) having increased by approximately 5 percent points since 2004. Following an upturn in condition in 2004, the conifers have therefore registered consecutive years of improvement in crown density for the first time since 1995.

The improvement in the condition of the broadleaves in 2005 largely reflected a marked increase in the crown density of *Fagus sylvatica*, with the proportion of trees in defoliation class 0 for this species rising from 27.5% in 2004 to 38.3% in 2005. As in previous cases of such rapid recovery, this change was attributable to much-reduced mast formation, with fruiting being absent or scarce on 96.7% of the assessed trees this year. Discolouration of beech was more evident than in 2004, however, due largely to an increase in both the incidence and severity of attacks by the beech leaf miner *Rhynchaenus fagi*. The condition of *Quercus robur* was largely unchanged since last year and continued to display marked regional variation.

Following a marked improvement in crown condition last year, the crown density of *Picea sitchensis* displayed a further slight increase in 2005 as the species continued to recover from the severe aphid-induced defoliations which it suffered in 2002 and 2003. Although attacks by the green spruce aphid (*Elatobium abietinum*) were recorded in 50.9% of plots they were minor in extent and insect damage was only adjudged to be common or abundant on 3.9% of the surveyed trees. *Pinus sylvestris* exhibited its greatest improvement in condition since 1993, with an increase in mean crown density of 1.6 percent points compared with last year. Following a marked improvement in 2004, needle retention of this species was once again good in 2005 with 62.8% of assessed trees retaining their needles for 3 or more years. Concomitantly, damage due to the pine shoot beetle (*Tomicus piniperda*) was reduced this year being evident in only 32% of plots and generally of low severity.

4.5 South-Eastern Europe

4.5.1 Bulgaria

In 2005, the forest condition survey was carried out at 139 plots on a grid net of 16 x 16 km, 8 x 8 km and 4 x 4 km. A total of 4 817 sample trees was assessed, 2 585 of them conifers and 2 232 broadleaves. For all species, there was a slight recovery of crown condition. The share of moderately to severely damaged trees (defoliation classes 2-4) decreased compared to the 2004 results. The share of trees without visible defoliation increased from 19.8% in 2004 to 22.4% in 2005.

For conifers, the percentage of damaged trees slightly increased. As compared to the previous year, trees without visible defoliation decreased by 5.2 percent points. The share of severely defoliated trees remained almost the same and that of dead trees increased by 1.3 percent points.

For *Abies alba*, *Picea abies* and *Pinus sylvestris*, some of the damages were caused by needle-rust, canker and root rot fungi including *Lophodermium pinostri*, *Genangium ferruginosum*, *Heterobasidion annosum* and *Armillaria mellea*.

Defoliation of broadleaves (*Quercus* spp. and *Fagus sylvatica*) was lower in 2005 as compared to 2004. The share of the trees without any defoliation increased by 10.7 percent points, compared to the 2004 results. The share of severely defoliated *Quercus* trees decreased. *Quercus* trees were attacked by defoliating insects including *Operophtera brumata* and pathogens such as *Nectria* spp., *Stereum rugosum* and *Hypoxylon mediterraneum*. Beech stands suffered under mining insects such as *Rhyngaenus fagi*.

Abiotic agents like weather extremes (snow, ice) and anthropogenic factors such as silvicultural operations at nearby trees were identified as damage causes. Nevertheless, no specific damage factor was observed for more than half of the trees.

4.5.2 Hungary

The crown condition assessment in Hungary revealed on the average a slightly worse situation as compared to the previous year. This is mainly due to a continuing *Lymantria dispar* gradation. Some colder days had eased the situation during late spring killing a lot of caterpillars. In spite of this, defoliation by the caterpillars was recognized on a quarter of million hectares mainly in the *Quercus cerris*, *Q. petraea* and *Q. robur* forests.

Chemical control was carried out on more than 40 thousand hectares. Gradation collapsed in different places due to the lack of nourishment. On the other hand, despite all efforts the infestation spread from North of lake Balaton to the North-Hungarian mountains and it is expected to remain constantly strong in South-West Hungary in the future too.

The rest of the forests, untouched by the caterpillars, showed less defoliation as compared to 2004. This is mainly due to an increased precipitation. The benefit of increased humidity is reflected in the decreasing defoliation of *Pinus sylvestris* and *Pinus nigra*. This tendency was followed by *Picea abies* too, which also showed a higher resistance against bark beetles (mainly *Ips typhographus*).

After a year with elevated defoliation, *Fagus sylvatica* was in 2005 the tree species with lowest defoliation, although some older beech stands still seem to suffer from the drought of 2003.

Effects of leaf miners (*Parectopa robiniella* and *Phyllonoricter robiniella*) on *Robinia pseudoacacia* were lower as compared to the previous year.

4.5.3 Romania

In 2005, 100 718 trees were assessed on the national monitoring network (4 x 4 km) which comprised 4 132 permanent plots. From the total number of sample trees, 8.1% were rated as damaged (defoliation classes 2-4). The respective shares were 4.7%, for conifers and 9.3% for broadleaves. In 2005, the forest health status in Romania significantly improved as compared to the previous years (2003 and 2004); the shares of damaged trees decreased by 4.5 percent points for conifers and by 3.6 percent points for broadleaves.

Among the main tree species, *Picea abies* (4.0%), *Fagus sylvatica* (5.5%) and *Abies alba* (6.4%) had the lowest shares of damaged trees (defoliation classes 2-4), and *Quercus frainetto* (26.4%), *Quercus robur* (18.6%), *Robinia pseudoacacia* (17.2%), *Quercus cerris* (15.9%) and *Quercus pedunculiflora* + *Q. pubescens* (14.5%), had the highest shares. As compared to the previous year (2004) a reduction in the shares of damaged trees was registered for *Picea abies* (1.7 percent points), *Fagus sylvatica* (2.3 percent points), *Abies alba* (5.2 percent points), *Quercus robur* (3.3 percent points), *Q. frainetto* (8.6 percent points), *Q. cerris* (5.3 percent points), *Q. pedunculiflora* + *Q. pubescens* (1.0 percent points) and *Robinia pseudoacacia* (17.5 percent points).

This situation can be explained by favourable weather conditions that led to a shift from defoliation class 2 to class 1 for many trees. As compared to 2002 – 2004, precipitation was higher in 2005. In the southern and south-eastern part of the country the improvement of tree crown condition lasted already since 2003.

4.5.4 Serbia

In 2005, the total number of trees assessed on all sampling plots was 2 995, comprising 338 conifers and 2 657 broadleaved trees. Among the conifers, *Abies alba* had the lowest share of damaged or dead trees (11.6%), whereas *Pinus nigra* had the highest share (47.8%). Taking the total sample of conifers, 21.3% of the trees were damaged or dead (defoliation classes 2-4).

The broadleaved trees were on average in a better condition, with 15.7% of the trees assessed as damaged or dead. *Quercus petraea* had the highest share of trees in defoliation classes 2-4 (35.3%), and *Carpinus betulus* had the lowest share in these classes (2.6%).

Moderate or severe discolouration was detected on 9.2% of the conifers and on 5.3% of the broadleaves.

Defoliation above 25% does not always indicate a reduction of vitality caused by the effect of adverse agents (climate stress, insect pests, and pathogenic fungi). In some cases elevated defoliation indicates a temporary phase in the natural variability of crown density.

The monitoring of forest condition will be continued on the 16 x 16 km grid and in some regions on a denser national grid 4 x 4 km including the plots newly established in 2004 on which the changes of crown condition were assessed in 2005 as well.

4.6 Eastern Europe

4.6.1 Belarus

The forest condition survey in Belarus in 2005 was carried out on 1 212 permanent observation plots of the national network. The assessments covered as main tree species *Pinus sylvestris*, *Picea abies*, *Quercus robur*, *Betula* spp., *Fraxinus excelsior*, and *Alnus glutinosa*. The lowest defoliation was observed for *Pinus sylvestris*, with 7.2% of the trees in defoliation classes 2-4 (8.5% in 2004). The respective shares were 6.5% for *Alnus glutinosa*, 6.8% for *Betula* spp., and 9.6% for *Picea abies* (11.4% in 2004). Highest defoliation was observed for *Quercus robur* (27.3%; 33.1% in 2004) and *Fraxinus excelsior* (27.4%; 25.4% in 2004).

Damage symptoms were identified at 17.5% of all trees. For individual tree species the shares of damaged trees were as follows: *Pinus sylvestris*: 10.5%, *Picea abies*: 19.2%, *Quercus robur*: 50.3%, *Betula* spp.: 35.1% and *Alnus glutinosa*: 25.9%. The most frequent damage type was insect damage, which was observed on 30.0% of all damaged trees (fungi: 18.1%; human activities: 13.3% and abiotic factors: 12.6%).

4.6.2 Republic of Moldova

The forest condition survey in 2005 was carried out on a national 2 x 2 km grid in Moldova and included a total number of 14 575 trees of which 26.5% were rated as damaged (defoliation classes 2-4). 91% of the trees did not show any discolouration or were only slightly discoloured.

The most defoliated broadleaved tree species were *Quercus pubescens* and *Quercus pedunculiflora* with 36.7% of the trees in defoliation classes 2-4, followed by *Robinia pseudoacacia* (32.6%) and *Quercus robur* (35.2%). 45.6% of the *Pinus* spp. and 20.3% of the assessed *Fraxinus* spp. trees were classified as damaged or dead.

26.7% of all trees showed signs of easily identifiable damage. The majority of the damages was caused by insects (78.9% of all damaged trees). 53.0% of the trees damaged by insects were included in defoliation classes 2-4.

4.6.3 Ukraine

In 2005, 26 720 sample trees were assessed on 1 329 forest monitoring plots in 19 administrative regions of Ukraine (covering around 75% of the country). Mean defoliation of conifers was 11.6% and for broadleaves it was 12.2%.

For the sample of common sample trees, being assessed in 2004 and 2005 (26 325 trees) a very minor overall improvement was observed. Mean defoliation of all species in 2005

(12.0%) was lower than in 2004 (12.9%). Changes are characterised by a decrease of tree shares in defoliation classes 1 and 2 and an increase in classes 0 and 4. However, changes in classes 1 and 4 were not significant. A statistically significant improvement in tree crown condition was registered for *Quercus robur*. The share of trees in class 1 increased by 2.5 percent points, corresponding to a decrease in classes 2 and 3 by 2.7 percent points. The same tendency was observed for *Fagus sylvatica* and *Fraxinus excelsior*. For *Pinus sylvestris* an increase in the share of trees in class 0 and a decrease in classes 1 and 2 were observed. In contrast to this, the share of *Picea abies* trees in the classes 0 and 1 decreased and the share of trees in class 2 increased.

The overall improvement in tree crown condition can be explained by better weather conditions in 2005 and by a decreasing impact of defoliating insects.

4.7 Northern America

4.7.1 Canada

Natural Resources Canada's Canadian Forest Service (CFS) does not have a national monitoring program for forest health. In 1995, the Canadian Council of Forest Ministers put in place a framework of Criteria and Indicators (C&I) for sustainable forest management. This framework is compatible with the Montréal Process and shares the themes identified in the Global Forest Resources Assessment that are also common to the Ministerial Conference for the Protection of Forests in Europe and the other international C&I processes. The indicators in this framework, revised in 2003 are used for national reporting on sustainable forest management, including forest health. A report on the latest status of these indicators will be published in 2006. Canada, along with the provinces is putting in place a new plot-based National Forest Inventory, to generate much of the information for reporting on C&I and forest condition. Other information is gathered through regionally based surveys or through partner agencies. Forest health is tracked using an indicator measuring the areas of forest disturbed by fire, insects, disease and timber harvest and the areas of forest with impaired function due to ozone or acid rain.

Ozone

A Canada wide standard of 62 ppb for the 30-year average of the annual fourth highest daily maximum 8-hour average ozone concentration was endorsed as a numerical target to be achieved by 2010. Trends in this standard for 1993-2002 averaged across western and eastern Canada show little overall change or slight decreases in some areas with values ranging between 52 and 53 ppb in western Canada and 68-77 ppb in eastern Canada. In general three major areas in Canada have consistent episodic ozone events every summer. These are southern British Columbia, the Windsor-Quebec corridor and southern Atlantic Canada. There is limited information on the impacts of these episodic events on forest ecosystems in the respective areas. Studies in these areas have been primarily limited to single or few immature trees. Extensive, long term studies of the impact on ecosystem structure and function are being done in partnership with the US Forest Service, academic institutions and other countries in the Aspen Free-Air Carbon Dioxide Enrichment (FACE) experiment on 32 ha of forest land in northern Wisconsin.

In 1998, the Canada-wide acid rain strategy established the long term goal of remaining below the critical loads of acidifying compounds. A critical load is the highest deposition of acidifying compounds that will not cause changes leading to long term harmful effects

on the overall structure or function of an ecosystem. Critical loads have been developed for some forest soils in Canada. The working group under the New England Governors and the Eastern Canadian Premiers have mapped the extent of exceedance of the critical loads for soils in eastern Canada, under a no harvest scenario. Areas where critical loads are exceeded, cover almost 52% of eastern Canada. In some cases this exceedances would be greater if nutrient depletions associated with harvesting were considered. Work is underway to improve accuracy of critical load estimates and exceedances and to understand the linkage with biological effects. Research in Quebec (OUIOMET et al. 2001 Focus 1: 119-134), where many research plots are located on nutrient poor sites, revealed that critical load exceedance is associated with a 30% reduction in forest growth. The conclusions from this research were that further reductions in national and international sulphate and nitrate emission rates were required to protect forest soils from excessive acidification. Models developed for south central Ontario predicted that soil acidification will continue even with proposed reductions in sulphur emissions and that nutrient removals through harvesting will exacerbate the condition (WATMOUGH et al 2004 critical loads Ontario report no 2, Environmental and resource studies Trent University).

Fire

Neither the area burned nor the number of fires in Canada show particular trends between 1975 and 2003. Most fires are caused by human error while the largest areas burned result from lightning strikes. An average of the data from 1993-2003 indicates that 7591 fires have burned a total of 1.1 million hectares annually although year to year variation is large.

Insects

From 1975 to 2003, the annual area disturbed by insects declined. Insect outbreaks tend to be cyclical with outbreaks occurring in peak years in certain areas of the country. Spruce budworm and forest tent caterpillar are two insects that have been tracked nationally since 1975. Forest tent caterpillar has had three outbreaks since 1975. Recent newcomers on the insect pest list include: the large aspen tortrix (*Choristoneura conflictana*) which, has caused significant damage in Alberta since 2002; the spruce bark beetle (*Dendroctonus rufipennis*) which, has affected about 400 000 ha in the Yukon and continues to expand; and, the mountain pine beetle (*Dendroctonus ponderosae*) which, by the end of 2004, was estimated to have destroyed approximately 230 million m³ of timber, covering an area of 4 million ha.

Climate Change Impacts on the Productivity and Health of Aspen (CIPHA)

Trembling aspen (*Populus tremuloides*) is of significant ecological importance as the most widely distributed tree species in North America and for its value as a carbon stock and a commercial species for fiber. In 2000, the CFS together with Environment Canada and other partners initiated CIPHA to investigate the dieback and reduced growth observed since the 1990's with this species in areas of the southern boreal forest and the aspen parkland in western Canada. The objectives of this network of long term research plots, in 72 aspen stands, along a regional climate gradient are: i) to provide early detection of climate change impacts; ii) understand how climatic variation, insects and other factors have affected health and growth of aspen forests in western Canada iii) predict future changes in biomass, productivity and health of aspen forests in western Canada; iv) provide a framework for linking research and monitoring. Some results from this monitoring research are starting to be published.

Tree ring analysis showed that between 1951 and 2000, there were several cycles of reduced growth. Most of the variation was explained by interannual variation in a climate moisture index in combination with insect defoliation. Continued annual monitoring of forest health and dieback within the CIPHA plot network coupled with re-sampling of tree rings in these stands will serve to elucidate the long term impacts of a severe drought in the region between 2001 and 2003. This work has demonstrated the potential for extending such plot-based field sampling across a wide range of forest types over large areas, to become a valuable tool for the validation of national and global scale models of forest responses (HOGG et al. 2005. Can J. For. Res. 35: 610-622).

Defoliation histories based on tree ring analyses and records of past insect outbreaks pointed to several factors contributing to the observed dieback. Defoliation by forest tent caterpillar (*Malacosoma disstria*) and drought between 1960 and 80 led to reduced growth and predisposed some stands to secondary damage by wood-boring insects and fungal pathogens. That global change may increase the severity of these stressors, underscores the need for long term monitoring (HOGG et al. 2002. Can. J. For. Res. 32:823-832).

A study to determine the biotic and abiotic agents affecting trembling aspen showed that large aspen tortrix and poplar peniophora (*Peniophora polygonia*) were the most common pests occurring on 15 and 13% of live trees respectively. Tree age, climate moisture index, number of years of forest tent caterpillar defoliation and incidence of *Armillaria* root disease accounted for a significant proportion of the variation in trembling aspen health and mortality (BRANDT et al. 2003. For Ecol & Manage 178: 287-300).

4.7.2 USA

Background Information

Since 2002, USDA Forest Service has been working develop a systematic approach to critical loads and levels. This activity has involved both researchers and forest managers. One of the pivotal facets of the program has been partnership with Canada and Mexico. Additionally, reliance on ICP agencies, in particular ICP Forests, has advanced this work. USA Forest Service is in the process of developing nine ICP Forests demonstration Level II sites within the USA. In the last year, four of these nine sites have become increasingly operational and active in critical loads and levels research.

Main results

During 2005, field measurements were continued at Riverside (CA), Kings River (CA), Glacier Lakes Ecosystem Study Site (GLEES, WY), and Otter Creek Wilderness (WV). Data from these is being used to calculate critical loads for nitrogen and sulphur using a simple mass-balance approach. Additional work on critical levels for ozone is on-going at Riverside and Kings River in California and GLEES in Wyoming.

A critical loads map for New England has been developed under the New England Governors' & Eastern Canadian Premiers' Forest Mapping Group for Critical Loads of Sulfur and Nitrogen. This study has been evaluating current ecological indicators (crown health, growth and mortality) at the plot level as a comparison between sensitivity and current health status using the US Forest Inventory Analysis database.

A national critical loads map for the USA (see Figure) has also been developed by the Southern Research Station’s Global Change Research Program. This one kilometre resolution map utilizes published data for runoff (United States Geological Survey), a national forest cover dataset (USGS/USFS, 25 tree classes), and soil information (Miller and White, 1998). This map is presented as preliminary result and will be refined through collection of site specific data sets.

Outlook

During 2006, the described activities will continue at all sites. The draft national critical loads map for sulphur and nitrogen will be evaluated and improved. Work on critical loads mapping in the North-eastern States will also continue. Work is also continuing to work cooperatively with the USDA Forest Service FIA and Forest Health Monitoring (FHM) programs. In February of 2007, a fourth Critical Loads and Levels Research Workshop will be held in Riverside, California in cooperation with the North American Forestry Commission.

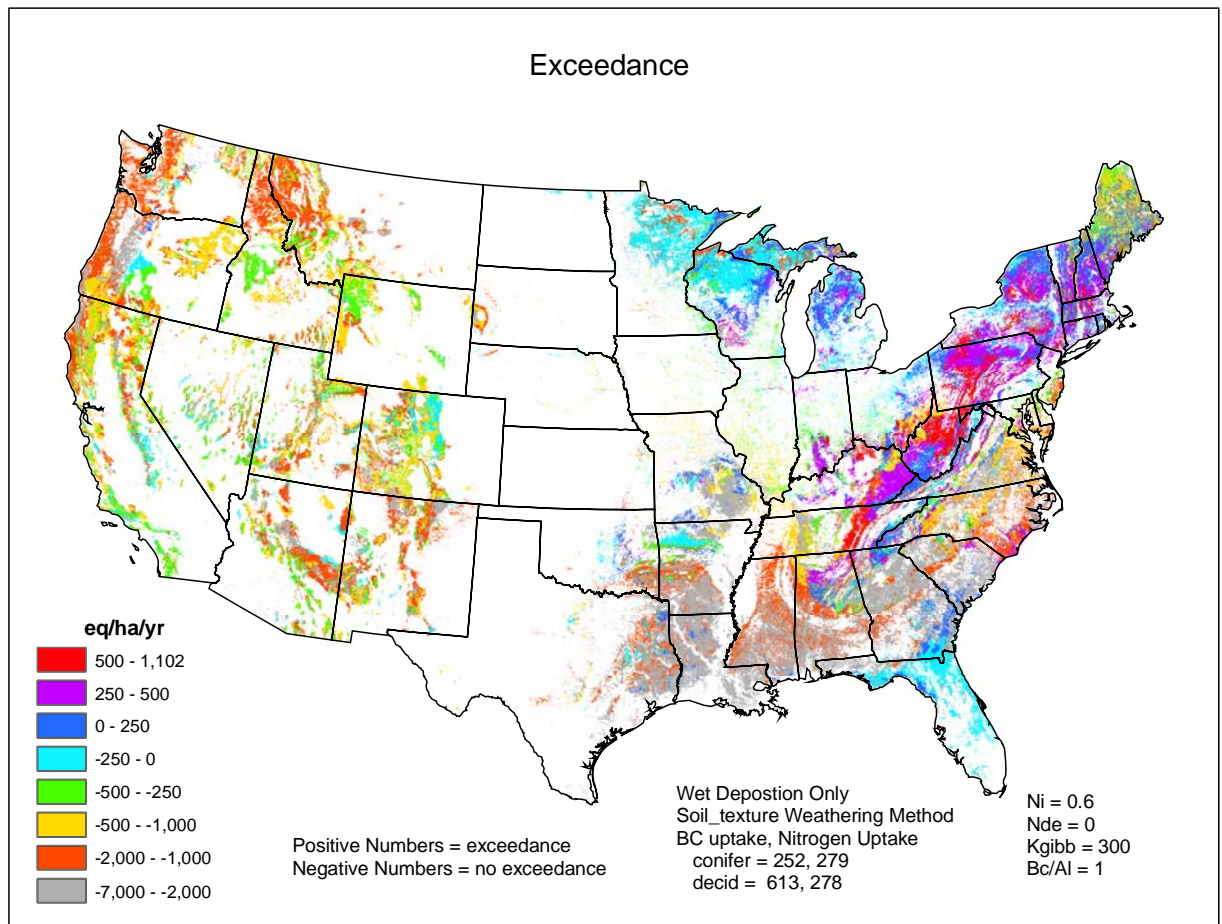


Figure 4.7.2-1: Draft Continental Critical Loads Map Calculated by Simple Mass Balance Approach using Published Data (source: USDA Southern Global Change Research Program)

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Annex I-1

Climatic regions

The **Boreal** region comprises Finland, the central and northern parts of Sweden, Estonia except the coastal regions and some plots in northern and central Norway. The climate is mainly cold with a short vegetation period. In the northernmost parts the climate changes to arctic conditions. The Boreal region is dominated by *Picea abies* and *Pinus sylvestris*. In 2005, 19.2% of the plots of the European survey were located in the Boreal region.

The **Boreal (Temperate)** region covers most parts of southern Sweden and Norway, the whole of the Baltic countries Latvia and Lithuania, the coastal regions of Estonia and the whole of Belarus. This region contains a higher proportion of deciduous tree species, compared to the colder Boreal region. 15.4% of the assessed trees were in the Boreal (Temperate) region.

The **Atlantic (North)** region comprises the United Kingdom, Ireland, Denmark, the Netherlands, the southern coasts of Sweden and Norway, north-west Germany, northern Belgium and France. The climate is characterised by mild winters, a relatively uniform distribution of precipitation over the year and long transitional seasons. The forests consist of *Picea abies*, *Pinus sylvestris*, *Picea sitchensis*, *Quercus robur* and *Fagus sylvatica*. 5.6% of the plots were situated in this region.

The **Atlantic (South)** region comprises central and south-western France, the atlantic coast of Spain and the northern parts of Portugal. The climate is warm, with high precipitation in winter, but very little frost and snow. There is a higher proportion of oak species, dependent on warmer summers, than in the Atlantic (North) region. Also frequent are *Castanea sativa*, *Pinus pinaster*, *Pinus radiata* and *Pinus sylvestris*. 4.6% of the plots were located in this region.

The plots of the **Sub-Atlantic** region are located in Poland, the Czech Republic, the western parts of Slovakia, northern Austria and Switzerland, eastern and southern Germany, southern Belgium, central-eastern France, and the whole of Luxembourg. The climate is typically temperate and characterised by large temperature differences between summer and winter, with a gradient from the western parts to the eastern parts. If the whole region is considered, the forests are very heterogeneous, dominated by *Picea abies*, *Pinus sylvestris* and *Fagus sylvatica*. In this region 18.5% of all plots were located.

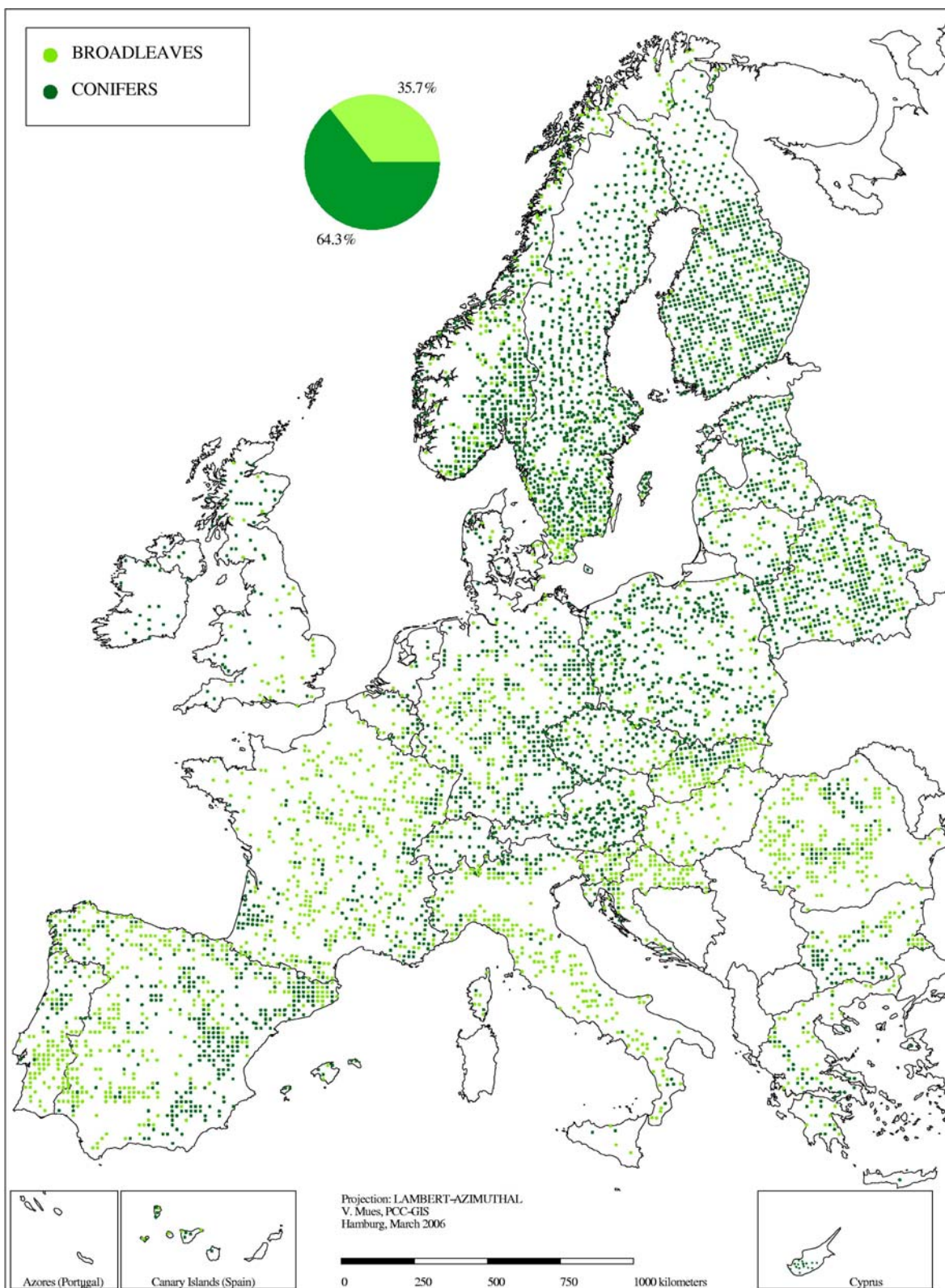
The **Continental** region consists of the Republic of Moldova, large parts of Romania, eastern and northern Bulgaria and nearly all Hungary. The climate is typically continental with warm and dry summers, and low temperatures in winter. The forests are characterised by oak species, *Fagus sylvatica*, *Robinia pseudoacacia*, *Carpinus betulus*, *Picea abies* and *Abies alba*. In 2005, 4% of the sample plots were located in this region.

The **Mountainous (South)** region comprises plots on several mountain ridges. They share steep climatic gradients and consequently complex geobotanical structures, depending on altitude and exposition. They comprise the Alpine system (Pyrenees, Alps, Tatras, Carpathians and the Balkan), the Appenin, the Vosges, and in Germany the Black Forest and the Bavarian/Bohemian Forests. The dominant species are *Picea abies*, *Fagus sylvatica*, *Larix decidua*, *Pinus nigra*, *Pinus sylvestris* and *Abies alba*. This climatic region comprises 11.6% of all sample plots.

The **Mountainous (North)** region was introduced to account for the peculiarities of the mountainous climate in northernmost Europe in comparison to that in the other parts of Europe. This region is located only in Norway. It is characterised by large seasonal variations in climate, but with a generally shorter vegetation period. The plots at lower altitudes on the Atlantic coast are influenced by the Gulf stream and have a more temperate climate. The most frequently occurring species are *Betula pubescens*, *Picea abies* and *Pinus sylvestris*. 5% of the sample plots were located in the Mountainous (North) region.

The Mediterranean region as a whole is divided in the **Mediterranean (Higher)** and **Mediterranean (Lower)** regions. The higher areas (6.5% of the plots) are situated between 400 m and ca. 1000 m altitude in Portugal, Spain, southern France, Italy, Slovenia, Croatia, Romania and Greece with humid climate. The Mediterranean (Lower) regions (9.6% of the plots) cover Cyprus and lower parts of the countries mentioned above. The climate is characterised by hot and dry summers and frequent drought periods in summer. Both Mediterranean regions are dominated by *Pinus halepensis*, *Pinus nigra*, *Pinus pinaster*, *Quercus ilex*, *Quercus cerris* and *Quercus pubescens*.

Annex I-2 Broadleaves and conifers (2005)



Annex I-3

Species assessed (2005)

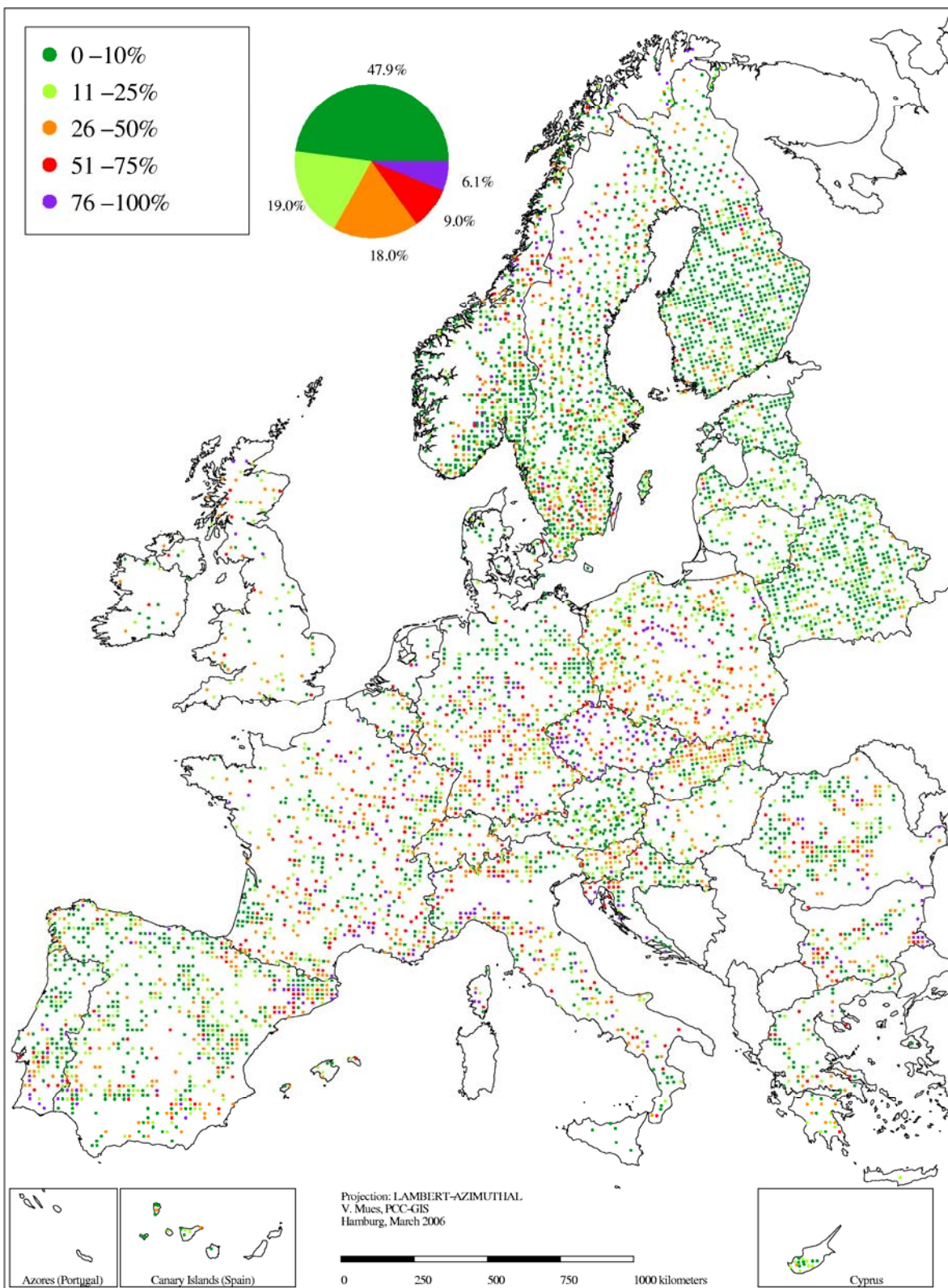
Species	Observed trees		Observed plots	
	Number	%	Number	%
<i>Pinus sylvestris</i>	37180	27.78	1925	18.30
<i>Picea abies</i>	26582	19.86	1549	14.72
<i>Fagus sylvatica</i>	11898	8.89	666	6.33
<i>Quercus robur</i>	5009	3.74	441	4.19
<i>Betula pubescens</i>	4859	3.63	748	7.11
<i>Quercus ilex</i>	3833	2.86	223	2.12
<i>Betula pendula</i>	3683	2.75	665	6.32
<i>Quercus petraea</i>	3438	2.57	351	3.34
<i>Pinus pinaster</i>	3279	2.45	173	1.64
<i>Pinus nigra</i>	2878	2.15	166	1.58
<i>Pinus halepensis</i>	2657	1.99	135	1.28
<i>Abies alba</i>	2147	1.60	210	2.00
<i>Quercus pubescens</i>	1936	1.45	159	1.51
<i>Carpinus betulus</i>	1718	1.28	232	2.20
<i>Quercus suber</i>	1593	1.19	90	0.86
<i>Quercus cerris</i>	1505	1.12	133	1.26
<i>Eucalyptus spp.</i>	1439	1.08	65	0.62
<i>Castanea sativa</i>	1275	0.95	148	1.41
<i>Larix decidua</i>	1233	0.92	181	1.72
<i>Populus tremula</i>	1068	0.80	260	2.47
<i>Alnus glutinosa</i>	1017	0.76	139	1.32
<i>Fraxinus excelsior</i>	980	0.73	194	1.84
<i>Quercus pyrenaica</i>	963	0.72	54	0.51
<i>Picea sitchensis</i>	902	0.67	46	0.44
<i>Quercus frainetto</i>	812	0.61	43	0.41
<i>Robinia pseudoacacia</i>	735	0.55	66	0.63
<i>Quercus rotundifolia</i>	633	0.47	36	0.34
<i>Acer pseudoplatanus</i>	564	0.42	160	1.52
<i>Pseudotsuga menziesii</i>	540	0.40	47	0.45
<i>Populus hybridus</i>	473	0.35	23	0.22
<i>Pinus pinea</i>	454	0.34	37	0.35
<i>Quercus faginea</i>	395	0.30	50	0.48
<i>Pinus brutia</i>	378	0.28	19	0.18
<i>Ostrya carpinifolia</i>	365	0.27	60	0.57
other broadleaves	339	0.25	75	0.71
<i>Pinus radiata</i>	322	0.24	16	0.15
<i>Tilia cordata</i>	309	0.23	74	0.70
<i>Juniperus thurifera</i>	279	0.21	22	0.21
<i>Abies cephalonica</i>	269	0.20	13	0.12
<i>Alnus incana</i>	225	0.17	39	0.37
<i>Prunus avium</i>	224	0.17	101	0.96
<i>Quercus coccifera</i>	208	0.16	16	0.15
<i>Pinus contorta</i>	190	0.14	15	0.14
<i>Abies borisii-regis</i>	178	0.13	9	0.09
<i>Olea europaea</i>	174	0.13	21	0.20
<i>Acer campestre</i>	165	0.12	69	0.66

Species	Observed trees		Observed plots	
	Number	%	Number	%
<i>Quercus rubra</i>	153	0.11	21	0.20
<i>Pinus uncinata</i>	146	0.11	13	0.12
<i>Tilia platyphyllos</i>	130	0.10	19	0.18
<i>Fraxinus angustifolia</i>	126	0.09	14	0.13
<i>Fraxinus ornus</i>	125	0.09	43	0.41
<i>Fagus moesiaca</i>	121	0.09	6	0.06
<i>Acer platanoides</i>	117	0.09	43	0.41
<i>Populus nigra</i>	108	0.08	10	0.10
<i>Platanus orientalis</i>	89	0.07	5	0.05
<i>Alnus cordata</i>	85	0.06	4	0.04
<i>Pinus cembra</i>	82	0.06	9	0.09
<i>Larix kaempferi</i>	72	0.05	9	0.09
<i>Sorbus aucuparia</i>	66	0.05	29	0.28
<i>Pinus strobus</i>	63	0.05	8	0.08
<i>Sorbus aria</i>	49	0.04	31	0.29
<i>Juniperus oxycedrus</i>	49	0.04	17	0.16
<i>Salix caprea</i>	46	0.03	29	0.28
<i>Juniperus phoenicea</i>	46	0.03	10	0.10
<i>Populus canescens</i>	45	0.03	5	0.05
<i>Ulmus glabra</i>	45	0.03	23	0.22
<i>Acer monspessulanum</i>	44	0.03	13	0.12
<i>Acer opalus</i>	44	0.03	17	0.16
<i>Juniperus communis</i>	43	0.03	7	0.07
<i>Populus alba</i>	42	0.03	10	0.10
<i>Salix spp.</i>	41	0.03	10	0.10
<i>Phillyrea latifolia</i>	39	0.03	9	0.09
<i>Cupressus sempervirens</i>	37	0.03	6	0.06
<i>Other conifers</i>	37	0.03	8	0.08
<i>Cedrus atlantica</i>	32	0.02	4	0.04
<i>Salix alba</i>	30	0.02	6	0.06
<i>Sorbus torminalis</i>	27	0.02	22	0.21
<i>Arbutus unedo</i>	27	0.02	8	0.08
<i>Ulmus minor</i>	24	0.02	9	0.09
<i>Cedrus brevifolia</i>	24	0.02	1	0.01
<i>Arbutus andrachne</i>	22	0.02	2	0.02
<i>Buxus sempervirens</i>	21	0.02	3	0.03
<i>Quercus macrolepis</i>	21	0.02	1	0.01
<i>Quercus trojana</i>	20	0.01	3	0.03
<i>Corylus avellana</i>	19	0.01	10	0.10
<i>Quercus fruticosa</i>	19	0.01	1	0.01
<i>Fagus orientalis</i>	15	0.01	1	0.01
<i>Juglans regia</i>	14	0.01	6	0.06
<i>Pistacia terebinthus</i>	11	0.01	2	0.02
<i>Pinus leucodermis</i>	11	0.01	1	0.01
<i>Alnus viridis</i>	10	0.01	2	0.02
<i>Sorbus domestica</i>	10	0.01	9	0.09
<i>Ilex aquifolium</i>	9	0.01	6	0.06
<i>Pyrus communis</i>	9	0.01	6	0.06
<i>Ulmus laevis</i>	9	0.01	5	0.05

Species	Observed trees		Observed plots	
	Number	%	Number	%
<i>Tsuga</i> spp.	9	0.01	1	0.01
<i>Cercis siliquastrum</i>	8	0.01	1	0.01
<i>Cupressus lusitanica</i>	8	0.01	1	0.01
<i>Ceratonia siliqua</i>	7	0.01	2	0.02
<i>Cedrus deodara</i>	4	0.00	1	0.01
<i>Prunus serotina</i>	3	0.00	1	0.01
<i>Abies grandis</i>	3	0.00	1	0.01
<i>Pinus mugo</i>	3	0.00	1	0.01
<i>Thuja</i> spp.	3	0.00	1	0.01
<i>Malus domestica</i>	2	0.00	1	0.01
<i>Prunus padus</i>	2	0.00	2	0.02
<i>Salix fragilis</i>	2	0.00	2	0.02
<i>Pistacia lentiscus</i>	2	0.00	1	0.01
<i>Chamaecyparis lawsonia</i>	2	0.00	1	0.01
<i>Carpinus orientalis</i>	1	0.00	1	0.01
<i>Salix cinerea</i>	1	0.00	1	0.01
<i>Salix eleagnos</i>	1	0.00	1	0.01
<i>Picea omorika</i>	1	0.00	1	0.01
<i>Taxus baccata</i>	1	0.00	1	0.01
All species	133840	100.00	10522	100.00

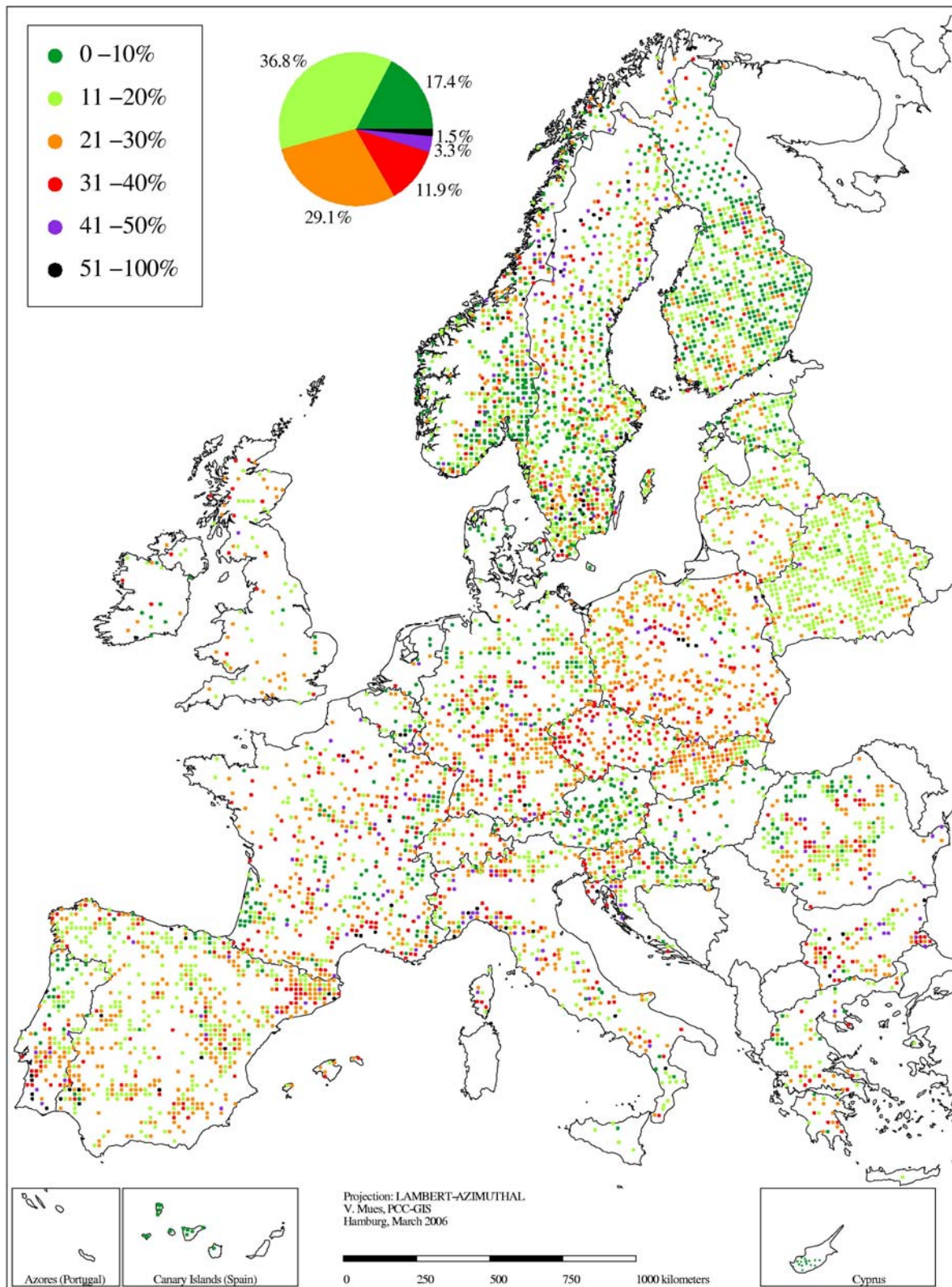
Annex I-4
Percentage of trees damaged (2005)

Note that some differences in the level of damage across national borders may be at least partly due to differences in standards used. This restriction however does not affect the reliability of the trends over time.



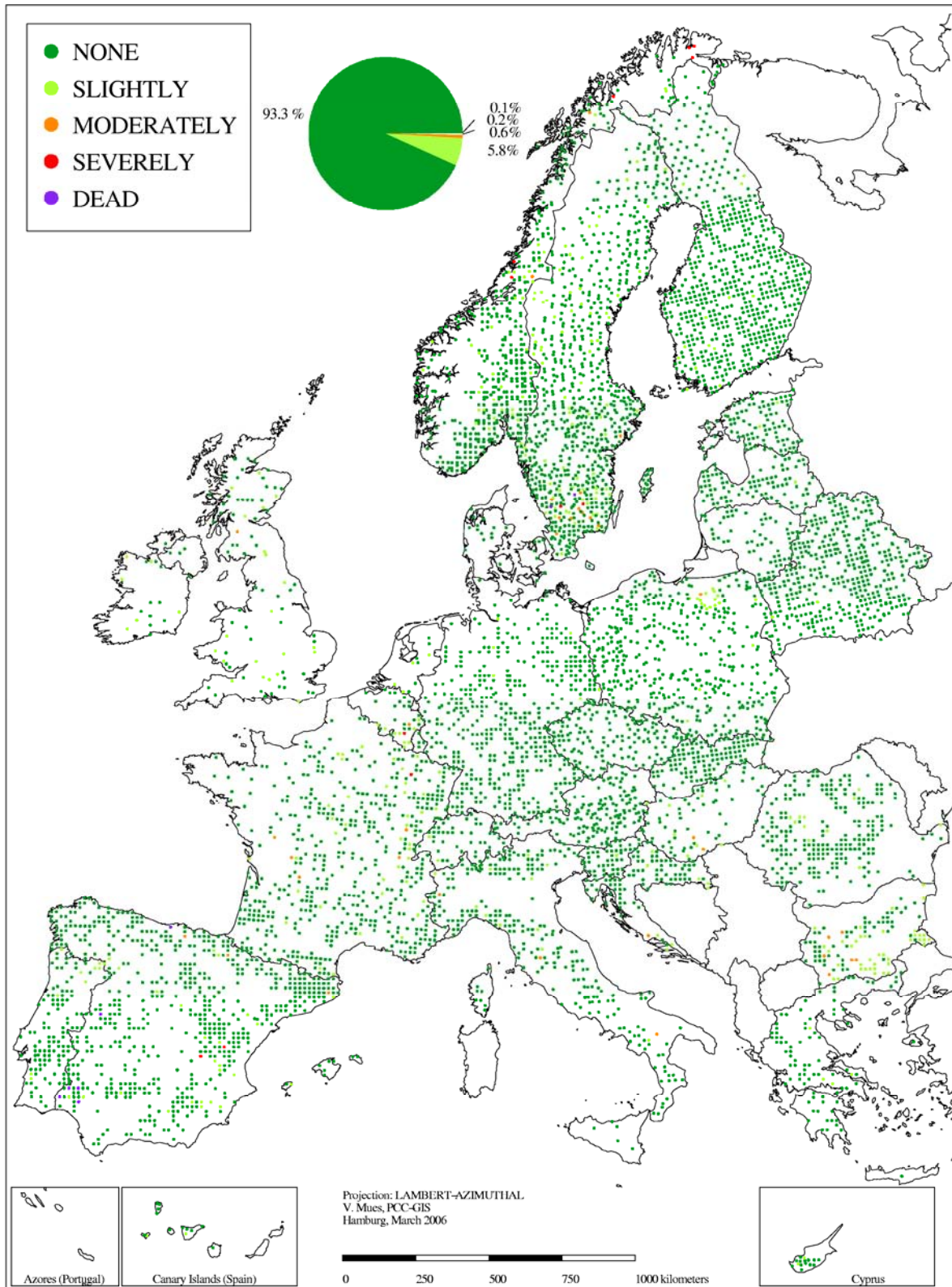
Annex I-5 Mean plot defoliation of all species (2005)

Note that some differences in the level of damage across national borders may be at least partly due to differences in standards used. This restriction however does not affect the reliability of the trends over time.

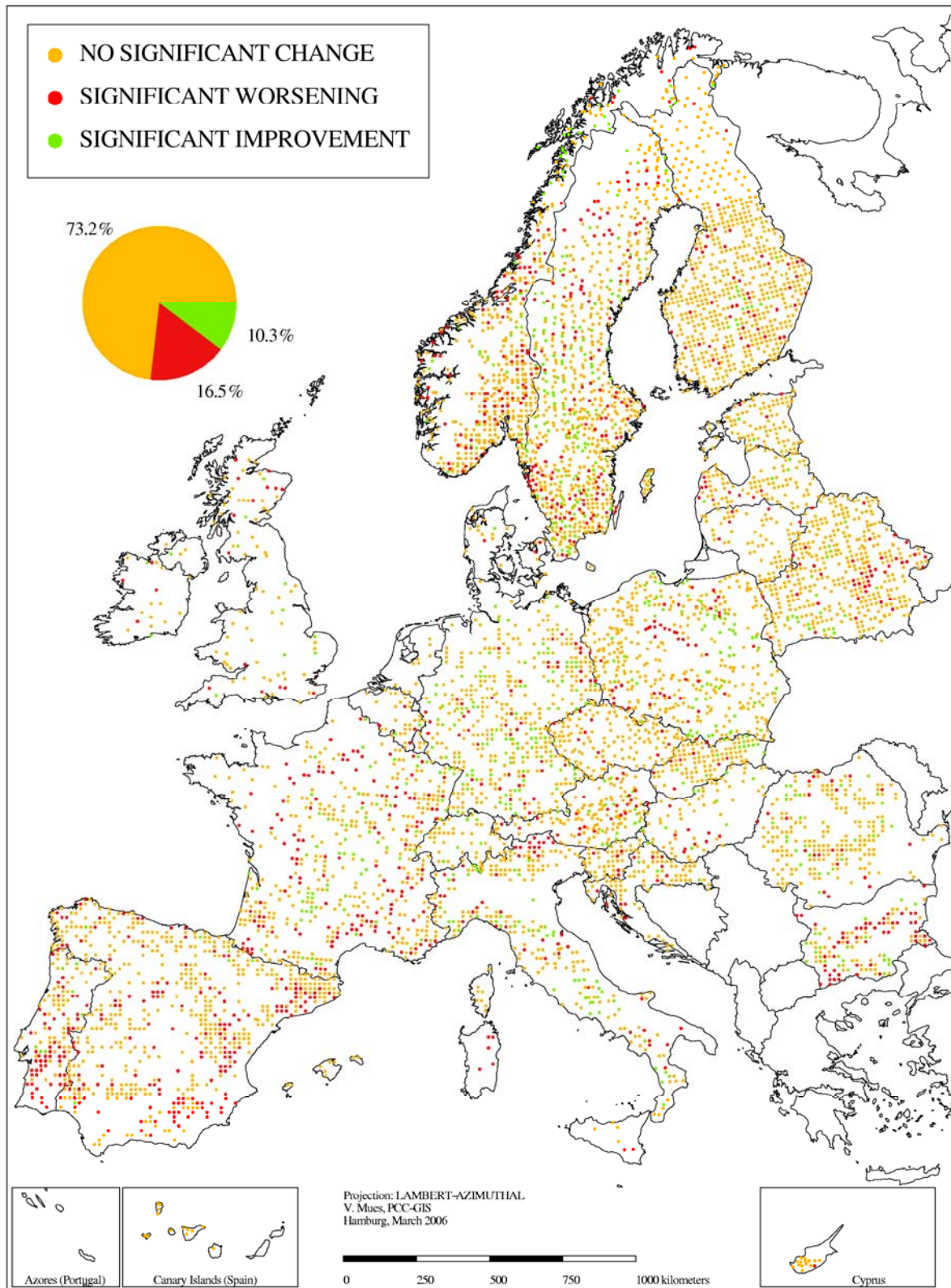


Annex I-6
Plot discolouration (2005)

Note that some differences in the level of damage across national borders may be at least partly due to differences in standards used. This restriction however does not affect the reliability of the trends over time.



Annex I-7 Changes in mean plot defoliation (2004-2005)



Annex I-8**Development of defoliation of most common species (1990-2005).*****Picea abies***

ATLANTIC (NORTH)	Number of trees	0-10%	>10-25%	>25%	SUB-ATLANTIC	Number of trees	0-10%	>10-25%	>25%
1990	526	52.3	28.3	19.4	1990	3822	27.4	39.5	33.1
1991	524	54.8	22.7	22.5	1991	3767	25.5	39.1	35.4
1992	525	49.5	30.7	19.8	1992	3826	24.6	40.7	34.7
1993	521	47.8	21.7	30.5	1993	3781	24.6	37.2	38.2
1994	522	39.7	26.2	34.1	1994	3778	21.1	37.8	41.1
1995	503	42.6	28.6	28.8	1995	3833	25.9	34.0	40.1
1996	495	49.5	30.1	20.4	1996	3835	31.0	36.4	32.6
1997	475	51.6	26.3	22.1	1997	3855	25.1	40.4	34.5
1998	497	52.3	27.6	20.1	1998	4674	27.6	39.9	32.5
1999	507	56.0	24.7	19.3	1999	4651	26.7	40.9	32.4
2000	489	53.1	26.0	20.9	2000	4651	22.9	43.6	33.5
2001	490	61.9	21.6	16.5	2001	4444	21.9	44.8	33.3
2002	466	64.0	22.3	13.7	2002	4509	21.3	42.1	36.6
2003	466	61.8	21.9	16.3	2003	4563	21.0	44.5	34.5
2004	465	62.4	21.7	15.9	2004	4540	18.0	40.4	41.6
2005	444	61.5	24.1	14.4	2005	4495	18.7	45.1	36.2
BOREAL (TEMP.)	Number of trees	0-10%	>10-25%	>25%	MOUNTAIN- OUS (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1990	405	35.6	41.2	23.2	1990	1715	29.6	37.3	33.1
1991	599	32.4	46.6	21.0	1991	1727	22.4	44.5	33.1
1992	595	30.1	50.9	19.0	1992	1697	15.4	45.5	39.1
1993	594	29.0	54.0	17.0	1993	1674	18.2	44.2	37.6
1994	531	37.1	47.5	15.4	1994	1708	17.1	42.3	40.6
1995	547	39.5	45.5	15.0	1995	1803	21.1	44.3	34.6
1996	585	30.4	52.0	17.6	1996	1778	25.2	42.9	31.9
1997	545	32.5	48.1	19.4	1997	1726	23.0	44.2	32.8
1998	551	36.5	47.5	16.0	1998	2151	25.8	43.2	31.0
1999	552	32.8	49.6	17.6	1999	2131	29.1	43.1	27.8
2000	549	24.8	51.3	23.9	2000	2076	24.0	47.2	28.8
2001	540	25.7	53.2	21.1	2001	2016	20.2	50.6	29.2
2002	540	23.1	60.8	16.1	2002	1994	16.3	55.0	28.7
2003	522	24.3	58.8	16.9	2003	2011	13.2	58.1	28.7
2004	518	27.8	56.2	16.0	2004	1955	9.4	49.6	41.0
2005	518	33.8	51.9	14.3	2005	1937	17.2	49.4	33.4
ALL REGIONS	Number of trees	0-10%	>10-25%	>25%					
1990	6485	30.7	38.0	31.3					
1991	6634	27.8	39.8	32.4					
1992	6660	24.9	41.9	33.2					
1993	6584	25.4	39.2	35.4					
1994	6553	23.0	38.8	38.2					
1995	6700	27.1	37.2	35.7					
1996	6707	30.9	39.0	30.1					
1997	6615	27.2	40.9	31.9					
1998	7887	29.4	40.5	30.1					
1999	7855	29.8	41.0	29.2					
2000	7779	25.4	43.9	30.7					
2001	7504	24.4	45.5	30.1					
2002	7523	22.7	45.7	31.6					
2003	7568	21.7	47.7	30.6					
2004	7484	19.2	42.8	38.0					
2005	7400	22.0	45.4	32.6					

Pinus sylvestris

ATLANTIC (NORTH)	Number of trees	0-10%	>10-25%	>25%	MEDITERR. (HIGHER)	Number of trees	0-10%	>10-25%	>25%
1990	588	50.2	41.8	8.0	1990	541	85.9	12.8	1.3
1991	591	51.3	37.2	11.5	1991	541	72.8	21.3	5.9
1992	581	55.1	32.7	12.2	1992	564	67.4	23.0	9.6
1993	592	50.0	39.4	10.6	1993	564	56.6	26.6	16.8
1994	591	45.7	42.5	11.8	1994	540	51.5	31.3	17.2
1995	576	44.3	45.8	9.9	1995	549	45.2	39.9	14.9
1996	577	38.1	51.0	10.9	1996	541	47.4	43.4	9.2
1997	573	47.5	46.2	6.3	1997	540	45.0	44.3	10.7
1998	573	54.1	39.4	6.5	1998	540	44.4	48.2	7.4
1999	647	46.4	43.7	9.9	1999	603	50.6	44.3	5.1
2000	643	44.0	45.6	10.4	2000	602	55.5	40.2	4.3
2001	648	42.4	48.5	9.1	2001	604	53.3	40.1	6.6
2002	648	46.5	43.8	9.7	2002	603	48.0	41.6	10.4
2003	647	48.8	41.6	9.6	2003	601	44.1	46.9	9.0
2004	639	55.5	38.2	6.3	2004	601	41.6	49.6	8.8
2005	639	54.0	40.5	5.5	2005	599	36.9	54.8	8.3
MOUNTAINOUS (SOUTH)	Number of trees	0-10%	>10-25%	>25%	BOREAL (TEMP.)	Number of trees	0-10%	>10-25%	>25%
1990	739	66.9	21.2	11.9	1990	960	10.4	34.4	55.2
1991	742	51.1	32.3	16.6	1991	1154	4.9	32.8	62.3
1992	758	39.4	40.7	19.9	1992	1130	3.1	26.3	70.6
1993	743	36.9	41.2	21.9	1993	1156	4.0	34.2	61.8
1994	731	29.5	40.7	29.8	1994	1099	9.9	43.8	46.3
1995	747	31.7	54.9	13.4	1995	1079	15.9	56.6	27.5
1996	754	35.5	49.5	15.0	1996	1117	20.0	57.8	22.2
1997	763	34.3	55.7	10.0	1997	1096	18.0	61.7	20.3
1998	829	39.6	50.0	10.4	1998	1115	19.5	60.7	19.8
1999	918	48.4	41.7	9.9	1999	1134	14.2	67.0	18.8
2000	904	35.6	51.7	12.7	2000	1068	15.0	67.8	17.2
2001	895	37.5	49.5	13.0	2001	1121	12.3	74.9	12.8
2002	896	26.2	54.7	19.1	2002	1133	15.5	72.0	12.5
2003	896	23.1	59.0	17.9	2003	1131	19.6	71.0	9.4
2004	899	20.7	61.7	17.6	2004	1134	17.5	72.7	9.8
2005	895	22.0	60.1	17.9	2005	1124	12.4	74.7	12.9
SUB-ATLANTIC	Number of trees	0-10%	>10-25%	>25%	CONTINENTAL	Number of trees	0-10%	>10-25%	>25%
1990	8491	13.5	46.2	40.3	1990	149	46.3	18.1	35.6
1991	8534	8.2	45.8	46.0	1991	157	56.0	25.5	18.5
1992	8538	8.6	43.9	47.5	1992	158	62.6	20.3	17.1
1993	8549	8.9	44.6	46.5	1993	162	63.0	16.0	21.0
1994	8011	5.4	41.5	53.1	1994	162	59.9	17.3	22.8
1995	7838	7.5	42.1	50.4	1995	166	69.3	12.0	18.7
1996	7838	12.4	51.7	35.9	1996	168	66.7	14.3	19.0
1997	7815	12.1	54.8	33.1	1997	168	64.9	14.9	20.2
1998	8210	12.9	56.8	30.3	1998	181	62.4	21.0	16.6
1999	8205	12.5	61.0	26.5	1999	180	68.4	17.2	14.4
2000	8216	10.5	61.9	27.6	2000	170	65.9	14.7	19.4
2001	8195	10.4	62.4	27.2	2001	170	68.8	15.9	15.3
2002	8059	9.1	63.2	27.7	2002	170	61.2	18.2	20.6
2003	8103	8.5	63.4	28.1	2003	169	53.3	26.0	20.7
2004	8139	8.1	61.9	30.0	2004	168	57.8	20.2	22.0
2005	8120	12.1	57.5	30.4	2005	166	56.6	18.1	25.3
ALL REGIONS	Number of trees	0-10%	>10-25%	>25%					
1990	11630	23.1	41.1	35.8					
1991	11877	17.2	41.5	41.3					
1992	11887	16.6	40.0	43.4					
1993	11924	15.9	41.6	42.5					
1994	11292	13.2	40.6	46.2					
1995	11113	15.3	44.0	40.7					
1996	11154	19.1	51.0	29.9					
1997	11115	19.2	53.6	27.2					
1998	11608	20.4	54.6	25.0					
1999	11847	20.6	57.3	22.1					
2000	11764	18.3	58.7	23.0					
2001	11794	17.9	59.8	22.3					
2002	11670	16.4	60.3	23.3					
2003	11708	15.9	60.9	23.2					
2004	11741	15.5	60.2	24.3					
2005	11705	17.4	57.6	25.0					

Fagus sylvatica

ATLANTIC (NORTH)	Number of trees	0-10%	>10-25%	>25%	ATLANTIC (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1990	420	18.8	45.0	36.2	1990	123	65.9	21.1	13.0
1991	420	28.3	47.2	24.5	1991	95	57.9	28.4	13.7
1992	420	25.0	46.2	28.8	1992	119	59.7	31.1	9.2
1993	420	25.5	45.2	29.3	1993	119	62.2	31.1	6.7
1994	425	28.2	44.3	27.5	1994	80	33.8	54.9	11.3
1995	423	14.4	43.8	41.8	1995	120	59.2	35.0	5.8
1996	404	19.8	47.5	32.7	1996	96	33.3	52.1	14.6
1997	420	24.5	43.8	31.7	1997	120	29.2	54.1	16.7
1998	420	27.1	42.4	30.5	1998	120	27.5	60.8	11.7
1999	431	22.0	47.8	30.2	1999	121	35.5	55.4	9.1
2000	436	15.8	41.1	43.1	2000	126	42.9	47.6	9.5
2001	461	29.7	41.9	28.4	2001	127	48.8	46.5	4.7
2002	459	26.1	43.4	30.5	2002	128	28.9	57.8	13.3
2003	463	28.3	42.5	29.2	2003	128	27.3	60.2	12.5
2004	472	23.1	31.1	45.8	2004	128	15.6	71.1	13.3
2005	497	31.4	36.6	32.0	2005	130	16.2	69.2	14.6
SUB-ATLANTIC	Number of trees	0-10%	>10-25%	>25%	MOUNTAINOUS (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1990	2371	31.1	46.3	22.6	1990	976	48.3	41.7	10.0
1991	2429	33.6	44.3	22.1	1991	994	59.0	33.8	7.2
1992	2446	20.4	48.4	31.2	1992	1001	52.2	31.9	15.9
1993	2424	23.8	47.1	29.1	1993	1014	52.2	32.9	14.9
1994	2385	16.2	49.8	34.0	1994	950	48.0	36.7	15.3
1995	2420	18.0	46.0	36.0	1995	1010	40.4	42.7	16.9
1996	2434	21.4	51.2	27.4	1996	1004	35.4	48.5	16.1
1997	2476	22.5	54.2	23.3	1997	1011	30.7	49.9	19.4
1998	2684	23.5	51.5	25.0	1998	1053	45.4	44.5	10.1
1999	2718	17.8	56.3	25.9	1999	1158	34.4	52.3	13.3
2000	2731	23.6	50.6	25.8	2000	1204	43.1	45.9	11.0
2001	2721	20.6	48.4	31.0	2001	1193	29.0	54.7	16.3
2002	2724	24.9	52.0	23.1	2002	1200	31.8	56.4	11.8
2003	2742	23.9	51.4	24.7	2003	1202	17.8	49.7	32.5
2004	2757	14.6	50.5	34.9	2004	1195	25.2	49.4	25.4
2005	2763	15.1	54.7	30.2	2005	1188	34.9	45.2	19.9
ALL REGIONS	Number of trees	0-10%	>10-25%	>25%					
1990	4014	37.0	43.0	20.0					
1991	4063	40.9	41.2	17.9					
1992	4090	31.4	42.8	25.8					
1993	4108	33.6	42.0	24.4					
1994	3947	27.0	45.4	27.6					
1995	4126	25.9	44.0	30.1					
1996	4091	26.2	49.9	23.9					
1997	4162	25.8	51.6	22.6					
1998	4416	30.2	48.7	21.1					
1999	4567	24.1	53.9	22.0					
2000	4636	29.6	47.9	22.5					
2001	4639	25.0	49.2	25.8					
2002	4648	27.6	52.3	20.1					
2003	4677	23.9	50.0	26.1					
2004	4693	19.4	48.5	32.1					
2005	4719	22.7	50.4	26.9					

Quercus ilex and *Q. rotundifolia*

MEDITERR. (HIGHER)	Number of trees	0-10%	>10-25%	>25%	MEDITERR. (LOWER)	Number of trees	0-10%	>10-25%	>25%
1990	652	80.4	18.7	0.9	1990	2326	65.0	21.5	13.5
1991	652	56.1	40.8	3.1	1991	2308	47.2	36.3	16.5
1992	653	42.0	49.1	8.9	1992	2323	38.2	45.7	16.1
1993	653	31.2	60.4	8.4	1993	2298	36.4	56.9	6.7
1994	653	25.4	56.1	18.5	1994	2294	31.4	57.4	11.2
1995	671	17.1	50.7	32.2	1995	2277	16.6	56.4	27.0
1996	665	21.1	53.5	25.4	1996	2278	20.5	54.7	24.8
1997	665	25.6	58.5	15.9	1997	2278	29.0	56.2	14.8
1998	657	35.0	51.6	13.4	1998	2278	31.9	54.4	13.7
1999	770	26.6	56.5	16.9	1999	2896	21.8	56.2	22.0
2000	764	27.0	56.2	16.8	2000	2914	17.6	60.8	21.6
2001	765	24.7	62.8	12.5	2001	2914	19.4	65.2	15.4
2002	765	17.3	64.4	18.3	2002	2918	17.6	64.4	18.0
2003	766	20.2	60.7	19.1	2003	2919	14.1	66.1	19.8
2004	766	20.9	61.3	17.8	2004	2916	20.3	64.4	15.3
2005	770	9.5	57.0	33.5	2005	2888	8.8	69.1	22.1

Quercus ilex and *Q. rotundifolia*

ALL REGIONS	Number of trees	0-10%	>10-25%	>25%
1990	3074	67.8	20.9	11.3
1991	3064	49.4	37.2	13.4
1992	3080	38.6	46.6	14.8
1993	3055	35.1	57.8	7.1
1994	3027	29.3	57.4	13.3
1995	3052	16.3	55.6	28.1
1996	3034	20.6	55.1	24.3
1997	3034	28.3	56.9	14.8
1998	3026	32.8	53.8	13.4
1999	3820	23.4	56.4	20.2
2000	3852	20.2	59.8	20.0
2001	3853	20.4	64.5	15.1
2002	3857	17.4	63.8	18.8
2003	3859	15.6	64.4	20.0
2004	3855	20.2	63.7	16.1
2005	3832	8.9	66.5	24.6

Pinus pinaster

ATLANTIC (SOUTH)	Number of trees	0-10%	>10-25%	>25%	MEDITERR. (HIGHER)	Number of trees	0-10%	>10-25%	>25%
1990	467	44.3	17.8	37.9	1990	426	77.5	14.3	8.2
1991	461	38.6	27.8	33.6	1991	380	75.0	14.7	10.3
1992	482	53.3	26.6	20.1	1992	370	84.1	13.5	2.4
1993	451	59.0	31.9	9.1	1993	370	75.9	21.4	2.7
1994	423	60.3	31.0	8.7	1994	432	72.9	17.8	9.3
1995	420	57.1	36.2	6.7	1995	432	69.3	27.5	3.2
1996	420	54.5	34.3	11.2	1996	432	69.2	22.9	7.9
1997	410	60.3	32.9	6.8	1997	427	72.6	20.1	7.3
1998	410	52.7	39.3	8.0	1998	432	69.6	26.2	4.2
1999	598	52.9	43.1	4.0	1999	511	61.2	28.8	10.0
2000	600	49.0	40.2	10.8	2000	482	61.2	29.0	9.8
2001	592	41.7	53.2	5.1	2001	481	62.4	34.7	2.9
2002	593	41.3	48.8	9.9	2002	482	54.2	42.5	3.3
2003	565	37.0	57.0	6.0	2003	482	50.6	44.0	5.4
2004	563	32.9	52.9	14.2	2004	472	55.3	37.3	7.4
2005	504	35.3	54.8	9.9	2005	473	42.9	48.4	8.7
MEDITERR. (LOWER)	Number of trees	0-10%	>10-25%	>25%	ALL REGIONS	Number of trees	0-10%	>10-25%	>25%
1990	1712	71.4	18.6	10.0	1990	2654	68.1	17.5	14.4
1991	1699	61.7	27.6	10.7	1991	2589	60.1	25.4	14.5
1992	1698	64.1	25.6	10.3	1992	2599	65.3	23.8	10.9
1993	1582	67.7	23.5	8.8	1993	2452	67.5	24.6	7.9
1994	1638	65.7	27.8	6.5	1994	2542	66.0	26.8	7.2
1995	1480	59.2	32.2	8.6	1995	2381	60.9	31.9	7.2
1996	1449	57.0	34.6	8.4	1996	2350	59.3	32.0	8.7
1997	1433	43.6	45.9	10.5	1997	2333	52.9	38.0	9.1
1998	1427	44.2	45.8	10.0	1998	2332	51.2	40.2	8.6
1999	1661	42.9	47.4	9.7	1999	2886	50.0	41.8	8.2
2000	1661	46.5	45.4	8.1	2000	2859	51.1	40.3	8.6
2001	1653	47.7	46.3	6.0	2001	2842	50.1	44.8	5.1
2002	1649	48.4	45.7	5.9	2002	2840	48.5	45.3	6.2
2003	1459	45.9	44.6	9.5	2003	2622	45.2	47.1	7.7
2004	1427	43.9	41.7	14.4	2004	2579	44.1	43.5	12.4
2005	1281	36.2	44.0	19.8	2005	2375	38.4	46.9	14.7

Quercus suber

MEDITERR. (LOWER)	Number of trees	0-10%	>10-25%	>25%	ALL REGIONS	Number of trees	0-10%	>10-25%	>25%
1990	1403	39.1	19.2	41.7	1990	1442	38.9	18.9	42.2
1991	1382	26.6	29.7	43.7	1991	1419	26.7	29.2	44.1
1992	1449	29.6	37.7	32.7	1992	1487	29.6	37.2	33.2
1993	1401	46.1	44.5	9.4	1993	1438	47.6	43.3	9.1
1994	1397	39.2	47.0	13.8	1994	1434	40.7	45.8	13.5
1995	1398	19.4	54.3	26.3	1995	1435	21.3	53.1	25.6
1996	1400	32.9	52.1	15.0	1996	1437	33.9	51.5	14.6
1997	1403	34.3	53.2	12.5	1997	1440	35.8	52.0	12.2
1998	1403	26.8	58.2	15.0	1998	1440	28.1	57.2	14.7
1999	1511	23.4	56.9	19.7	1999	1548	24.5	56.3	19.2
2000	1533	21.2	62.0	16.8	2000	1570	22.4	61.2	16.4
2001	1534	22.0	59.6	18.4	2001	1571	22.5	59.4	18.1
2002	1557	22.1	60.4	17.5	2002	1594	22.5	60.2	17.3
2003	1541	19.4	54.4	26.2	2003	1578	19.8	54.5	25.7
2004	1557	20.9	52.4	26.7	2004	1594	21.6	52.2	26.2
2005	1500	3.8	60.1	36.1	2005	1534	4.2	60.3	35.5

Quercus robur and *Q. petraea*

ATLANTIC (NORTH)	Number of trees	0-10%	>10-25%	>25%	ATLANTIC (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1990	322	57.2	30.4	12.4	1990	269	66.5	8.6	24.9
1991	323	39.9	43.7	16.4	1991	257	55.3	13.2	31.5
1992	323	25.1	56.3	18.6	1992	237	49.4	27.8	22.8
1993	326	25.2	41.4	33.4	1993	238	51.7	34.9	13.4
1994	316	35.8	33.2	31.0	1994	197	55.3	33.5	11.2
1995	331	37.2	41.0	21.8	1995	239	40.2	48.1	11.7
1996	328	15.9	39.0	45.1	1996	237	32.9	49.4	17.7
1997	335	17.9	43.0	39.1	1997	238	34.5	52.1	13.4
1998	335	25.7	47.7	26.6	1998	240	33.8	44.5	21.7
1999	335	23.6	39.4	37.0	1999	280	35.4	53.5	11.1
2000	337	27.3	47.2	25.5	2000	278	30.6	57.9	11.5
2001	341	20.8	52.8	26.4	2001	281	20.3	60.8	18.9
2002	342	24.9	46.4	28.7	2002	282	20.6	62.7	16.7
2003	338	15.1	51.5	33.4	2003	298	22.1	62.5	15.4
2004	340	12.9	47.1	40.0	2004	299	20.4	58.9	20.7
2005	363	19.6	50.1	30.3	2005	302	21.9	60.9	17.2
SUB-ATLANTIC	Number of trees	0-10%	>10-25%	>25%	MOUNTAINOUS (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1990	1634	27.3	49.2	23.5	1990	205	12.2	23.4	64.4
1991	1635	17.0	48.6	34.4	1991	212	26.9	39.6	33.5
1992	1624	13.1	49.1	37.8	1992	212	14.6	58.5	26.9
1993	1624	10.2	43.6	46.2	1993	214	18.7	34.1	47.2
1994	1630	6.9	37.3	55.8	1994	197	11.2	55.8	33.0
1995	1631	8.5	38.6	52.9	1995	210	21.0	45.2	33.8
1996	1608	10.6	43.0	46.4	1996	209	12.9	30.6	56.5
1997	1627	11.2	45.4	43.4	1997	209	17.2	26.8	56.0
1998	1693	12.2	42.4	45.4	1998	238	19.3	35.3	45.4
1999	1723	13.8	52.1	34.1	1999	243	18.5	39.5	42.0
2000	1725	12.3	52.7	35.0	2000	241	18.3	44.8	36.9
2001	1729	12.1	52.7	35.2	2001	244	18.4	45.1	36.5
2002	1735	15.4	52.0	32.6	2002	246	13.8	46.8	39.4
2003	1737	9.4	53.8	36.8	2003	247	15.4	45.3	39.3
2004	1744	10.7	47.3	42.0	2004	267	19.1	39.7	41.2
2005	1746	9.6	47.7	42.7	2005	266	21.4	30.8	47.8

Quercus robur and *Q. petraea*

CONTINENTAL	Number of trees	0-10%	>10-25%	>25%	ALL REGIONS	Number of trees	0-10%	>10-25%	>25%
1990	166	47.6	25.3	27.1	1990	2633	35.8	38.8	25.4
1991	178	35.9	29.8	34.3	1991	2640	26.4	42.2	31.4
1992	177	42.4	27.1	30.5	1992	2609	20.7	47.0	32.3
1993	177	28.2	32.8	39.0	1993	2615	18.3	40.9	40.8
1994	185	30.3	19.5	50.2	1994	2559	16.8	36.7	46.5
1995	185	33.0	27.0	40.0	1995	2643	18.1	39.8	42.1
1996	190	36.8	27.4	35.8	1996	2619	15.7	41.1	43.2
1997	191	38.2	24.1	37.7	1997	2651	17.2	42.9	39.9
1998	207	37.1	30.0	32.9	1998	2764	18.7	41.9	39.4
1999	207	47.8	25.1	27.1	1999	2839	20.5	47.7	31.8
2000	208	47.1	22.6	30.3	2000	2868	20.2	49.3	30.5
2001	205	52.7	23.9	23.4	2001	2879	18.2	50.9	30.9
2002	205	46.4	26.8	26.8	2002	2889	19.5	50.4	30.1
2003	204	40.7	26.5	32.8	2003	2902	14.1	52.3	33.6
2004	264	43.6	26.1	30.3	2004	2998	16.0	46.3	37.7
2005	264	50.4	22.7	26.9	2005	3029	17.1	46.1	36.8

Abies alba

SUB-ATLANTIC	Number of trees	0-10%	>10-25%	>25%	MOUNTAIN-OUS (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1990	385	11.2	27.5	61.3	1990	335	21.5	30.1	48.4
1991	385	10.1	23.9	66.0	1991	348	22.7	34.2	43.1
1992	386	9.8	23.1	67.1	1992	347	14.7	43.5	41.8
1993	382	8.1	26.7	65.2	1993	347	11.2	30.8	58.0
1994	385	7.8	22.9	69.3	1994	343	15.5	39.7	44.8
1995	402	8.0	30.8	61.2	1995	359	14.8	37.6	47.6
1996	401	9.7	35.4	54.9	1996	366	13.7	32.8	53.5
1997	392	11.5	35.7	52.8	1997	360	10.3	40.8	48.9
1998	432	11.6	34.5	53.9	1998	342	16.4	38.9	44.7
1999	429	10.5	37.5	52.0	1999	347	13.8	42.1	44.1
2000	430	9.3	36.0	54.7	2000	383	17.5	43.1	39.4
2001	419	10.3	29.6	60.1	2001	374	16.0	46.3	37.7
2002	459	15.9	32.2	51.9	2002	425	13.4	49.7	36.9
2003	459	13.7	38.3	48.0	2003	439	10.0	44.6	45.4
2004	459	14.2	37.9	47.9	2004	440	11.1	47.1	41.8
2005	458	19.0	42.8	38.2	2005	449	16.0	51.9	32.1
ALL REGIONS	Number of trees	0-10%	>10-25%	>25%					
1990	748	15.6	28.9	55.5					
1991	761	16.0	28.6	55.4					
1992	761	13.8	32.9	53.3					
1993	757	9.5	29.2	61.3					
1994	756	12.4	31.2	56.4					
1995	785	11.1	34.1	54.8					
1996	795	11.8	35.0	53.2					
1997	780	11.4	39.4	49.2					
1998	802	14.6	36.8	48.6					
1999	804	12.9	39.6	47.5					
2000	817	13.1	39.4	47.5					
2001	793	13.0	37.5	49.5					
2002	884	14.7	40.6	44.7					
2003	898	11.9	41.4	46.7					
2004	903	12.6	42.5	44.9					
2005	911	17.7	47.2	35.1					

Picea sitchensis

ATLANTIC (NORTH)	Number of trees	0-10%	>10-25%	>25%	ALL REGIONS	Number of trees	0-10%	>10-25%	>25%
1990	294	61.2	28.6	10.2	1990	294	61.2	28.6	10.2
1991	285	45.9	30.2	23.9	1991	285	45.9	30.2	23.9
1992	286	45.8	29.7	24.5	1992	286	45.8	29.7	24.5
1993	287	33.4	29.3	37.3	1993	287	33.4	29.3	37.3
1994	266	35.7	39.1	25.2	1994	266	35.7	39.1	25.2
1995	259	39.0	33.6	27.4	1995	259	39.0	33.6	27.4
1996	265	52.1	29.8	18.1	1996	265	52.1	29.8	18.1
1997	269	61.4	24.5	14.1	1997	269	61.4	24.5	14.1
1998	288	51.7	29.5	18.8	1998	288	51.7	29.5	18.8
1999	266	72.9	16.2	10.9	1999	266	72.9	16.2	10.9
2000	267	65.9	22.5	11.6	2000	267	65.9	22.5	11.6
2001	262	62.3	22.1	15.6	2001	262	62.3	22.1	15.6
2002	266	49.6	31.6	18.8	2002	266	49.6	31.6	18.8
2003	245	61.3	26.9	11.8	2003	245	61.3	26.9	11.8
2004	250	60.4	20.8	18.8	2004	250	60.4	20.8	18.8
2005	251	63.0	21.1	15.9	2005	251	63.0	21.1	15.9

All species

ATLANTIC (NORTH)	Number of trees	0-10%	>10-25%	>25%	ATLANTIC (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1990	2729	47.8	34.3	17.9	1990	1668	66.6	14.0	19.4
1991	2729	44.8	34.8	20.4	1991	1555	56.6	21.7	21.7
1992	2718	41.4	37.8	20.8	1992	1799	64.3	23.2	12.5
1993	2710	38.8	35.6	25.6	1993	1782	61.3	27.3	11.4
1994	2693	38.5	36.8	24.7	1994	1608	59.2	28.7	12.1
1995	2642	36.2	37.6	26.2	1995	1704	58.8	33.0	8.2
1996	2624	37.0	39.9	23.1	1996	1560	51.4	37.9	10.7
1997	2605	42.0	38.0	20.0	1997	1680	56.1	35.2	8.7
1998	2628	45.8	36.2	18.0	1998	1704	49.3	38.3	12.4
1999	2754	45.9	35.4	18.7	1999	2376	55.2	37.1	7.7
2000	2726	43.6	36.2	20.2	2000	2376	48.6	37.2	14.2
2001	2765	45.7	36.4	17.9	2001	2376	42.8	48.5	8.7
2002	2746	43.6	37.9	18.5	2002	2376	36.6	50.1	13.3
2003	2724	43.7	37.2	19.1	2003	2376	34.8	51.9	13.3
2004	2746	43.4	33.9	22.7	2004	2376	35.6	48.9	15.5
2005	2776	45.0	37.2	17.8	2005	2316	31.8	51.5	16.7
SUB-ATLANTIC	Number of trees	0-10%	>10-25%	>25%	MEDITERR. (HIGHER)	Number of trees	0-10%	>10-25%	>25%
1990	18600	21.3	43.3	35.4	1990	3636	78.4	16.9	4.7
1991	18638	17.8	43.2	39.0	1991	3586	60.3	30.8	8.9
1992	18707	15.2	43.0	41.8	1992	3600	50.9	36.0	13.1
1993	18654	15.6	42.1	42.3	1993	3600	46.8	40.8	12.4
1994	18016	11.6	40.5	47.9	1994	3612	43.0	39.6	17.4
1995	18056	14.8	39.6	45.6	1995	3684	34.0	44.9	21.1
1996	18005	19.0	46.1	34.9	1996	3660	36.1	46.1	17.8
1997	18052	18.3	49.2	32.5	1997	3636	40.2	46.3	13.5
1998	19727	19.5	48.8	31.7	1998	3636	42.9	45.9	11.2
1999	19765	18.6	52.6	28.8	1999	4356	40.0	48.3	11.7
2000	19847	17.8	52.6	29.6	2000	4326	39.2	49.7	11.1
2001	19547	17.1	52.5	30.4	2001	4326	33.6	53.1	13.3
2002	19570	16.9	53.2	29.9	2002	4326	30.4	53.7	15.9
2003	19577	15.6	54.0	30.4	2003	4326	28.7	56.6	14.7
2004	19591	13.0	51.9	35.1	2004	4326	28.5	56.6	14.9
2005	19505	15.1	52.2	32.7	2005	4326	20.6	57.6	21.8
MEDITERR. (LOWER)	Number of trees	0-10%	>10-25%	>25%	MOUNTAINOUS (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1990	8715	67.4	18.5	14.1	1990	5271	45.5	31.8	22.7
1991	8634	57.5	26.5	16.0	1991	5336	42.3	35.7	22.0
1992	8853	50.8	32.7	16.5	1992	5347	32.4	40.7	26.9
1993	8622	51.6	38.6	9.8	1993	5320	31.6	40.6	27.8
1994	8578	46.8	39.4	13.8	1994	5232	28.0	42.2	29.8
1995	8394	32.6	46.2	21.2	1995	5506	27.2	47.0	25.8
1996	8424	36.3	47.1	16.6	1996	5498	29.2	45.4	25.4
1997	8435	37.0	50.9	12.1	1997	5458	28.9	46.1	25.0
1998	8454	38.1	48.9	13.0	1998	6074	35.2	42.5	22.3
1999	10038	33.7	51.5	14.8	1999	6633	36.7	43.8	19.5
2000	10188	31.5	54.1	14.4	2000	6763	33.3	47.0	19.7
2001	10218	30.5	56.6	12.9	2001	6647	28.2	50.6	21.2
2002	10248	28.5	57.2	14.3	2002	6745	24.3	53.4	22.3
2003	9978	25.7	57.4	16.9	2003	6794	19.8	53.7	26.5
2004	9888	27.9	56.6	15.5	2004	6734	19.9	51.3	28.8
2005	9527	15.3	59.9	24.8	2005	6736	25.1	50.4	24.5

All species

Annex I-8

BOREAL (TEMP.)	Number of trees	0-10%	>10-25%	>25%	CONTINENTAL	0-10%	>10-25%	>25%	0-10%
1990	1920	28.9	34.1	37.0	1990	1133	60.9	19.2	19.9
1991	2424	22.6	37.7	39.7	1991	1151	64.0	19.1	16.9
1992	2396	18.7	37.5	43.8	1992	1151	62.3	18.2	19.5
1993	2420	20.1	41.9	38.0	1993	1162	56.9	18.5	24.6
1994	2257	27.1	43.7	29.2	1994	1140	53.9	17.9	28.2
1995	2262	34.4	46.2	19.4	1995	1160	61.5	15.9	22.6
1996	2368	31.8	50.1	18.1	1996	1117	65.3	15.0	19.7
1997	2297	30.0	53.5	16.5	1997	1073	66.9	14.9	18.2
1998	2326	30.4	53.6	16.0	1998	1155	66.5	16.0	17.5
1999	2348	25.2	57.9	16.9	1999	1230	71.9	13.7	14.4
2000	2256	18.8	61.1	20.1	2000	1230	67.7	13.6	18.7
2001	2325	18.0	65.9	16.1	2001	1211	64.1	18.9	17.0
2002	2340	19.7	66.7	13.6	2002	1182	63.5	17.3	19.2
2003	2293	21.4	65.9	12.7	2003	1182	58.0	18.3	23.7
2004	2290	21.3	65.8	12.9	2004	1422	62.1	16.5	21.4
2005	2263	21.5	65.2	13.3	2005	1375	66.0	15.4	18.6
ALL REGIONS	Number of trees	0-10%	>10-25%	>25%					
1990	43672	42.9	32.1	25.0					
1991	44053	36.5	35.8	27.7					
1992	44571	32.2	38.1	29.7					
1993	44270	31.6	39.5	28.9					
1994	43136	28.6	39.3	32.1					
1995	43408	26.7	41.6	31.7					
1996	43256	29.3	44.9	25.8					
1997	43236	29.8	47.1	23.1					
1998	45704	31.2	46.1	22.7					
1999	49500	30.9	48.4	20.7					
2000	49712	28.7	49.7	21.6					
2001	49415	26.8	51.9	21.3					
2002	49533	25.2	52.8	22.0					
2003	49250	23.1	53.6	23.3					
2004	49373	22.9	51.6	25.5					
2005	48824	21.2	52.7	26.1					

Annex I-9

Development of defoliation of most common species (1997-2005).

Picea abies

ATLANTIC (NORTH)	Number of trees	0-10%	>10-25%	>25%	SUB-ATLANTIC	Number of trees	0-10%	>10-25%	>25%
1997	1285	64.4	23.1	12.5	1997	8253	20.9	31.0	48.1
1998	1314	57.2	30.2	12.6	1998	7269	30.3	34.2	35.5
1999	1336	55.0	31.9	13.1	1999	7551	31.1	34.0	34.9
2000	1333	56.5	26.8	16.7	2000	7527	28.6	35.7	35.7
2001	1216	61.6	25.5	12.9	2001	7323	26.7	37.9	35.4
2002	1196	60.0	24.9	15.1	2002	7380	26.9	35.2	37.9
2003	1178	55.2	27.8	17.0	2003	7434	26.6	36.9	36.5
2004	1162	52.6	30.1	17.3	2004	7483	24.3	34.0	41.7
2005	1131	52.6	26.7	20.7	2005	7380	25.1	37.0	37.9
MEDITERR. (HIGHER)	Number of trees	0-10%	>10-25%	>25%	MEDITERR. (LOWER)	Number of trees	0-10%	>10-25%	>25%
1997	116	40.5	41.4	18.1	1997	84	76.2	15.5	8.3
1998	116	26.7	42.3	31.0	1998	77	41.5	36.4	22.1
1999	128	27.3	45.4	27.3	1999	88	55.7	26.1	18.2
2000	128	25.8	51.5	22.7	2000	83	63.9	25.3	10.8
2001	116	31.0	42.3	26.7	2001	82	67.1	20.7	12.2
2002	103	35.0	47.5	17.5	2002	109	42.2	29.4	28.4
2003	116	44.8	36.2	19.0	2004	102	36.2	36.2	27.5
2004	115	47.8	33.9	18.3	2004	102	30.4	36.3	33.3
2005	122	51.6	27.9	20.5	2005	103	30.1	41.7	28.2
MOUNTAIN-IOUS (NORTH)	Number of trees	0-10%	>10-25%	>25%	MOUNTAIN-IOUS (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1997	735	44.8	21.5	33.7	1997	5372	55.4	26.7	17.9
1998	728	45.5	20.2	34.3	1998	5803	53.4	27.3	19.3
1999	724	48.9	22.9	28.2	1999	5927	55.4	27.6	17.0
2000	713	47.5	26.6	25.9	2000	6105	53.6	28.8	17.6
2001	791	53.6	18.7	27.7	2001	5994	51.7	30.5	17.8
2002	837	49.1	23.4	27.5	2002	5957	51.2	31.4	17.4
2003	862	54.2	20.5	25.3	2003	6001	47.7	34.6	17.7
2004	916	61.0	19.3	19.7	2004	5985	44.7	32.9	22.4
2005	974	58.6	19.5	21.9	2005	5632	44.9	34.0	21.1
BOREAL	Number of trees	0-10%	>10-25%	>25%	BOREAL (TEMPERATE)	Number of trees	0-10%	>10-25%	>25%
1997	5804	40.9	32.1	27.0	1997	4653	37.6	42.6	19.8
1998	5877	39.7	33.9	26.4	1998	4587	38.4	41.3	20.3
1999	5863	40.0	32.9	27.1	1999	4559	33.6	42.8	23.6
2000	5779	37.3	36.6	26.1	2000	4566	38.2	41.8	20.0
2001	5738	35.0	35.4	29.6	2001	4548	35.9	45.2	18.9
2002	5700	37.5	35.9	26.6	2002	4558	45.9	41.7	12.4
2003	5639	36.0	35.4	28.6	2003	4587	41.2	43.7	15.1
2004	6207	38.6	35.7	25.7	2004	4539	39.8	41.2	19.0
2005	6194	38.9	36.4	24.7	2005	4562	42.2	38.6	19.2
CONTINENTAL	Number of trees	0-10%	>10-25%	>25%	ALL REGIONS	Number of trees	0-10%	>10-25%	>25%
1997	551	33.9	30.7	35.4	1997	26908	38.4	31.7	29.9
1998	511	34.4	29.2	36.4	1998	26341	40.9	33.1	26.0
1999	502	37.2	31.1	31.7	1999	26728	40.9	33.3	25.8
2000	465	31.6	34.9	33.5	2000	26748	40.0	34.6	25.4
2001	463	42.5	29.4	28.1	2001	26320	38.8	35.5	25.7
2002	455	37.2	32.5	30.3	2002	26344	40.6	34.7	24.7
2003	447	33.5	33.5	32.9	2003	26415	38.5	36.2	25.3
2004	395	37.2	37.7	25.1	2004	26953	37.6	34.7	27.7
2005	430	48.9	30.9	20.2	2005	26575	38.5	35.2	26.3

Pinus sylvestris

ATLANTIC (NORTH)	Number of trees	0-10%	>10-25%	>25%	ATLANTIC (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1997	1165	49.9	41.2	8.9	1997	216	59.3	24.5	16.2
1998	1243	47.9	42.8	9.3	1998	216	52.3	36.1	11.6
1999	1318	45.0	42.3	12.7	1999	217	43.7	42.9	13.4
2000	1361	43.5	42.8	13.7	2000	212	57.5	32.1	10.4
2001	1360	36.5	49.8	13.7	2001	211	51.7	33.6	14.7
2002	1362	42.9	41.0	16.1	2002	212	44.8	42.9	12.3
2003	1379	42.9	43.1	14.0	2003	210	48.6	35.7	15.7
2004	1370	45.0	40.7	14.3	2004	210	50.9	36.7	12.4
2005	1413	45.1	42.3	12.6	2005	212	58.0	27.4	14.6
SUB-ATLANTIC	Number of trees	0-10%	>10-25%	>25%	MEDITERR. (HIHGER)	Number of trees	0-10%	>10-25%	>25%
1997	10366	18.8	48.5	32.7	1997	785	40.3	44.8	14.9
1998	10650	19.8	52.9	27.3	1998	786	41.3	45.0	13.7
1999	10676	20.0	54.9	25.1	1999	875	45.5	43.8	10.7
2000	10684	18.2	55.9	25.9	2000	872	47.7	42.7	9.6
2001	10678	17.3	57.4	25.3	2001	875	47.8	39.5	12.7
2002	10546	15.7	57.7	26.6	2002	876	43.1	41.3	15.6
2003	10587	14.0	58.9	27.1	2003	871	37.3	47.4	15.3
2004	10639	14.0	56.5	29.5	2004	872	36.9	45.9	17.2
2005	10613	16.7	52.9	30.4	2005	870	33.0	49.3	17.7
MEDITERR. (LOWER)	Number of trees	0-10%	>10-25%	>25%	MOUNTAIN-IOUS (NORTH)	Number of trees	0-10%	>10-25%	>25%
1997	138	49.3	35.5	15.2	1997	823	47.0	36.6	16.4
1998	138	50.7	34.1	15.2	1998	823	44.7	39.4	15.9
1999	155	49.0	31.6	19.4	1999	826	48.3	37.5	14.2
2000	154	41.6	43.5	14.9	2000	825	52.8	36.5	10.7
2001	154	38.3	46.1	15.6	2001	843	53.6	36.2	10.2
2002	154	37.0	44.2	18.8	2002	841	49.5	38.6	11.9
2003	155	31.6	49.0	19.4	2003	851	54.6	35.3	10.1
2004	155	29.0	52.9	18.1	2004	871	62.9	28.7	8.4
2005	156	35.3	46.1	18.6	2005	863	58.8	30.9	10.3
MOUNTAIN-IOUS (SOUTH)	Number of trees	0-10%	>10-25%	>25%	BOREAL	Number of trees	0-10%	>10-25%	>25%
1997	2561	23.7	37.4	38.9	1997	7815	65.0	28.2	6.8
1998	2623	26.0	32.1	41.9	1998	7823	65.7	28.7	5.6
1999	2562	31.3	34.1	34.6	1999	7807	65.6	28.5	5.9
2000	2185	28.1	40.9	31.0	2000	7837	65.9	29.3	4.8
2001	2128	36.4	37.7	25.9	2001	7904	59.7	32.3	8.0
2002	2119	27.1	44.6	28.3	2002	7955	58.4	35.5	6.1
2003	2388	19.3	50.6	30.1	2003	7931	55.6	37.4	7.0
2004	2293	19.9	45.7	34.4	2004	9536	59.6	34.9	5.5
2005	2157	17.7	47.1	35.2	2005	9803	61.9	33.1	5.0
BOREAL (TEMP.)	Number of trees	0-10%	>10-25%	>25%	CONTINENTAL	Number of trees	0-10%	>10-25%	>25%
1997	10654	17.3	52.1	30.6	1997	435	44.2	17.2	38.6
1998	10679	21.8	50.9	27.3	1998	449	50.2	12.2	37.6
1999	10631	19.3	57.1	23.6	1999	370	58.6	23.0	18.4
2000	10576	23.4	57.2	19.4	2000	503	55.9	26.2	17.9
2001	10650	21.3	60.9	17.8	2001	544	43.9	37.7	18.4
2002	10611	31.9	57.1	11.0	2002	500	44.0	32.6	23.4
2003	10610	35.9	54.5	9.6	2003	482	38.2	38.4	23.4
2004	10576	36.7	53.9	9.4	2004	451	35.0	41.5	23.5
2005	10592	36.0	54.6	9.4	2005	478	35.8	34.9	29.3
ALL REGIONS	Number of trees	0-10%	>10-25%	>25%					
1997	34958	31.9	43.1	25.0					
1998	35430	33.8	43.8	22.4					
1999	35437	33.6	46.5	19.9					
2000	35209	34.4	47.5	18.1					
2001	35347	32.2	49.9	17.9					
2002	35176	34.2	49.6	16.2					
2003	35464	33.5	50.3	16.2					
2004	36973	36.0	47.7	16.3					
2005	37157	37.2	46.4	16.4					

Fagus sylvatica

ATLANTIC (NORTH)	Number of trees	0-10%	>10-25%	>25%	ATLANTIC (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1997	965	38.5	40.6	20.9	1997	252	35.7	43.7	20.6
1998	966	31.3	46.7	22.0	1998	229	46.7	47.2	6.1
1999	993	24.9	49.8	25.3	1999	230	42.2	51.7	6.1
2000	994	22.8	43.9	33.3	2000	238	53.8	39.5	6.7
2001	1011	31.0	43.6	25.4	2001	239	59.4	38.1	2.5
2002	1029	25.2	46.2	28.6	2002	240	36.7	53.3	10.0
2003	1034	30.1	45.8	24.1	2003	239	31.4	53.5	15.1
2004	1041	18.7	40.1	41.2	2004	241	16.2	63.9	19.9
2005	1066	34.2	39.7	26.1	2005	243	30.9	49.3	19.8
SUB-ATLANTIC	Number of trees	0-10%	>10-25%	>25%	MEDITERR. (HIGHER)	Number of trees	0-10%	>10-25%	>25%
1997	3184	27.0	51.1	21.9	1997	762	38.6	34.9	26.5
1998	3366	28.5	48.4	23.1	1998	787	36.0	35.7	28.3
1999	3503	24.0	52.0	24.0	1999	892	34.2	38.9	26.9
2000	3434	27.5	48.1	24.4	2000	893	33.7	41.9	24.4
2001	3458	24.3	47.1	28.6	2001	910	28.9	41.4	29.7
2002	3489	27.8	49.1	23.1	2002	874	30.1	44.0	25.9
2003	3513	25.8	50.5	23.7	2003	849	29.4	49.3	21.3
2004	3534	17.8	46.3	35.9	2004	853	26.3	48.7	25.0
2005	3528	18.8	51.8	29.4	2005	929	30.7	47.1	22.2
MEDITERR. (LOWER)	Number of trees	0-10%	>10-25%	>25%	MOUNTAINOUS (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1997	617	47.5	31.9	20.6	1997	3433	36.5	44.0	19.5
1998	630	47.1	32.7	20.2	1998	3527	40.3	42.1	17.6
1999	828	36.8	37.5	25.7	1999	3643	36.9	43.6	19.5
2000	827	36.2	38.6	25.2	2000	3869	39.8	41.9	18.3
2001	833	28.5	39.9	31.6	2001	3665	31.3	46.8	21.9
2002	822	31.4	45.9	22.7	2002	3717	33.4	46.2	20.4
2003	790	31.6	48.1	20.3	2003	3755	29.6	45.3	25.1
2004	851	26.9	49.0	24.1	2004	3612	28.0	48.5	23.5
2005	827	40.4	41.2	18.4	2005	3663	36.8	41.6	21.6
CONTINENTAL	Number of trees	0-10%	>10-25%	>25%	ALL REGIONS	Number of trees	0-10%	>10-25%	>25%
1997	1636	48.0	32.9	19.1	1997	10854	36.4	42.8	20.8
1998	1754	46.7	34.7	18.6	1998	11264	37.2	42.4	20.4
1999	1448	51.1	26.5	22.4	1999	11542	33.6	43.9	22.5
2000	1436	49.4	27.6	23.0	2000	11697	35.5	41.8	22.7
2001	1576	48.3	28.2	23.5	2001	11699	31.7	43.0	25.3
2002	1636	51.8	30.1	18.1	2002	11814	33.2	44.9	21.9
2003	1559	50.2	31.8	18.0	2003	11746	31.4	45.7	22.9
2004	1509	49.1	35.5	15.4	2004	11648	26.3	45.8	27.9
2005	1543	53.2	32.9	13.9	2005	11806	33.0	43.9	23.1

Quercus ilex and *Q. rotundifolia*

MEDITERR. (HIGHER)	Number of trees	0-10%	>10-25%	>25%	MEDITERR. (LOWER)	Number of trees	0-10%	>10-25%	>25%
1997	865	25.8	53.4	20.8	1997	2567	27.9	55.3	16.8
1998	815	32.3	50.8	16.9	1998	2552	29.5	54.7	15.8
1999	936	25.9	55.0	19.1	1999	3190	21.4	56.4	22.2
2000	930	26.3	54.9	18.8	2000	3211	17.2	60.2	22.6
2001	931	24.3	58.4	17.3	2001	3225	19.1	64.2	16.7
2002	931	17.6	60.3	22.1	2002	3212	17.4	63.6	19.0
2003	933	20.2	56.5	23.3	2003	3186	13.9	64.8	21.3
2004	957	19.7	60.2	20.1	2004	3188	19.7	63.0	17.3
2005	962	10.8	55.2	34.0	2005	3156	9.2	66.4	24.4
MOUNTAINOUS (SOUTH)	Number of trees	0-10%	>10-25%	>25%	ALL REGIONS	Number of trees	0-10%	>10-25%	>25%
1997	155	24.5	41.3	34.2	1997	3677	27.2	54.6	18.2
1998	155	25.2	64.5	10.3	1998	3612	30.0	54.2	15.8
1999	240	30.0	54.2	15.8	1999	4456	23.0	56.0	21.0
2000	281	31.7	56.9	11.4	2000	4512	20.3	58.5	21.2
2001	282	25.2	53.9	20.9	2001	4528	20.6	62.0	17.4
2002	281	22.4	44.1	33.5	2002	4514	17.8	61.5	20.7
2003	237	16.0	42.2	41.8	2003	4446	15.8	61.3	22.9
2004	281	19.6	48.7	31.7	2004	4516	19.9	61.4	18.7
2005	239	12.6	52.3	35.1	2005	4448	10.0	62.8	27.2

Pinus pinaster

ATLANTIC (SOUTH)	Number of trees	0-10%	>10-25%	>25%	MEDITERR. (HIGHER)	Number of trees	0-10%	>10-25%	>25%
1997	1279	58.0	28.6	13.4	1997	475	65.5	20.2	14.3
1998	1283	41.8	41.7	16.5	1998	466	65.4	25.8	8.8
1999	1458	58.0	34.4	7.6	1999	544	57.7	29.8	12.5
2000	1409	58.4	33.2	8.4	2000	511	58.2	29.5	12.3
2001	1421	54.4	38.8	6.8	2001	510	59.2	35.1	5.7
2002	1401	52.3	38.3	9.4	2002	512	51.4	41.4	7.2
2003	1373	49.2	39.5	11.3	2003	512	47.6	42.0	10.4
2004	1372	48.1	38.3	13.6	2004	506	51.6	35.8	12.6
2005	1292	45.5	43.0	11.5	2005	505	40.4	46.1	13.5
MEDITERR. (LOWER)	Number of trees	0-10%	>10-25%	>25%	MOUNTAIN. (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1997	1546	42.6	45.6	11.8	1997	71	78.8	12.7	8.5
1998	1520	43.8	46.1	10.1	1998	69	71.1	15.9	13.0
1999	1754	42.9	47.4	9.7	1999	134	79.2	10.4	10.4
2000	1754	45.9	45.9	8.2	2000	130	76.9	13.1	10.0
2001	1746	46.4	47.0	6.6	2001	129	69.8	18.6	11.6
2002	1742	46.9	45.9	7.2	2002	129	58.2	30.2	11.6
2003	1552	43.8	45.0	11.2	2003	129	47.3	40.3	12.4
2004	1500	42.5	42.1	15.4	2004	128	50.0	41.4	8.6
2005	1354	35.2	42.9	21.9	2005	128	53.1	35.2	11.7
ALL REGIONS	Number of trees	0-10%	>10-25%	>25%					
1997	3371	52.4	34.9	12.7					
1998	3338	46.6	40.9	12.5					
1999	3890	51.9	38.8	9.3					
2000	3804	53.2	37.9	8.9					
2001	3806	51.9	41.4	6.7					
2002	3784	49.9	42.0	8.1					
2003	3566	46.5	42.3	11.2					
2004	3506	46.4	39.6	14.0					
2005	3279	40.7	43.2	16.1					

Quercus suber

MEDITERR. (LOWER)	Number of trees	0-10%	>10-25%	>25%	ALL REGIONS	Number of trees	0-10%	>10-25%	>25%
1997	1434	33.9	53.1	13.0	1997	1502	36.7	50.8	12.5
1998	1434	26.9	57.6	15.5	1998	1501	29.6	55.6	14.8
1999	1541	23.4	56.9	19.7	1999	1632	25.6	55.1	19.3
2000	1563	21.5	61.8	16.7	2000	1654	22.9	61.0	16.1
2001	1564	22.2	58.6	19.2	2001	1654	22.8	58.9	18.3
2002	1587	22.3	59.5	18.2	2002	1678	22.6	59.6	17.8
2003	1571	19.4	54.1	26.5	2003	1638	20.0	54.4	25.6
2004	1587	20.6	52.9	26.5	2004	1655	21.8	52.5	25.7
2005	1529	3.9	60.3	35.8	2005	1593	5.5	59.9	34.6

Quercus robur and *Q. petraea*

ATLANTIC (NORTH)	Number of trees	0-10%	>10-25%	>25%	ATLANTIC (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1997	1230	24.2	46.3	29.5	1997	1431	20.3	40.4	39.3
1998	1296	25.1	45.5	29.4	1998	1450	25.7	40.0	34.3
1999	1299	21.7	48.3	30.0	1999	1475	25.6	48.0	26.4
2000	1287	28.1	51.2	20.7	2000	1495	29.8	44.5	25.7
2001	1294	18.8	49.7	31.5	2001	1483	25.0	46.8	28.2
2002	1300	17.8	48.2	34.0	2002	1488	21.6	50.0	28.4
2003	1292	16.8	48.9	34.3	2003	1502	17.1	46.6	36.3
2004	1294	15.8	47.1	37.1	2004	1502	19.2	45.2	35.6
2005	1322	15.8	47.1	37.1	2005	1484	14.4	48.1	37.5
SUB-ATLANTIC	Number of trees	0-10%	>10-25%	>25%	MEDITERR. (HIGHER)	Number of trees	0-10%	>10-25%	>25%
1997	2606	11.3	46.4	42.3	1997	213	16.0	44.6	39.4
1998	2666	16.0	44.7	39.3	1998	219	19.2	42.0	38.8
1999	2727	16.9	50.5	32.6	1999	221	24.9	44.3	30.8
2000	2736	14.7	51.2	34.1	2000	220	23.2	46.8	30.0
2001	2739	14.3	51.9	33.8	2001	224	17.4	51.3	31.3
2002	2748	16.0	52.3	31.7	2002	217	13.4	53.4	33.2
2003	2750	11.3	48.7	40.0	2003	213	10.3	53.5	36.2
2004	2764	10.0	45.6	44.4	2004	220	8.6	50.9	40.5
2005	2776	9.1	43.4	47.5	2005	214	9.3	49.1	41.6

Quercus robur* and *Q. petraea

MEDITERR. (LOWER)	Number of trees	0-10%	>10-25%	>25%	MOUNTAINOUS (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1997	515	21.4	40.5	38.1	1997	682	14.4	30.2	55.4
1998	585	20.0	39.0	41.0	1998	726	14.5	36.0	49.5
1999	632	23.9	43.7	32.4	1999	708	13.8	40.3	45.9
2000	629	26.1	39.9	34.0	2000	778	14.3	40.6	45.1
2001	630	27.3	45.4	27.3	2001	672	17.4	41.7	40.9
2002	635	26.0	48.8	25.2	2002	661	12.6	46.4	41.0
2003	628	23.7	50.0	26.3	2003	678	13.6	45.1	41.3
2004	645	28.1	45.7	26.2	2004	752	16.4	40.6	43.0
2005	688	28.8	41.8	29.4	2005	686	14.4	37.3	48.3
BOREAL (TEMPERATE)	Number of trees	0-10%	>10-25%	>25%	CONTINENTAL	Number of trees	0-10%	>10-25%	>25%
1997	308	15.9	43.2	40.9	1997	841	20.1	34.8	45.1
1998	303	23.1	42.6	34.3	1998	850	21.5	35.3	43.2
1999	289	14.9	48.8	36.3	1999	780	29.7	33.5	36.8
2000	310	27.1	42.3	30.6	2000	813	23.9	25.2	50.9
2001	312	22.1	48.7	29.2	2001	812	23.9	28.6	47.5
2002	304	31.6	51.3	17.1	2002	651	24.0	30.1	45.9
2003	307	18.2	48.6	33.2	2003	645	19.7	36.9	43.4
2004	308	21.8	41.5	36.7	2004	678	21.2	35.7	43.1
2005	310	25.2	44.8	30.0	2005	767	25.7	31.6	42.7
ALL REGIONS	Number of trees	0-10%	>10-25%	>25%					
1997	7836	17.2	42.1	40.7					
1998	8105	20.3	41.6	38.1					
1999	8140	21.0	46.3	32.7					
2000	8276	21.9	45.1	33.0					
2001	8174	19.6	46.8	33.6					
2002	8010	19.0	48.7	32.3					
2003	8022	15.3	47.4	37.3					
2004	8169	16.0	44.5	39.5					
2005	8253	15.4	43.3	41.3					

Abies alba

SUB-ATLANTIC	Number of trees	0-10%	>10-25%	>25%	MEDITERR. (HIGHER)	Number of trees	0-10%	>10-25%	>25%
1997	640	30.9	28.4	40.7	1997	125	30.4	17.6	52.0
1998	647	29.4	29.1	41.5	1998	123	32.5	13.8	53.7
1999	688	29.2	32.0	38.8	1999	141	31.2	17.7	51.1
2000	647	29.5	29.8	40.7	2000	141	28.4	17.7	53.9
2001	637	30.0	25.3	44.7	2001	128	24.2	18.8	57.0
2002	679	32.8	27.4	39.8	2002	129	26.4	19.4	54.2
2003	678	30.2	32.3	37.5	2003	128	25.0	19.5	55.5
2004	682	29.8	33.0	37.2	2004	128	21.1	19.5	59.4
2005	678	32.7	35.4	31.9	2005	130	23.1	17.7	59.2
MOUNTAINOUS (SOUTH)	Number of trees	0-10%	>10-25%	>25%	CONTINENTAL	Number of trees	0-10%	>10-25%	>25%
1997	1055	35.4	33.7	30.9	1997	176	17.6	26.7	55.7
1998	1046	34.4	35.7	29.9	1998	181	16.0	30.9	53.1
1999	1070	32.6	38.5	28.9	1999	170	20.0	28.8	51.2
2000	1109	34.8	38.1	27.1	2000	164	15.2	33.5	51.3
2001	1057	36.9	38.6	24.5	2001	164	29.9	31.1	39.0
2002	1079	34.9	38.0	27.1	2002	166	28.3	36.2	35.5
2003	1128	31.1	37.4	31.5	2003	166	21.1	46.4	32.5
2004	1127	35.1	35.0	29.9	2004	171	28.1	32.2	39.7
2005	1118	35.8	40.4	23.8	2005	184	28.3	29.3	42.4
ALL REGIONS	Number of trees	0-10%	>10-25%	>25%					
1997	2060	32.2	31.0	36.8					
1998	2060	31.4	32.1	36.5					
1999	2131	30.8	34.1	35.1					
2000	2098	31.6	33.6	34.8					
2001	2020	33.6	32.5	33.9					
2002	2086	33.4	33.3	33.3					
2003	2135	30.1	35.3	34.6					
2004	2145	32.3	33.2	34.5					
2005	2147	33.8	36.3	29.9					

Picea sitchensis

ATLANTIC (NORTH)	Number of trees	0-10%	>10-25%	>25%	ALL REGIONS	Number of trees	0-10%	>10-25%	>25%
1997	972	42.8	39.3	17.9	1997	995	44.1	38.4	17.5
1998	1017	36.5	37.6	25.9	1998	1039	37.8	36.9	25.3
1999	923	44.9	34.9	20.2	1999	945	46.2	34.1	19.7
2000	970	41.4	35.8	22.8	2000	992	42.7	35.0	22.3
2001	941	37.4	38.8	23.8	2001	963	38.5	38.2	23.3
2002	921	29.4	41.3	29.3	2002	943	30.2	41.2	28.6
2003	900	28.2	41.5	30.3	2003	922	29.2	41.2	29.6
2004	881	32.6	38.9	28.5	2004	902	33.5	38.7	27.8
2005	881	36.2	38.3	25.5	2005	902	37.7	37.4	24.9

All species

ATLANTIC (NORTH)	Number of trees	0-10%	>10-25%	>25%	ATLANTIC (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1997	6919	46.0	37.5	16.5	1997	5720	45.0	31.6	23.4
1998	7109	42.8	39.4	17.8	1998	5724	42.9	35.2	21.9
1999	7190	42.0	39.9	18.1	1999	6336	49.3	35.8	14.9
2000	7247	43.2	38.0	18.8	2000	6215	48.8	34.6	16.6
2001	7137	40.7	39.7	19.6	2001	6215	45.7	39.9	14.4
2002	7159	38.9	39.0	22.1	2002	6196	39.6	42.5	17.9
2003	7120	37.9	40.3	21.8	2003	6136	35.6	41.2	23.2
2004	7109	35.1	39.7	25.2	2004	6096	34.5	41.6	23.9
2005	7188	38.1	39.1	22.8	2005	5976	32.0	43.9	24.1
SUB-ATLANTIC	Number of trees	0-10%	>10-25%	>25%	MEDITERR. (HIGHER)	Number of trees	0-10%	>10-25%	>25%
1997	28382	22.0	42.3	35.7	1997	7402	33.5	39.6	26.9
1998	28077	25.9	44.2	29.9	1998	7387	36.4	41.3	22.3
1999	28774	26.0	46.2	27.8	1999	8423	34.3	43.7	22.0
2000	28572	24.8	46.6	28.6	2000	8379	32.9	45.7	21.4
2001	28348	23.4	47.5	29.1	2001	8389	28.7	46.4	24.9
2002	28414	22.9	47.9	29.2	2002	8235	27.3	47.5	25.2
2003	28437	20.9	48.6	30.5	2003	8233	25.0	49.9	25.1
2004	28594	18.7	46.2	35.1	2004	8401	25.4	49.7	24.9
2005	28441	20.3	46.3	33.4	2005	8375	23.2	48.4	28.4
MEDITERR. (LOWER)	Number of trees	0-10%	>10-25%	>25%	MOUNTAINOUS (NORTH)	Number of trees	0-10%	>10-25%	>25%
1997	12101	35.3	46.6	18.1	1997	2632	42.7	34.3	23.0
1998	12099	34.8	46.5	18.7	1998	2673	42.7	33.7	23.6
1999	14446	31.4	49.0	19.6	1999	2672	43.9	34.7	21.4
2000	14542	29.5	50.9	19.6	2000	2686	46.6	35.8	17.6
2001	14604	28.1	52.4	19.5	2001	2864	48.9	32.4	18.7
2002	14691	26.6	53.3	20.1	2002	2975	44.9	34.8	20.3
2003	14266	24.2	53.6	22.2	2003	3025	47.9	33.0	19.1
2004	14323	26.0	52.9	21.1	2004	3302	51.4	28.7	19.9
2005	13888	19.5	53.0	27.5	2005	3425	53.0	28.7	18.3
MOUNTAINOUS (SOUTH)	Number of trees	0-10%	>10-25%	>25%	BOREAL	0-10%	>10-25%	>25%	0-10%
1997	17746	38.2	34.8	27.0	1997	15922	56.1	29.3	14.6
1998	18560	39.1	33.5	27.4	1998	15978	55.6	30.5	13.9
1999	19778	39.7	35.4	24.9	1999	15892	55.5	30.0	14.5
2000	20029	38.8	36.7	24.5	2000	15870	53.9	32.7	13.4
2001	19692	37.0	37.9	25.1	2001	15860	50.0	33.7	16.3
2002	19268	36.2	39.2	24.6	2002	15879	50.3	35.8	13.9
2003	19516	32.8	41.3	25.9	2003	15808	48.4	36.4	15.2
2004	19617	31.3	41.1	27.6	2004	18659	52.1	35.0	12.9
2005	18914	32.9	41.8	25.3	2005	19011	54.1	33.8	12.1
BOREAL (TEMP.)	Number of trees	0-10%	>10-25%	>25%	CONTINENTAL	Number of trees	0-10%	>10-25%	>25%
1997	19935	27.1	48.0	24.9	1997	6405	35.5	32.1	32.4
1998	19893	29.2	47.3	23.5	1998	6922	33.7	31.8	34.5
1999	19801	25.6	52.8	21.6	1999	6167	41.8	29.9	28.3
2000	19815	28.7	52.6	18.7	2000	6323	38.7	27.9	33.4
2001	19933	27.5	55.5	17.0	2001	6538	39.4	31.2	29.4
2002	19906	37.0	51.8	11.2	2002	6418	37.9	34.6	27.5
2003	19942	37.5	50.3	12.2	2003	6174	34.5	35.9	29.6
2004	19815	38.0	49.4	12.6	2004	6013	36.5	36.1	27.4
2005	19827	38.6	49.5	11.9	2005	6283	41.8	32.7	25.5

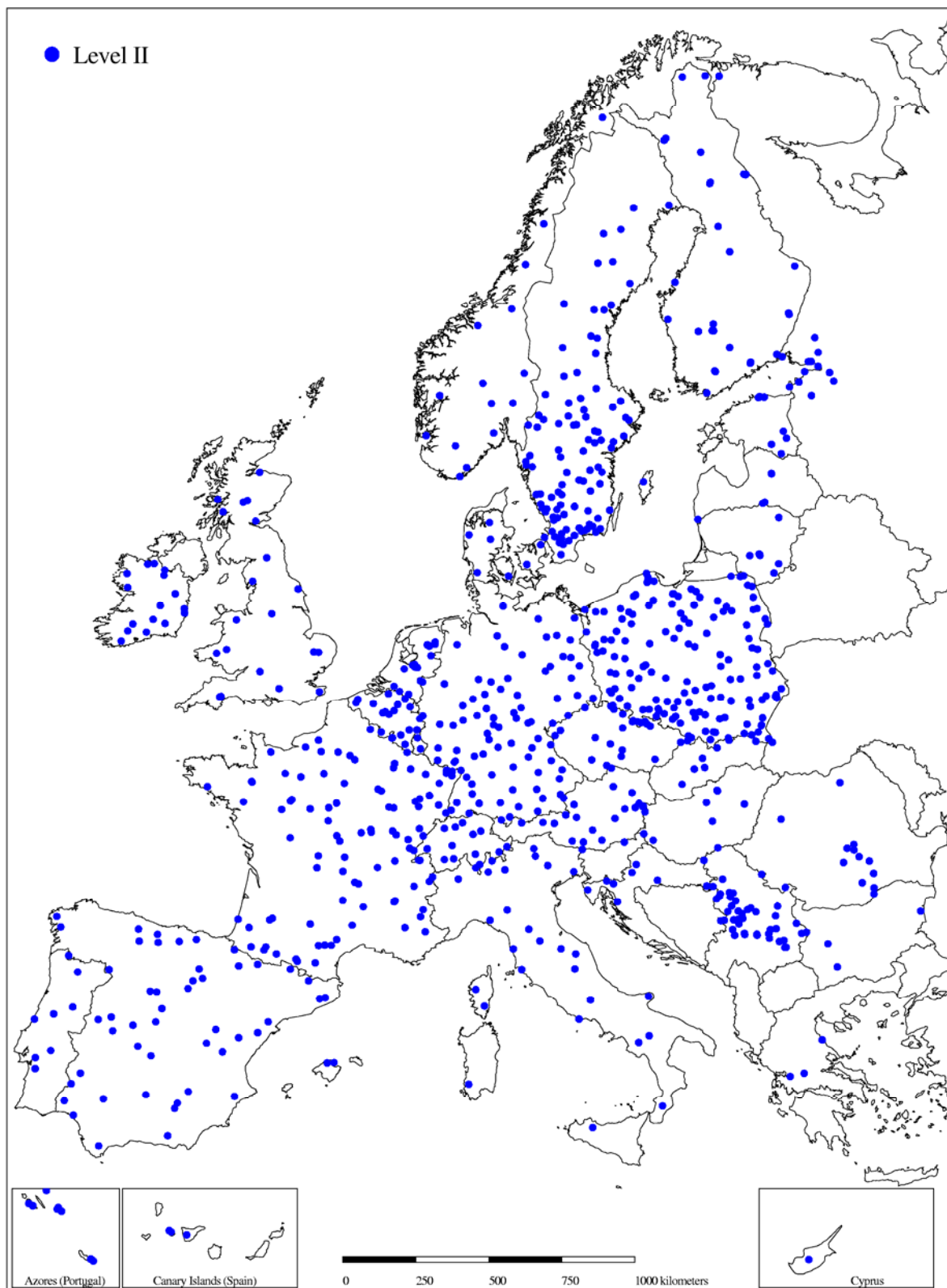
All species

ALL REGIONS	Number of trees	0-10%	>10-25%	>25%
1997	123164	35.1	39.3	25.6
1998	124422	36.2	39.8	24.0
1999	129479	35.9	41.9	22.2
2000	129678	35.5	42.5	22.0
2001	129580	33.6	44.1	22.3
2002	129141	34.1	44.6	21.3
2003	128657	32.2	45.1	22.7
2004	131929	32.7	43.8	23.5
2005	131328	33.3	43.5	23.2

Period 1990 - 2005				Period 1997 - 2005		
Year	No. of trees N	Mean defoliation \bar{x}	Standard error $s \bar{x} = s/\sqrt{N}$	No. of trees N	Mean defoliation \bar{x}	Standard error $s \bar{x} = s/\sqrt{N}$
<i>Pinus sylvestris</i>						
1990	11630	24.3	0.15			
1991	11877	26.2	0.14			
1992	11887	26.9	0.14			
1993	11924	26.6	0.14			
1994	11292	27.7	0.14			
1995	11113	26.0	0.14			
1996	11154	23.3	0.13			
1997	11115	22.5	0.12	34958	20.7	0.08
1998	11608	21.9	0.12	35430	20.0	0.08
1999	11847	21.3	0.11	35437	19.3	0.07
2000	11764	21.9	0.12	35209	18.8	0.07
2001	11794	21.8	0.11	35347	19.2	0.07
2002	11670	22.4	0.12	35176	18.6	0.07
2003	11708	22.5	0.12	35464	18.7	0.07
2004	11741	22.7	0.12	36973	18.4	0.07
2005	11705	22.6	0.13	37157	18.3	0.07
<i>Picea abies</i>						
1990	6485	22.4	0.22			
1991	6634	22.5	0.21			
1992	6660	23.3	0.20			
1993	6584	24.3	0.22			
1994	6553	25.7	0.23			
1995	6700	24.6	0.23			
1996	6707	22.3	0.21			
1997	6615	22.9	0.20	26908	20.4	0.10
1998	7887	22.0	0.18	26341	19.2	0.10
1999	7855	21.8	0.18	26728	19.3	0.10
2000	7779	22.9	0.18	26748	19.4	0.10
2001	7504	22.7	0.17	26320	19.4	0.10
2002	7523	23.3	0.18	26344	19.1	0.10
2003	7568	23.2	0.18	26415	19.6	0.10
2004	7484	25.3	0.19	26953	20.3	0.10
2005	7400	23.3	0.18	26575	20.2	0.11
<i>Quercus robur</i> and <i>Q. petraea</i>						
1990	2633	21.0	0.34			
1991	2640	23.4	0.33			
1992	2609	24.1	0.32			
1993	2615	26.2	0.32			
1994	2559	27.6	0.34			
1995	2643	26.9	0.34			
1996	2619	27.9	0.36			
1997	2651	26.3	0.32	7836	27.1	0.20
1998	2764	25.9	0.31	8105	26.0	0.20
1999	2839	23.8	0.28	8140	24.2	0.18
2000	2868	23.5	0.28	8276	24.1	0.18
2001	2879	23.7	0.27	8174	24.6	0.18
2002	2889	23.3	0.27	8010	23.9	0.17
2003	2902	24.6	0.26	8022	25.9	0.17
2004	2998	26.6	0.30	8169	26.7	0.18
2005	3029	25.5	0.29	8253	26.9	0.18

Period 1990 - 2005				Period 1997 - 2005		
Year	No. of trees	Mean defoliation	Standard error	No. of trees	Mean defoliation	Standard error
	N	\bar{x}	$s_{\bar{x}} = s/\sqrt{N}$	N	\bar{x}	$s_{\bar{x}} = s/\sqrt{N}$
<i>Fagus sylvatica</i>						
1990	4014	17.9	0.22			
1991	4063	17.2	0.21			
1992	4090	20.8	0.23			
1993	4108	20.0	0.24			
1994	3947	21.6	0.22			
1995	4126	22.2	0.22			
1996	4091	21.1	0.21			
1997	4162	20.6	0.20	10854	19.3	0.15
1998	4416	19.5	0.20	11264	18.9	0.14
1999	4567	20.6	0.19	11542	19.8	0.14
2000	4636	20.5	0.21	11697	19.8	0.15
2001	4639	21.5	0.20	11699	20.8	0.14
2002	4648	20.0	0.19	11814	19.9	0.14
2003	4677	21.7	0.20	11746	20.3	0.14
2004	4693	24.2	0.22	11648	22.3	0.14
2005	4719	22.2	0.21	11806	20.4	0.14
<i>Pinus pinaster</i>						
1990	2654	13.2	0.30			
1991	2589	15.8	0.37			
1992	2599	14.0	0.33			
1993	2452	12.1	0.33			
1994	2542	12.5	0.31			
1995	2381	12.8	0.28			
1996	2350	14.6	0.36			
1997	2333	15.5	0.33	3371	16.3	0.31
1998	2332	15.8	0.32	3338	16.7	0.27
1999	2886	16.5	0.32	3890	15.8	0.27
2000	2859	17.8	0.38	3804	16.5	0.31
2001	2842	14.7	0.23	3806	14.4	0.21
2002	2840	15.4	0.24	3784	15.3	0.22
2003	2622	16.1	0.27	3566	16.4	0.25
2004	2579	18.6	0.37	3506	18.1	0.31
2005	2375	18.9	0.36	3279	18.4	0.30
<i>Quercus ilex</i> and <i>Q. rotundifolia</i>						
1990	3074	13.8	0.25			
1991	3064	16.0	0.22			
1992	3080	17.4	0.24			
1993	3055	16.0	0.17			
1994	3027	19.6	0.29			
1995	3052	24.0	0.28			
1996	3034	22.6	0.27			
1997	3034	19.4	0.25	3677	20.4	0.24
1998	3026	18.5	0.23	3612	19.3	0.21
1999	3820	21.1	0.23	4456	21.2	0.21
2000	3852	20.9	0.19	4512	21.1	0.18
2001	3853	20.2	0.19	4528	20.7	0.18
2002	3857	21.2	0.18	4514	21.7	0.18
2003	3859	22.3	0.22	4446	22.8	0.21
2004	3855	20.3	0.17	4516	21.0	0.18
2005	3832	23.8	0.18	4448	24.3	0.18

Annex I-10
Level II plots for which data are available



Annex II-1

Forests and surveys in European countries (2005)

Participating countries	Total area (1000 ha)	Forest area (1000 ha)	Coniferous forest (1000 ha)	Broadleav. forest (1000 ha)	Area surveyed (1000 ha)	Grid size (km x km)	No. of sample plots	No. of sample trees
Albania	2875	1036	172	607	no survey in 2005			
Andorra	47	17	15	2	no survey in 2005			
Austria	8385	3878	2683	798	3481	16 x 16	136	3528
Belarus	20760	7812	4685	3127	7812	16 x 16	406	9490
Belgium	3035	691	281	324	691	4 ² / 8 ²	132	3126
Bulgaria	11100	4064	1289	2775	4064	4 ² /8 ² /16 ²	139	4817
Croatia	5654	2061	321	1740	2061	16 x 16	86	2046
Cyprus	925	298	172	0	138	16x16	15	360
Czech Republic	7886	2630	2057	573	2630	8 ² /16 ²	138	6128
Denmark	4300	468	294	174	468	7 ² /16 ²	22	528
Estonia	4510	2285	1142	1143	2285	16 x 16	92	2167
Finland	30460	20302	18058	1962	20020	16 ² / 24x32	609	11535
France	54926	14591	9228	4058	1305	16 x 16	509	10129
Germany	35562	11076	6084	4236	10890	16 ² / 4 ²	451	13630
Greece	12890	2512	954	1080	2512	16 x 16	72	1697
Hungary	9300	1851	239	1612	1851	4 x 4	1218	28506
Ireland	7028	680	399	37	436	16 x 16	22	382
Italy	30128	8675	1735	6940	8675	16 x 16	238	6573
Latvia	6459	2944	1563	1230	2944	8 x 8	349	8208
Liechtenstein	16	8	6	2	no survey in 2005			
Lithuania	6520	2091	1155	833	1988	8x8/16x16	262	6315
Luxembourg	259	89	30	54	no survey in 2005			
Rep. of Moldova	3376	318	6	312	318	2x2/2x4	528	14575
The Netherlands	3482	334	158	52	210	16 x 16	11	229
Norway	32376	12000	6800	5200	12000	3 ² /9 ²	1595	8497
Poland	31268	8756	6868	1970	6868	16 x 16	1298	25960
Portugal	8893	3234	1081	2153	3234	16 x 16	119	3570
Romania	23750	6244	1929	4315	6244	4 x 4	6132	100718
Russian Fed.	11100	8125			no survey in 2005			
Serbia and Montenegro	8836	2360	179	2181	1868	16x16/4x4	129	2995
Slovak Republic	4901	1961	815	1069	1961	16 x 16	108	4111
Slovenia	2027	1099	410	688	1099	16 x 16	44	1056
Spain	50471	11588	5910	4056	11588	16 x 16	620	14880
Sweden	41000	23400	19600	900	20600	varying	3954	17610
Switzerland	4129	1186	818	368	1186	16 x 16	48	1031
Turkey	77945	20199	9426	10773	no survey in 2005			
Ukraine	60350	9400	3969	5347	4921	16 x 16	1329	26720
United Kingdom	24291	2825	1647	1178	2825	random	345	8280
TOTAL	651220	203088	112178	73869	149969	varying	21156	349397

Russian Federation: North-western and Central European parts only.
Serbia and Montenegro: Serbia only.

Annex II-2

Defoliation of all species by classes and class aggregates (2005)

Participating countries	Area surveyed (1000 ha)	No. of sample trees	0 none	1 slight	2 moderate	3+4 severe and dead	2+3+4
Albania			no survey in 2005				
Andorra			no survey in 2005				
Austria	3481	3528	50.5	34.7	11.7	3.1	14.8
Belarus	7812	9490	37.7	53.3	7.1	1.9	9.0
Belgium	691	3126	38.4	41.7	16.4	3.5	19.9
Bulgaria	4064	4817	22.4	42.6	27.1	7.9	35.0
Croatia		2046	36.3	36.6	23.8	3.3	27.1
Cyprus	138	360	20.0	69.2	10.8	0.0	10.8
Czech Republic	2630	6128	11.6	31.3	56.1	1.0	57.1
Denmark	468	528	68.8	21.8	8.1	1.3	9.4
Estonia	2285	2167	54.2	40.4	4.4	1.0	5.4
Finland	20020	11535	57.6	33.6	8.0	0.8	8.8
France	13100	10129	30.5	35.3	31.3	2.9	34.2
Germany	10890	13630	29.1	42.4	26.7	1.8	28.5
Greece	2512	1697	44.2	39.5	13.3	3.0	16.3
Hungary	1851	28506	38.8	40.2	15.2	5.8	21.0
Ireland	399	382	51.1	32.7	12.3	3.9	16.2
Italy	436	6573	25.6	41.5	28.3	4.6	32.9
Latvia	2944	8208	19.7	67.2	11.2	1.9	13.1
Liechtenstein			no survey in 2005				
Lithuania	1988	6315	14.1	74.9	9.0	2.0	11.0
Luxembourg			no survey in 2005				
Rep. of Moldova		14575	41.0	32.5	21.8	4.7	26.5
The Netherlands	210	229	55.2	14.6	28.4	1.8	30.2
Norway	12000	8497	44.2	34.2	17.6	4.0	21.6
Poland	6868	25960	12.2	57.1	28.2	2.5	30.7
Portugal	3234	3570	28.2	47.5	19.8	4.5	24.3
Romania	6244	100718	73.1	18.8	7.2	0.9	8.1
Russian Fed.			no survey in 2005				
Serbia and Montenegro	1868	2995	50.7	32.9	15.6	0.8	16.4
Slovak Republic	1961	4111	14.2	62.9	21.8	1.1	22.9
Slovenia	1099	1056	29.3	40.1	25.1	5.5	30.6
Spain	11588	14880	17.0	61.7	18.0	3.3	21.3
Sweden	20600	17610	46.1	35.5	14.8	3.6	18.4
Switzerland	1186	1031	28.8	43.1	19.4	8.7	28.1
Turkey			no survey in 2005				
Ukraine	4921	26720	62.6	28.7	7.6	1.1	8.7
United Kingdom	2825	8280	29.1	46.1	23.0	1.8	24.8

Serbia and Montenegro: Serbia only.

Note that some differences in the level of damage across national borders may be at least partly due to differences in standards used. This restriction, however, does not affect the reliability of the trends over time.

Annex II-3

Defoliation of conifers by classes and class aggregates (2005)

Participating countries	Coniferous forest (1000 ha)	No. of sample trees	0 none	1 slight	2 moderate	3+4 severe and dead	2+3+4
Albania	171		no survey in 2005				
Andorra	15		no survey in 2005				
Austria	2683	3140	50.7	34.2	11.9	3.2	15.1
Belarus	4685	6940	37.2	54.4	6.8	1.6	8.4
Belgium	281	1062	40.5	42.7	14.2	2.6	16.8
Bulgaria	1289	2585	9.0	45.6	35.7	9.7	45.4
Croatia	321	268	4.5	16.0	66.4	13.1	79.5
Cyprus	172	360	20.0	69.2	10.8	0.0	10.8
Czech Republic	2057	5023	9.7	27.6	61.7	1.0	62.7
Denmark	294	291	80.4	14.1	4.8	0.7	5.5
Estonia	1142	2051	52.7	41.7	4.6	1.0	5.6
Finland	18058	9539	56.7	34.1	8.4	0.8	9.2
France	9228	3503	51.7	27.5	18.8	2.0	20.8
Germany	6084	9392	31.0	44.1	23.6	1.3	24.9
Greece	954	938	48.5	36.5	12.3	2.7	15.0
Hungary	239	3950	36.4	41.6	15.9	6.1	22.0
Ireland	399	382	51.1	32.7	12.3	3.9	16.2
Italy	1735	1719	41.0	36.2	19.9	2.9	22.8
Latvia	1563	6021	16.1	70.7	11.3	1.9	13.2
Liechtenstein	6		no survey in 2005				
Lithuania	1155	4454	14.9	75.8	7.9	1.4	9.3
Luxembourg	30		no survey in 2005				
Rep. of Moldova	6	71	43.7	18.3	35.2	2.8	38.0
The Netherlands	158	151	78.8	3.3	17.2	0.7	17.9
Norway	6800	6426	47.2	33.1	16.3	3.4	19.7
Poland	6786	19860	12.3	58.1	27.2	2.4	29.6
Portugal	1081	965	47.5	35.4	16.5	0.6	17.1
Romania	1929	25627	79.6	15.7	3.9	0.8	4.7
Russian Fed.	5800		no survey in 2005				
Serbia and Montenegro	179	338	46.2	32.5	20.1	1.2	21.3
Slovak Republic	815	1781	5.6	59.1	33.4	1.9	35.3
Slovenia	410	410	28.1	38.1	27.3	6.5	33.8
Spain	5910	7511	20.4	60.2	16.2	3.2	19.4
Sweden	19600	16095	45.1	35.3	15.5	4.1	19.6
Switzerland	818	718	23.7	48.1	20.9	7.3	28.2
Turkey	9426		no survey in 2005				
Ukraine	3969	10635	63.0	28.9	7.0	1.1	8.1
United Kingdom	1647	4656	30.8	47.0	20.8	1.4	22.2

Russian Federation: North-western and Central European parts only.

Serbia and Montenegro: Serbia only.

Note that some differences in the level of damage across national borders may be at least partly due to differences in standards used. This restriction, however, does not affect the reliability of the trends over time.

Annex II-4

Defoliation of broadleaves by classes and class aggregates (2005)

Participating countries	Broadleav. forest (1000 ha)	No. of sample trees	0 none	1 slight	2 moderate	3+4 severe and dead	2+3+4
Albania	599		no survey in 2005				
Andorra			no survey in 2005				
Austria	798	388	48.7	38.4	10.6	2.3	12.9
Belarus	3108	2550	39.1	50.3	8.0	2.6	10.6
Belgium	324	2064	37.3	41.3	17.8	3.6	21.4
Bulgaria	2775	2232	37.8	39.1	17.1	6.0	23.1
Croatia	1740	1778	41.1	39.7	17.4	1.8	19.2
Cyprus			only conifers assessed				
Czech Republic	573	1105	19.8	48.2	30.7	1.3	32.0
Denmark	174	237	54.4	31.2	12.3	2.1	14.4
Estonia	1143	116	78.5	18.1	1.7	1.7	3.4
Finland	1962	1996	61.7	31.1	6.1	1.1	7.2
France	4058	6626	19.3	39.4	37.9	3.4	38.7
Germany	4236	4238	25.2	39.0	32.8	3.0	35.8
Greece	1080	759	38.7	43.4	14.6	3.3	17.9
Hungary	1612	24556	39.1	40.0	15.0	5.9	20.9
Ireland	37		only conifers assessed				
Italy	6940	4854	20.1	43.4	31.2	5.3	36.5
Latvia	1230	2187	29.6	57.5	11.0	1.9	12.9
Liechtenstein	2		no survey in 2005				
Lithuania	833	1861	12.1	72.5	11.6	3.8	15.4
Luxembourg	54		no survey in 2005				
Rep. of Moldova		14504	41.1	32.5	21.7	4.7	26.4
The Netherlands	52	81	11.1	35.8	49.4	3.7	53.1
Norway	5200	2071	34.8	37.6	21.8	5.8	27.6
Poland	1970	6100	12.0	53.9	31.4	2.7	34.1
Portugal	2153	2605	21.0	52.0	21.0	6.0	27.0
Romania	4315	75091	70.9	19.8	8.4	0.9	9.3
Russian Fed.	510		no survey in 2005				
Serbia and Montenegro	2181	2657	51.3	33.0	15.0	0.7	15.7
Slovak Republic	1069	2330	20.7	65.7	13.0	0.6	13.6
Slovenia	688	646	30.2	41.3	23.7	4.8	28.5
Spain	4056	7369	13.5	63.2	19.9	3.4	23.3
Sweden	900	1515	55.9	34.9	7.9	1.3	9.2
Switzerland	368	313	39.0	33.1	16.3	11.6	27.9
Turkey	10773		no survey in 2005				
Ukraine	5347	16085	62.2	28.6	8.0	1.2	9.2
United Kingdom	1178	3624	26.8	45.0	25.8	2.4	28.2

Norway: Special study on birch. Russian Federation: North-western and Central European parts only.

Serbia and Montenegro: Serbia only.

Note that some differences in the level of damage across national borders may be at least partly due to differences in standards used. This restriction, however, does not affect the reliability of the trends over time.

Annex II-5

Defoliation of all species (1994-2005)

Participating countries	All species Defoliation classes 2-4												change % points
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2004/ 2005
Albania					9.8	9.9	10.1	10.2	13.1		12.2		
Andorra											36.1		
Austria	7.8	6.6	7.9	7.1	6.7	6.8	8.9	9.7	10.2	11.1	13.1	14.8	1.7
Belarus	37.4	38.3	39.7	36.3	30.5	26.0	24.0	20.7	9.5	11.3	10.0	9.0	-1.0
Belgium	16.9	24.5	21.2	17.4	17.0	17.7	19.0	17.9	17.8	17.3	19.4	19.9	0.5
Bulgaria	28.9	38.0	39.2	49.6	60.2	44.2	46.3	33.8	37.1	33.7	39.7	35.0	-4.7
Croatia	28.8	39.8	30.1	33.1	25.6	23.1	23.4	25.0	20.6	22.0	25.2	27.1	1.9
Cyprus								8.9	2.8	18.4	12.2	10.8	-1.4
Czech Rep.	57.7	58.5	71.9	68.6	48.8	50.4	51.7	52.1	53.4	54.4	57.3	57.1	-0.2
Denmark	36.5	36.6	28.0	20.7	22.0	13.2	11.0	7.4	8.7	10.2	11.8	9.4	-2.4
Estonia	15.7	13.6	14.2	11.2	8.7	8.7	7.4	8.5	7.6	7.6	5.3	5.4	0.1
Finland	13.0	13.3	13.2	12.2	11.8	11.4	11.6	11.0	11.5	10.7	9.8	8.8	-1.0
France	8.4	12.5	17.8	25.2	23.3	19.7	18.3	20.3	21.9	28.4	31.7	34.2	2.5
Germany	24.4	22.1	20.3	19.8	21.0	21.7	23.0	21.9	21.4	22.5	31.4	28.5	-2.9
Greece	23.2	25.1	23.9	23.7	21.7	16.6	18.2	21.7	20.9			16.3	
Hungary	21.7	20.0	19.2	19.4	19.0	18.2	20.8	21.2	21.2	22.5	21.5	21.0	-0.5
Ireland	19.7	26.3	13.0	13.6	16.1	13.0	14.6	17.4	20.7	13.9	17.4	16.2	-1.2
Italy	19.5	18.9	29.9	35.8	35.9	35.3	34.4	38.4	37.3	37.6	35.9	32.9	-3.0
Latvia	30.0	20.0	21.2	19.2	16.6	18.9	20.7	15.6	13.8	12.5	12.5	13.1	0.6
Liechtenstein													
Lithuania	25.4	24.9	12.6	14.5	15.7	11.6	13.9	11.7	12.8	14.7	13.9	11.0	-2.9
Luxembourg	34.8	38.3	37.5	29.9	25.3	19.2	23.4						
Rep. of Moldova		40.4	41.2				29.1	36.9	42.5	42.4	34.0	26.5	-7.5
The Netherlands	19.4	32.0	34.1	34.6	31.0	12.9	21.8	19.9	21.7	18.0	27.5	30.2	2.7
Norway	27.5	28.8	29.4	30.7	30.6	28.6	24.3	27.2	25.5	22.9	20.7	21.6	0.9
Poland	54.9	52.6	39.7	36.6	34.6	30.6	32.0	30.6	32.7	34.7	34.6	30.7	-3.9
Portugal	5.7	9.1	7.3	8.3	10.2	11.1	10.3	10.1	9.6	13.0	16.6	24.3	7.7
Romania	21.2	21.2	16.9	15.6	12.3	12.7	14.3	13.3	13.5	12.6	11.7	8.1	-3.6
Russian Fed.	10.7	12.5						9.8	10.9				
Serbia and Montenegro			3.6	7.7	8.4	11.2	8.4	14.0	3.9	22.8	14.3	16.4	2.1
Slovak Rep.	41.8	42.6	34.0	31.0	32.5	27.8	23.5	31.7	24.8	31.4	26.7	22.9	-3.8
Slovenia	16.0	24.7	19.0	25.7	27.6	29.1	24.8	28.9	28.1	27.5	29.3	30.6	1.3
Spain	19.4	23.5	19.4	13.7	13.6	12.9	13.8	13.0	16.4	16.6	15.0	21.3	6.3
Sweden		14.2	17.4	14.9	14.2	13.2	13.7	17.5	16.8	19.2	16.5	18.4	1.9
Switzerland	18.2	24.6	20.8	16.9	19.1	19.0	29.4	18.2	18.6	14.9	29.1	28.1	-1.0
Turkey													
Ukraine	32.4	29.6	46.0	31.4	51.5	56.2	60.7	39.6	27.7	27.0	29.9	8.7	-21.2
United Kingdom	13.9	13.6	14.3	19.0	21.1	21.4	21.6	21.1	27.3	24.7	26.5	24.8	-1.7

Austria: From 2003 on, results are based on the 16x16 km transnational gridnet and must not be compared with previous years. *Czech Republic:* Only trees older than 60 years assessed until 1997. *France:* Due to methodological changes, only the time series 1993-94 and 1997-2005 are consistent, but not comparable to each other. *Italy:* Due to methodological changes, only the time series 1993-96 and 1997-2005 are consistent, but not comparable to each other. *Russian Federation:* North-western and Central European parts only. *United Kingdom:* The difference between 1992 and subsequent years is mainly due to a change of assessment method in line with that used in other States. *Ukraine:* Due to a denser gridnet since 2005, results must not be compared with previous years.

Note that some differences in the level of damage across national borders may be at least partly due to differences in standards used. This restriction, however, does not affect the reliability of the trends over time.

Annex II-6

Defoliation of conifers (1994-2005)

Participating countries	Conifers												change points
	Defoliation classes 2-4												
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2004/2005
Albania					12.0	12.1	12.3	12.4	15.5		14.0		
Andorra											36.1		
Austria	7.9	6.6	7.3	6.3	6.3	6.4	9.1	9.6	10.1	11.2	13.1	15.1	2.0
Belarus	44.0	43.9	43.1	41.2	33.9	28.9	26.1	23.4	9.7	9.5	8.9	8.4	-0.5
Belgium	21.2	21.0	25.8	19.2	13.5	15.5	19.5	17.5	19.7	18.6	15.6	16.8	1.2
Bulgaria	25.0	41.4	46.5	53.5	69.8	48.9	46.4	39.1	44.0	38.4	47.1	45.4	-1.7
Croatia	39.3	57.5	57.0	68.7	45.8	53.2	53.3	65.1	63.5	77.4	70.6	79.5	8.9
Cyprus								8.9	2.8	18.4	12.2	10.8	-1.4
Czech Rep.	59.0	60.7	74.9	71.9	54.6	57.4	58.3	58.1	60.1	60.7	62.6	62.7	0.1
Denmark	38.7	34.8	23.2	15.9	17.0	9.9	8.8	6.7	4.5	6.1	5.8	5.5	-0.3
Estonia	16.0	14.2	14.6	11.4	9.0	9.1	7.5	8.8	7.9	7.7	5.3	5.6	0.3
Finland	13.1	13.7	13.7	12.8	12.2	11.9	12.0	11.4	11.9	11.1	10.1	9.2	-0.9
France	8.2	9.2	13.5	16.2	16.8	14.1	12.0	14.0	15.2	18.9	18.6	20.8	2.2
Germany	21.6	18.3	16.7	15.4	19.0	19.2	19.6	20.0	19.8	20.1	26.3	24.9	-1.4
Greece	13.2	13.6	14.4	13.8	12.9	13.5	16.5	17.2	16.1			15.0	
Hungary	21.2	18.7	17.8	17.4	18.7	17.6	21.5	19.5	22.8	27.6	24.2	22.0	-2.2
Ireland	19.7	26.3	13.0	13.6	16.1	13.0	14.6	17.4	20.7	13.9	17.4	16.2	-1.2
Italy	15.0	19.4	25.1	28.1	25.5	23.1	19.2	19.1	20.5	20.4	21.7	22.8	1.1
Latvia	34.0	23.0	24.8	21.9	18.9	20.6	20.1	15.8	14.3	12.2	11.9	13.2	1.3
Liechtenstein													
Lithuania	26.3	26.6	12.9	13.9	13.6	11.5	12.0	9.8	9.3	10.7	10.2	9.3	-0.9
Luxembourg	12.8	12.9	12.7	8.0	10.5	8.7	7.0						
Rep. of Moldova		33.3	48.4							55.4	35.5	38.0	2.5
The Netherlands	27.7	45.4	43.5	45.3	43.2	14.5	23.5	20.7	17.5	9.4	17.2	17.9	0.7
Norway	22.4	24.0	25.1	28.5	27.5	24.3	21.8	25.1	24.1	21.2	16.7	19.7	3.0
Poland	55.6	54.5	40.5	36.8	34.6	30.6	32.1	30.3	32.5	33.2	33.4	29.6	-3.8
Portugal	5.4	6.6	5.6	7.8	6.6	6.0	4.3	4.3	3.6	5.3	10.8	17.1	6.3
Romania	15.5	15.2	10.4	10.3	9.0	9.1	9.8	9.6	9.9	9.8	7.6	4.7	-2.9
Russian Fed.	9.4	10.1	9.4	0.0				9.8	10.0				
Serbia and Monten.			4.4	7.9	6.0	9.2	10.0	21.3	7.3	39.6	19.8	21.3	1.5
Slovak Rep.	50.3	52.0	41.0	42.2	40.3	40.2	37.9	38.7	40.4	39.7	36.2	35.3	-0.9
Slovenia	19.0	33.6	26.0	32.5	36.7	38.0	34.5	32.2	31.4	35.3	37.4	33.8	-3.6
Spain	19.1	18.1	18.1	11.5	12.9	9.8	12.0	11.6	15.6	14.1	14.0	19.4	5.4
Sweden	16.2	14.5	16.9	15.9	15.0	13.6	13.5	18.4	17.7	20.4	16.0	19.6	3.6
Switzerland	19.6	23.2	21.4	19.9	19.7	18.3	33.0	19.1	19.9	13.3	27.4	28.2	0.8
Turkey													
Ukraine	34.8	25.7	45.8	32.7	64.9	50.0	47.3	16.8	14.6	15.4	11.4	8.1	-3.3
United Kingdom	15.0	13.0	13.9	17.0	19.8	20.1	20.2	20.6	25.1	25.8	23.2	22.2	-1.0

Austria: From 2003 on, results are based on the 16x16 km transnational gridnet and must not be compared with previous years. *Czech Republic:* Only trees older than 60 years assessed until 1997. *France:* Due to methodological changes, only the time series 1993-94 and 1997-2005 are consistent, but not comparable to each other. *Italy:* Due to methodological changes, only the time series 1993-96 and 1997-2005 are consistent, but not comparable to each other. *Russian Federation:* North-western and Central European parts only. *United Kingdom:* The difference between 1992 and subsequent years is mainly due to a change of assessment method in line with that used in other States. *Ukraine:* Due to a denser gridnet since 2005, results must not be compared with previous years. *Note that some differences in the level of damage across national borders may be at least partly due to differences in standards used. This restriction, however, does not affect the reliability of the trends over time.*

Annex II-7

Defoliation of broadleaves (1994-2005)

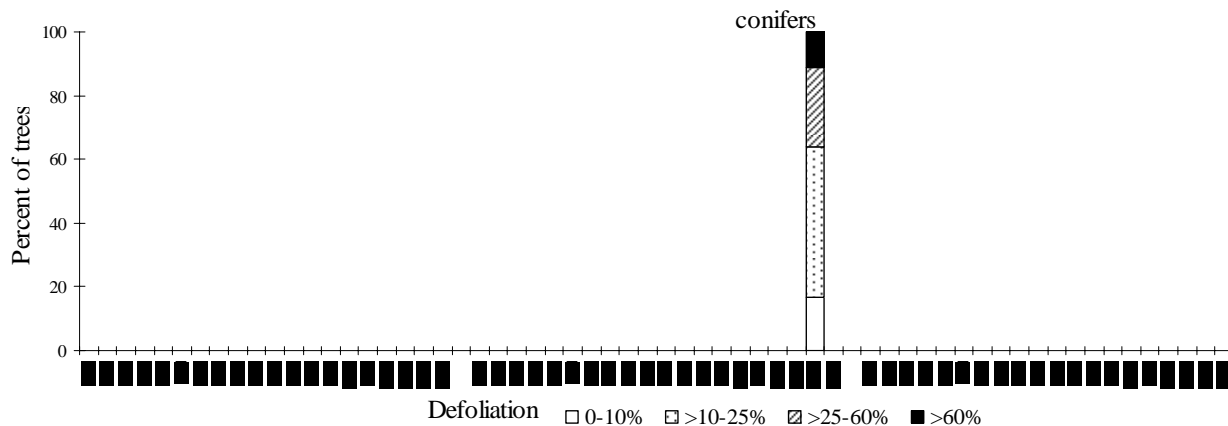
Participating countries	Broadleaves												change % points 2004/2005
	Defoliation classes 2-4												
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	
Albania					8.0	8.1	8.4	8.4	10.7		10.3		
Andorra									only conifers assessed				
Austria	7.4	6.5	11.6	12.2	9.6	9.4	7.6	10.4	11.3	10.2	13.6	12.9	-0.7
Belarus	18.6	22.9	29.2	23.0	19.3	17.0	16.9	13.3	9.0	15.8	12.9	10.6	-2.3
Belgium	12.8	26.6	18.5	16.1	19.2	19.1	18.8	18.3	17.0	16.6	21.3	21.4	0.1
Bulgaria	34.4	32.7	33.0	43.9	48.4	35.9	45.8	26.0	29.0	27.2	30.1	23.1	-7.0
Croatia	26.4	35.2	26.0	27.8	21.9	16.8	18.3	18.7	14.4	14.3	17.2	19.2	2.0
Cyprus									only conifers assessed				
Czech Rep.	48.0	30.6	34.0	26.5	13.5	17.1	21.4	21.7	19.9	24.4	31.8	32.0	0.2
Denmark	32.4	39.7	36.1	28.4	30.1	18.8	13.9	8.5	15.4	16.6	19.1	14.4	-4.7
Estonia	2.0	1.1	5.3	7.4	1.0	1.1	9.5	2.1	2.7	6.7	5.3	3.4	-1.9
Finland	12.0	11.0	10.3	8.4	9.4	8.6	9.9	8.8	8.8	8.3	8.4	7.2	-1.2
France	8.4	14.3	20.1	29.9	26.9	22.9	21.6	23.6	25.5	33.5	38.7	41.3	2.6
Germany	30.1	29.9	30.8	28.6	25.2	26.9	29.9	25.4	24.7	27.3	41.5	35.8	-5.7
Greece	35.0	38.2	34.6	34.9	31.7	20.2	20.2	26.6	26.5			17.9	
Hungary	21.8	20.2	19.5	19.7	19.0	18.2	20.8	21.5	20.8	22.0	21.0	20.9	-0.1
Ireland									only conifers assessed				
Italy	20.7	18.5	31.2	38.0	38.9	39.3	40.5	46.3	44.6	45.0	42.0	36.5	-5.5
Latvia	15.0	10.0	11.4	11.3	13.6	14.2	22.2	14.8	12.8	13.5	14.3	12.9	-1.4
Liechtenstein													
Lithuania	23.3	20.8	12.2	15.9	19.7	11.8	17.7	16.3	19.0	24.6	21.8	15.4	-6.4
Luxembourg	46.8	51.4	49.8	41.8	33.3	25.8	33.5						
Rep. of Moldova	21.9	40.5	41.1	30.0		41.4	29.2	36.9	42.5	42.3	33.9	26.4	-7.5
The Netherlands	5.1	10.8	19.2	17.8	14.0	10.0	18.8	18.5	29.6	33.7	46.9	53.1	6.2
Norway	47.6	47.4	45.0	38.9	42.2	44.8	34.0	33.7	30.4	29.0	33.2	27.6	-5.6
Poland	51.5	46.7	37.4	35.8	34.8	31.1	32.0	31.4	33.1	39.6	38.7	34.1	-4.6
Portugal	5.8	10.4	8.3	8.6	12.0	13.7	13.2	12.8	12.6	16.2	19.0	27.0	8.0
Romania	22.9	23.1	18.7	16.9	13.3	14.0	15.8	14.7	14.8	13.3	13.0	9.3	-3.7
Russian Fed.	39.4	34.4							16.0				
Serbia and Monten.			3.5	7.4	10.1	13.0	6.7	6.7	0.6	21.5	13.5	15.7	2.2
Slovak Rep.	35.6	35.8	28.0	23.3	27.0	19.3	13.9	26.9	14.5	25.6	19.9	13.6	-6.3
Slovenia	13.0	19.3	15.0	21.4	21.7	23.2	18.4	26.7	25.9	22.6	24.2	28.5	4.3
Spain	19.6	28.7	20.7	15.8	14.4	16.1	15.7	14.4	17.3	19.1	16.1	23.3	7.2
Sweden		7.9	20.7	6.1	7.4	8.7	7.5	14.1	9.6	11.1	8.3	9.2	0.9
Switzerland	16.2	27.0	19.8	12.5	18.1	20.4	22.1	16.3	16.0	18.1	32.8	27.9	-4.9
Turkey													
Ukraine	29.9	33.0	46.2	30.7	43.2	59.7	69.6	53.3	36.7	35.3	43.2	9.2	-34.0
United Kingd.	12.4	14.5	15.0	22.0	22.9	23.2	23.8	21.9	30.3	23.2	30.6	28.2	-2.4

Austria: From 2003 on, results are based on the 16x16 km transnational gridnet and must not be compared with previous years. *Czech Republic:* Only trees older than 60 years assessed until 1997. *France:* Due to methodological changes, only the time series 1993-94 and 1997-2005 are consistent, but not comparable to each other. *Italy:* Due to methodological changes, only the time series 1993-96 and 1997-2005 are consistent, but not comparable to each other. *Russian Federation:* North-western and Central European parts only. *United Kingdom:* The difference between 1992 and subsequent years is mainly due to a change of assessment method in line with that used in other States. *Ukraine:* Due to a denser gridnet since 2005,

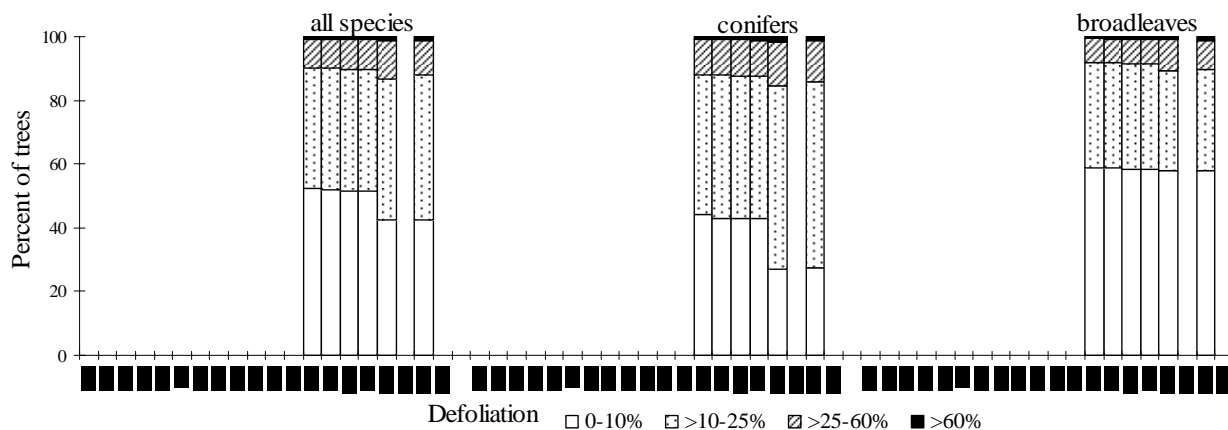
results must not be compared with previous years. *Note that some differences in the level of damage across national borders may be at least partly due to differences in standards used. This restriction, however, does not affect the reliability of the trends over time.*

Annex II-8
Changes in defoliation (1986-2005)

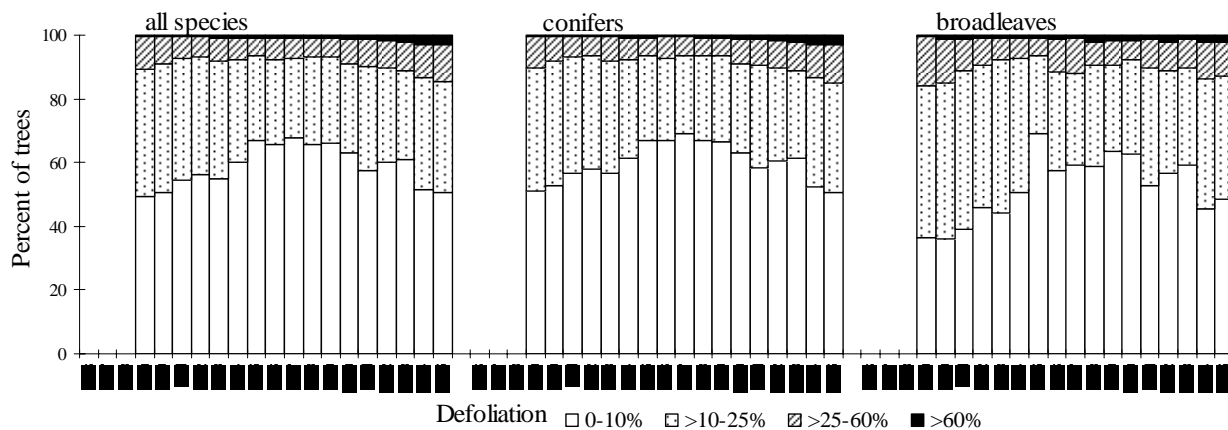
Andorra



Albania

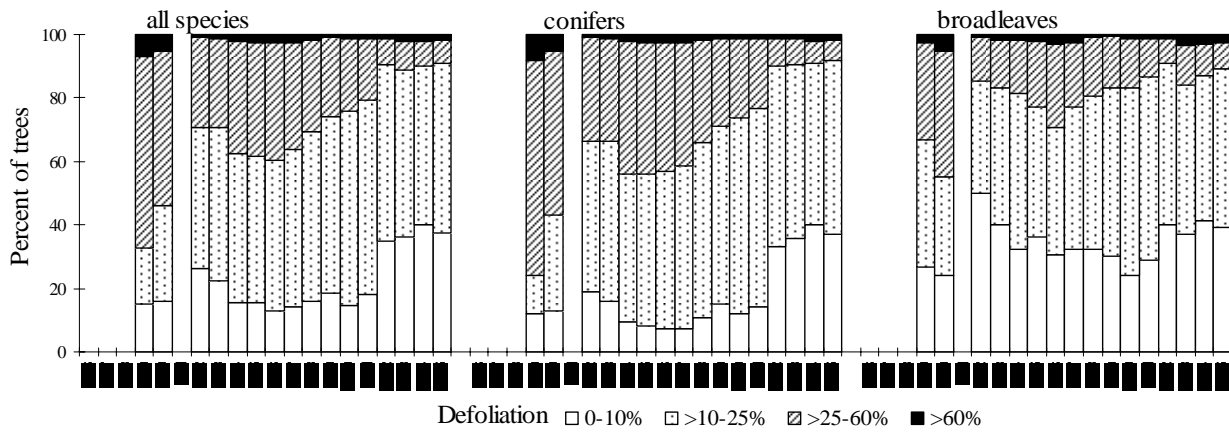


Austria *

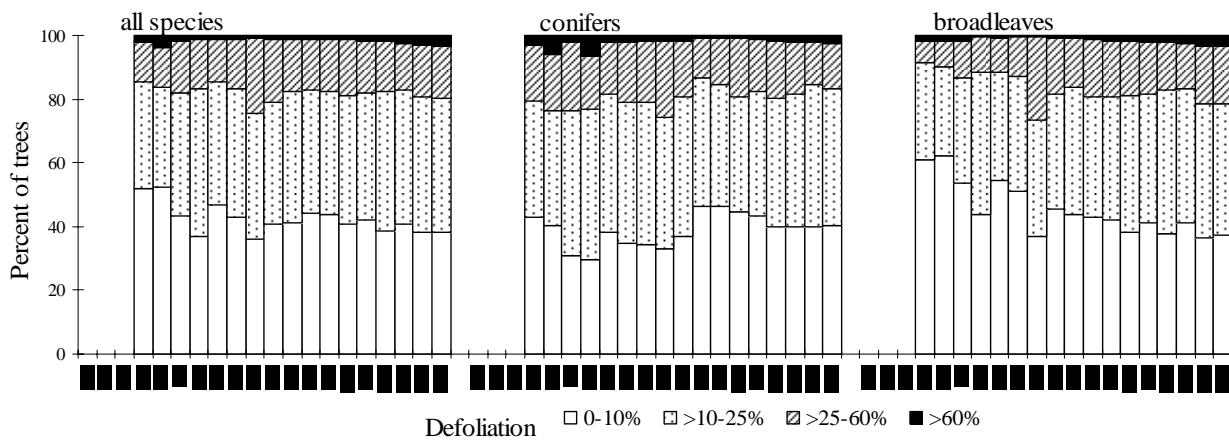


* from 2003 on, results are based on the 16x16 km transnational gridnet and must not be compared with previous years.

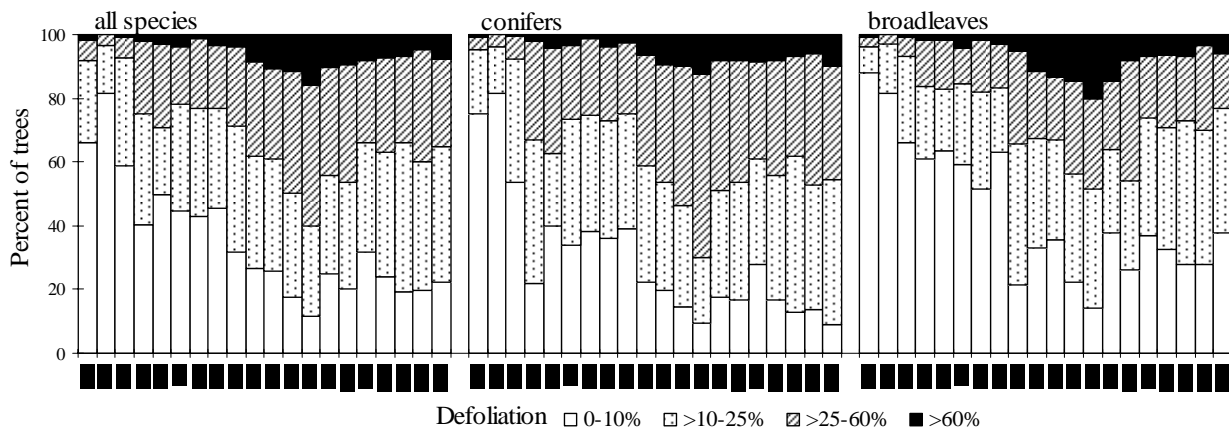
Belarus



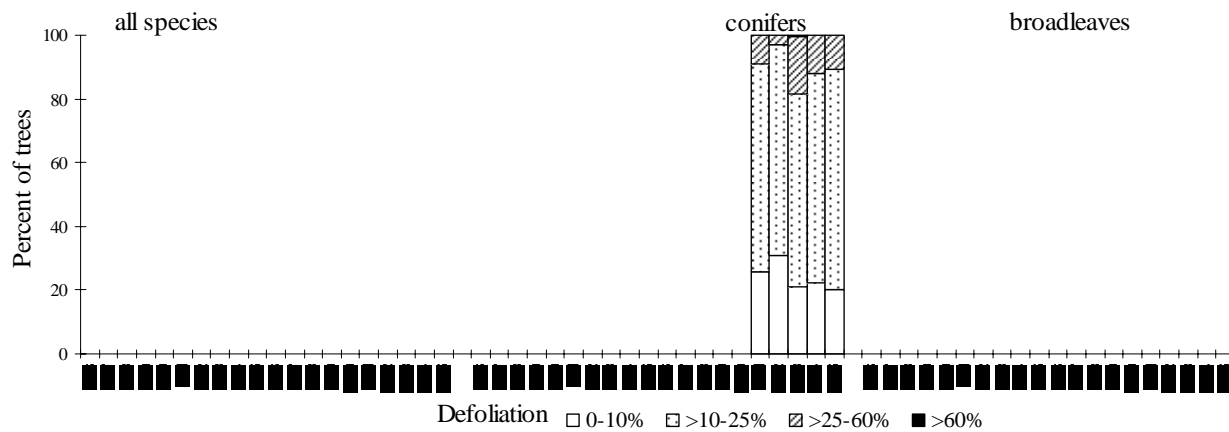
Belgium



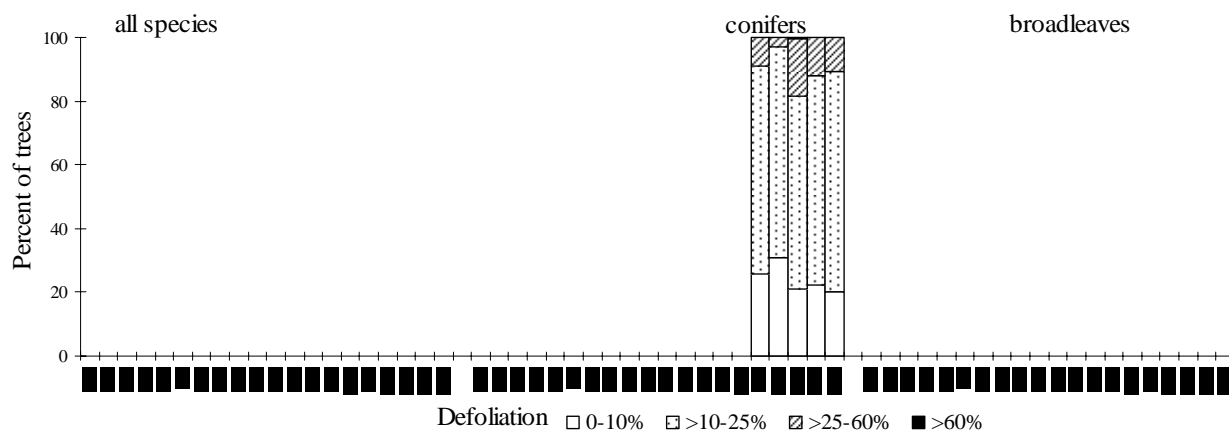
Bulgaria



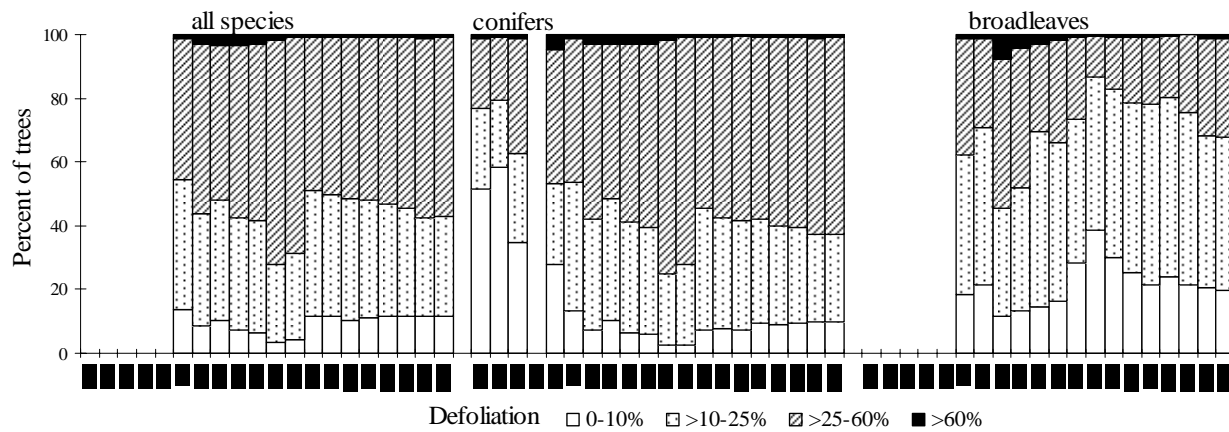
Croatia



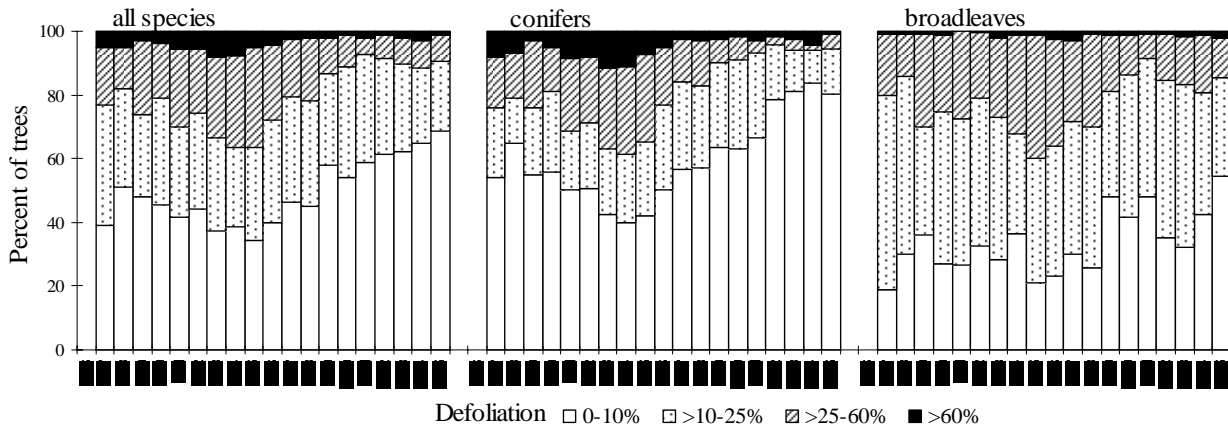
Cyprus



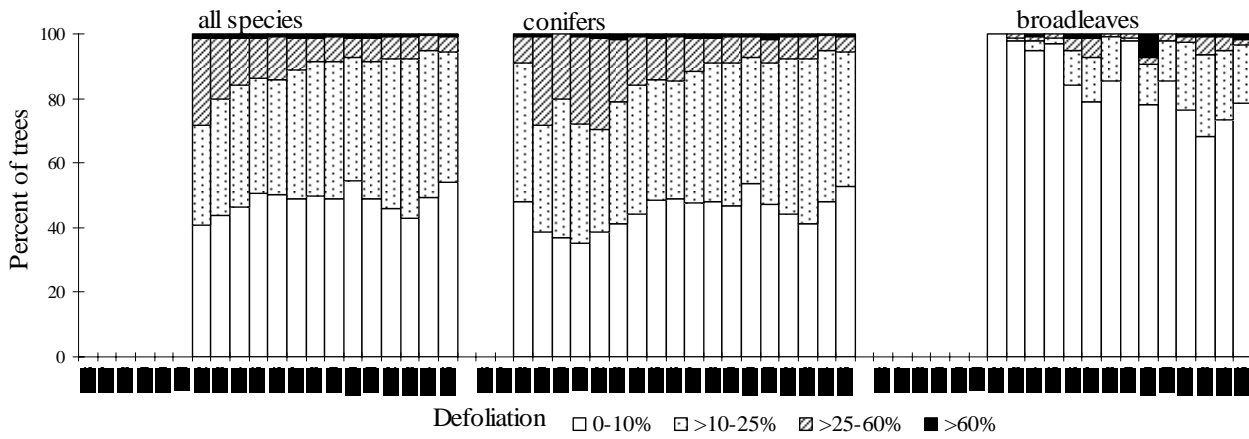
Czech Republic



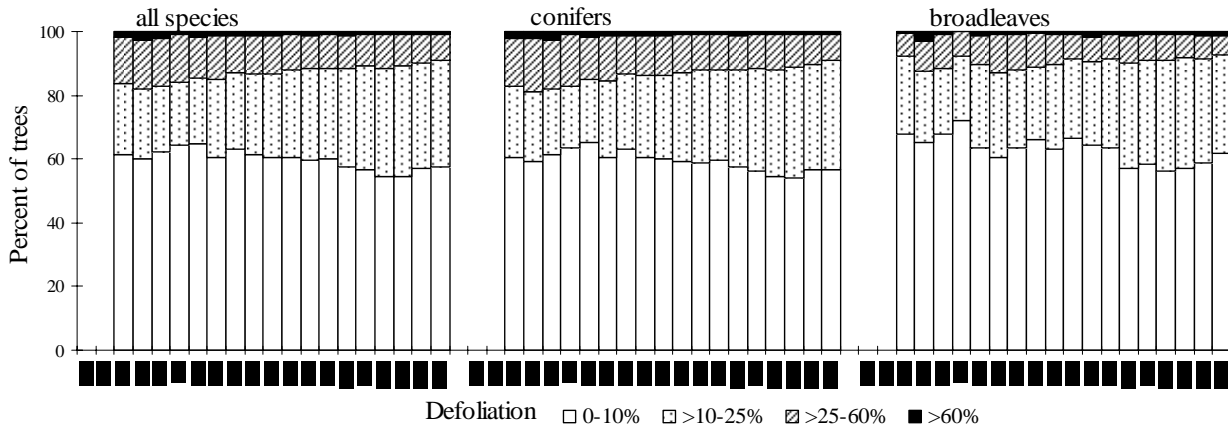
Denmark



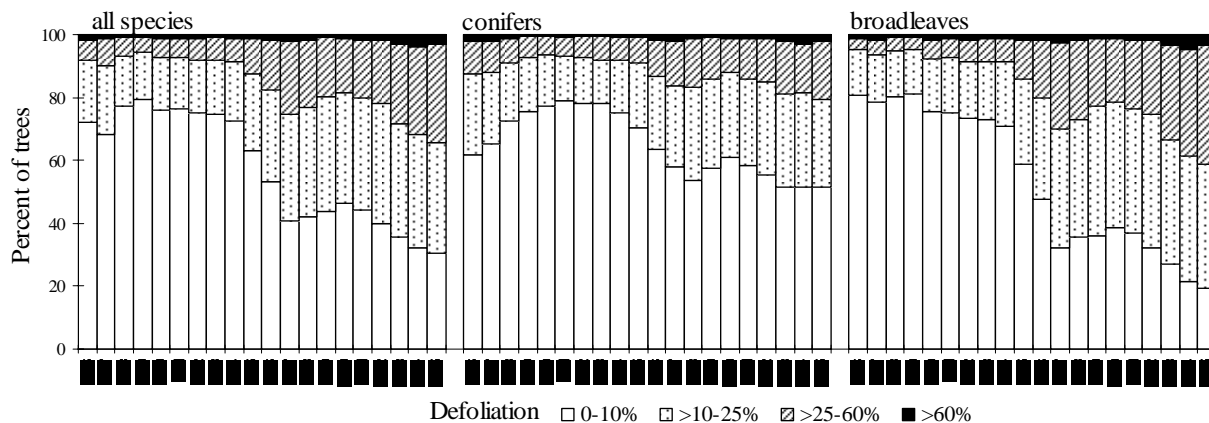
Estonia



Finland

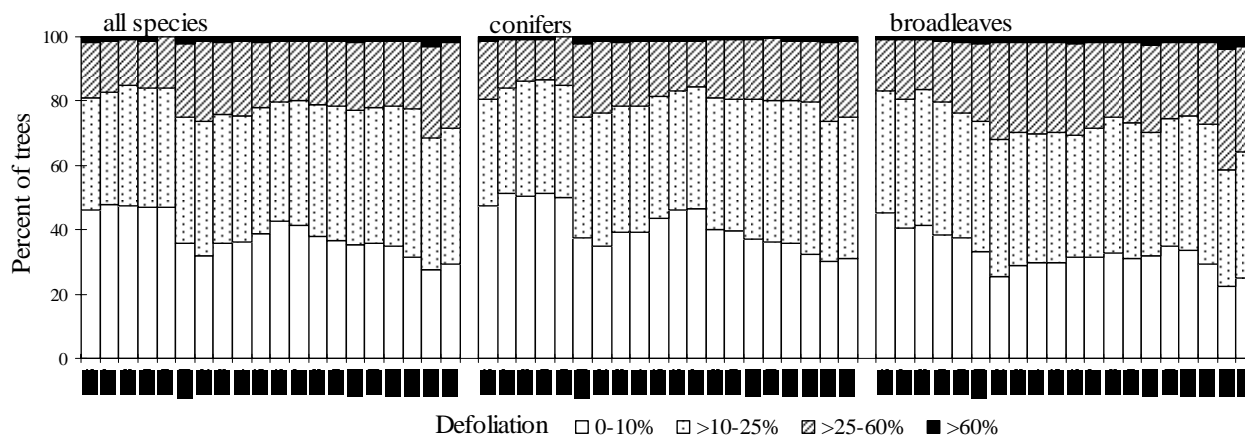


France *



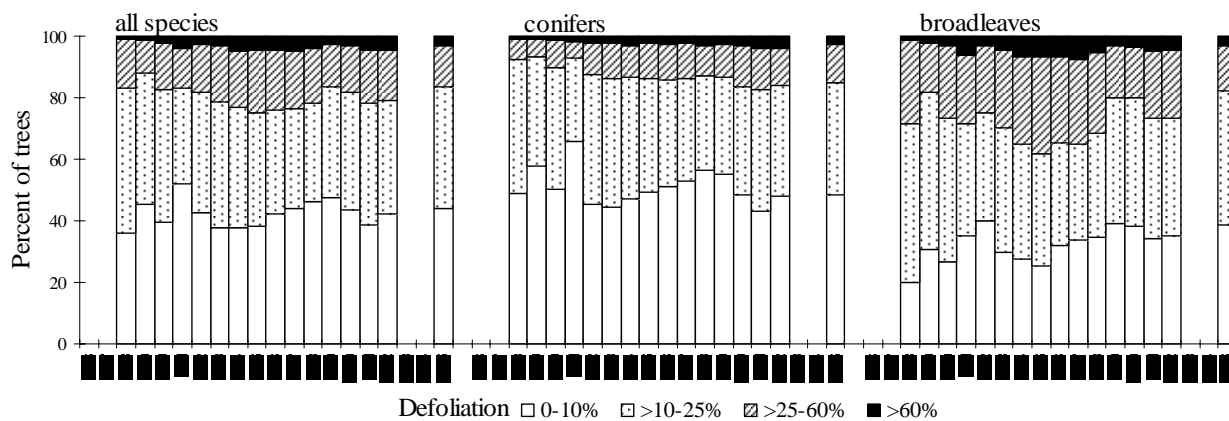
* due to methodological changes, only the time series 1988-94 and 1997-99 are consistent, but not comparable to each other.

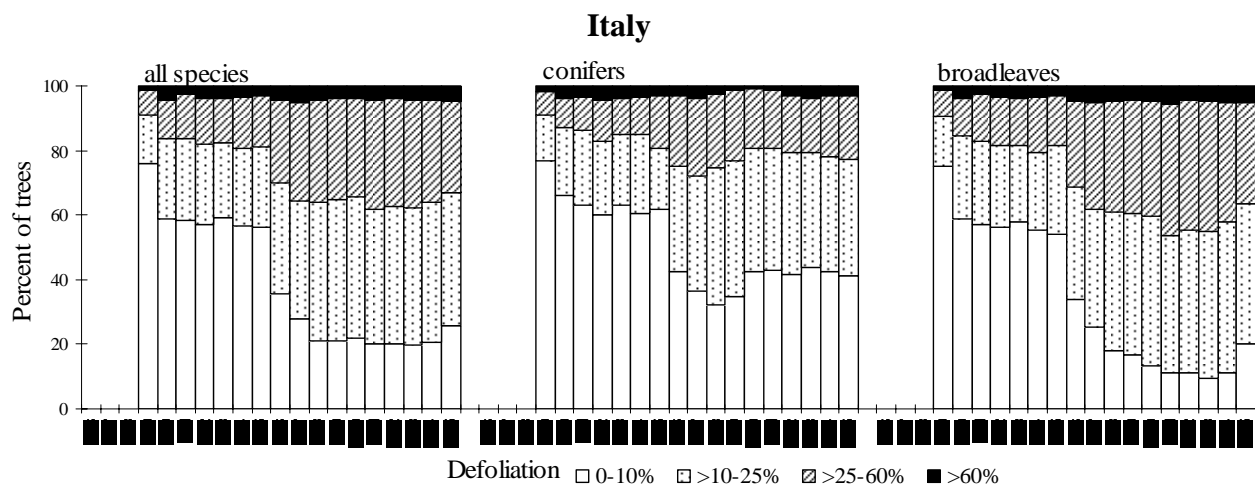
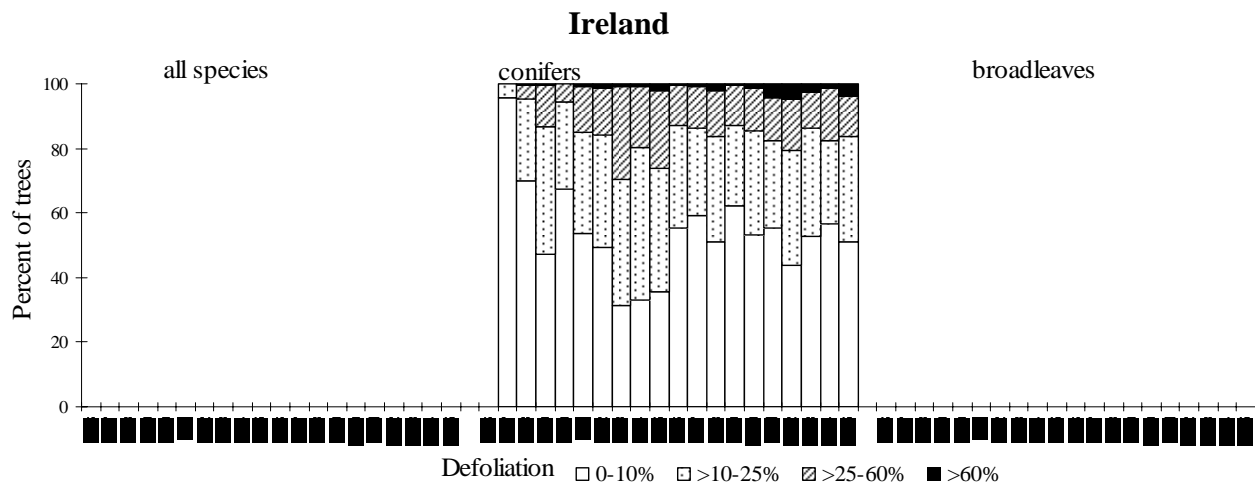
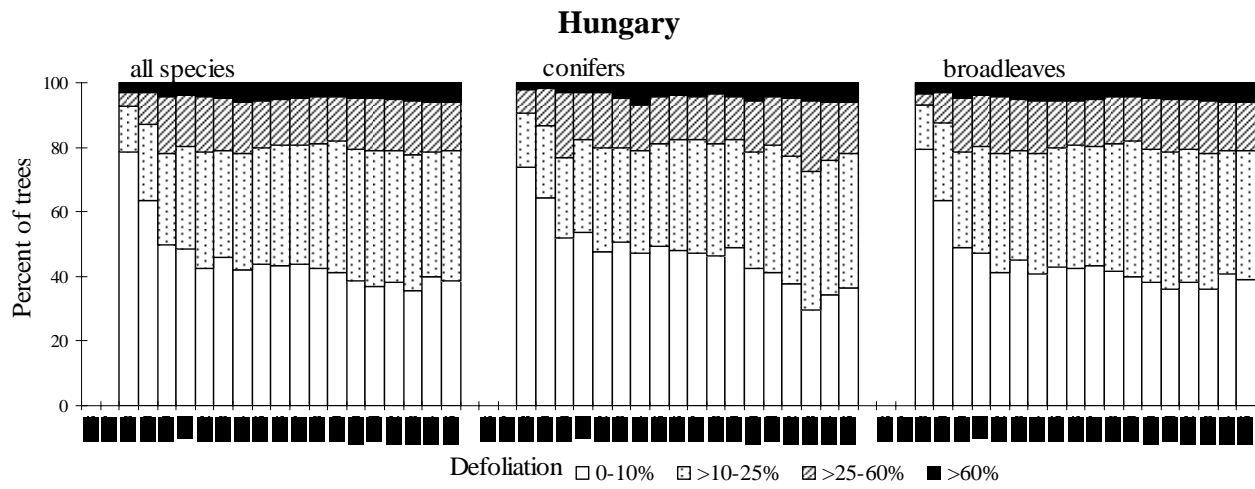
Germany

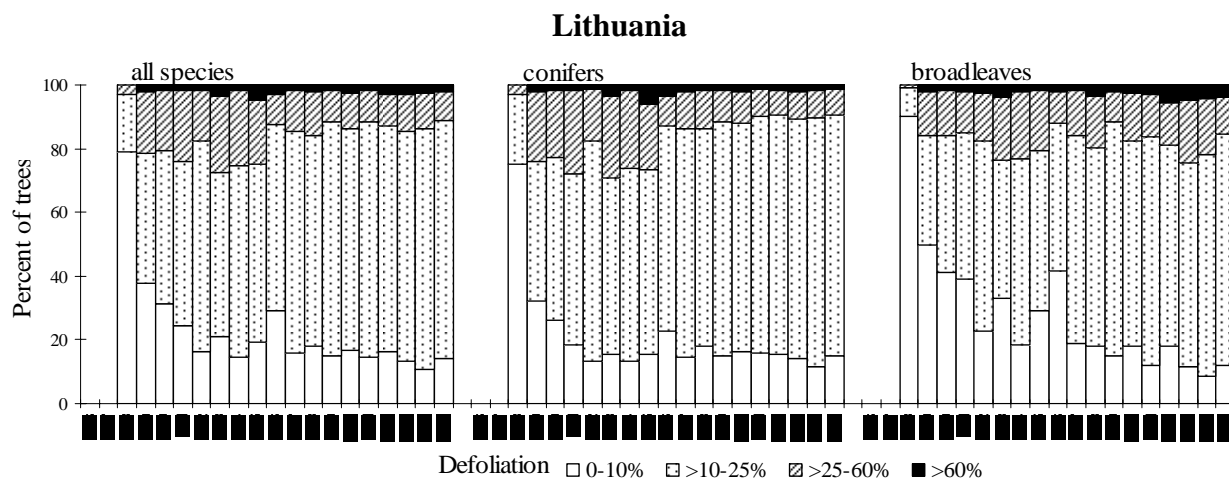
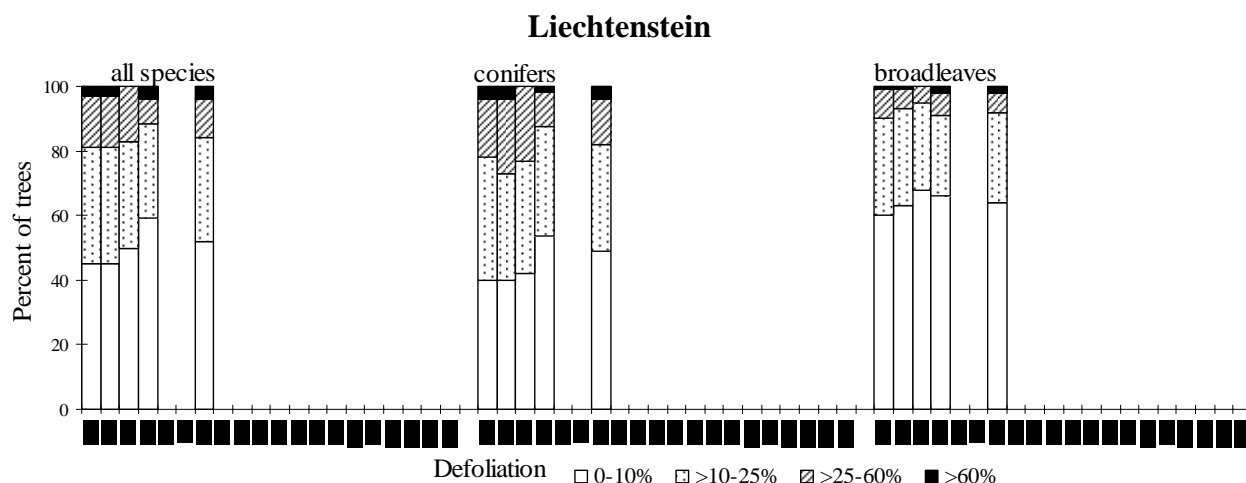
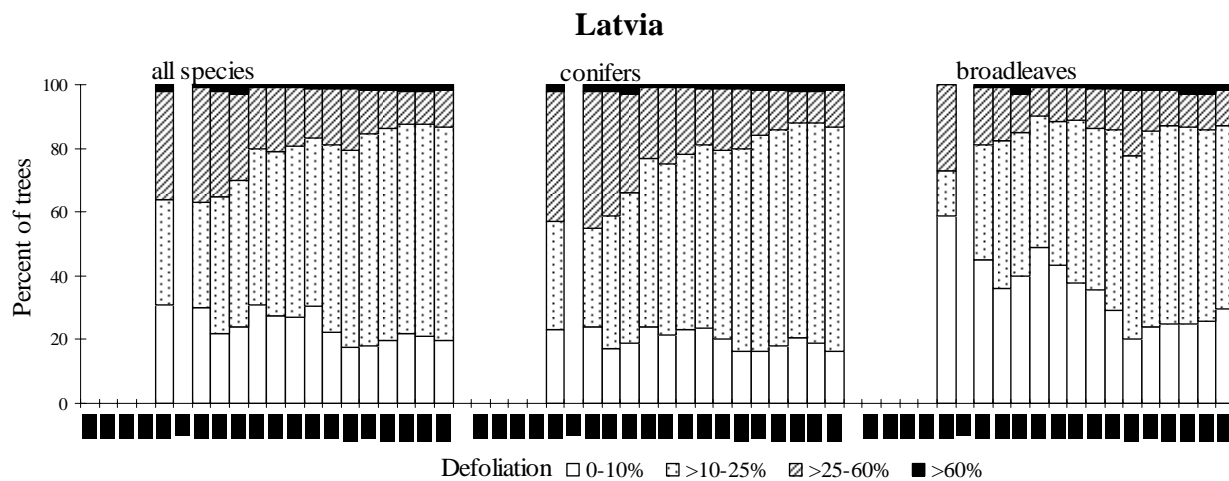


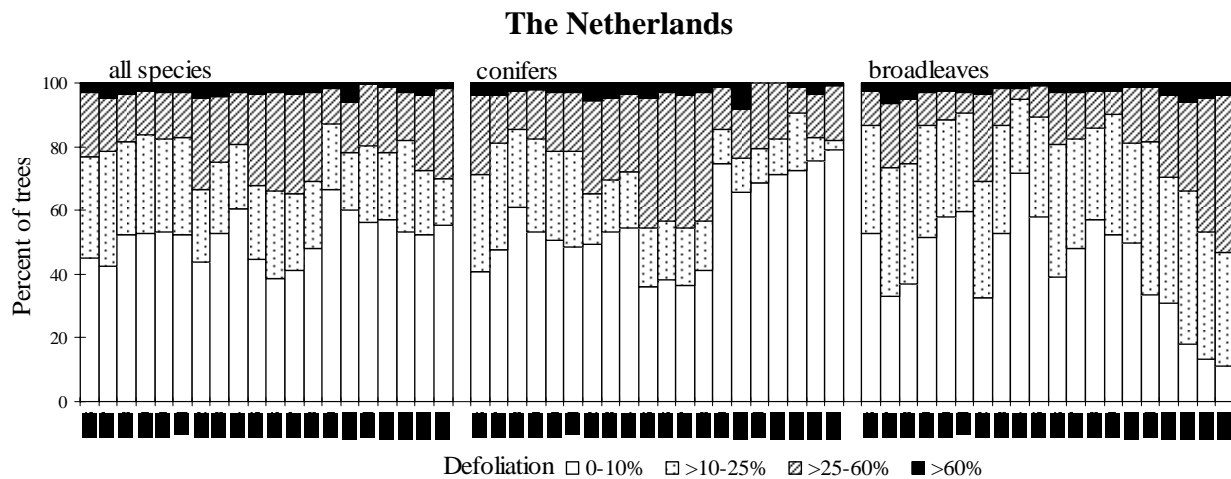
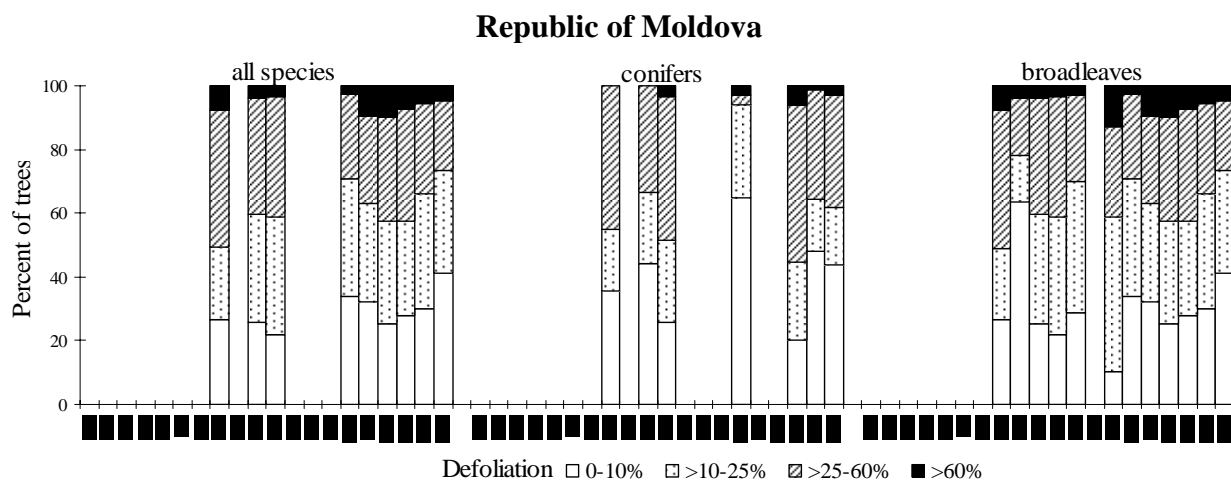
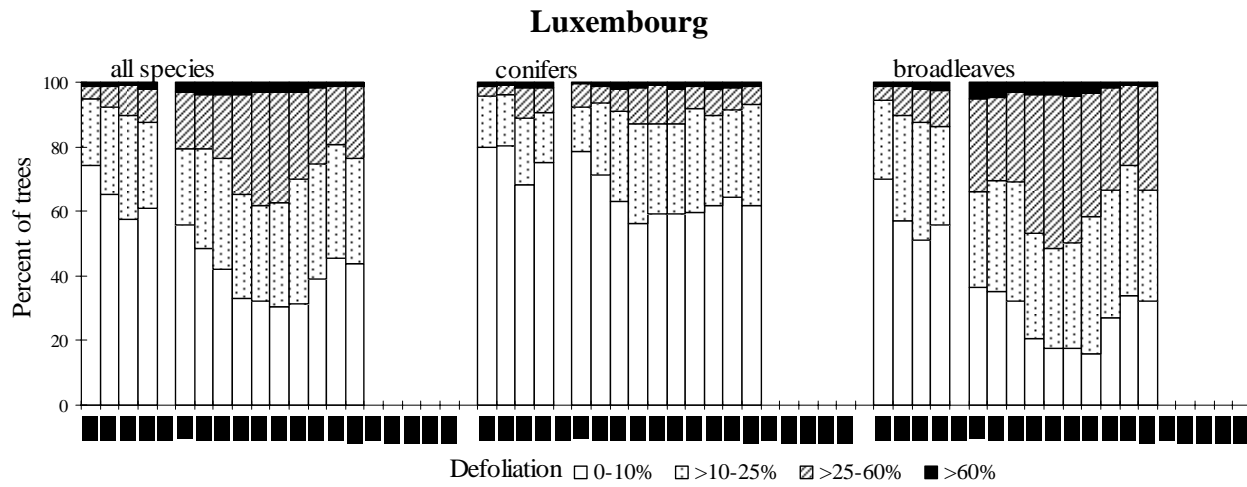
* since 1991 with former GDR

Greece

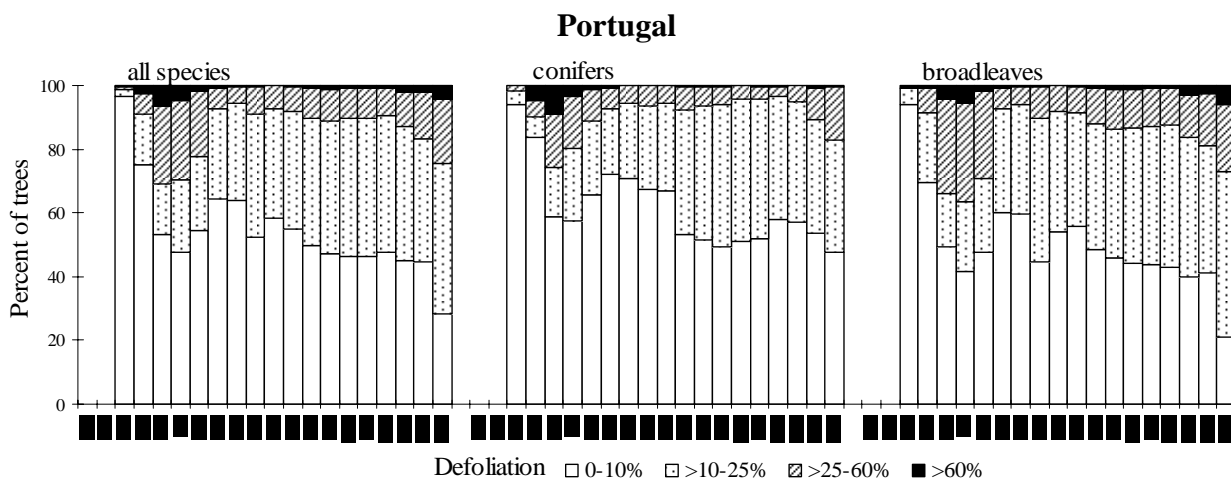
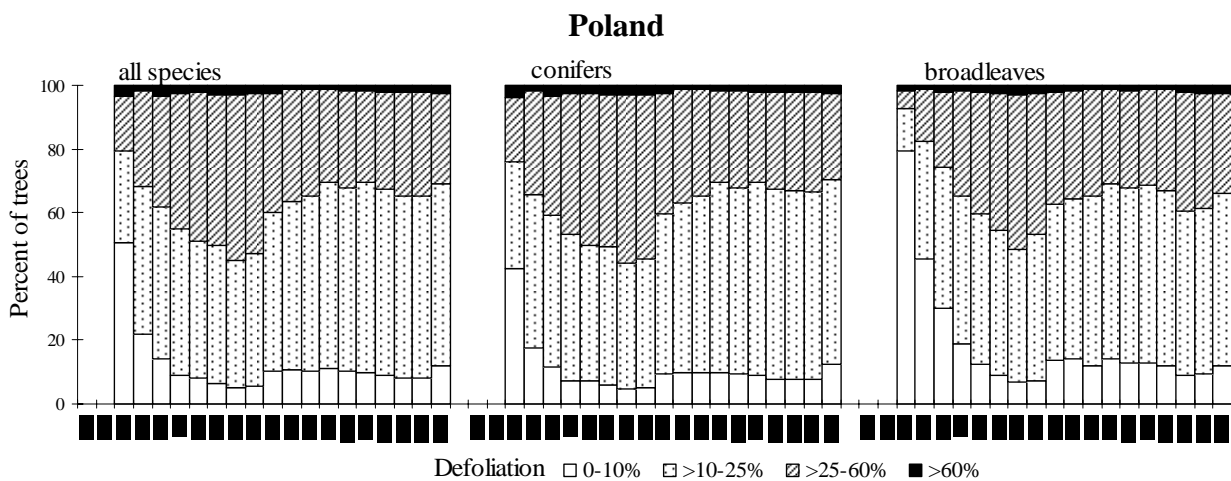
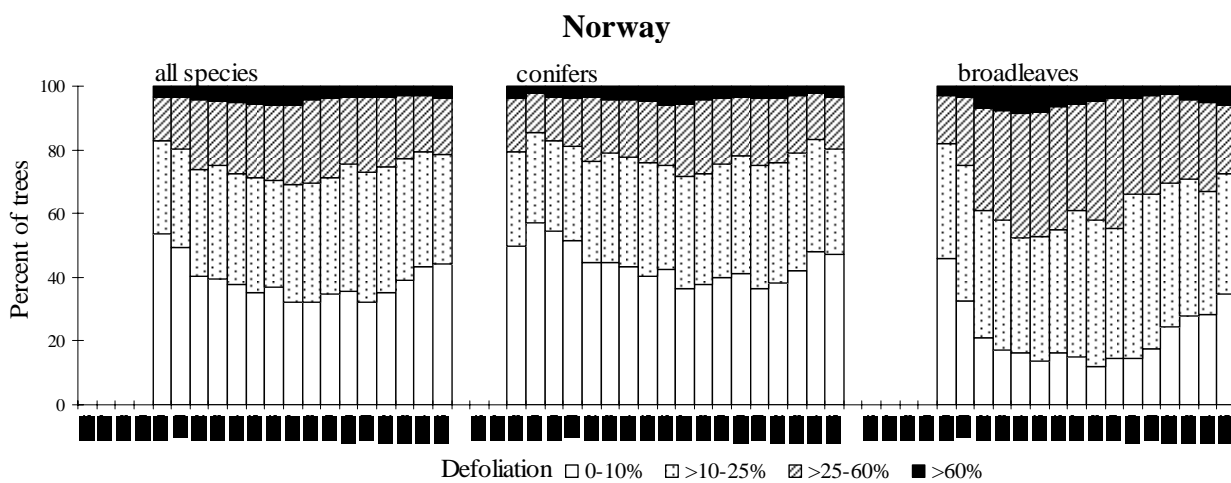


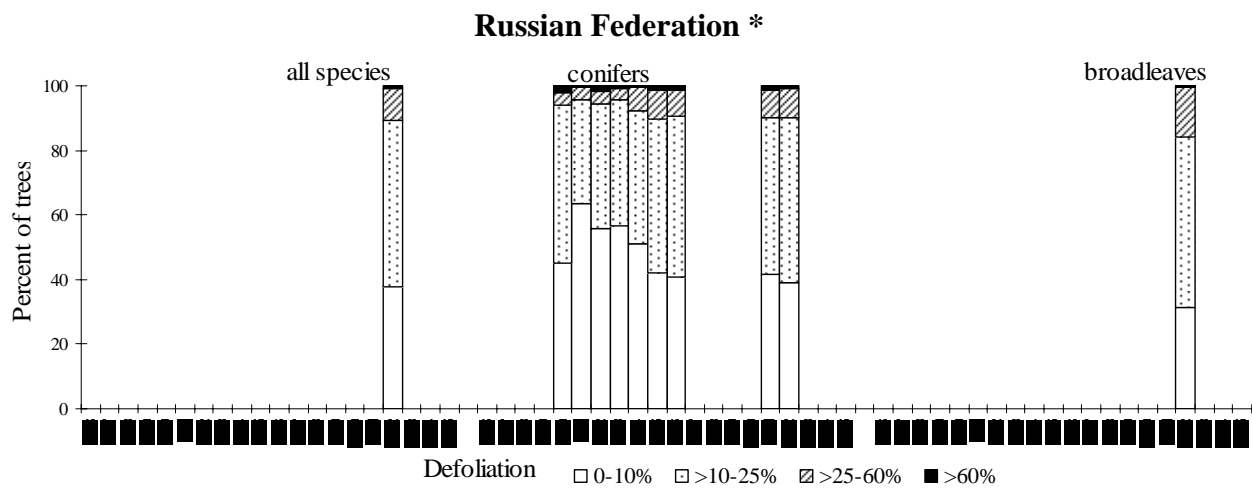
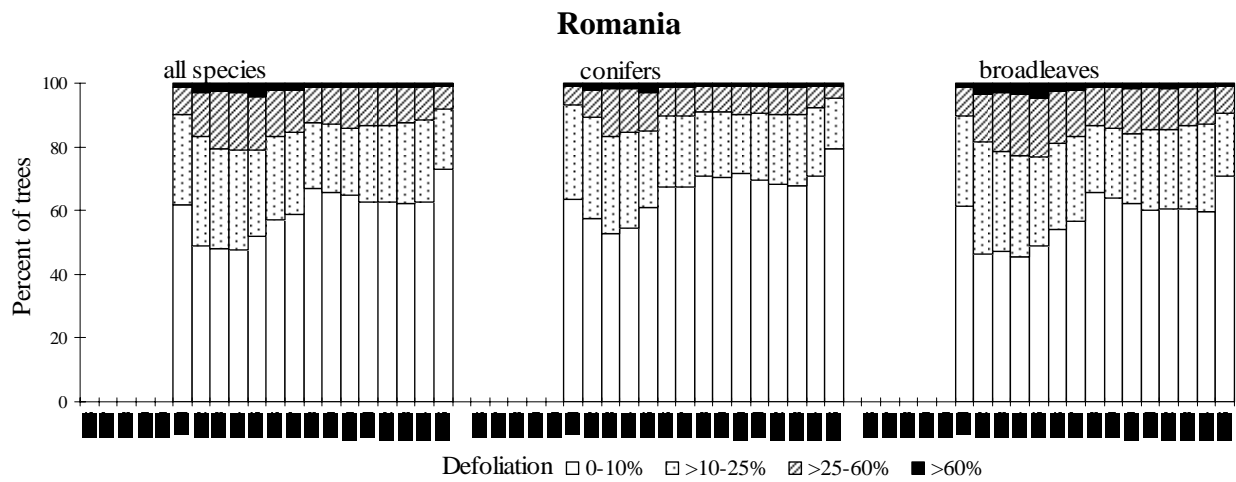




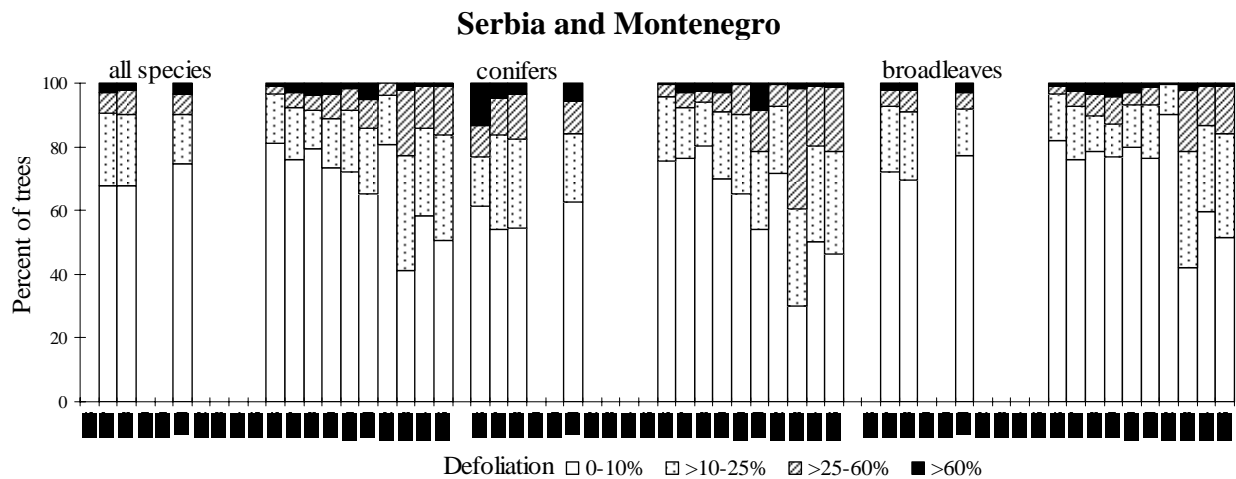


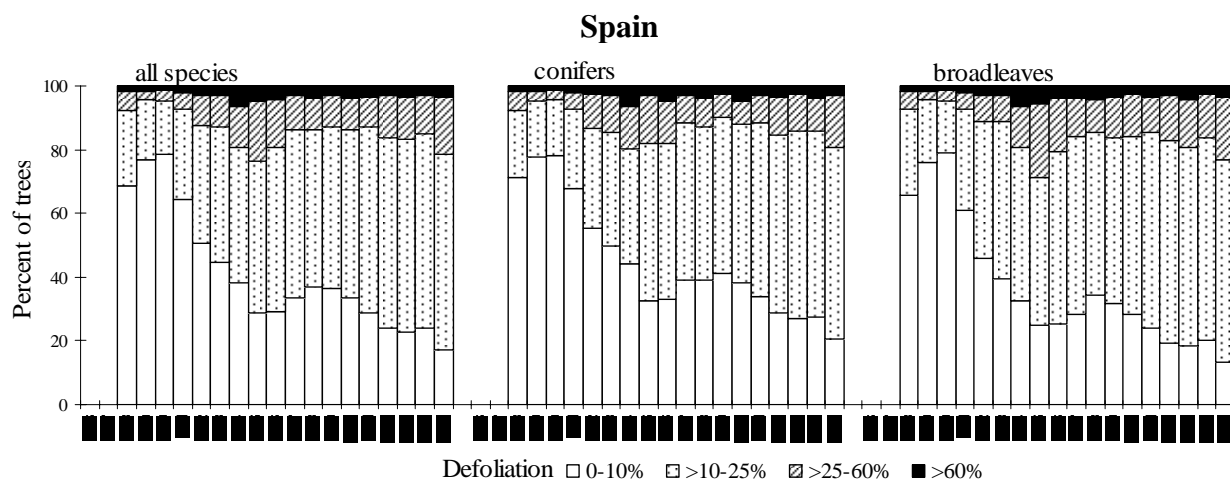
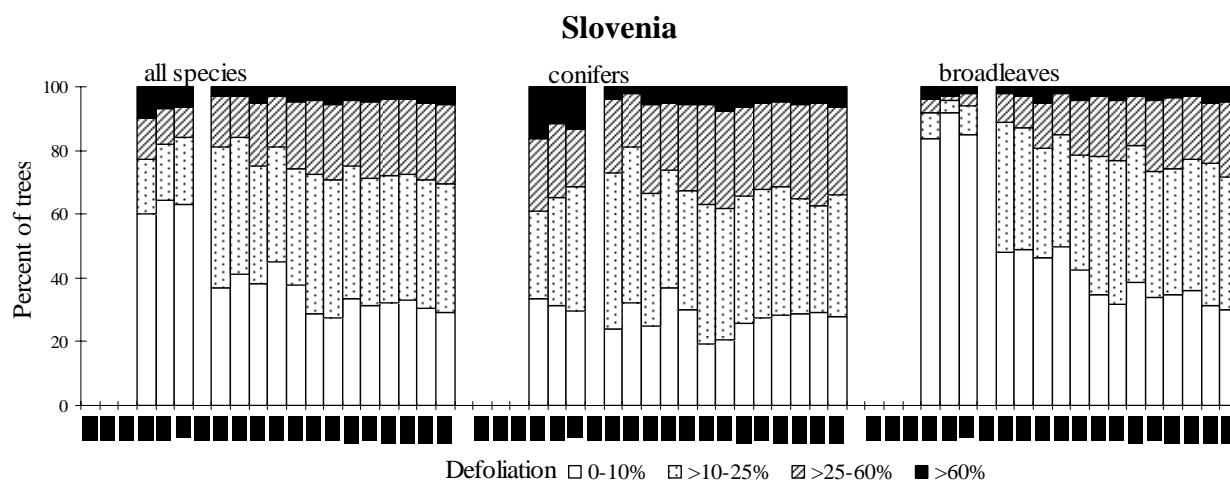
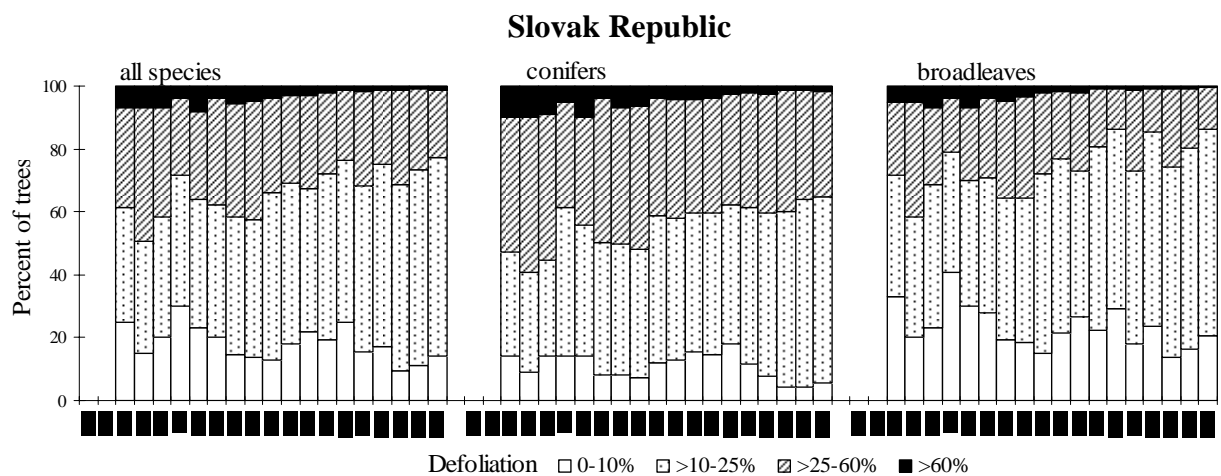
1989-1994: 1500 plots, 1995-1998: 200 plots, since 1999: 11 plots



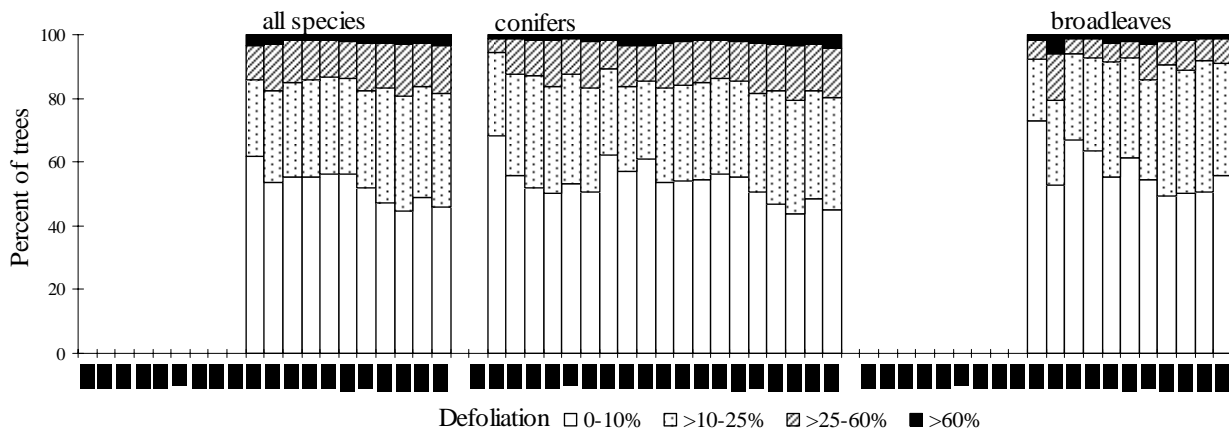


* Only regional surveys in north-western and Central European parts of Russia.

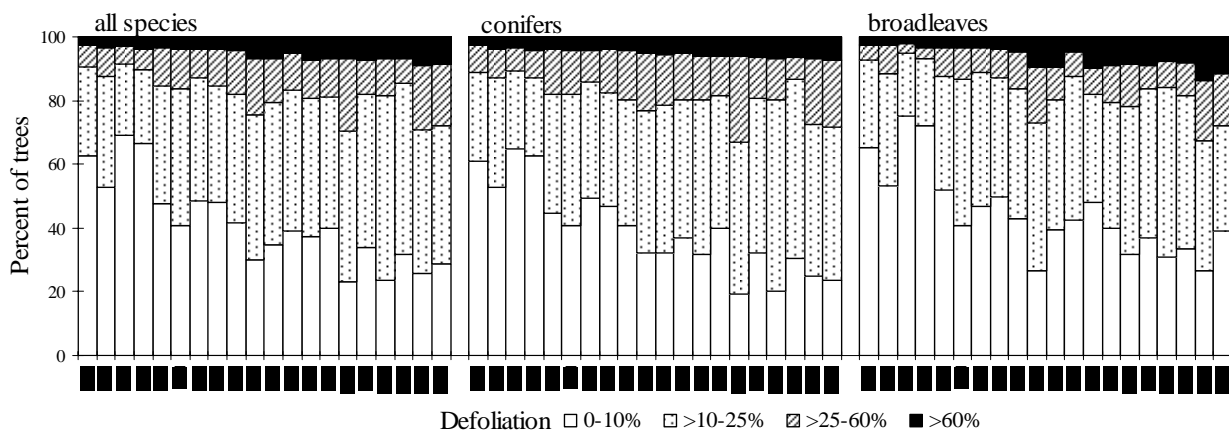




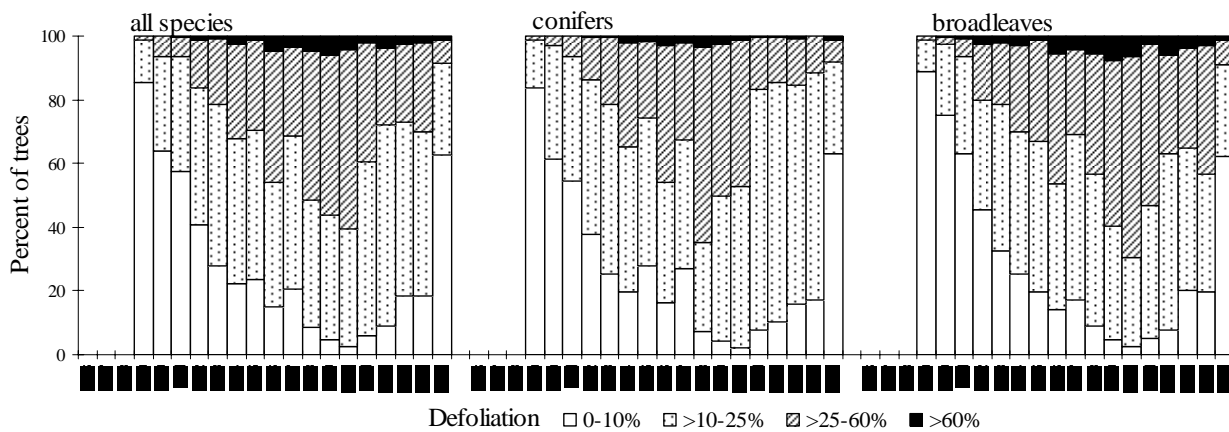
Sweden



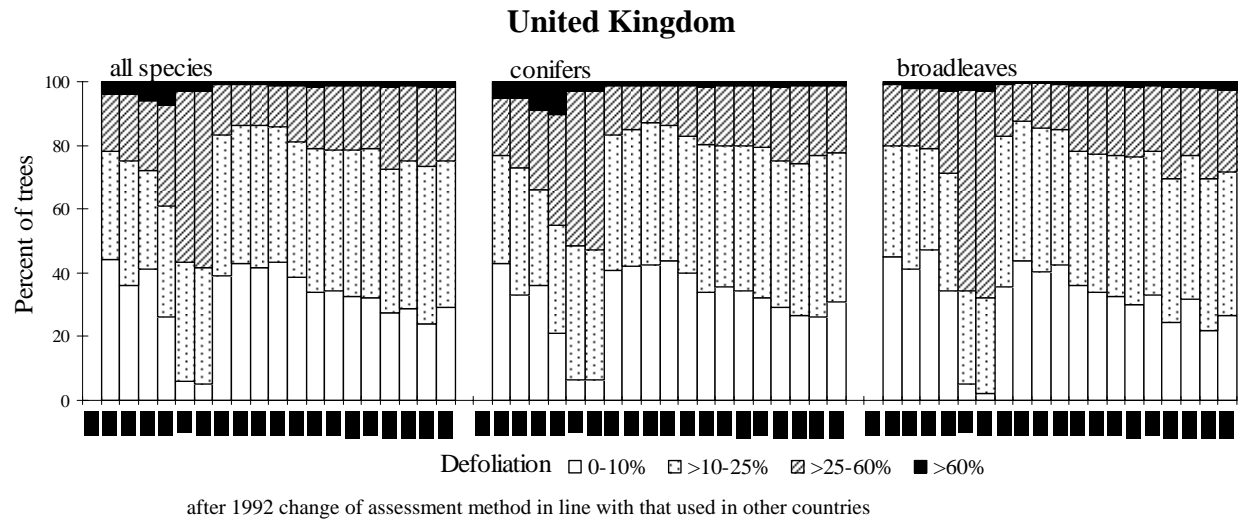
Switzerland



Ukraine



since 2005 change of assessment grid



Annex III

Main species referred to in the text

Botanical name	Danish	Dutch	English	Finnish	French	German
<i>Fagus sylvatica</i>	Bøg	Beuk	Common beech	Pyökki	Hêtre	Rotbuche
<i>Quercus petraea</i>	Vintereg	Wintereik	Sessile oak	Talvitammi	Chêne rouvre	Traubeneiche
<i>Quercus robur</i>	Stilkeg	Zomereik	European oak	Metsätammi	Chêne pédonculé	Stieleiche
<i>Quercus ilex</i>	Steneg	Steeneik	Holm oak	Rautatammi	Chêne vert	Steineiche
<i>Quercus suber</i>	Korkeg	Kurkeik	Cork oak	Korkkitammi	Chêne liège	Korkeiche
<i>Pinus sylvestris</i>	Skovfyr	Grove den	Scots pine	Metsämänty	Pin sylvestre	Gemeine Kiefer
<i>Pinus nigra</i>	Østrigsk fyr	Oostenrijkse Corsicaanse zwarte den	Corsican/ Aus- trian black pine	Euroopanmusta- mänty	Pin noir	Schwarzkiefer
<i>Pinus pinaster</i>	Strandfyr	Zeeden	Maritime pine	Rannikomänty	Pin maritime	Seestrandkiefer
<i>Pinus halepensis</i>	Aleppofyr	Aleppoden	Aleppo pine	Aleponmänty	Pin d'Alep	Aleppokiefer
<i>Picea abies</i>	Rødgran	Fijnspaar	Norway spruce	Metsäkuusi	Epicéa commun	Rotfichte
<i>Picea sitchensis</i>	Sitkagran	Sitkaspaar	Sitka spruce	Sitkankuusi	Epicéa de Sitka	Sitkafichte
<i>Abies alba</i>	Ædelgran	Zilverden	Silver fir	Saksanpihta	Sapin pectiné	Weißtanne
<i>Larix decidua</i>	Lærk	Europese lariks	European larch	Euroopanlehti- kuusi	Mélèze d'Europe	Europäische Lärche

Botanical name	Greek	Italian	Portuguese	Russian	Spanish	Swedish
<i>Fagus sylvatica</i>	Οξυά δασική	Faggio	Faia	бук лесной	Haya	Bok
<i>Quercus petraea</i>	Δρυς απόδισκος	Rovere	Carvalho branco Americano	дуб скальный	Roble albar	Bergek
<i>Quercus robur</i>	Δρυς ποδισκοφόρος	Farnia	Carvalho roble	дуб черешчатый	Roble común	Ek
<i>Quercus ilex</i>	Αριά	Leccio	Azinheira	дуб каменный	Encina	Stenek
<i>Quercus suber</i>	Φελλοδρύς	Sughera	Sobreiro	дуб пробковый	Alcornoque	Korkek
<i>Pinus sylvestris</i>	Δασική πεύκη	Pino silvestre	Pinheiro silvestre	сосна обыкновенная	Pino silvestre	Tall
<i>Pinus nigra</i>	Μαύρη πεύκη	Pino nero	Pinheiro Austriaco	сосна чёрная	Pino laricio	Svarttall
<i>Pinus pinaster</i>	Θαλασσία πεύκη	Pino marittimo	Pinheiro bravo	сосна приморская	Pino negral	Terpentintall
<i>Pinus halepensis</i>	Χαλέπιος πεύκη	Pino d'Aleppo	Pinheiro de alepo	сосна алеппская	Pino carrasco	Aleppotall
<i>Picea abies</i>	Ερυθρελάτη υψηλή	Abete rosso	Picea	ель европейская	Abeto rojo	Gran
<i>Picea sitchensis</i>	Ερυθρελάτη	Picea di Sitka	Picea de Sitka	ель ситхинская	Picea de Sitka	Sitkagran
<i>Abies alba</i>	Λευκή ελάτη	Abete bianco	Abeto branco	пихта белая	Abeto común	Sivergran
<i>Larix decidua</i>	Λάριξ ευρωπαϊκή	Larice	Larício Europeu	литвенница европейская	Alerce	Europeisklärk

Annex IV

Testing statistical significance of the differences in mean plot defoliation between two years of assessment.

Differences between mean plot defoliation were statistically examined for Common Sample Plots (CSPs) using the following test statistic:

$$t = \frac{|\bar{x}_{2005} - \bar{x}_{2004}|}{\sqrt{\frac{s^2}{n_{2005}} + \frac{s^2}{n_{2004}}}}$$

where $\bar{x}_{2005} - \bar{x}_{2004}$ is the difference in mean plot defoliation between the assessments in 2004 and 2005,

s - the standard deviation of these differences,

n_{2005}, n_{2004} - number of sample trees on plots being tested.

The standard deviation s is calculated as follows

$$s = \sqrt{\frac{(n_{2005} - 1)s_{2005}^2 + (n_{2004} - 1)s_{2004}^2}{n_{2005} + n_{2004} - 2}}$$

with standard deviations s_{2005}, s_{2004} derived from the defoliation scores for the years 2005 and 2004 on the plots investigated.

The minimal difference for qualifying a plot as having changed its mean defoliation was 5% and more. This applies to the map in Annex I-7. This additional criterion to the formal statistical test was chosen since 5% is the highest accuracy in the assessment of defoliation in the field.

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