International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests)

Further development and implementation of an EU-level Forest Monitorng System (FutMon)

Forest Condition in Europe

2011 Technical Report of ICP Forests and FutMon

Work Report of the:

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Institute for World Forestry

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Forest Condition in Europe

2011 Technical Report of ICP Forests and FutMon

Richard Fischer, Martin Lorenz (eds.)

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Cover photos: Dan Aamlid (landscape, top), Richard Fischer (middle) Silvia Stofer (bottom)

Table of Contents

Preface 9

Part I INTRODUCTION

1. Background, set-up and current state of the ICP Forests and FutMon monitoring system .. 13

Martin Lorenz and Oliver Granke

1.1 BACKGROUND 13
1.2 LARGE-SCALE FOREST MONITORING (LEVEL I) 13
1.3 INTENSIVE FOREST MONITORING (LEVEL II) 15

2. Quality Assurance and Quality Control within the monitoring system 19

Marco Ferretti, Nils König, Oliver Granke, Nathalie Cools, John Derome(†), Kirsti Derome, Alfred Fürst, Friedhelm Hosenfeld, Aldo Marchetto, Volker Mues

2.1 THE OVERALL QUALITY ASSURANCE PERSPECTIVE 19
2.2 QUALITY IMPROVEMENT IN THE LABORATORIES 20
2.3 QUALITY CONTROL IN THE DATA BASE 23
2.3.1 Compliance checks 24
2.3.2 Conformity checks 24
2.3.3 Uniformity checks 24
2.3.4 Experience with improved data base system 25
2.4 REFERENCES 25

Part II TREE HEALTH AND VITALITY

3. Tree crown condition and damage causes 29

Stefan Meining and Richard Fischer

3.1 ABSTRACT 29
3.2 LARGE SCALE TREE CROWN CONDITION 29
3.2.1 Methods of the surveys in 2010 29
3.2.2 Results of the transnational crown condition survey in 2010 37
3.2.3 Defoliation trends 46
3.3 DAMAGE CAUSE ASSESSMENT 64
3.3.1 Background 64
3.3.2 Methods of the Surveys in 2011 64
3.3.3 Results 69
3.4 CONCLUSIONS 78
3.5 REFERENCES 79
3.6 ANNEXES 80

Part III ELEMENT FLUXES

4. Exceedance of critical limits of nitrogen concentration in soil solution 87

Susanne Iost, Pasi Rautio, Antti-Jussi Lindroos, Richard Fischer, Martin Lorenz

4.1 ABSTRACT 87
4.2 INTRODUCTION 87
4.3 DATA 88
4.4 METHODS 89
4.5 RESULTS 89
4.6 DISCUSSION AND CONCLUSIONS 94
4.7 REFERENCES 95

5. Exceedance of critical loads for acidity and nitrogen and scenarios for the future development of soil solution chemistry 97

Hans-Dieter Nagel, Thomas Scheuschner, Angela Schlutow, Oliver Granke, Nicholas Clarke, Richard Fischer

5.1 ABSTRACT 97
5.2 INTRODUCTION 97
5.3 DATA 98
5.4 METHODS 99
5.5 RESULTS OF CRITICAL LOADS AND THEIR EXCEEDANCES 102
5.6 RESULTS OF DYNAMIC MODELLING WITH VSD+ 105
5.6.1 Base saturation 107
5.6.2 pH value 108
5.6.3 C:N ratio 109
5.7 DISCUSSION AND CONCLUSIONS 110
5.8 REFERENCES 111

Part IV CARBON AND CLIMATE CHANGE

6. Analysis of forest growth data on intensive monitoring plots 115

Matthias Dobbertin, Georg Kindermann, Markus Neumann

6.1 ABSTRACT 115
6.2 INTRODUCTION 115
6.3 DATA AND METHODS 116
6.3.1 Data completeness and spatial/temporal extent 116
6.3.2 Measurement accuracy 119
6.3.3 Differences caused by different calculation methods 120
6.3.4 Methods used for calculations 121
6.4 RESULTS 122
6.4.1 Development on plot level 122
6.4.2 Spatial stocking volume and increment on all observed plots 123
6.5 DISCUSSION AND CONCLUSIONS 125
6.6 REFERENCES 125

Part V BIODIVERSITY

7. Epiphytic lichen diversity in relation to atmospheric deposition 128

Paolo Giordani, Vicent Calatayud, Silvia Stofer, Oliver Granke

7.1. INTRODUCTION 128
7.2 METHODS 128
7.2.1. Data 128
7.2.2. Lichen diversity 129
7.2.3 Nitrogen deposition and lichen functional groups 129
7.3 RESULTS: METHOD DEVELOPMENT 130
7.3.1 Representativeness of sampled trees 130
7.4 RESULTS: EFFECTS OF NITROGEN DEPOSITION 131
7.4.1 Relation between nitrogen deposition and % oligotrophic macrolichen species 132
7.4.2 Mapping of the percentage of oligotrophic lichens 134
7.5 DISCUSSION AND CONCLUSIONS 135
7.6 REFERENCES 136
7.7 ANNEX 138

8. Development of vegetation under different deposition scenarios 144

Angela Schlutow, Thomas Scheuschner, Hans Dieter Nagel

8.1 ABSTRACT 144
8.2 INTRODUCTION 144
8.3 DATA 144
8.4 METHODS 144
8.5 RESULTS 146
8.6 DISCUSSION AND CONCLUSIONS 149
8.7 REFERENCES 150

Part VI NATIONAL SURVEYS

9. National crown condition surveys and contacts 152

Richard Fischer and Georg Becher

9.1 NATIONAL SURVEY REPORTS 152
9.1.1 Andorra 152
9.1.2 Austria 152
9.1.3 Belarus 153
9.1.4 Belgium 153
9.1.5 Bulgaria 155
9.1.6 Cyprus 155
9.1.7 Czech Republic 156
9.1.8 Denmark 157
9.1.9 Estonia 157
9.1.10 Finland 158
9.1.11 France 158
9.1.12 Germany 159
9.1.13 Greece 160
9.1.14 Hungary 160
9.1.15 Ireland 161
9.1.16 Italy 162
9.1.17 Latvia 162

9.1.18 Lithuania *163*
9.1.19 Republic of Moldova *164*
9.1.20 The Netherlands *164*
9.1.21 Norway *165*
9.1.22 Poland *166*
9.1.23 Romania *166*
9.1.24 Russian Federation *167*
9.1.25 Serbia *167*
9.1.26 Slovak Republic *167*
9.1.27 Slovenia *168*
9.1.28 Spain *168*
9.1.29 Sweden *169*
9.1.30 Switzerland *169*
9.1.31 Turkey *170*
9.1.32 United Kingdom *171*
9.1.33 Ukraine *171*
9.1.34 United States of America *171*
9.2 ANNEX: NATIONAL RESULTS 173
9.2.1 Forests and surveys in European countries (2010). *173*
9.2.2 Percent of trees of all species by defoliation classes and class aggregates (2010). *174*
9.2.3 Percent of conifers by defoliation classes and class aggregates (2010) *175*
9.2.4 Percent of broadleaves by defoliation classes and class aggregates (2010). *176*
9.2.5 Percent of damaged trees of all species (1999-2010) *177*
9.2.6 Percent of damaged conifers (1999-2010). *178*
9.2.7 Percent of damaged broadleaves (1999-2010). *179*
9.2.8 Changes in defoliation (1988-2010) *180*
9.3 ANNEX: ADDRESSES 193

Preface

Forests provide a wealth of benefits to the society but are at the same time subject to numerous natural and anthropogenic impacts. For this reason several processes of international environmental and forest politics were established and the monitoring of forest condition is considered as indispensable by the countries of Europe. Forest condition in Europe has been monitored since 1986 by the International Co-operative Programme on the Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) in the framework of the Convention on Long-range Transboundary Air Pollution (CLRTAP) under the United Nations Economic Commission for Europe (UNECE). The number of countries participating in ICP Forests has meanwhile grown to 41 including Canada and the United States of America, rendering ICP Forests one of the largest biomonitoring networks of the world. ICP Forests has been chaired by Germany from the beginning on. The Institute for World Forestry of the Johann Heinrich von Thünen-Institute (vTI) hosts the Programme Coordinating Centre (PCC) of ICP Forests.

Aimed mainly at the assessment of effects of air pollution on forests, ICP Forests provides scientific information to CLRTAP as a basis of legally binding protocols on air pollution abatement policies. For this purpose ICP Forests developed a harmonised monitoring approach comprising a large-scale forest monitoring (Level I) as well as a forest ecosystem forest monitoring (Level II) approach laid down in the ICP Forests Manual. The participating countries have obliged themselves to submit their monitoring data to PCC for validation, storage, and analysis. The monitoring, the data management and the reporting of results used to be conducted in close cooperation with the European Commission (EC). EC co-financed the work of PCC and of the Expert Panels of ICP Forests as well as the monitoring by the EU-Member States until 2006.

While ICP Forests - in line with its obligations under CLRTAP - focuses on air pollution effects, it delivers information also to other processes of international environmental politics. This holds true in particular for the provision of information on several indicators for sustainable forest management laid down by Forest Europe (FE). The monitoring system offers itself for being further developed towards assessments of forest information related to carbon budgets, climate change, and biodiversity. This is accomplished by means of the project “Further Development and Implementation of an EU-level Forest Monitoring System” (FutMon). FutMon is carried out from January 2009 to June 2011 by a consortium of 38 partners in 23 EU-Member States, is also coordinated by the Institute for World Forestry of vTI, and is co-financed by EC under its Regulation “LIFE+”. FutMon revises the monitoring system in close cooperation with ICP Forests. It establishes links between large-scale forest monitoring and National Forest Inventories (NFIs). It increases the efficiency of forest ecosystem monitoring by reducing the number of plots for the benefit of a higher monitoring intensity per plot. This is reached by means of a higher number of surveys per plot and newly developed monitoring parameters adopted by ICP Forests for inclusion into its Manual. Moreover, data quality assurance and the database system are greatly improved.

Given the current cooperation between ICP Forests and FutMon, the present Technical Report is published as a joint report of both of them.

3. Tree crown condition and damage causes

Stefan Meining[1] and Richard Fischer[2]

3.1 Abstract

The study presents results of the 2010 forest health and vitality survey carried out on the representative net of Level I plots of ICP Forests and the FutMon project. The survey was based on over 7 500 plots and 145 000 trees in 33 participating countries, including 26 EU member states. It was thus the most comprehensive survey that has ever been carried out on the Level I network.

Defoliation results show slightly higher mean defoliation for broadleaves as compared to the conifers assessed. Deciduous temperate oaks had the highest mean defoliation (24.8%), followed by the south European tree species groups. *Picea abies* and *Pinus sylvestris* showed lowest mean defoliation with 17.0% and 17.4% respectively. The Mediterranean coast in southern France and northern Spain was a hot spot with specifically high defoliation in several species groups.

Over the last five years, temporal defoliation trends show some recuperation for evergreen oaks and a continuously increasing defoliation of *Pinus sylvestris*. For the other species/-goups there is no pronounced trend in the most recent years. After the heat and drought in central Europe in 2003 defoliation clearly increased for most tree species. This points to the value of the data as basis of an early warning system for tree health under changing environmental conditons.

For the first time, forest damage assessments were evaluated based on newly introduced assessments that had started in 2005. In 2010, damage causes were assessed with harmonized methods on 6 413 plots in 32 different countries across Europe. Insects and fungi were the most widespread agents occurring on 27% and 15% of the trees within the survey. The occurrence of these factors shows clear regional trends like plots with high insect occurrence in north-eastern Spain, Italy or Hungary or high occurrence of trees with fungal infestations in Estonia.

3.2 Large scale tree crown condition

3.2.1 Methods of the surveys in 2010

The annual transnational tree crown condition survey was carried out on 7 503 plots in 33 participating countries, including 26 EU member states. It was thus the most comprehensive survey that has ever been carried out on the Level I network. Due to co-financing through the FutMon project Austria, Greece, The Netherlands, Romania and United Kingdom again conduted the survey after one or several years without assessments. Montenegro participated for the first time. The assessment was carried out under national responsibilities according to harmonized methods laid down in ICP Forests (2010). Data were compiled and checked for consistency by the participating countries and submitted online to the European Coordinating Centre at the Institute for World Forestry in Hamburg, Germany.

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Aditional data quality checks were carried out in the context of the online data submission (Chapt. 2).

Table 3-1: Number of sample plots assessed for crown condition from 1998 to 2010

Country	Number of sample plots assessed												
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Austria	130	130	130	130	133	131	136	136	135				135
Belgium	29	30	29	29	29	29	29	29	27	27	26	26	9
Bulgaria	134	114	108	108	98	105	103	102	97	104	98	159	140
Cyprus				15	15	15	15	15	15	15	15	15	15
Czech Republic	116	139	139	139	140	140	140	138	136	132	136	133	132
Denmark	23	23	21	21	20	20	20	22	22	19	19	16	17
Estonia	91	91	90	89	92	93	92	92	92	93	92	92	97
Finland	459	457	453	454	457	453	594	605	606	593	475	886	932
France	537	544	516	519	518	515	511	509	498	504	508	500	532
Germany	421	433	444	446	447	447	451	451	423	420	423	412	411
Greece	93	93	93	92	91			87				97	98
Hungary	59	62	63	63	62	62	73	73	73	72	72	73	71
Ireland	21	20	20	20	20	19	19	18	21	30	31	32	29
Italy	177	239	255	265	258	247	255	238	251	238	236	252	253
Latvia	97	98	94	97	97	95	95	92	93	93	92	207	207
Lithuania	67	67	67	66	66	64	63	62	62	62	70	72	75
Luxemburg	4	4	4		4	4	4	4	4	4	4		
The Netherlands	11	11	11	11	11	11	11	11	11			11	11
Poland	431	431	431	431	433	433	433	432	376	458	453	376	374
Portugal*	149	149	149	150	151	142	139	125	124				
Romania	235	238	235	232	231	231	226	229	228	218		227	239
Slovak Republic	109	110	111	110	110	108	108	108	107	107	108	108	108
Slovenia	41	41	41	41	39	41	42	44	45	44		44	44
Spain**	465	611	620	620	620	620	620	620	620	620	620	620	620
Sweden	764	764	769	770	769	776	775	784	790			789	830
United Kingdom	88	85	89	86	86	86	85	84	82	32			76
EU	4751	4984	4982	5004	4997	4887	5039	5110	4938	3885	3478	5147	5455
Andorra							3		3	3	3	3	3
Belarus	416	408	408	408	407	406	406	403	398	400	400	409	410
Croatia	89	84	83	81	80	78	84	85	88	83	84	83	83
Moldova	10	10	10	10									
Montenegro													49
Norway	386	381	382	408	414	411	442	460	463	476	481	487	491
Russian Fed.												365	288
Serbia						103	130	129	127	125	123	122	121
Switzerland	49	49	49	49	49	48	48	48	48	48	48	48	48
Turkey												563	555
Total Europe	5701	5916	5914	5960	5947	5933	6152	6235	6065	5020	4617	7227	7503

* including Azores, **including Canares

3.2.1.1 Assessment parameters

For the monitoring year 2010, the following stand and site characteristics are reported from transnational plots: *country, plot number, plot coordinates, altitude, aspect, water availability, humus type*, and *mean age of dominant storey*. Besides *defoliation* and *discolouration*, the tree related data reported are *tree numbers, tree species* and *identified damage types*. (Tab. 3-2). Also recorded is the *date of observation*.

Table 3-2: Stand and site parameters given within the crown condition data base.

Registry and location	country	state in which the plot is assessed [code number]
	plot number	identification of each plot
	plot coordinates	latitude and longitude [degrees, minutes, seconds] (geographic)
	date	day, month and year of observation
Physiography	altitude [m a.s.l.]	elevation above sea level, in 50 m steps
	aspect [°]	aspect at the plot, direction of strongest decrease of altitude in 8 classes (N, NE, ... , NW) and "flat"
Soil	water availability	three classes: insufficient, sufficient, excessive water availability to principal species
	humus type	mull, moder, mor, anmor, peat or other
Forest type	Forest type	14 forest categories according to EEA (2007)
Stand related data	mean age of dominant storey	classified age; class size 20 years; class 1: 0-20 years, ..., class 7: 121-140 years, class 8: irregular stands
Additional tree related data	tree number	number of tree, allows the identification of each particular tree over all observation years
	tree species	species of the observed tree [code]
	identified damage types	treewise observations concerning damage caused by game and grazing, insects, fungi, abiotic agents, direct action of man, fire, known regional pollution, and other factors

Nearly all countries submitted data on water availability, humus type, altitude, aspect, and mean age (Tab. 3-3).

Table 3-3: Number of sample plots assessed for crown condition and plots per site parameter

Country	Number of plots	Number of plots per site parameter				
		Water	Humus	Altitude	Aspect	Age
Austria	135	135	135	135	135	135
Belgium	9	9	9	9	9	9
Bulgaria	140	140	140	140	140	140
Cyprus	15	15	15	15	15	15
Czech Rep.	132	132	53	132	132	132
Denmark	17	17	17	17	17	17
Estonia	97	97	97	97	97	97
Finland	932	932	923	932	932	932
France	532	497	497	532	532	532
Germany	411	411	345	411	411	411
Greece	98	98	98	98	98	98
Hungary	71	71	39	71	71	71
Ireland	29	29	17	29	29	29
Italy	253	253	253	253	253	253
Latvia	207	207		207	207	207
Lithuania	75	75	75	75	75	75
Netherlands	11	11	11	11	11	11
Poland	374	374	374	374	374	374
Romania	239	239	239	239	239	239
Slovak Rep.	108		108	108	108	108
Slovenia	44	44	44	44	44	44
Spain	620	620	620	620	620	620
Sweden	830	830	785	830	830	830
United Kingdom	76	73	62	76	76	76
EU	**5455**	**5309**	**4956**	**5455**	**5455**	**5455**
Percent of EU plot sample		**97.3%**	**90.9%**	**100.0%**	**100.0%**	**100.0%**
Andorra	3	3	3	3	3	3
Belarus	410	410	410	410	410	410
Croatia	83	83	83	83	83	83
Montenegro	49	49	49	49	49	49
Norway	491		481	491	491	491
Federation	288			288	288	288
Serbia	121	121	39	121	121	121
Switzerland	48	47	46	48	48	48
Turkey	555	538	524	555	555	555
Total Europe	**7503**	**6560**	**6591**	**7503**	**7503**	**7503**
Percent of total plot sample		**87.4%**	**87.8%**	**100.0%**	**100.0%**	**100.0%**

3.2.1.2 Defoliation

On each sampling point, sample trees were selected according to national procedures. On 52.8% of the plots sample tree number per plot was between 20 and 24 trees. On 22.5% of all plots less than 10 sample trees were observed (Fig. 3-1).

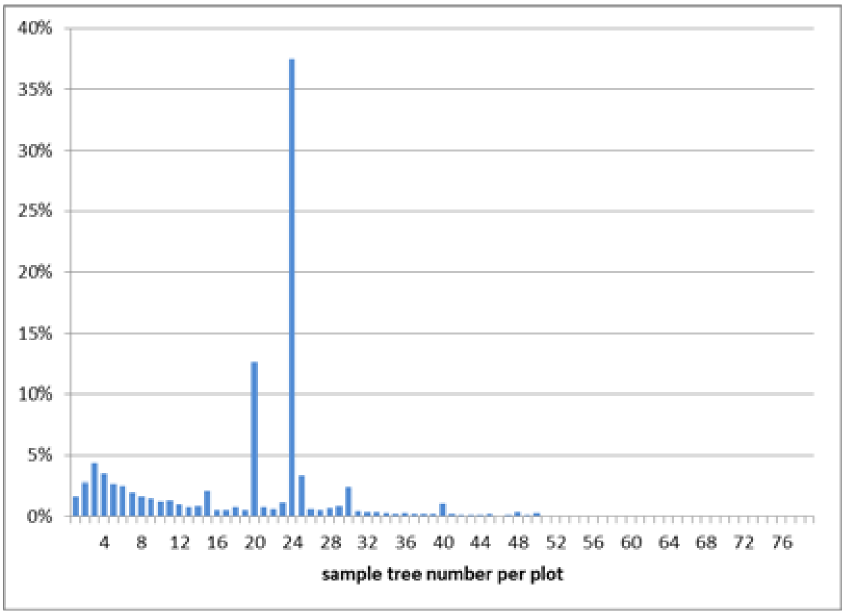

Figure 3-1: Percentage of sample tree number per plot

Due to harmonisation with plot designs of national forest inventories, the variation of numbers of trees per plot has been increasing in comparison to previous years. Predominant, dominant, and co-dominant trees (according to the system of Kraft) of all species qualify as sample trees, provided that they have a minimum height of 60 cm and that they do not show significant mechanical damage.

The variation of crown condition is mainly the result of intrinsic factors, age and site conditions. Moreover, defoliation may be caused by a number of biotic and abiotic stressors. Defoliation assessment attempts to quantify foliage missing as an effect of stressors including air pollutants and not as an effect of long lasting site conditions. In order to compensate for site conditions, local reference trees are used, defined as the best tree with full foliage that could grow at the particular site. Alternatively, absolute references are used, defined as the best possible tree of a genus or a species, regardless of site conditions, tree age etc. depicted on regionally applicable photos, e.g. photo guides. Changes in defoliation and discolouration attributable to air pollution cannot be differentiated from those caused by other factors. Consequently, defoliation due to factors other than air pollution is included in the assessment results. Trees showing mechanical damage are not included in the sample. Should mechanical damage occur to a sample tree, any resulting loss of foliage is not counted as defoliation.

In 2010, 145 323 trees were assessed (Tab. 3-4). Defoliation scores were available for 144 724 trees (Tab. 3-6). Table 3-4 shows the total number of trees assessed in each participating country since 1998. The figures in the table are not necessarily identical to those published in previous reports as re-submission of older data is possible in case of reorganisation of national observation networks.

63.4% of the plots assessed in 2010 were dominated by conifers and 36.6% by broadleaves (Annex I). Plots in mixed stands were assigned to the species group which comprised the majority of the sample trees. On almost 90% of the plots assessed in 2010, only one to three different tree species occurred. On 9.1% of plots four to five species and on 1.8% of plots six to ten tree species occurred (Annex II)

The total number of species within the tree sample was 133. Most abundant were *Pinus sylvestris* (23.6%) followed by *Picea abies* (15.5%), *Fagus sylvatica* (8.4%), *Betula pendula* (4.7%), and *Pinus nigra* (3.8%). In the following evaluations a number of tree species are groupd into species groups:

- **Deciduous temperate oak:** (*Quercus robur* and *Q. petraea*) accounting together for 6.7% of the assessed trees,
- **Mediterranean lowland pines:** (*Pinus brutia, P. pinaster, P. halepensis* and *P. pinea*) accounting together for 6.1% of the assessed trees,
- **Deciduous (sub-) temperate oak:** (*Quercus frainetto, Q. pubescens, Q. pyrenaica* and *Q. cerris*) accounting together for 5.5% of the assessed trees,
- **Evergreen oak:** (*Quercus coccifera, Q. ilex, Q. rotundifolia* and *Q. suber*) accounting together for 3.9% of the assessed trees.

Table 3-4: Number of sample trees from 1998 to 2010 according to the current database

Country	Number of sample trees												
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Austria	3577	3535	3506	3451	3503	3470	3586	3528	3425				3087
Belgium	692	696	686	682	684	684	681	676	618	616	599	599	216
Bulgaria	5349	4344	4197	4174	3720	3836	3629	3592	3510	3569	3304	5560	4929
Cyprus				360	360	360	360	361	360	360	360	362	360
Czech Rep.	2899	3475	3475	3475	3500	3500	3500	3450	3425	3300	3400	3325	3300
Denmark	552	552	504	504	480	480	480	528	527	442	452	384	408
Estonia	2184	2184	2160	2136	2169	2228	2201	2167	2191	2209	2196	2202	2348
Finland	8758	8662	8576	8579	8593	8482	11210	11498	11489	11199	8812	7182	7946
France	10740	10883	10317	10373	10355	10298	10219	10129	9950	10074	10138	9949	10584
Germany	13178	13466	13722	13478	13534	13572	13741	13630	10327	10241	10347	10088	10063
Greece	2204	2192	2192	2168	2144			2054				2289	2311
Hungary	1383	1470	1488	1469	1446	1446	1710	1662	1674	1650	1661	1668	1626
Ireland	441	417	420	420	424	403	400	382	445	646	679	717	641
Italy	4939	6710	7128	7350	7165	6866	7109	6548	6936	6636	6579	6794	8338
Latvia	2326	2348	2256	2325	2340	2293	2290	2263	2242	2228	2184	3911	3888
Lithuania	1616	1613	1609	1597	1583	1560	1487	1512	1505	1507	1688	1734	1814
Luxemburg	96	96	96		96	96	96	97	96	96	96		
Netherlands	220	225	218	231	232	231	232	232	230			247	227
Poland	8620	8620	8620	8620	8660	8660	8660	8640	7520	9160	9036	7520	7482
Portugal*	4470	4470	4470	4500	4530	4260	4170	3749	3719				
Romania	5637	5712	5640	5568	5544	5544	5424	5496	5472	5232		5448	5736
Slovak Rep.	5094	5063	5157	5054	5076	5116	5058	5033	4808	4904	4956	4944	4831
Slovenia	984	984	984	984	936	983	1006	1056	1069	1056		1056	1052
Spain**	11160	14664	14880	14880	14880	14880	14880	14880	14880	14880	14880	14880	14880
Sweden	11044	11135	11361	11283	11278	11321	11255	11422	11186			2207	2742
Kingdom	2112	2039	2136	2064	2064	2064	2040	2016	1968	768			1803
EU	110275	115555	115798	115725	115296	112633	115424	116601	109572	90773	81367	93066	100612
Andorra							72		74	72	72	73	72
Belarus	9896	9745	9763	9761	9723	9716	9682	9484	9373	9424	9438	9615	9617
Croatia	2066	2015	1991	1941	1910	1869	2009	2046	2109	2013	2015	1991	1992
Moldova	234	259	234	234									
Montenegro													1176
Norway	4069	4052	4051	4304	4444	4547	5014	5319	5525	5824	6085	6014	6330
Russian Fed.												11016	8958
Serbia						2274	2915	2995	2902	2860	2788	2751	2786
Switzerland	868	857	855	834	827	806	748	807	812	790	773	801	795
Turkey												13219	12985
Total Europe	127408	132483	132692	132799	132200	131845	135864	137252	130367	111756	102538	138546	145323

* including Azores, ** including Canares

3.2.1.3 Scientific background for the defoliation data analysis

Defoliation reflects a variety of natural and human induced environmental influences. It would therefore be inappropriate to attribute it to a single factor such as air pollution without additional evidence. As the true influence of site conditions and the share of tolerable defoliation can not be quantified precisely, damaged trees can not be distinguished from healthy ones only by means of a certain defoliation threshold. Consequently, the 25% threshold for defoliation does not necessarily identify trees damaged in a physiological sense. 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 trends over time.

Natural factors strongly influence crown condition. As also stated by many participating countries, air pollution is thought to interact with natural stressors as a predisposing or accompanying factor, particularly in areas where deposition may exceed critical loads for acidification (CHAPPELKA and FREER-SMITH, 1995, CRONAN and GRIGAL, 1995, FREER-SMITH, 1998).

It has been suggested that the severity of forest damage has been underestimated as a result of the replacement of dead trees by living trees in the course of regular forest management activities. However, detailed statistical analyses of the results of 10 monitoring years have revealed that the number of dead trees has remained so small that their replacement has not influenced the results notably (LORENZ et al., 1994).

3.2.1.4 Classification of defoliation data

The results of the evaluations of the crown condition data are presented in terms of mean plot defoliation or the percentages of the trees falling into 5%-defoliation steps. In previous presentations of survey results, partly the traditional classification of both defoliation and discolouration had been applied, although it is considered arbitrary by some countries. This classification (Tab. 3-5) is a practical convention, as real physiological thresholds cannot be defined.

Table 3-5: Defoliation and discolouration classes according to UNECE and EU classification

Defoliation class	needle/leaf loss	degree of defoliation
0	up to 10 %	none
1	> 10 - 25 %	slight (warning stage)
2	> 25 - 60 %	moderate
3	> 60 - < 100 %	severe
4	100 %	dead
Discolouration class	foliage discoloured	degree of discolouration
0	up to 10 %	none
1	> 10 - 25 %	slight
2	> 25 - 60 %	moderate
3	> 60 %	severe
4		dead

In order to discount background perturbations which might be considered minor, a defoliation of >10-25% is con-sidered a warning stage, and a defoliation > 25% is taken as a threshold for damage. Therefore, in the present report a distinction has sometimes only been made between defoliation classes 0 and 1 (0-25% defoliation) on the one hand, and classes 2, 3 and 4 (defoliation > 25%) on the other hand.

Classically, trees in classes 2, 3 and 4 are referred to as "damaged", as they represent trees with considerable defoliation. In the same way, the sample points are referred to as "damaged" if the mean defoliation of their trees (expressed as percentages) falls into class 2 or higher. Otherwise the sample point is considered as "undamaged". The most important results have been tabulated separately for all countries having participated (called "all plots") and for the 26 participating EU-Member States.

3.2.1.5 Mean defoliation and temporal development

For all evaluations related to a particular tree species a criterion had to be set up to be able to decide if a given plot represents this species or not. This criterion was that the number of trees of the particular species had to be three or more per plot ($N \geq 3$). The mean plot defoliation for the particular species was calculated as the mean defoliation of the trees of the species on that plot.

The temporal development of defoliation is expressed on maps as the slope, or regression coefficient, of a linear regression of mean defoliation against the year of observation. It can be interpreted as the mean annual change in defoliation. These slopes were considered as "significant" only if there was at least 95% probability that they are different from zero.

Besides the temporal development, also the change in the results from 2009 to 2010 was calculated (Annex V). In this case, changes in mean defoliation per plot are called "significant" only if the significance at the 95% probability level was proven in a statistical test.

3.2.1.6 National surveys

National surveys are conducted in many countries in addition to the transnational surveys. The national surveys in most cases rely on denser national grids and aim at the documentation of forest condition and its development in the respective country. Since 1986, densities of national grids with resolutions between 1 x 1 km and 32 x 32 km have been applied due to differences in the size of forest area, in the structure of forests and in forest policies. Results of crown condition assessments on the national grids are presented in Chapter 11. Comparisons between the national surveys of different countries should be made with great care because of differences in species composition, site conditions and methods applied.

3.2.2 Results of the transnational crown condition survey in 2010

In 2010 crown condition was assessed on 7 503 plots (Tab. 3-3) comprising 144 724 sample trees with defoliation scores (Tab. 3-6). Of these, 80 709 conifers and 64 015 deciduous trees were investigated.

Mean defoliation of all assessed trees in Europe was 19.0%. Deciduous trees showed a mean defoliation of 20.1%, slightly higher than that of conifers (18.1%). Annex IV shows a map of mean plot defoliation for all species.

A share of 19.5% of the assessed trees was evaluated as damaged, i.e. had a defoliation of more than 25% (Tab. 3-6). The share of damaged broadleaves (21.9%) exceeded that of damaged conifers (17.6%). In Annex III the percentages of damaged trees are mapped for each plot.

Because of the different numbers of participating countries, the defoliation figures from 2010 are not comparable to those from previous reports. The development of defoliation over time is derived from tree and plot samples from defined sets of countries (Chapt. 3.2.4.1).

Table 3-6: Percentages of trees in defoliation classes and mean defoliation for broadleaves, conifers and all species

		Percentage of trees in defoliation class							Defoliation		No of
	Species type	**0-10**	**>10-25**	**0-25**	**>25-60**	**>60**	**dead**	**>25**	**mean**	**median**	trees
EU	broadleaves	28.5	46.5	75.0	22.1	2.1	0.7	25.0	21.7	20	45623
	conifers	35.5	43.7	79.3	18.5	1.3	0.9	20.7	19.4	15	54400
	all species	32.3	45.0	77.3	20.1	1.7	0.8	22.7	20.4	15	100023
Total Europe	*Fagus sylvatica*	35.9	43.7	79.6	19.0	1.2	0.3	20.4	18.9	15	12140
	Deciduous temperate oak	19.2	46.6	65.8	31.3	2.2	0.6	34.2	24.8	20	9674
	Deciduous (sub-) mediterranean oak	26.0	47.5	73.5	23.4	2.6	0.5	26.5	22.3	20	8010
	Evergreen oak	18.2	61.7	80.0	17.6	1.7	0.7	20.0	21.8	20	4762
	broadleaves	34.2	43.9	78.1	19.2	2.0	0.7	21.9	20.1	15	64015
	Pinus sylvestris	38.2	47.4	85.6	12.8	0.8	0.7	14.4	17.4	15	34210
	Picea abies	47.3	32.2	79.5	18.5	1.5	0.5	20.5	17.0	15	22449
	Mediterranean lowland pines	19.6	60.6	80.1	16.5	1.6	1.8	19.9	22.3	20	8917
	conifers	38.8	43.6	82.4	15.5	1.2	0.9	17.6	18.1	15	80709
	all species	36.8	43.7	80.5	17.1	1.6	0.8	19.5	19.0	15	144724

The frequency distribution of the sample trees is shown in 5% classes for broadleaves, conifers, and all species (Fig. 3-2). Dead trees are indicated by defoliation values of 100%.

More than 50% of all trees exhibit defoliation of 10 to 20%. The proportion of conifers is higher in defoliation classes of up to 15%, whereas it was found that deciduous trees showed higher shares in defoliation classes above 15%.

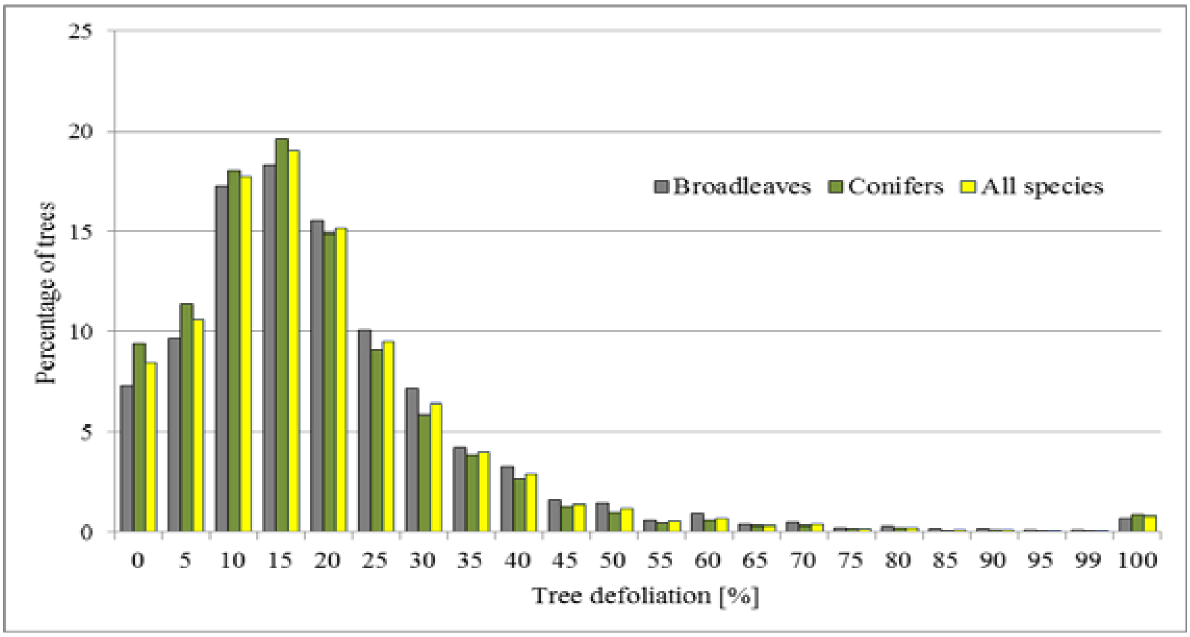

Figure 3-2: Frequency distribution of all trees assessed in 2010 in 5%-defoliation steps

Figures 3-3 to 3-9 show maps of mean plot defoliation for *Pinus sylvestris*, *Picea abies, Fagus sylvatica*, and for the species groups deciduous temperate oak, deciduous (sub-) mediterranean oak, evergreen oak and Mediterranean lowland pines. The maps partly reflect the differences in crown condition between species seen in Table 3-5.

Deciduous temperate oaks had the highest value of mean defoliation (24.8%) on the assessed plots. The spatial distribution on the maps shows clusters of plots with high defoliation concentrated in central Europe. The mean defoliation of deciduous (sub-) mediterranean oaks (22.3%) was higher than the defoliation of the evergreen oaks (21.8%). *Fagus sylvatica* showed a mean defoliation of 18.9%.

From the evaluated conifers Mediterranean lowland pines had the highest mean defoliation (22.3%). In contrast, the mean defoliation of *Pinus sylvestris* and *Picea abies* was lower. Of all the evaluated tree groups *Picea abies* showed the lowest mean defoliation (16.9%).

Clusters of plots with mean defoliation of *Pinus sylvestris* and *Picea abies* above 30% are located in central Europe. Specifically for *Pinus sylvestris* mean defoliation was lower on plots in boreal and hemiboreal regions.

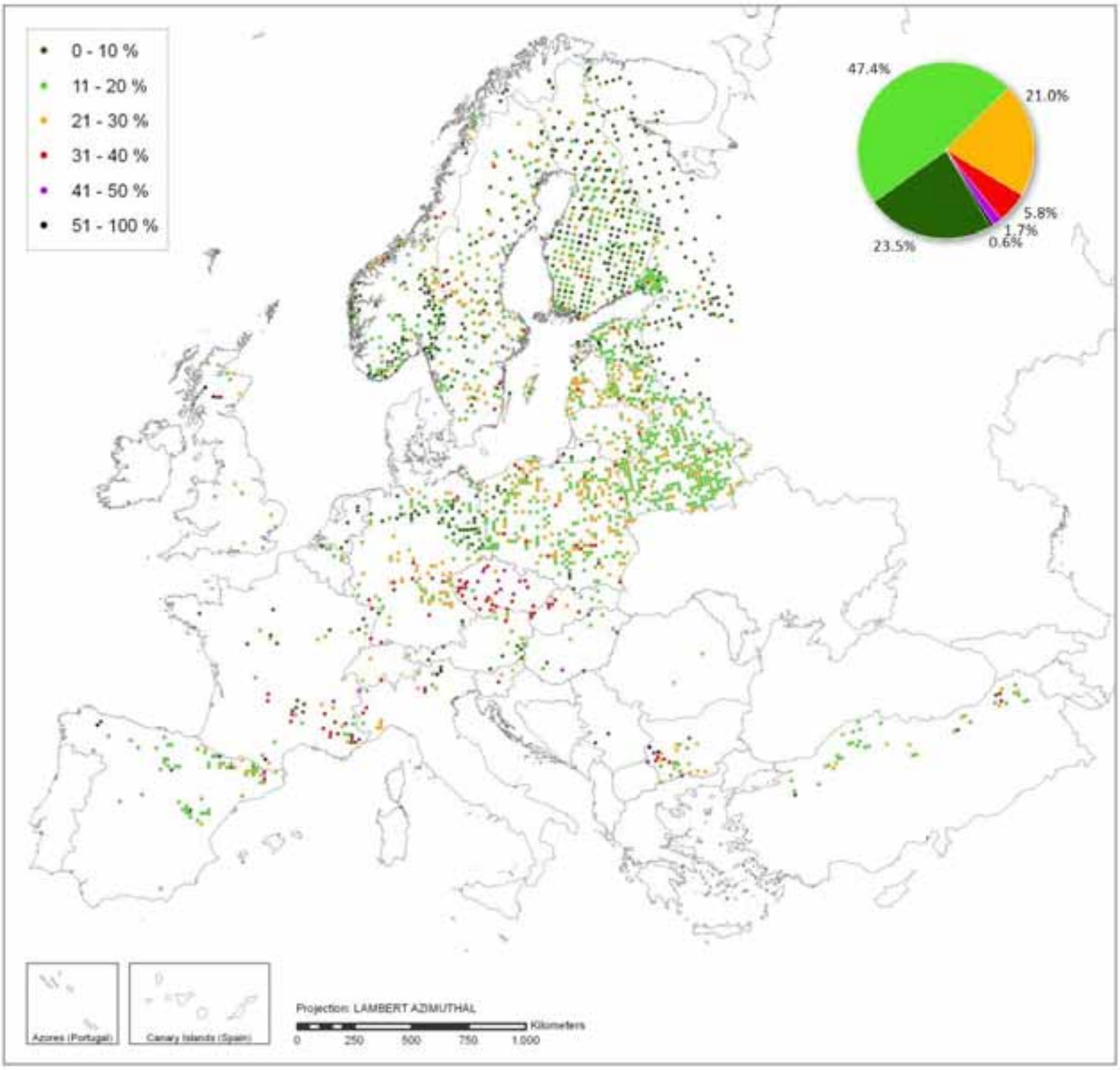

Figure 3-3: Mean plot defoliation for *Pinus sylvestris,* 2010

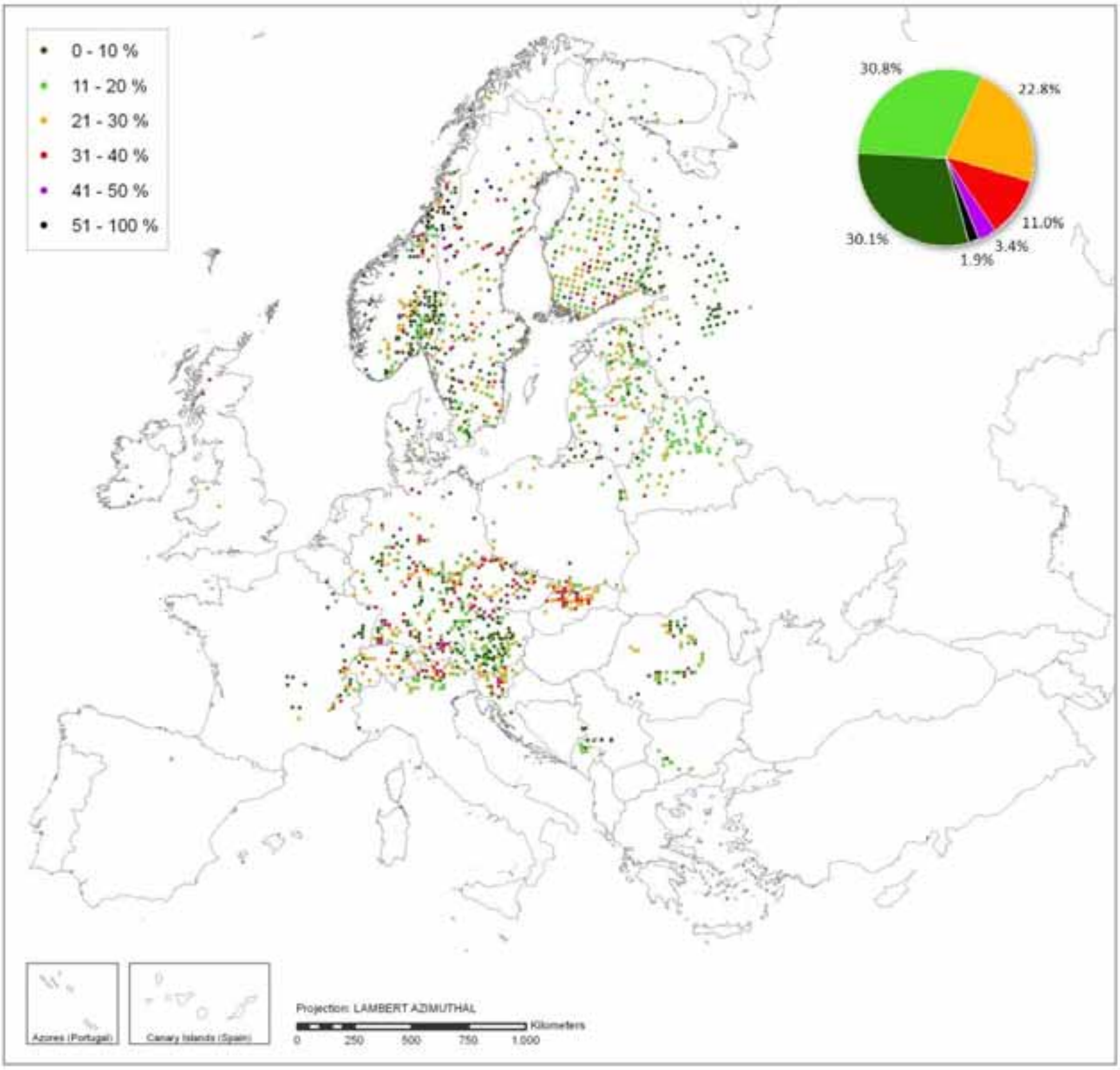

Figure 3-4: Mean plot defoliation for *Picea abies,* 2010

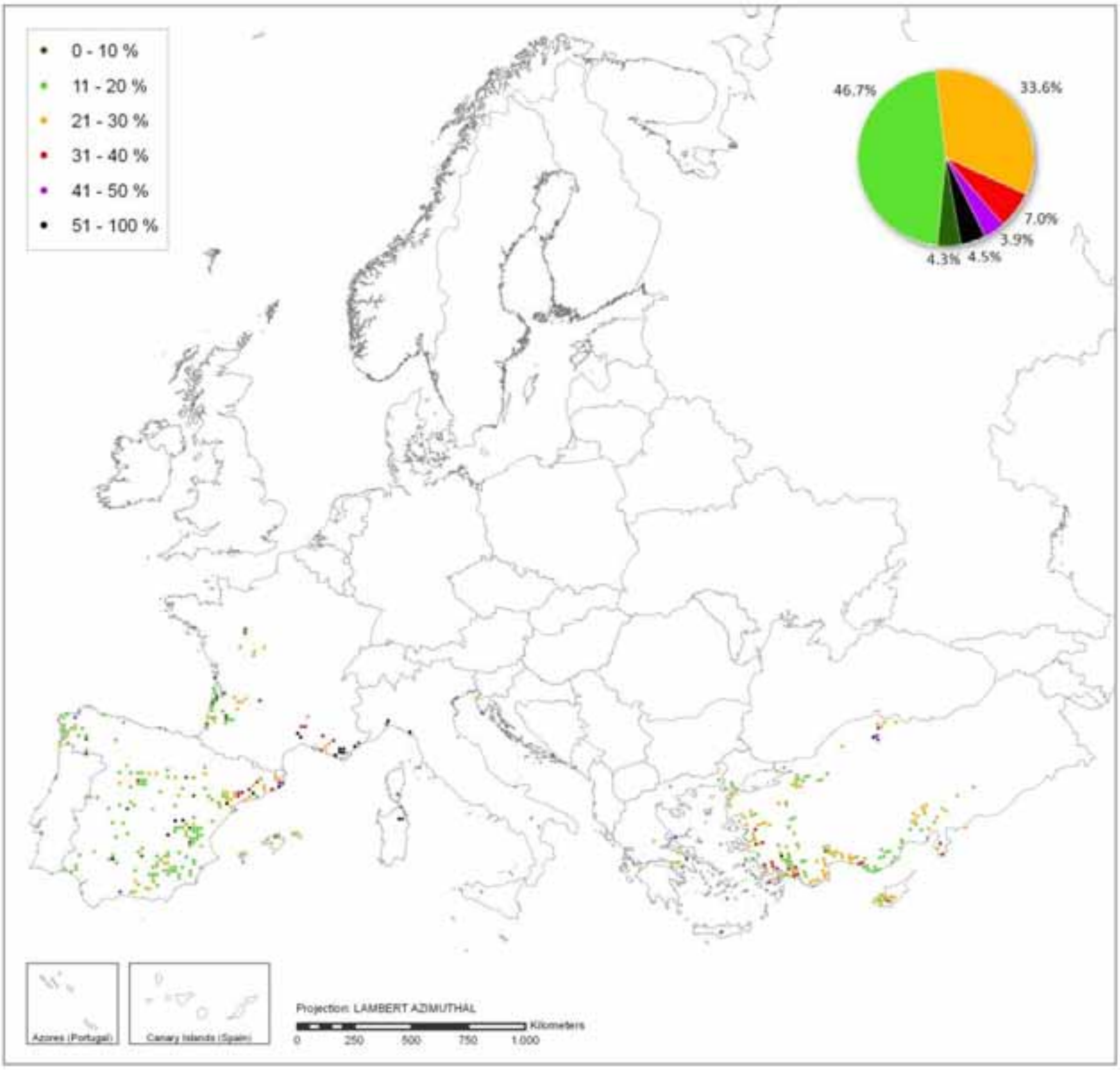

Figure 3-5: Mean plot defoliation for Mediterranean lowland pine (*Pinus brutia, Pinus halepensis, Pinus pinaster, Pinus pinea)*, 2010

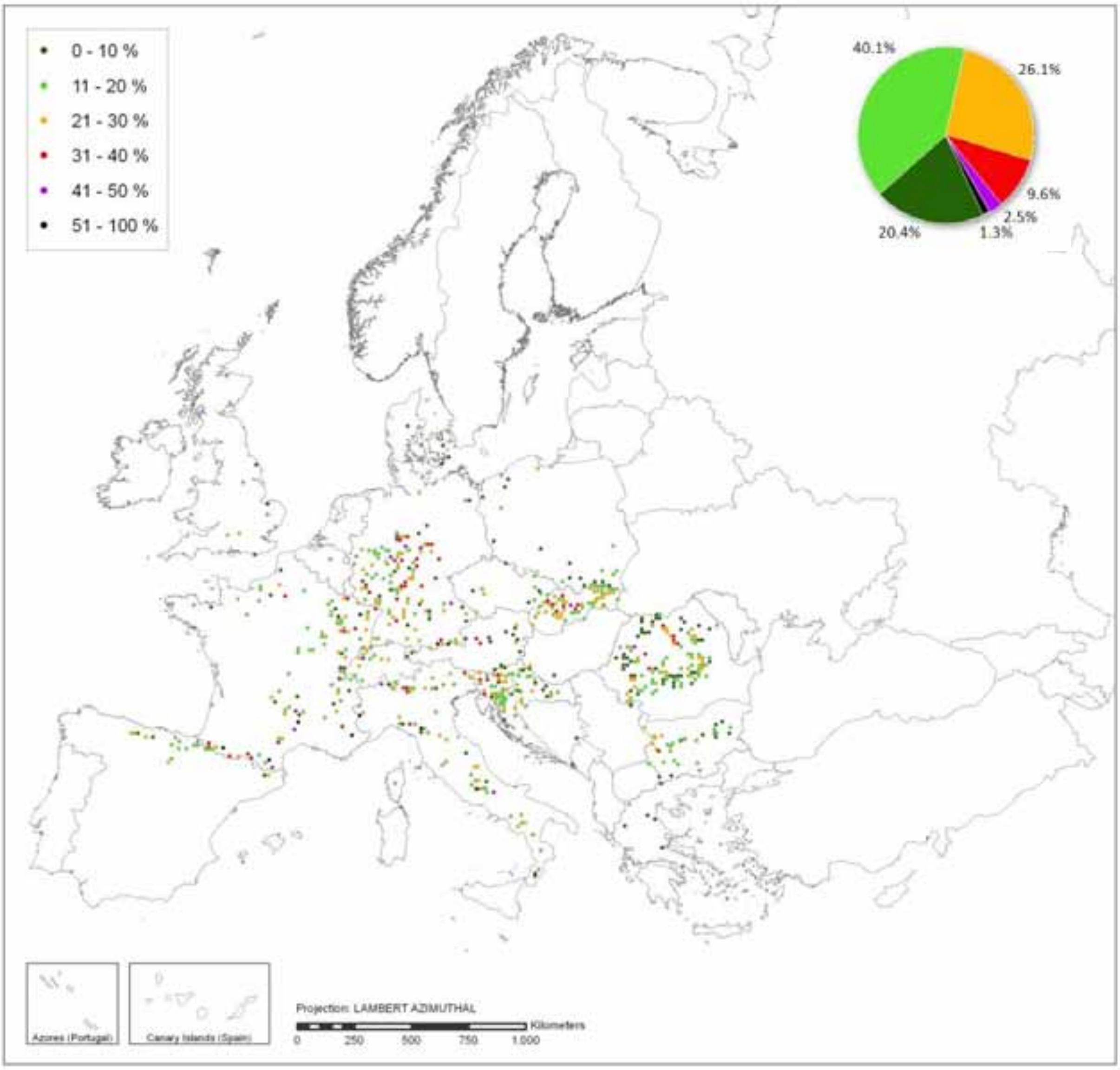

Figure 3-6: Mean plot defoliation for *Fagus sylvatica,* 2010

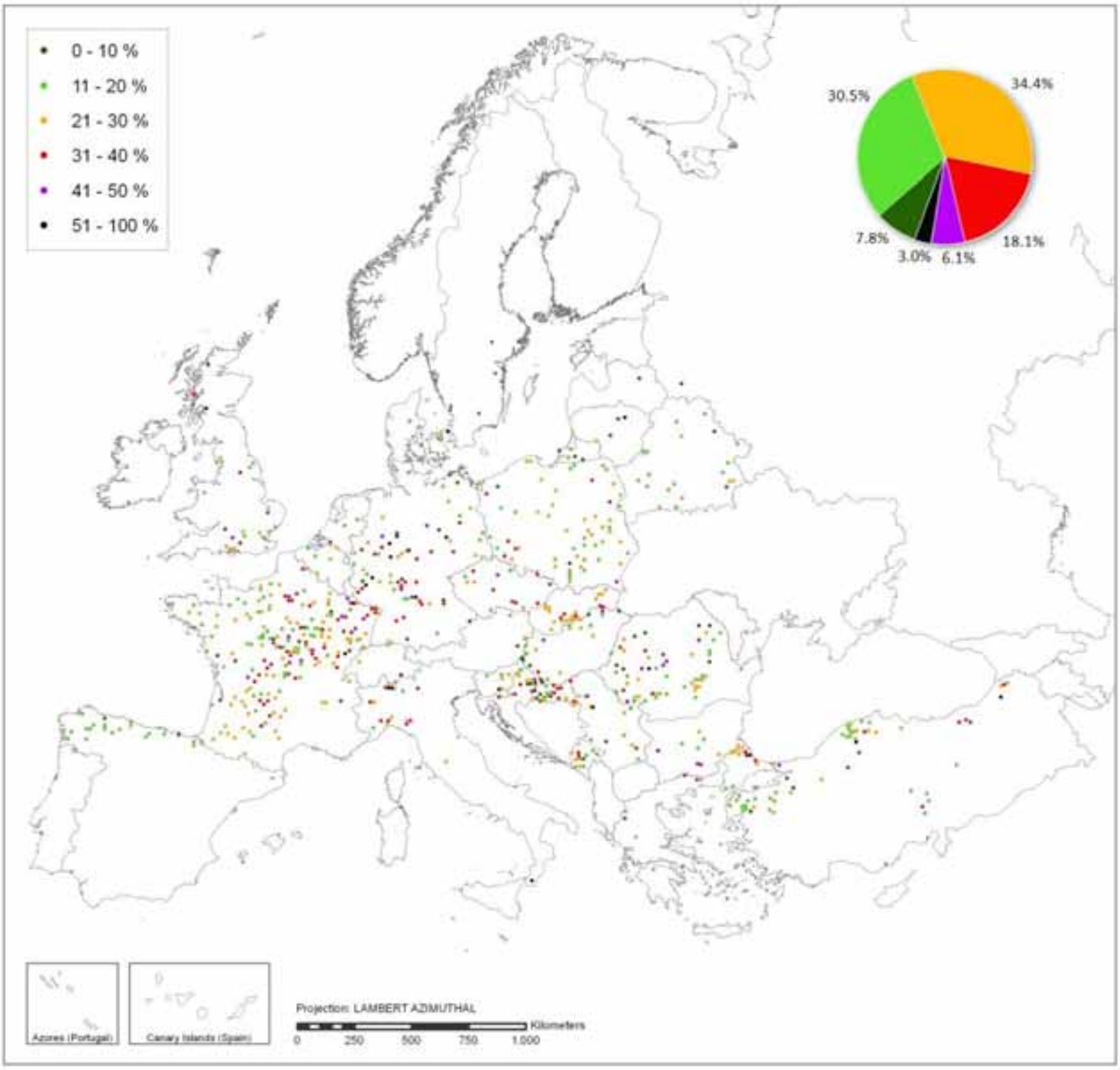

Figure 3-7: Mean plot defoliation for deciduous temperate oak (*Quercus petraea and Quercus robur*), 2010

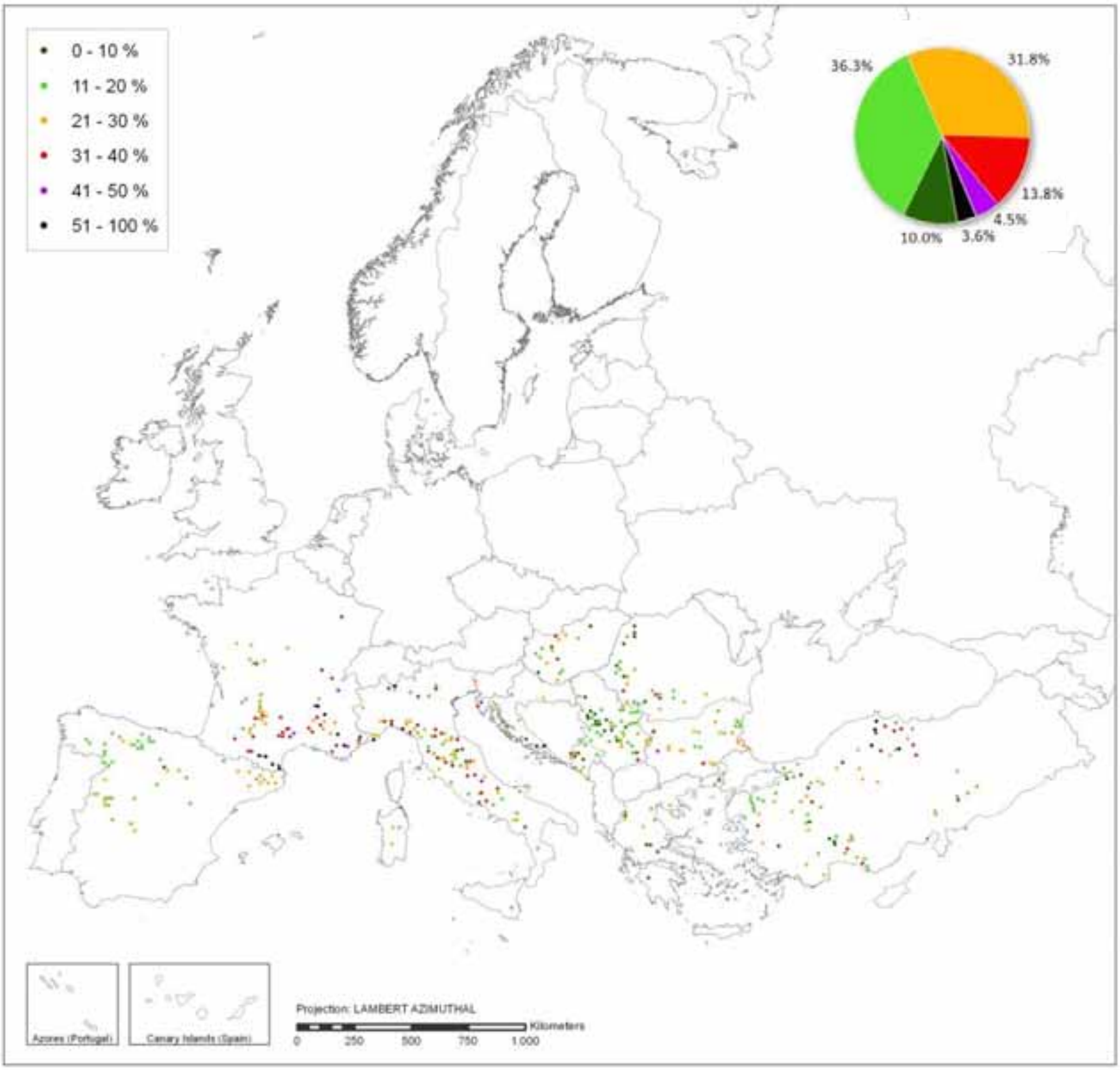

Figure 3-8: Mean plot defoliation for Deciduous (sub-) Mediterranean oak (*Quercus cerris, Quercus frainetto, Quercus pubescens, Quercus pyrenaica*), 2010

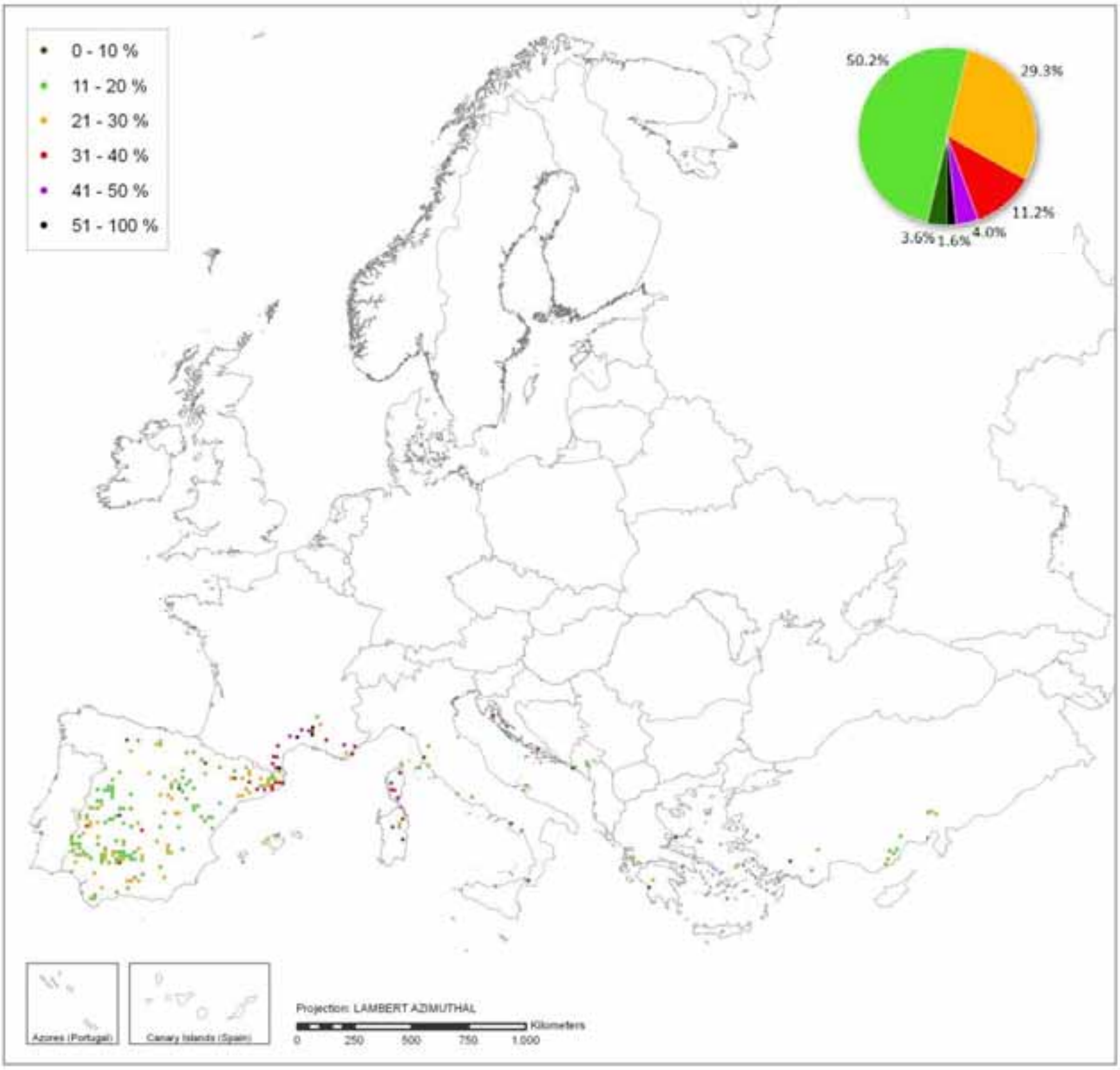

Figure 3-9: Mean plot defoliation for evergreen oak (*Quercus coccifera, Quercus ilex, Quercus rotundifolia, Quercus suber*), 2010

3.2.3 Defoliation trends

3.2.3.1 Approach

The development of defoliation is calculated assuming that the sample trees of each survey year represent forest condition. Studies of previous years show that the fluctuation of trees in this sample (due to the exclusion of dead and felled trees as well as inclusion of replacement trees) does not cause distortions of the results over the years. However, fluctuations due to the inclusion of newly participating countries must be excluded, because forest condition among countries can deviate greatly. For this reason, the development of defoliation can only be calculated for defined sets of countries. Different lengths of time series require different sets of countries, because at the beginning of the surveys the number of participating countries was much smaller than it is today.

For the present evaluation the following three time periods and the following countries were selected for tracing the development of defoliation:

- **Period 1991-2010 ("long term period")**: Belgium, Czech Republic, Denmark, Finland, France[1], Germany, Hungary, Ireland, Italy, Latvia, Poland, Slovak Republic, Spain, and Switzerland.
- **Period 1997-2010 ("many countries"):** Belarus, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Norway, Poland, Slovak Republic, Spain, and Switzerland.
- **Period 2002-2010 ("short term period used to calculate the trend of the mean plot defoliation"):** Belarus, Belgium, Bulgaria, Croatia, Czech Republic, Cyprus, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Norway, Poland, Slovak Republic, Spain, and Switzerland.

Several countries could not be included in one of the three time periods because of changes in their tree sample sizes, their assessment methods or missing assessments in certain years. Development of defoliation is presented for the periods 1991-2010 and 1997-2010 in graphs and in tables. Graphs show the fluctuations of mean defoliation and shares of trees in defoliation classes over time.

The maps depict trends in mean defoliation from 2002-2010. Whereas all plots of the countries mentioned above are included for the two respective time periods in graphs, the maps of the trend analysis only represent plots within these countries that were included in all of the surveys. In the last years plots were shifted within Finland and parts of northern Germany (Brandenburg). These plots are not depicted in the maps but the countries are included in the time series calculation.

The spatial pattern of the changes in mean defoliation from 2009 to 2010 across Europe is shown in Annex I-5. On 84.8% of the plots between 2009 and 2010 there was no statistical significance of the differences in mean plot defoliation detected. The share of plots with increasing defoliation was 6.9%, the share of plots with a decrease was 8.3%.

[1] Methodological changes in the first years of the assessments

3.2.3.2 All tree species

For all species depicted, the two time series show very similar trends for mean defoliation due to the fact that the countries included in the short time series were also included in the evaluation of the long time series (Fig. 3-10 and Fig. 3-11). For *evergreen oak* and *Mediterranean lowland pines* there was hardly any difference in sample sizes on which evaluations of the different time series were based. The largest differences occurred for *Pinus sylvestris* and *Picea abies* the sample sizes for the long time series being 70% smaller than that of the shorter time series.

Since 1991 mean defoliation of the evaluated tree species developed very differently. With the exception of *Picea abies* and *Pinus sylvestris*, all tree species showed a sharp rise in mean defoliation in the first years of the study. Mean defoliation of *Picea abies*, *Fagus sylvatica* and the deciduous temperate oaks peaked after the extremely dry and warm summer in 2003. In all samples studied, deciduous temperate oaks and deciduous (sub-) mediterranean oaks exhibited the highest mean defoliation over the last decade. In contrast, *Pinus sylvestris* clearly showed the lowest mean defoliation from all evaluated species.

Trends in mean plot defoliation for all tree species for the period 2002-2010 are mapped in Figure 3-12. The share of plots with distinctly increasing defoliation (16.8%) surmounts the share of plots with decreasing defoliation (10.0%). Plots showing deterioration are scattered across Europe, but their share is particularly high in southern France, at the eastern edge of the Pyrenean Mountains, Czech Republic, and northeastern Italy.

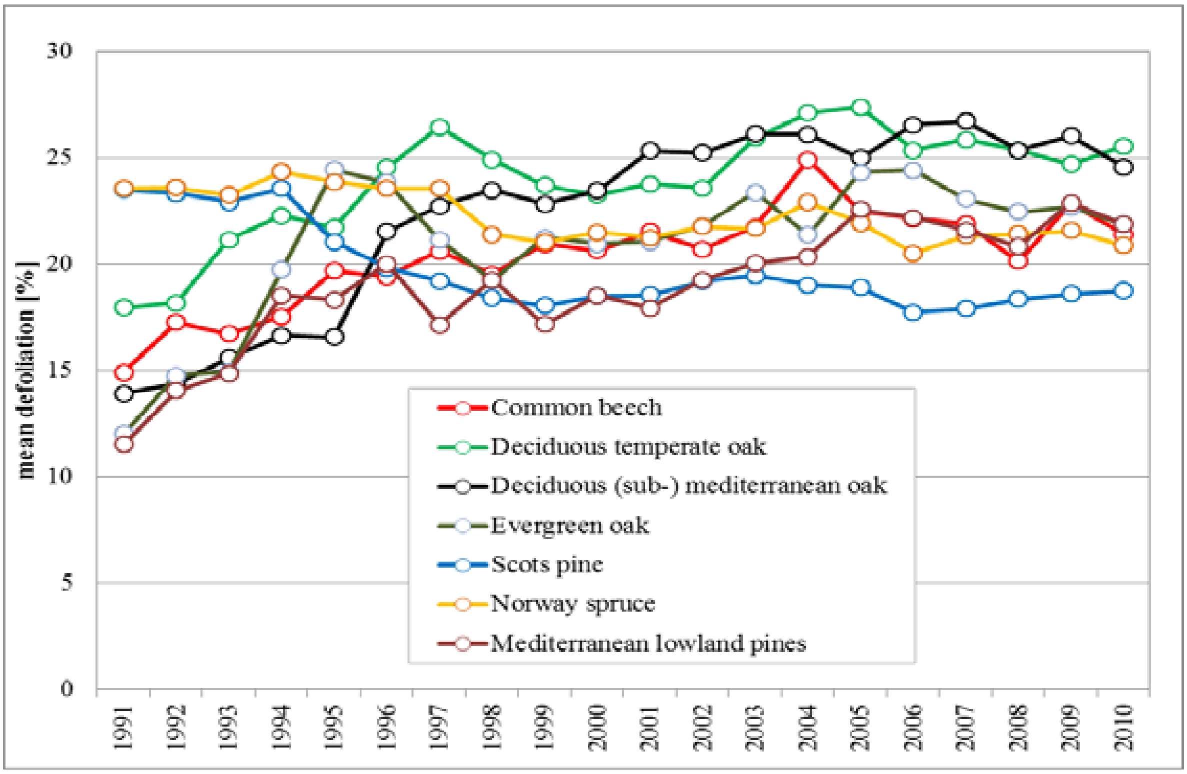

Figure 3-10: Mean defoliation of main species 1991 - 2010

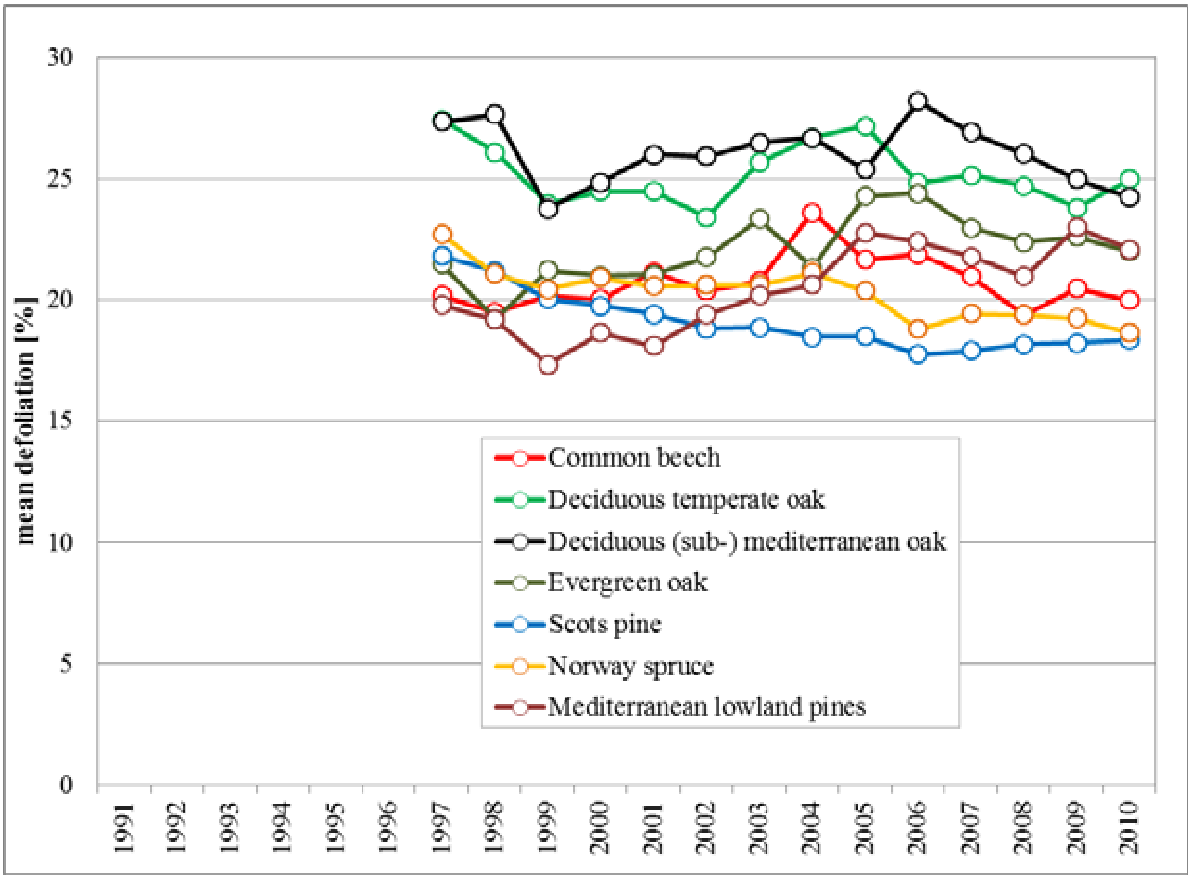

Figure 3-11: Mean defoliation of main species 1997 - 2010

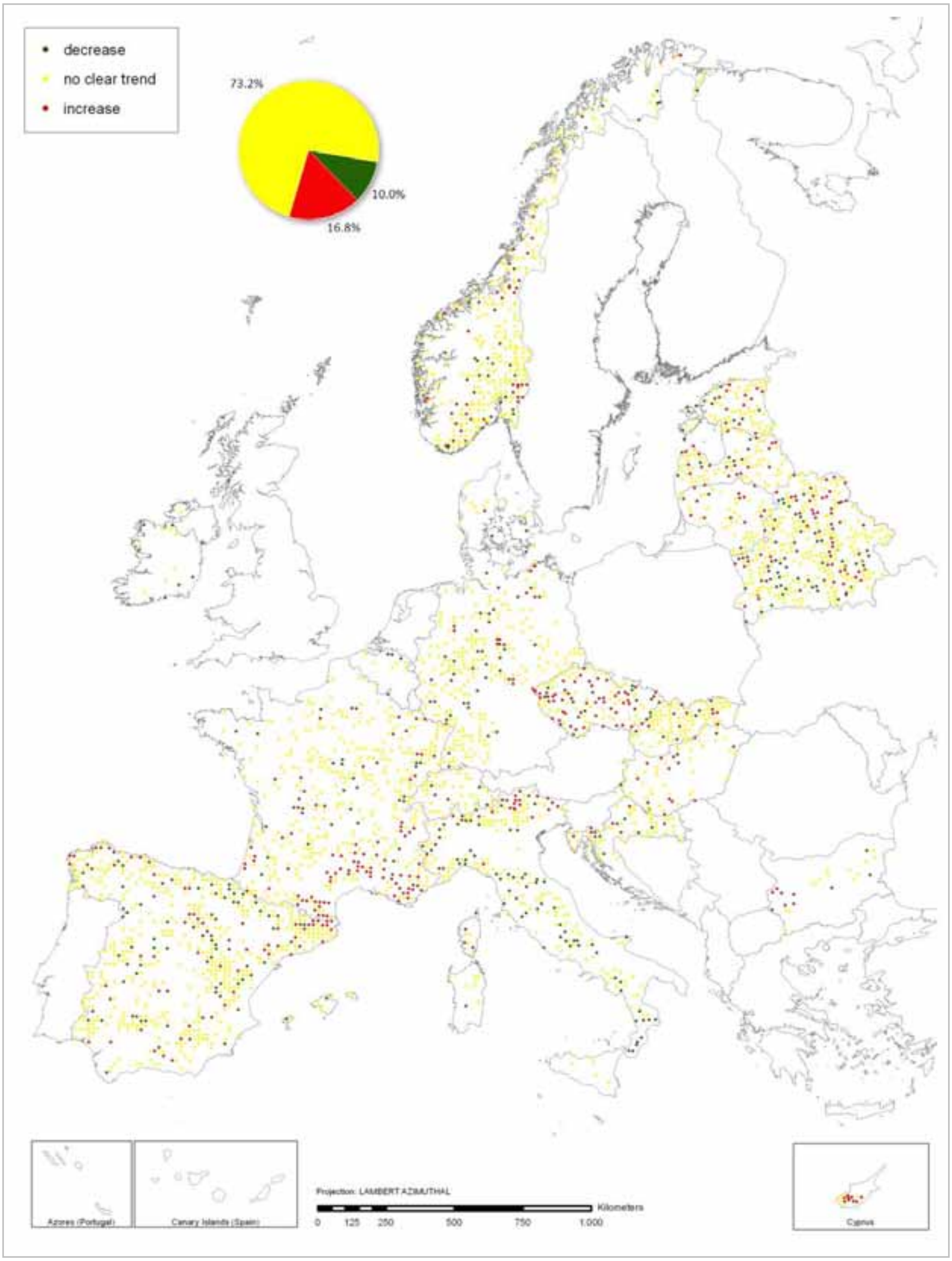

Figure 3-12: Development of mean plot defoliation (slope of linear regression) of all species over the years 2002 – 2010

3.2.3.3 Pinus sylvestris

Pinus sylvestris is by far the most common tree species in the sample. It covers most regions in Europe and occurs on Level I plots from northern Scandinavia to the Mediterranean region. Due to the large sample number and its occurrence throughout Europe, regional differences in the development of crown condition are leveled off in the aggregated results (Tab. 3-7).

Over the long time period, a decrease in the mean defoliation was noticed. In recent years, however, almost no change in crown condition was seen. Throughout both time periods, the share of healthy pines (0-10%) increased and the share of the damaged pine trees (>25%) decreased (Tab. 3-7, Fig. 3-13, Fig. 3-14).

Plots showing a deterioration are scattered across Europe (Fig. 3-15). Most plots show no clear trend from 2002 to 2010. Ths share of plots with increasing defoliation (16.9%) is larger than the share of plots with decresing defolaiton (9.2%).

	N Trees	0-10%	>10-25%	>25%
1991	17768	27.1	37.4	35.5
1992	17193	28.4	36.3	35.4
1993	17224	27.6	38.5	33.9
1994	16570	26.8	37.0	36.2
1995	18751	33.4	37.3	29.3
1996	18788	35.2	40.8	24.0
1997	18824	34.8	42.9	22.3
1998	19205	35.9	45.0	19.1
1999	19468	36.1	46.2	17.7
2000	19455	34.5	47.5	18.0
2001	19571	33.4	49.1	17.5
2002	19495	31.2	50.1	18.6
2003	19486	29.9	51.4	18.7
2004	21101	33.2	48.0	18.8
2005	21279	34.5	46.3	19.2
2006	18654	38.1	45.5	16.4
2007	19254	35.6	48.8	15.6
2008	17696	33.9	49.4	16.7
2009	16979	33.7	48.3	18.0
2010	17122	33.5	49.1	17.5
	N Trees	**0-10%**	**>10-25%**	**>25%**
1997	29838	27.7	44.6	27.7
1998	30196	29.2	45.8	25.0
1999	30148	30.6	47.6	21.8
2000	29855	30.2	49.9	19.9
2001	29967	30.4	51.3	18.3
2002	29798	32.0	51.6	16.4
2003	30077	31.6	52.0	16.5
2004	31593	35.2	48.3	16.6
2005	31722	35.5	47.6	16.9
2006	28990	37.4	48.1	14.6
2007	29570	34.8	50.9	14.2
2008	28046	32.5	52.7	14.8
2009	27662	32.6	52.0	15.4
2010	27851	33.0	51.9	15.1

Table 3-7: Shares of trees in different defoliaton classes

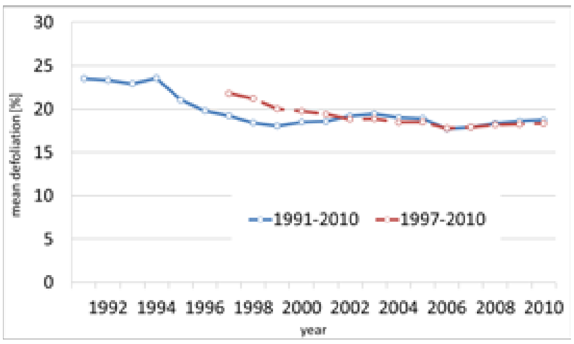

Figure 3-13: Mean defoliation in two periods (1991-2010 and 1997-2010)

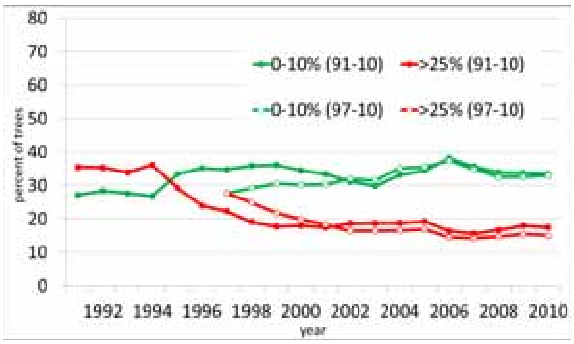

Figure 3-14: Shares of trees of defoliation 0-10% and >25% in two periods (1991-2010 and 1997-2010)

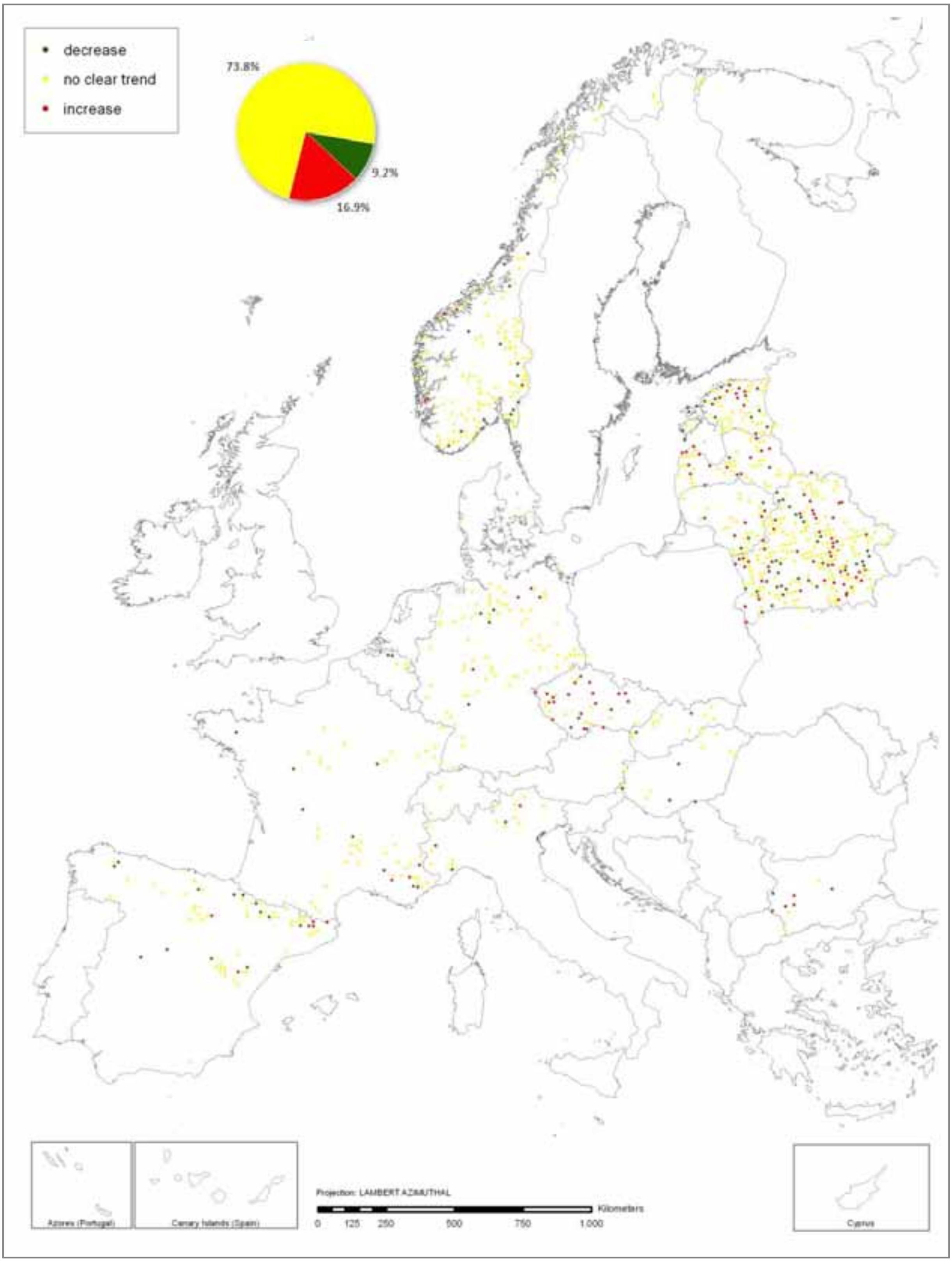

Figure 3-15: Development of mean plot defoliation (slope of linear regression) of *Pinus sylvestris* over the years 2002 – 2010

3.2.3.4 Picea abies

Picea abies is the second most frequently occurring tree species in the large scale tree sample. Its range extends mainly from Scandinavia to northern Italy.

The crown condition of *Picea abies* slightly improved over the course of both observation periods. Due to the extreme weather conditions in central Europe in summer 2003, mean defoliation peaked in this year. Until 2006 a regeneration phase was observed. Since then, the crown condition has remained more or less unchanged (Tab. 3-8, Fig. 3-16, Fig. 3-17).

Since 1991, the share of healthy trees (0-10%) increased slightly. In the same period the share of more damaged spruce (>25%) decreased slightly. A significant improvement in the crown condition of spruce was observed in 1998 and 2006.

From 2003 to 2010, a total of 19.4% of all plots showed an increase of mean defoliation; a significant decrease in crown damage was only observed on 9.2%. In particular, decreasing trends of defoliation were determined in Belarus and southern Norway (Fig. 3-18).

	N Trees	0-10%	>10-25%	>25%
1991	15090	26.0	37.4	36.6
1992	12298	26.8	37.4	35.8
1993	12473	28.1	37.6	34.4
1994	12812	26.3	35.7	38.0
1995	14480	28.9	33.7	37.4
1996	14437	29.4	31.9	38.7
1997	14234	27.0	33.9	39.1
1998	13729	32.2	36.6	31.3
1999	14129	33.2	36.8	30.1
2000	14174	31.3	38.0	30.7
2001	13898	30.3	39.7	30.0
2002	13935	29.3	39.4	31.3
2003	13928	28.7	40.8	30.5
2004	14364	27.1	38.3	34.6
2005	13913	28.1	40.3	31.6
2006	11916	33.9	37.2	29.0
2007	11385	30.5	39.5	30.0
2008	10991	30.6	39.2	30.2
2009	10664	30.4	39.4	30.2
2010	10991	32.2	39.3	28.5
	N Trees	**0-10%**	**>10-25%**	**>25%**
1997	17982	30.0	34.2	35.8
1998	17465	34.0	36.1	29.9
1999	17862	35.1	36.7	28.3
2000	17833	33.1	38.3	28.6
2001	17574	32.6	39.4	27.9
2002	17630	33.2	39.1	27.7
2003	17736	32.6	40.3	27.1
2004	18272	32.8	37.4	29.8
2005	17749	33.9	38.5	27.6
2006	15845	39.2	36.3	24.5
2007	15538	37.2	37.5	25.2
2008	15325	37.4	37.3	25.3
2009	15274	38.0	37.4	24.6
2010	15683	40.1	36.5	23.4

Table 3-8: Shares of trees in different defoliaton classes

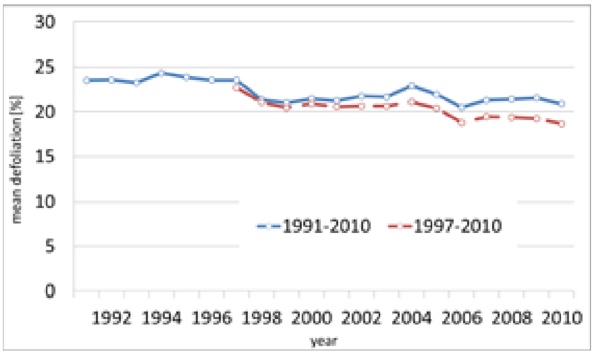

Figure 3-16: Mean defoliation in two periods (1991-2010 and 1997-2010)

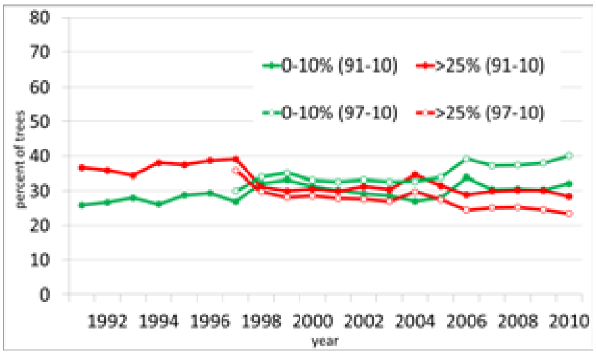

Figure 3-17: Shares of trees of defoliation 0-10% and >25% in two periods (1991-2010 and 1997-2010)

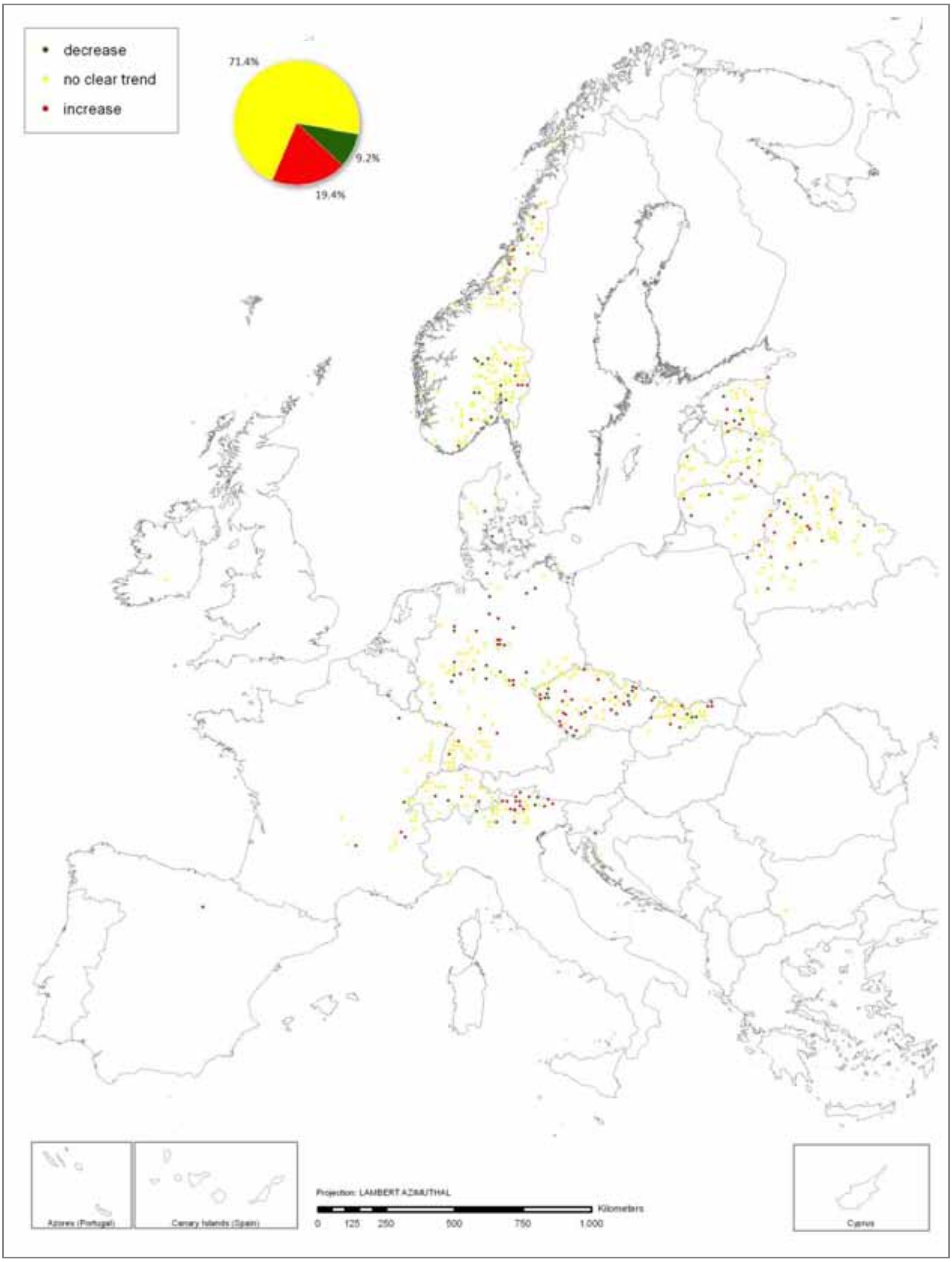

Figure 3-18: Development of mean plot defoliation (slope of linear regression) of *Picea abies* over the years 2002 – 2010

3.2.3.5 Mediterranean lowland pines

The group of Mediterranean lowland pines is composed of *Pinus brutia*, *P. pinaster*, *P. halepensis* and *P. pinea*. Their occurrence is limited to the Mediterranean region. The results for different time periods observed are similar because the two time periods included almost identical countries.

Crown condition of this tree species group is characterized by a considerable increase in mean defoliation of the pine trees since 1991. The share of healthy trees (0-10%) has decreased from 72.9% in 1991 to 23.2% in 2010. In contrast, the share of the damaged Mediterranean lowland pines (>25%) peaked in 2005, decreased thereafter and fluctuated since then (Tab. 3-9, Fig. 3-19, fig. 3-20).

The worsening trend is also reflected in the share of plots showing a significant increase in mean plot defoliation. Mean plot defoliation increased on 20.4% of the plots from 2002 to 2010. These plots are mainly located along the Mediterranean coast in France and in northern Spain (Fig. 3-21).

	N Trees	0-10%	>10-25%	>25%
1991	3758	72.9	20.9	6.1
1992	3866	63.9	24.3	11.8
1993	3891	60.3	27.1	12.6
1994	3802	50.3	32.7	17.0
1995	3823	39.2	43.8	17.0
1996	3815	36.6	45.4	17.9
1997	3769	40.3	48.3	11.5
1998	3827	37.1	47.3	15.6
1999	5202	40.8	47.6	11.6
2000	5279	39.1	48.6	12.2
2001	5287	34.0	54.6	11.5
2002	5280	29.6	55.8	14.7
2003	5215	27.3	56.6	16.1
2004	5235	28.7	55.2	16.1
2005	5198	20.7	56.0	23.3
2006	5201	21.3	56.6	22.1
2007	5240	22.9	57.0	20.1
2008	5248	21.2	60.5	18.3
2009	5105	18.1	61.0	20.8
2010	5085	23.2	58.7	18.1
	N Trees	**0-10%**	**>10-25%**	**>25%**
1997	3944	38.5	46.4	15.1
1998	3940	37.5	46.5	16.0
1999	5314	40.1	47.6	12.3
2000	5368	38.6	48.6	12.8
2001	5376	33.5	54.3	12.2
2002	5345	29.3	55.5	15.2
2003	5280	27.0	56.2	16.8
2004	5348	28.1	54.7	17.3
2005	5289	20.4	55.3	24.3
2006	5290	21.0	55.8	23.1
2007	5305	22.6	56.6	20.7
2008	5313	21.0	60.2	18.8
2009	5170	17.9	60.5	21.6
2010	5150	23.1	58.2	18.7

Table 3-9: Shares of trees in different defoliaton classes

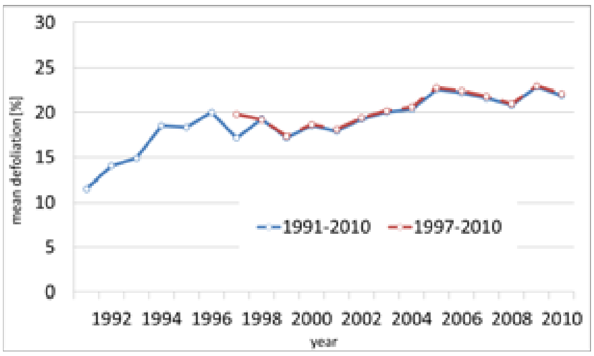

Figure 3-19: Mean defoliation in two periods (1991-2010 and 1997-2010)

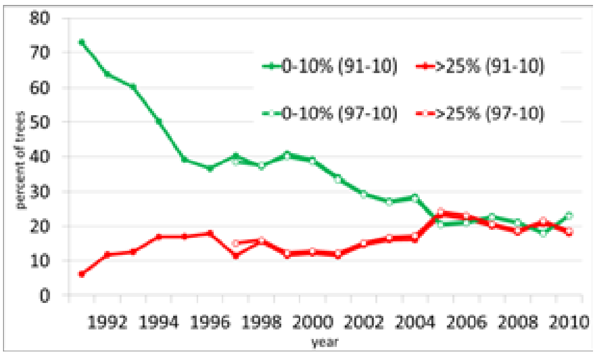

Figure 3-20: Shares of trees of defoliation 0-10% and >25% in two periods (1991-2010 and 1997-2010)

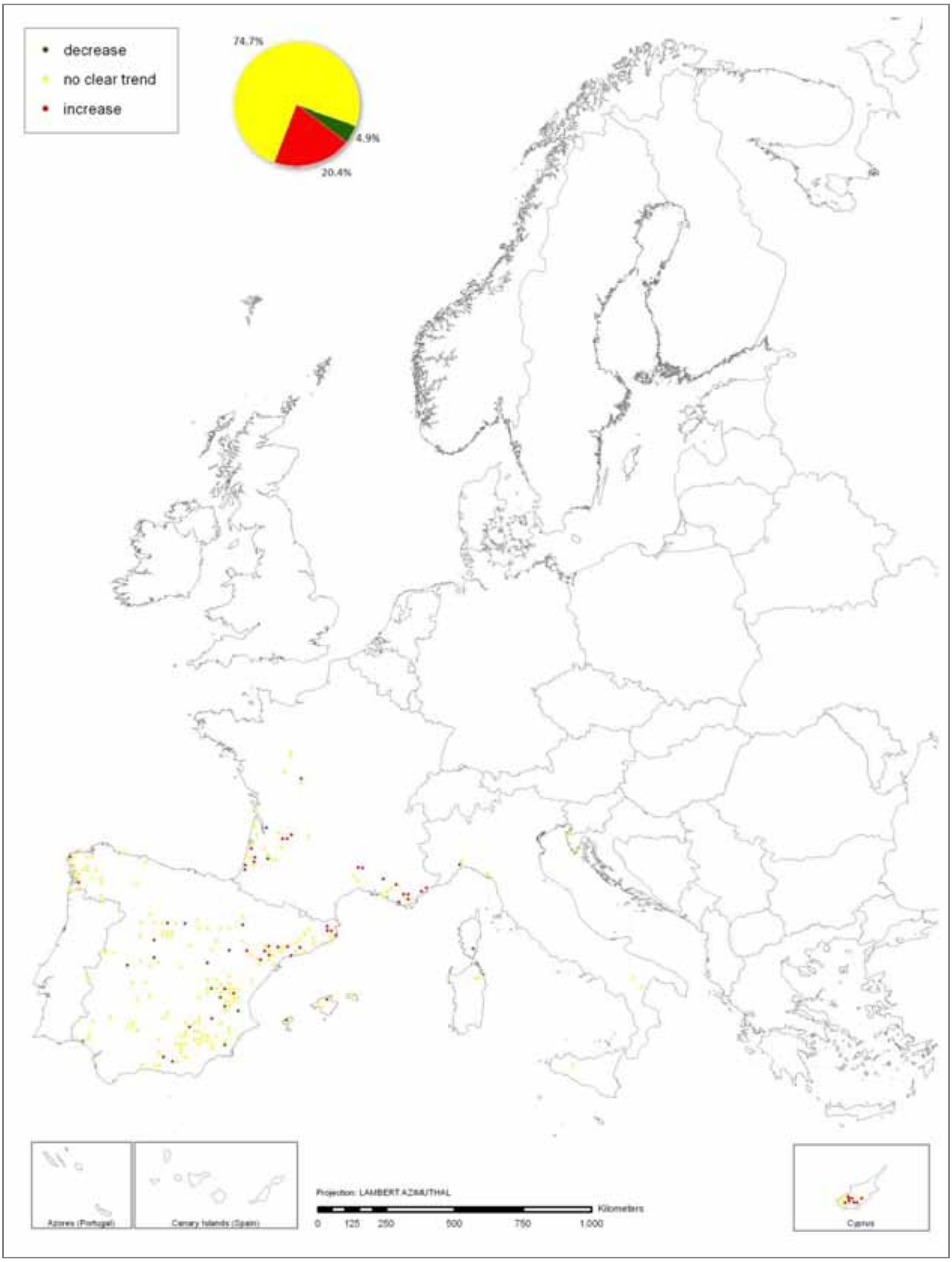

Figure 3-21: Development of mean plot defoliation (slope of linear regression) of *Mediterranean lowland pines* over the years 2002 – 2010

3.2.3.6 Fagus sylvatica

Fagus sylvatica is the most common deciduous tree species occurring on Level I plots. It ranges from southern Scandinavia to Sicily and from the northern coast of Spain to Bulgaria.

Since the beginning of the study in 1991, mean defoliation of this species slightly increased. Defoliation peaked in the year after the hot and dry summer in central Europe in 2003. Recuperation has been observed since then. The increase in defoliation in 2009 has been explained by, widespread fructification (Tab. 3-10, Fig. 3-22, Fig. 3-23).

The share of healthy trees (0-10%) steadily decreased from 49.6% in 1991, to 18.3% in 2004. In 2010, the share of healthy trees increased to 26.6%. The share of the damaged trees (> 25%) was 25.6% in 2010.

Temporal trends of mean defoliation from 2003 – 2010 show an increase in mean defoliation of *Fagus sylvatica*, especially on plots in France and Croatia. Decreasing trends were detected for plots in Italy and western Germany (Fig. 3-24).

	N Trees	0-10%	>10-25%	>25%
1991	6524	49.6	34.0	16.5
1992	6254	43.7	35.5	20.8
1993	6368	45.1	34.7	20.2
1994	6401	41.7	37.3	21.0
1995	6480	35.2	38.7	26.1
1996	6458	33.1	45.4	21.4
1997	6309	29.7	46.9	23.4
1998	6588	32.9	45.1	22.0
1999	7244	26.2	49.5	24.3
2000	7266	29.6	46.7	23.7
2001	7328	25.3	48.0	26.7
2002	7337	26.3	50.4	23.3
2003	7299	23.7	50.2	26.1
2004	7386	18.3	47.3	34.4
2005	7448	24.0	47.7	28.3
2006	6940	26.4	44.9	28.7
2007	7106	23.2	50.6	26.2
2008	7128	29.1	49.1	21.8
2009	6985	24.8	44.2	31.0
2010	7305	26.6	47.8	25.6
	N Trees	**0-10%**	**>10-25%**	**>25%**
1997	7792	33.1	44.5	22.4
1998	8176	35.6	43.3	21.0
1999	8454	30.7	46.9	22.4
2000	8668	33.9	44.0	22.1
2001	8664	29.3	45.4	25.4
2002	8772	30.3	47.5	22.1
2003	8666	28.1	48.4	23.5
2004	8613	21.9	47.3	30.8
2005	8760	28.6	45.9	25.5
2006	8315	30.3	43.4	26.3
2007	8577	28.4	48.1	23.5
2008	8533	32.8	47.6	19.6
2009	9041	32.6	42.2	25.2
2010	9187	31.8	45.8	22.4

Table 3-10: Shares of trees in different defoliaton classes

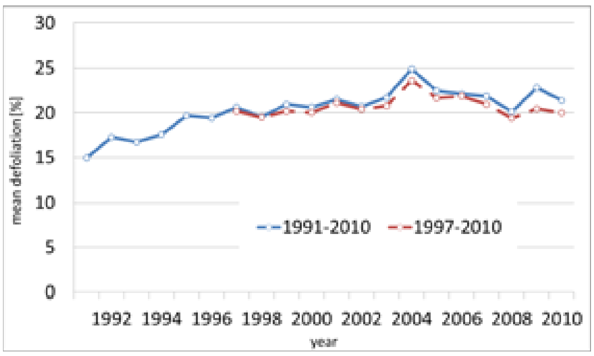

Figure 3-22: Mean defoliation in two periods (1991-2010 and 1997-2010)

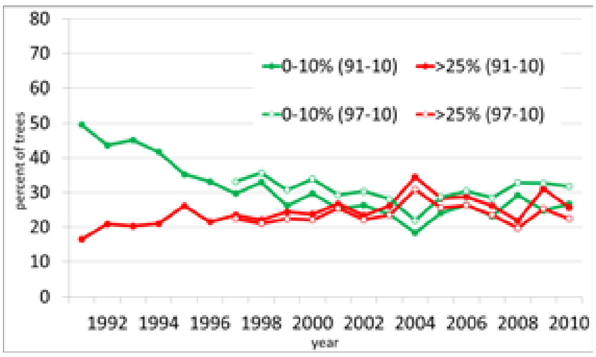

Figure 3-23: Shares of trees of defoliation 0-10% and >25% in two periods (1991-2010 and 1997-2010)

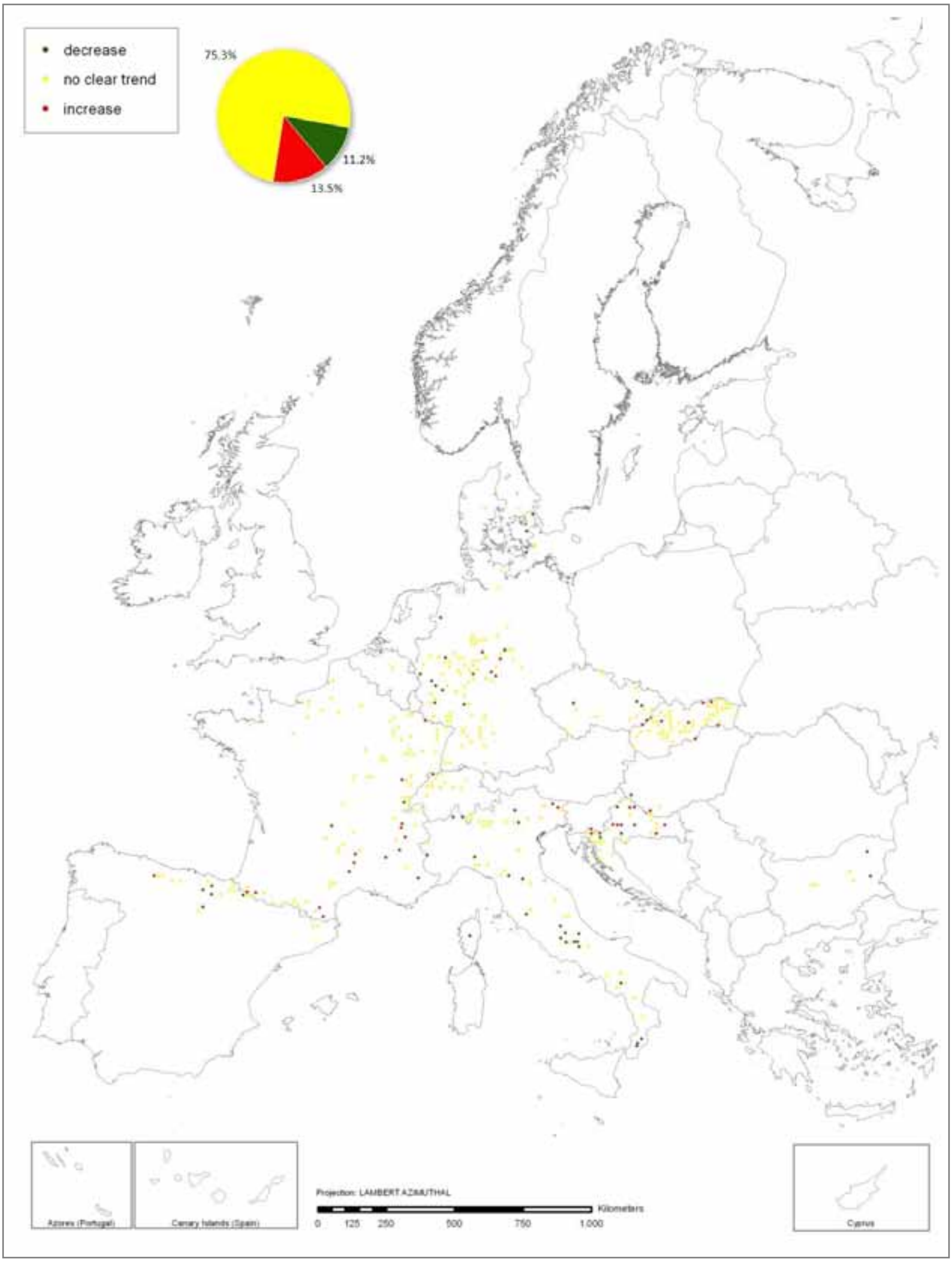

Figure 3-24: Development of mean plot defoliation (slope of linear regression) of *Fagus sylvatica* over the years 2002 – 2010

3.2.3.7 Deciduous temperate oak

The group of decidious temperate oaks includes two species: *Quercus robur* and *Q. petraea*. These species are occuring throughout central Europe.

Defoliation of deciduous temperate oaks has been characterized by two peaks in 1997 and 2005 with a slight recuperation in the subsequent years. In 2010, mean defoliation again increased to slightly over 25%.

The share of healthy oaks has decreased by more 50% since 1991. Consequently, the share of damaged oaks increased over this time period (Tab. 3-11, Fig. 3-26, Fig. 3-26).

An increasing trend of defoliation was observed on 12.9% of the plots from 2002 to 2010. On 9.8% of all plots, a decreasing trend of mean plot defoliation was identified. No clear spatial trends for the development of defoliation were detected for the deciduous temperate oaks (Fig. 3-27).

	N Trees	0-10%	>10-25%	>25%
1991	5730	45.0	32.2	22.8
1992	5295	42.5	35.0	22.5
1993	5377	36.9	33.0	30.1
1994	5593	34.1	31.8	34.1
1995	5449	33.0	36.4	30.6
1996	5422	24.6	39.0	36.4
1997	5435	16.3	42.6	41.1
1998	5589	20.5	42.5	37.0
1999	5708	20.4	47.8	31.7
2000	5737	21.0	48.3	30.7
2001	5738	18.9	49.6	31.5
2002	5750	18.2	51.0	30.8
2003	5750	14.5	47.3	38.2
2004	5852	14.7	44.7	40.5
2005	5863	13.3	43.7	43.0
2006	5373	16.9	46.2	37.0
2007	5475	15.6	47.1	37.2
2008	5646	15.7	48.0	36.2
2009	5579	17.9	46.6	35.5
2010	5639	16.1	47.6	36.3
	N Trees	**0-10%**	**>10-25%**	**>25%**
1997	6548	16.5	41.9	41.6
1998	6760	20.1	41.6	38.3
1999	6791	21.0	47.4	31.6
2000	6882	20.2	46.6	33.2
2001	6811	18.9	48.4	32.6
2002	6654	18.8	50.8	30.4
2003	6659	15.3	47.6	37.1
2004	6780	16.2	44.5	39.4
2005	6849	14.6	43.5	41.9
2006	6348	19.2	45.6	35.2
2007	6475	17.5	47.6	34.9
2008	6642	17.2	48.8	34.0
2009	6928	19.3	48.1	32.7
2010	6817	17.7	47.3	35.0

Table 3-11: Shares of trees in different defoliaton classes

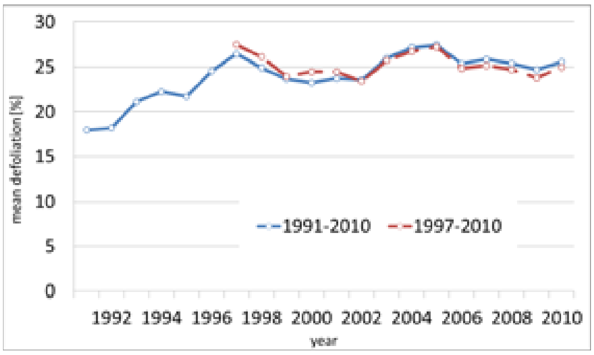

Figure 3-25: Mean defoliation in two periods (1991-2010 and 1997-2010)

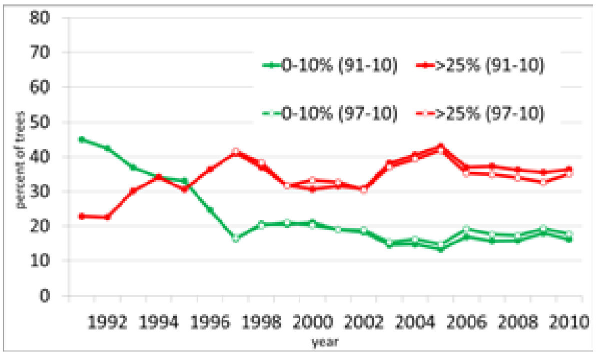

Figure 3-26: Shares of trees of defoliation 0-10% and >25% in two periods (1991-2010 and 1997-2010)

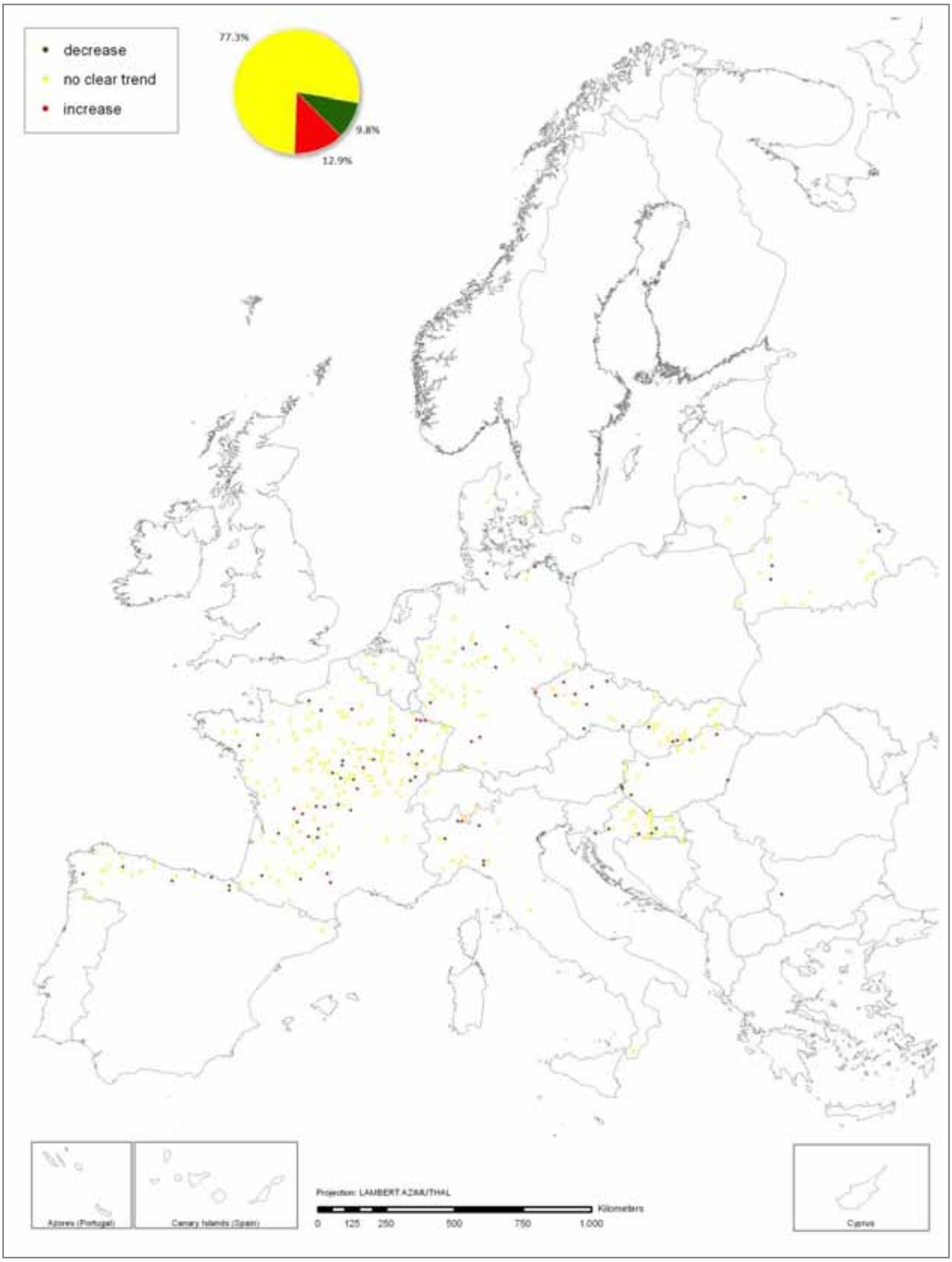

Figure 3-27: Development of mean plot defoliation (slope of linear regression) of deciduous temperate oak *(Quercus robur, Quercus petraea)* over the years 2002 – 2010

3.2.3.8 Deciduous (sub-) mediterranean oak

The group of deciduous (sub-) Mediterranean oak is composed of *Quercus cerris*, *Q. pubescens*, *Q. frainetto* and *Q. pyrenaica*. These species are occurring on plots in southern European countries.

Crown condition of these oaks declined drastically until the end of 1990s. For the first time in 1996, mean defoliation of this group increased to more than 20%. Since then, no prolonged phases with recuperating crown condition have been observed.

The share of healthy trees (0-10%) decreased by more than 50% since 1991. Accordingly, the proportion of damaged oaks rose to over 30% (Tab. 3-12, Fig. 3-28, Fig. 3-29).

The spatial distribution clearly shows a trend of deterioration of crown condition of deciduous (sub-) Mediterranean oaks since 2002, mainly in areas of southern France. In contrast, plots with an improving trend of mean plot defoliation were found in other areas, such as central Italy (Fig. 3-30).

	N Trees	0-10%	>10-25%	>25%
1991	3113	57.4	30.3	12.4
1992	3156	54.3	32.8	12.8
1993	3154	53.0	31.8	15.2
1994	3123	49.5	32.8	17.7
1995	3170	47.4	34.9	17.7
1996	3218	30.5	43.7	25.8
1997	3056	27.1	42.5	30.4
1998	3084	26.1	41.8	32.1
1999	3678	24.8	46.1	29.1
2000	3648	22.5	46.8	30.6
2001	3686	20.2	45.0	34.8
2002	3599	18.4	46.0	35.6
2003	3519	16.7	46.2	37.0
2004	3625	16.2	48.8	35.0
2005	3580	18.5	48.5	32.9
2006	3583	17.5	46.1	36.4
2007	3588	14.9	49.3	35.8
2008	3606	16.3	50.1	33.6
2009	3608	16.2	50.1	33.6
2010	3967	19.3	48.9	31.8
	N Trees	**0-10%**	**>10-25%**	**>25%**
1997	4037	23.4	40.0	36.6
1998	4392	21.7	39.9	38.3
1999	4628	24.4	45.2	30.4
2000	4530	20.4	45.5	34.1
2001	4704	19.0	44.7	36.3
2002	4599	15.9	48.6	35.4
2003	4376	14.2	48.0	37.8
2004	4468	14.3	48.6	37.1
2005	4409	17.1	49.7	33.2
2006	4577	15.8	47.2	37.0
2007	4387	13.6	50.7	35.7
2008	4390	14.9	51.4	33.7
2009	4832	15.8	53.1	31.1
2010	5112	18.0	51.3	30.7

Table 3-12: Shares of trees in different defoliaton classes

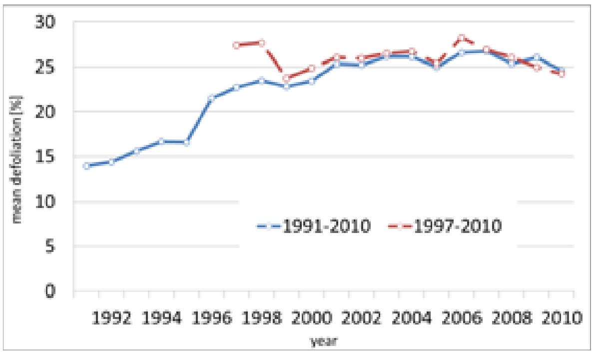

Figure 3-28: Mean defoliation in two periods (1991-2010 and 1997-2010)

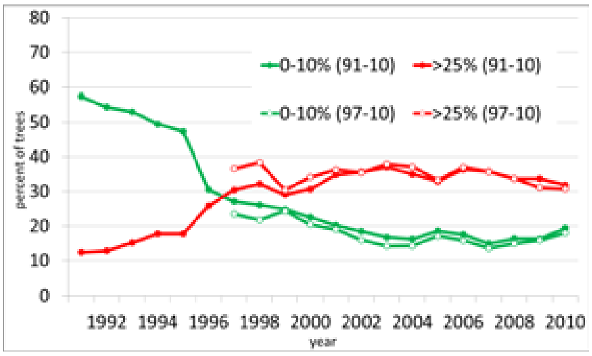

Figure 3-29: Shares of trees of defoliation 0-10% and >25% in two periods (1991-2010 and 1997-2010)

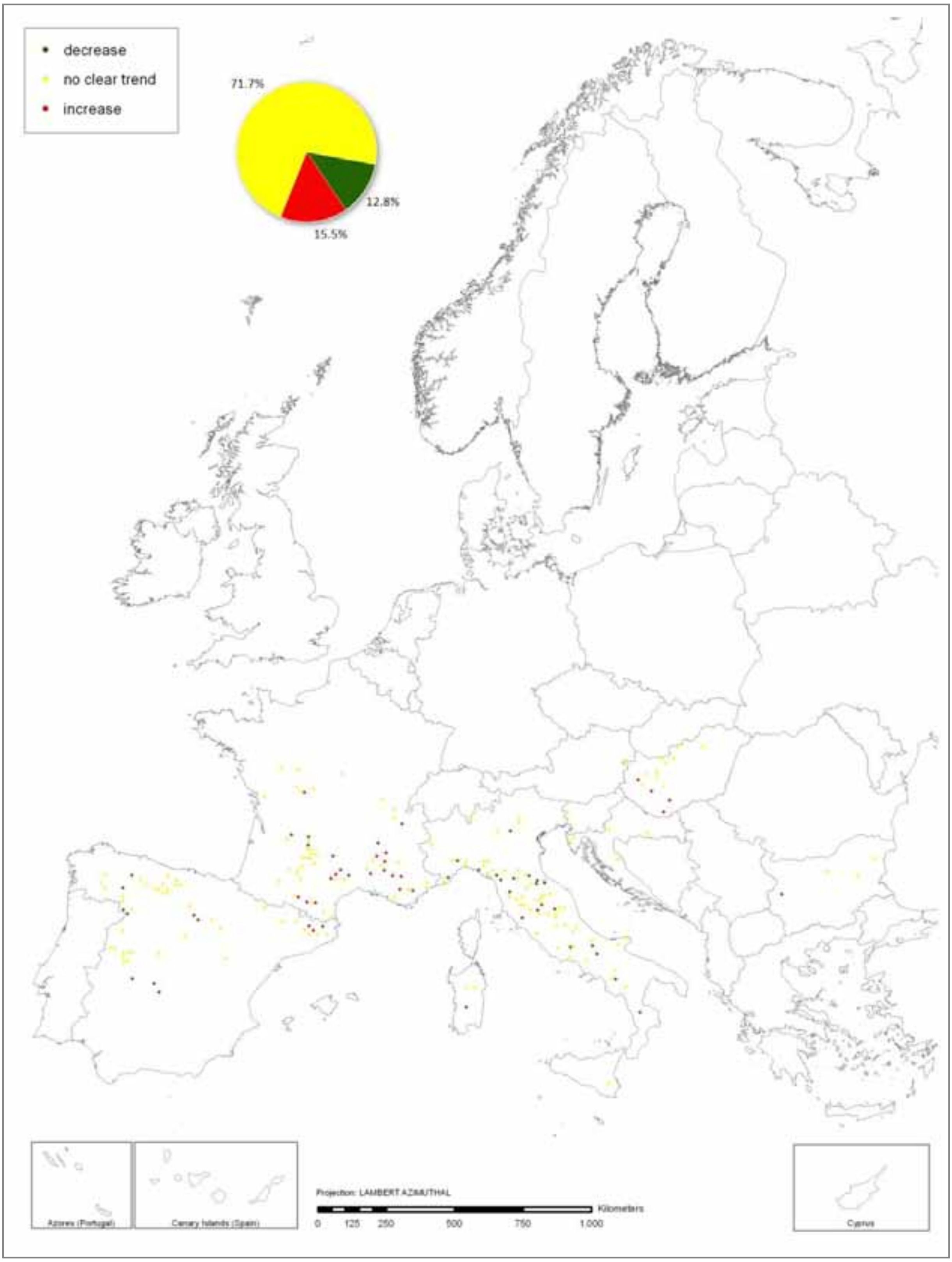

Figure 3-30: Development of mean plot defoliation (slope of linear regression) of deciduous (sub-Mediterranean oak *(Quercus cerris, Quercus frainetto, Quercus pubescens, Quercus pyrenaica*) over the years 2002 – 2010

3.2.3.9 Evergreen oak

The group of evergreen oaks includes *Quercus coccifera*, *Q. ilex*, *Q. rotundifolia* and *Q. suber*. The results for the different time periods shown in the graph are similar because of only marginal differences in the composition of countries represented by the figures.

At the beginning of the study in the early 1990s, mean defoliation of evergreen oak trees was relatively low – less than 15%. Accordingly, the share of healthy trees (0-10%) was high. The first peak (with just under 25% mean defoliation) was recorded in 1995, the second one in 2005 and 2006. Since then, a slight recovery of the crown condition has been recorded (Tab. 3-13, Fig. 3-31, Fig. 3-32).

14.7% of all plots showed a decreasing trend and 13.8% an increasing trend of mean plot defoliation of evergreen oaks from 2002 to 2010. In southern France there are clusters of plots with an increasing trend, while in the continental areas of Spain more plots with a decreasing trend can be identified (Fig. 3-33).

	N Trees	0-10%	>10-25%	>25%
1991	3224	59.9	35.7	4.3
1992	3362	47.4	44.4	8.2
1993	3315	41.5	51.0	7.5
1994	3288	31.4	52.4	16.2
1995	3329	19.2	48.5	32.3
1996	3307	18.1	53.6	28.4
1997	3306	22.3	58.1	19.6
1998	3264	28.6	56.0	15.4
1999	4232	21.7	57.0	21.3
2000	4308	19.3	60.4	20.4
2001	4324	19.9	62.6	17.5
2002	4311	16.2	62.8	21.0
2003	4218	14.0	62.3	23.6
2004	4280	17.7	63.5	18.8
2005	4229	9.8	62.3	27.9
2006	4233	8.8	63.9	27.3
2007	4318	10.1	67.5	22.5
2008	4336	11.6	67.2	21.2
2009	4345	11.0	67.0	22.0
2010	4446	17.3	62.2	20.5
	N Trees	**0-10%**	**>10-25%**	**>25%**
1997	3354	22.1	57.7	20.2
1998	3288	28.4	56.1	15.5
1999	4256	21.6	57.1	21.2
2000	4332	19.2	60.2	20.6
2001	4348	19.8	62.7	17.4
2002	4335	16.1	63.0	20.9
2003	4242	14.0	62.5	23.5
2004	4328	17.5	63.8	18.6
2005	4277	9.8	62.3	27.9
2006	4281	8.8	63.8	27.4
2007	4366	10.3	67.3	22.4
2008	4360	11.9	67.0	21.1
2009	4369	11.3	66.8	21.9
2010	4494	17.4	61.9	20.8

Table 3-13: Shares of trees in different defoliaton classes

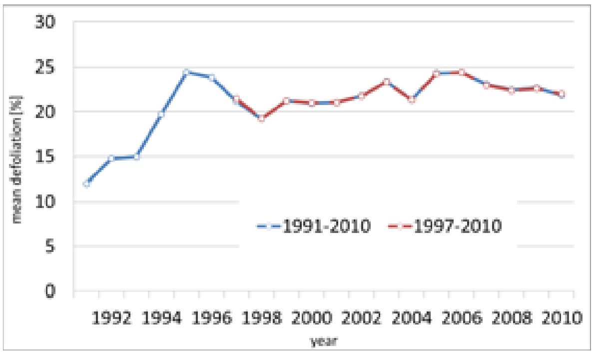

Figure 3-31: Mean defoliation in two periods (1991-2010 and 1997-2010)

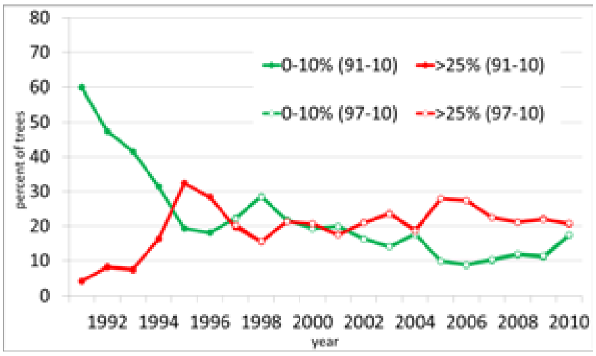

Figure 3-32: Shares of trees of defoliation 0-10% and >25% in two periods (1991-2010 and 1997-2010)

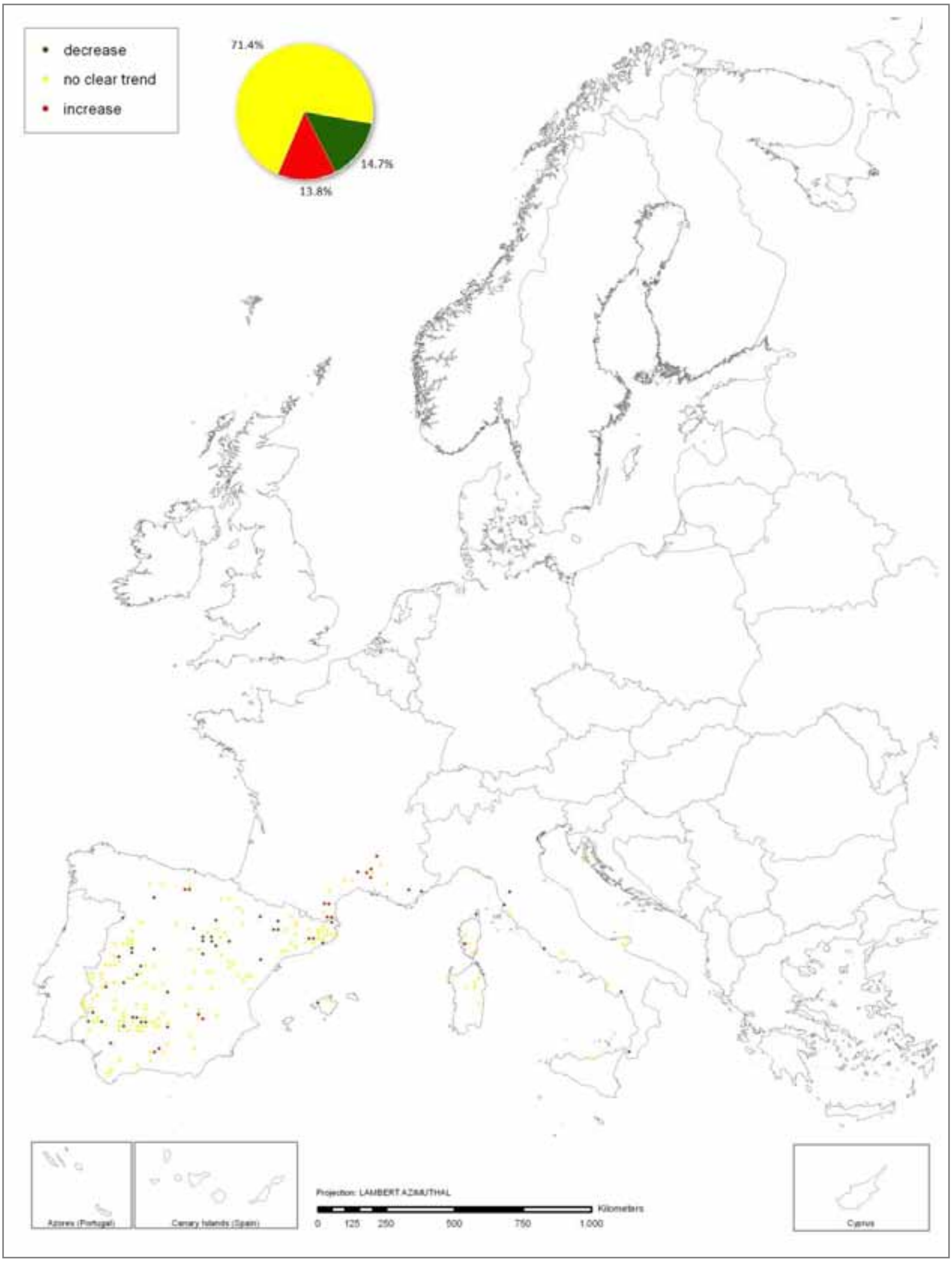

Figure 3-33: Development of mean plot defoliation (slope of linear regression) of evergreen oak *(Quercus coccifera, Quercus ilex, Quercus rotundifolia, Quercus suber)* over the years 2002 – 2010

3.3 Damage Cause Assessment

3.3.1 Background

Crown condition is the most widely applied indicator for forest-health and vitality in Europe. In order to interpret the crown condition accurately, it is necessary to assess tree parameters that have an influence on tree vitality. Parameters assessed in addition to crown condition include discolouration and damages caused by biotic and abiotic factors. Through the assessment of damage and its influence on the crown condition, it is possible to draw conclusions on cause-effect mechanisms. Since 2005, tree crowns on Level I plots have been examined based on an amended method for damage assessment, which allows to obtain more information on injury symptoms, possible causes of damage, and extent of the injury.

The aim of the damage cause assessment is to collect as much information as possible on the causal background of tree damages in order to enable a differential diagnosis and to better interpret the unspecific parameter “defoliation”.

3.3.2 Methods of the Surveys in 2011

3.3.2.1 Selection of sample plots

Assessment of damage causes is part of the visual assessment of crown condition. All trees included in the crown condition sample (Level I plots) are required to be regularly assessed for damage causes.

In 2010, damage causes were assessed on 6 413 plots in 32 different countries across Europe (Fig. 3-34, Tab. 3-14). This is the highest number of assessed plots since the start of the extended damage cause assessment in 2005. The increase in plotnumbers with damage cause assessment from 2009 to 2010 is partly due to the first assessments on plots in Turkey in 2010.

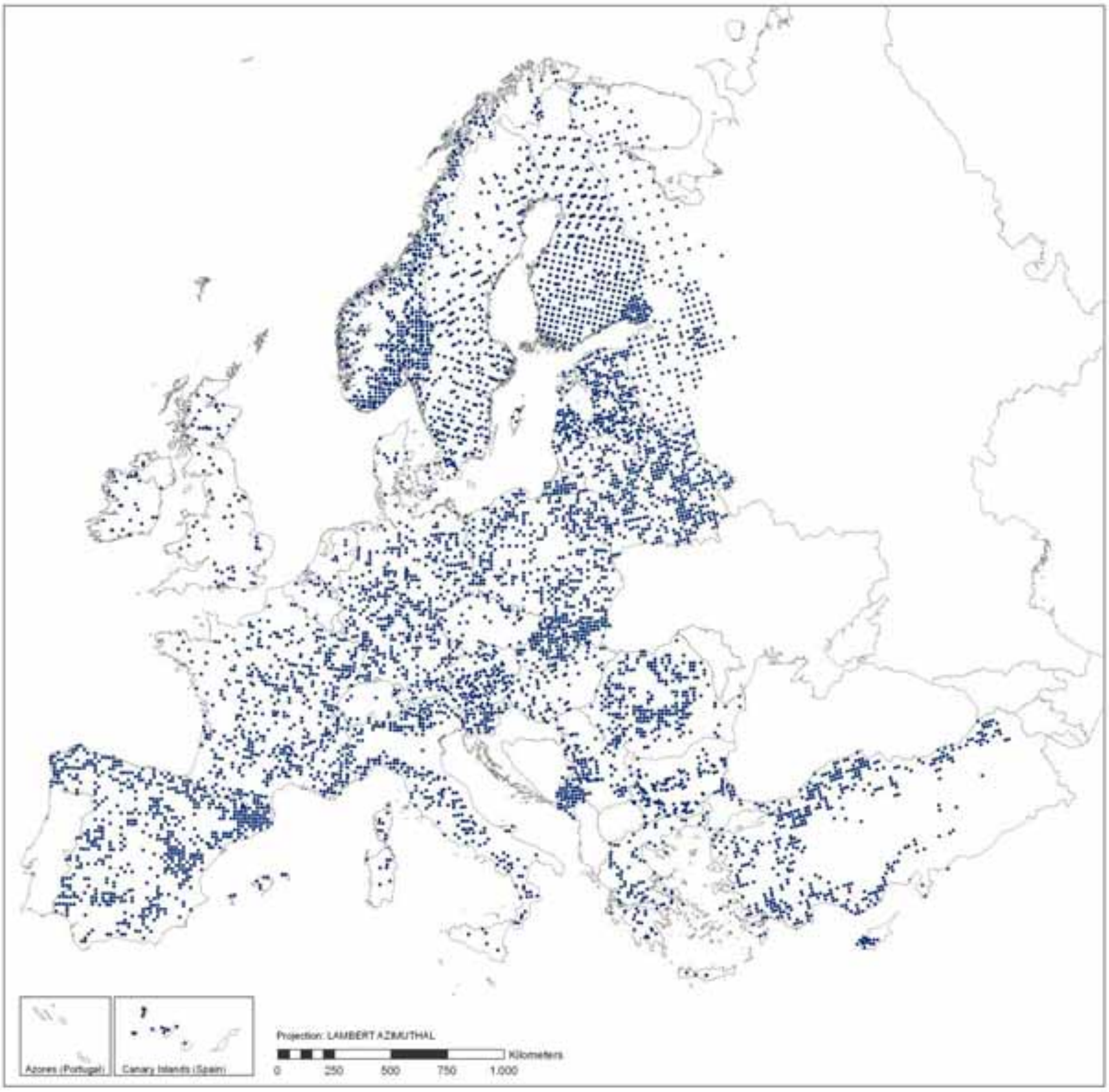

Figure 3-34: Plots with damage cause assessment 2010

Table 3-14: Number of sample plots assessed

Country	Number of sample plots assessed					
	2005	2006	2007	2008	2009	2010
Austria	136	135				135
Belgium	21	25	27	25	23	9
Bulgaria	96	96	100	54	134	132
Cyprus	15	15	15	15	15	15
Czech Rep.	138		40	35	38	43
Denmark					16	17
Estonia	85	81	64	76	92	97
Finland	605	606	518	423	886	932
France	464	498	450	459	459	489
Germany	208	235	255	238	412	389
Greece	79				97	98
Hungary	73	73			73	71
Ireland	17	15		31	32	29
Italy	236	250	238	235	251	253
Latvia	65	93	93	92	169	173
Lithuania	48	50	49	54	63	69
Luxembourg	4	4	2	4		
Netherlands	9	11			11	11
Poland	432	376	430	433	376	374
Portugal	88	6				
Romania	66	61	158		227	239
Slovak Rep.	108	107	107	102	108	108
Slovenia	33	23			44	44
Spain	620	620	620	620	590	582
Sweden	784	748			857	370
United Kingdom	84	82				70
EU	4514	4210	3166	2896	4973	4749
Andorra		3	3	3	3	3
Belarus	403	398	339	320	330	328
Croatia	33	32				
Montenegro						49
Norway	460	463	476	481	487	491
Russian Fed.					336	279
Serbia	62	74	53	35	97	88
Switzerland	20	19	18	23	6	11
Turkey						415
Total Europe	5492	5199	4055	3758	6232	6413

3.3.2.2 Assessment parameters

The assessment of damage to trees based on the ICP Forests methodology includes three steps: symptom description, determination of causes, and quantification of the symptoms. Several symptoms of damage can be described for each tree. The symptom description should focus on important factors which may influence crown condition.

Symptoms

Symptom description aims at describing visible damage causes for single trees. The description indicates affected parts of the assessed trees and type of symptoms observed. Symptom description should focus on important factors that may influence the crown condition.

Three main categories are distinguished for indicating the affected part of each tree: (a) leaves/needles, (b) branches, shoots, & buds, and (c) stem & collar. For each affected tree area, further specification is required (Tab. 3-15).

Table 3-15: Affected parts of a tree

Affected part	Specification of affected part	Location in crown
Leaves/needles	Current needle year Older needles Needles of all ages Broadleaves (incl. evergreen spec.)	Upper crown Lower crown Patches Total crown
Branches, shoots & buds	Current year shoots Twigs (diameter < 2 cm) Branches diameter 2 – < 10 cm Branches diameter ≥ 10 cm Varying size Top leader shoot Buds	Upper crown Lower crown Patches Total crown
Stem & collar	Crown stem: main trunk or bole within the crown Bole: trunk between the collar and the crown Roots (exposed) and collar (≤ 25 cm height) Whole trunk	
Dead tree	*see below*	
No symptoms on any part of tree	*see below*	
No assessment	*see below*	

Symptoms are grouped into broad categories like wounds, deformations, necrosis etc. This allows a detailed description of the occurring symptoms.

Extent

The damage extent is classified in eight classes (Tab. 3-16). In trees where multiple damages occurred (and thus multiple extent classes), only the highest value was evaluated. In total, 49.1% of all assessed trees have been assigned a damage extent class of 1.

Table 3-16: Damage extent classes

Class
0 %
1 – 10 %
11 – 20 %
21- 40 %
41 – 60 %
61 – 80 %
81 – 99 %
100 %

Causal agents

For each symptom description a causal agent must be determined. The determination of the causal agent is crucial for the study of the cause-effect mechanism. Causal agents are grouped into nine categories (Tab. 3-17). In each category a more detailed discription is possible through a hierarchical coding system. In 2010, agent groups were identified for 59 520 trees (Tab. 3-18).

Table 3-17: Main categories of causal agents

Agent group
Game and grazing
Insects
Fungi
Abiotic agents
Direct action of men
Fire
Atmospheric pollutants
Other factors
(Investigated but) unidentified

Table 3-18: Number of sample trees with agent group. In this overview trees with more than one agent group are only counted once.

Country	Number of sample trees					
	2005	2006	2007	2008	2009	2010
Austria	607	747				982
Belgium	239	450	408	455	451	193
Bulgaria	1283	1231	1155	469	2563	2522
Cyprus	255	248	234	321	341	310
Czech Rep.	59		144	110	134	170
Denmark					86	94
Estonia	1013	1007	732	830	897	2068
Finland	4261	4274	3278	2959	2310	2137
France	5385	6101	6259	5951	6107	6607
Germany	2146	2216	2471	2000	10088	2115
Greece	1023				2071	1983
Hungary	957	928			1225	1231
Ireland	198	143		211	283	171
Italy	5346	5274	5232	5148	5468	6541
Latvia	507	456	403	398	604	536
Lithuania	139	146	140	159	235	326
Luxembourg	70	41	6	20		
Netherlands	111				75	86
Poland	3734	4215	4869	5102	4165	4179
Portugal	1693	97				
Romania	585	565			1623	1890
Slovak Rep.	690	4229	3894	3907	4312	4211
Slovenia	312	185			765	799
Spain	9452	9150	8925	8168	8781	7620
Sweden	7653	3829			506	543
United Kingdom	1806	1619				1243
EU	49524	47151	38150	36208	53090	48557
Andorra		7	7	8	8	8
Belarus	1827	1628	1770	1393	1271	1276
Croatia	257	256				
Montenegro						626
Norway	792	973	1053	975	779	817
Russian Fed.					3723	3475
Serbia	856	1167	503	188	838	941
Switzerland	100	71	76	74	79	105
Turkey						3715
Total Europe	53356	51253	41559	38846	59788	59520

3.3.3 Results

3.3.3.1 Affected part in 2010

In 2010, a total of 96 197 trees were included in the damage cause assessment. A share of 21.7% of the assessed trees showed symptoms on their leaves (only broadleaves), 13.1% of the trees had symptoms on the bole, and 11.8% symptoms on twigs. 35.8% of the trees showed no symptoms at all (Fig. 3-35).

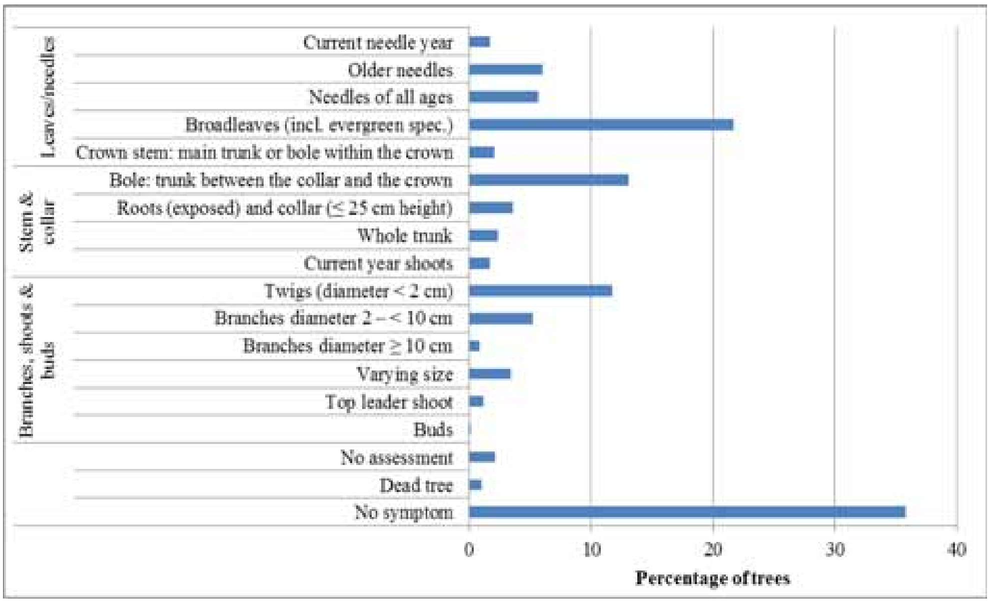

Figure 3-35: Frequency of affected part

3.3.3.2 Extent in 2010

About one quarter of all trees for which damage was recorded had an extent class of 2 and 16.1% had an extent class of 3. Higher classes rarely occurred (Fig. 3-36).

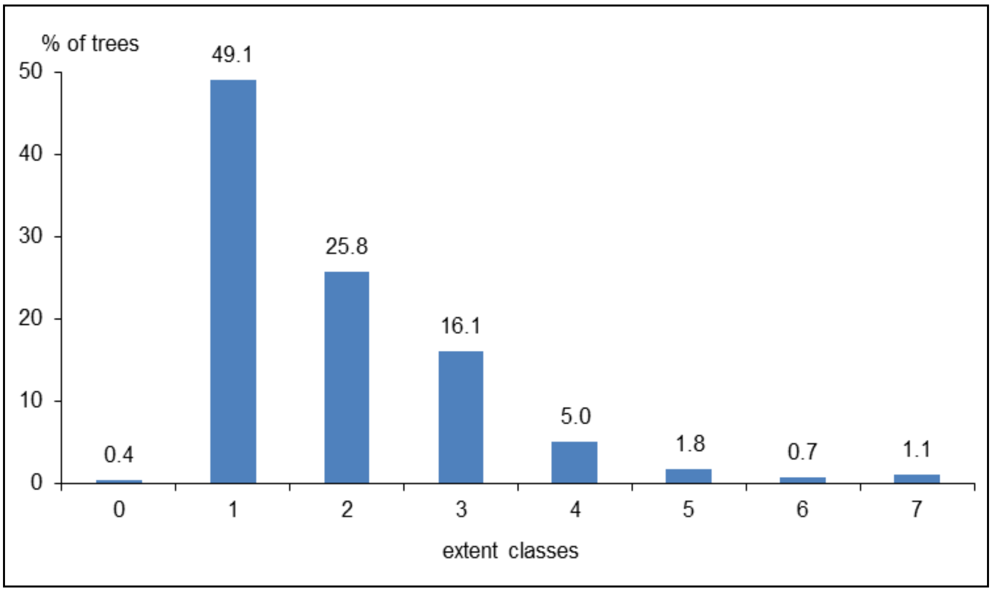

Figure 3-36: Share of trees with recorded damage extent class 2010

3.3.3.3 Agent groups in 2010

The distribution of the agent groups in 2010 shows that over 20 000 trees displayed symptoms caused by insects (Fig. 3-37) corresponding to 27% of the records (Tab. 3-19). Roughly half of the insect-caused symptoms were attributed to defoliators and to the other half to borers and other insects. Significantly fewer trees, namely just over 11 000, displayed damage caused by fungi, corresponding to 15% of the trees. In about 10 000 trees, an abiotic symptom (i.e. drought, frost) was found. Altogether, ca. 20 000 trees showed no signs of damage. Multiple agent groups were recorded for a number of trees.

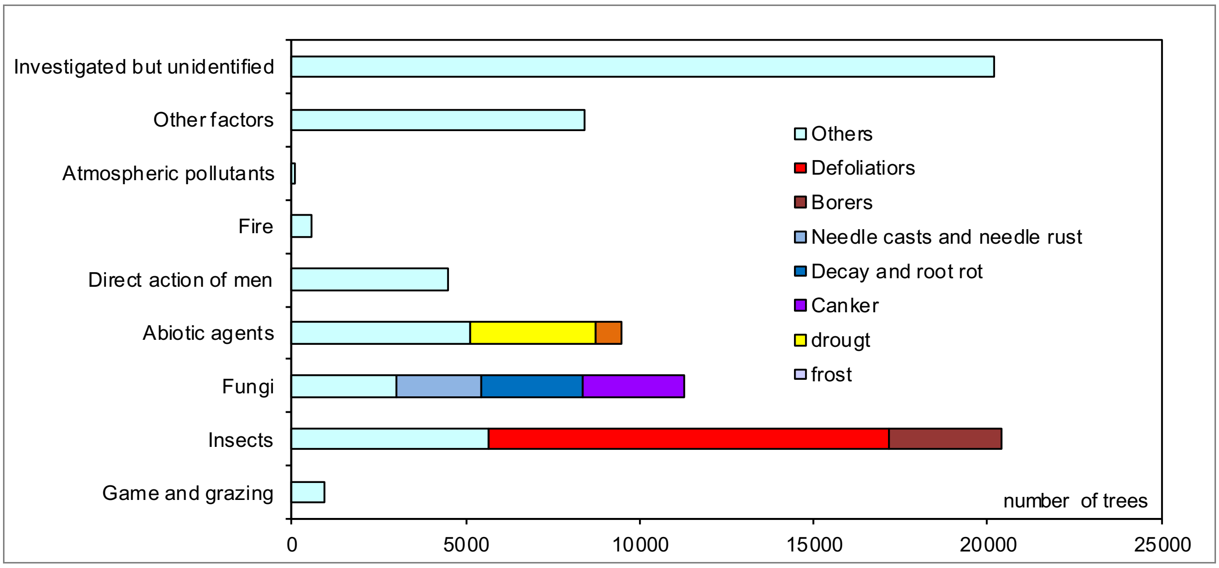

Figure 3-37: Frequency of agent groups

Table 3-19: Share of damages by agent group and country for the year 2010

share of damages by agent group and country for the year 2010	Game and grazing	Insects	Fungi	Abiotic agents	Direct action of men	Fire	Atmospheric pollutants	Other factors	Investigated but unidentified
Austria	9	4	10	29	21	0	0	19	8
Belgium	1	15	19	5	10	0	0	0	50
Bulgaria	0	46	29	3	5	0	0	0	16
Cyprus	0	81	0	12	0	0	0	7	0
Czech Rep.	31	0	1	36	6	0	0	10	15
Denmark	5	72	2	9	3	0	0	1	7
Estonia	1	6	37	5	6	0	0	1	43
Finland	1	21	20	14	8	0	0	18	18
France	0	12	6	7	0	0	0	2	73
Germany	4	47	10	4	5	0	0	5	25
Greece	2	26	6	26	4	0	0	31	6
Hungary	1	36	26	13	14	2	0	8	1
Ireland	0	1	27	43	27	0	0	2	0
Italy	1	33	7	5	0	0	0	6	48
Latvia	22	3	16	12	34	0	4	4	4
Lithuania	6	6	19	26	15	0	0	4	25
Netherlands	0	7	9	75	0	0	0	1	8
Poland	1	20	11	8	12	0	1	24	24
Romania	3	46	9	26	7	0	0	8	2
Slovak Rep.	1	29	23	11	11	0	0	17	8
Slovenia	0	30	14	8	8	0	0	5	34
Spain	0	30	14	28	5	3	0	12	7
Sweden	5	1	8	14	19	1	0	1	52
United Kingdom	0	40	10	12	2	0	0	15	21
EU	**1**	**27**	**14**	**13**	**6**	**1**	**0**	**10**	**28**
Andorra	0	13	63	13	0	0	0	0	13
Belarus	1	13	36	7	22	1	1	13	7
Montenegro	0	28	8	5	9	3	0	0	48
Norway	2	30	29	14	1	0	0	3	22
Russian Fed.	0	13	28	13	5	3	0	15	23
Serbia	0	67	24	3	2	1	0	4	1
Switzerland	0	45	0	18	8	0	0	30	0
Turkey	0	34	4	11	1	0	0	22	27
Total Europe	**1**	**27**	**15**	**12**	**6**	**1**	**0**	**11**	**27**

Agent Group "Game and grazing"

In 2010, only minor damage from "game and grazing" was observed on the assessed trees throughout Europe. Just 1.2% of all recorded damages were caused by this agent group. It has however to be taken into account that only adult trees in KRAFT classes 1-3 are regularly assessed for damage types and browsing in the herb and shrub layer is not recorded in this assessement. 80.4% of all affected plots show a share of damaged trees of 25% or lower (Fig. 3-38).

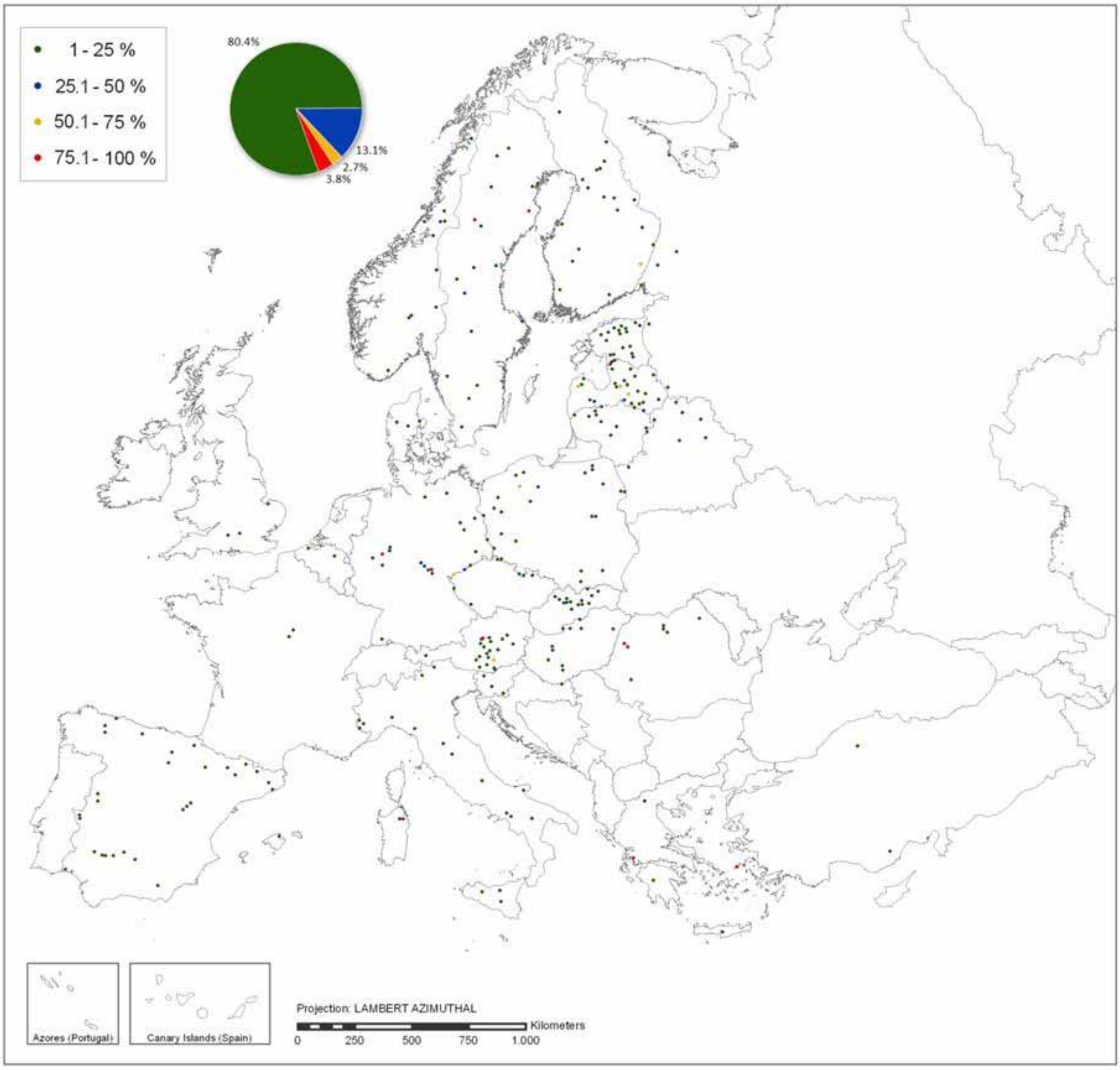

Figure 3-38: Shares of trees per plot with recorded agent group "game and grazing", 2010

Agent Group "Insects"

"Insects" were the most frequently detected agent group (26.9% of all damages) in 2010. They were observed in different intensities throughout Europe. On around half of all affected plots, more than 25% of the trees were damaged by insects. Plots with over 75% of the trees affected account for nearly one fifth of all plots. They are clustered e.g. at the eastern edge of the Pyrenean Mountains, Italy, Cyprus, and in the east of Slovak Republic (Fig. 3-39).

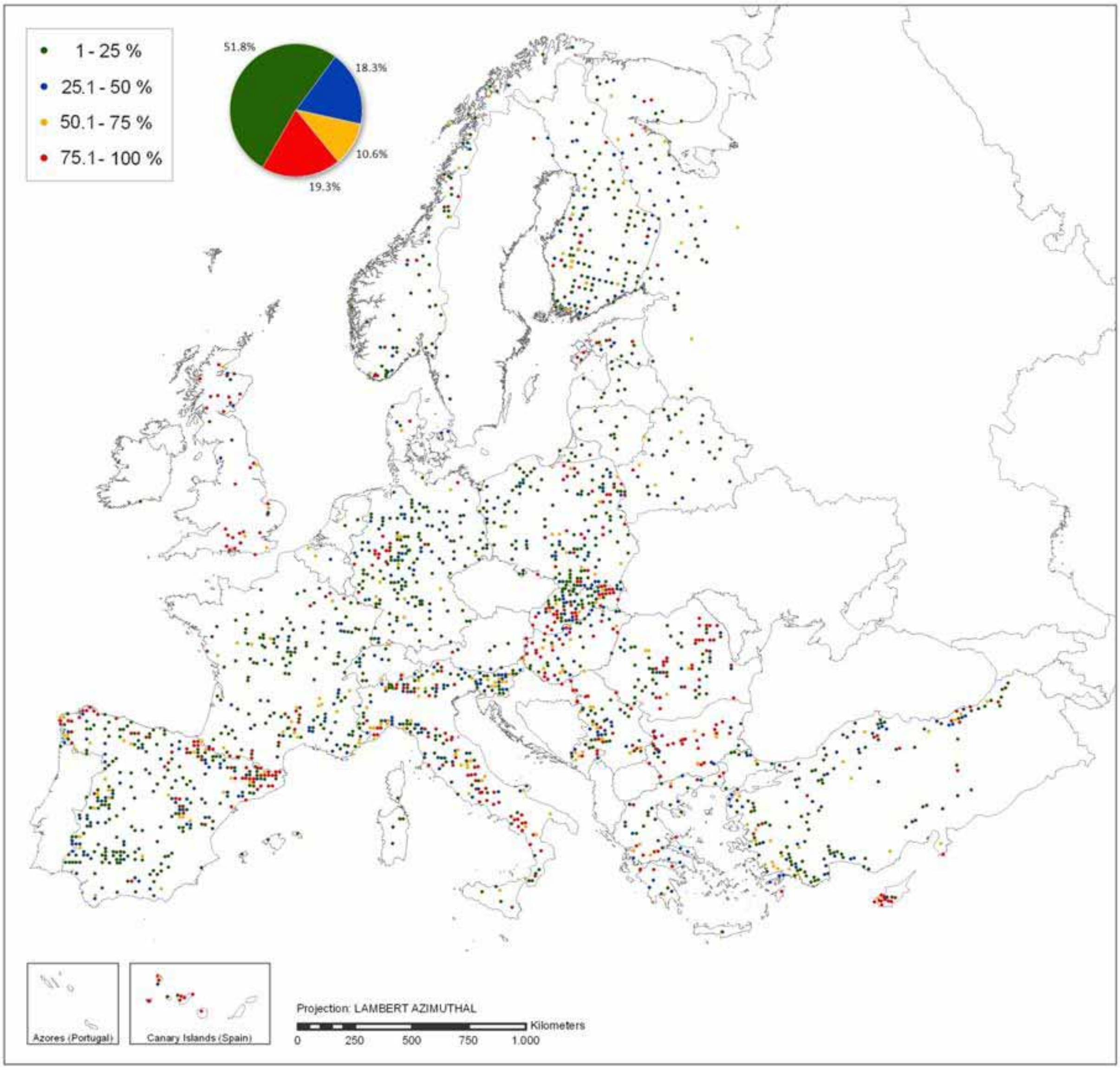

Figure 3-39: Shares of trees per plot with recorded agent group "insects", 2010

Agent Group "Fungi"

A total of 14.9% of all damages were included in the agent group "fungi". Most affected plots (68.5%) showed only a small share of damaged trees. On 7.3% of all affected plots, between 50 and 75% of the trees showed damage caused by fungi, and on 7.6% of all plots more than 75% of the trees were damaged. A particularly high share of plots damged by fungi was found in Estonia, in the north of Slovac Republic and western Bulgaria (Fig. 3-40).

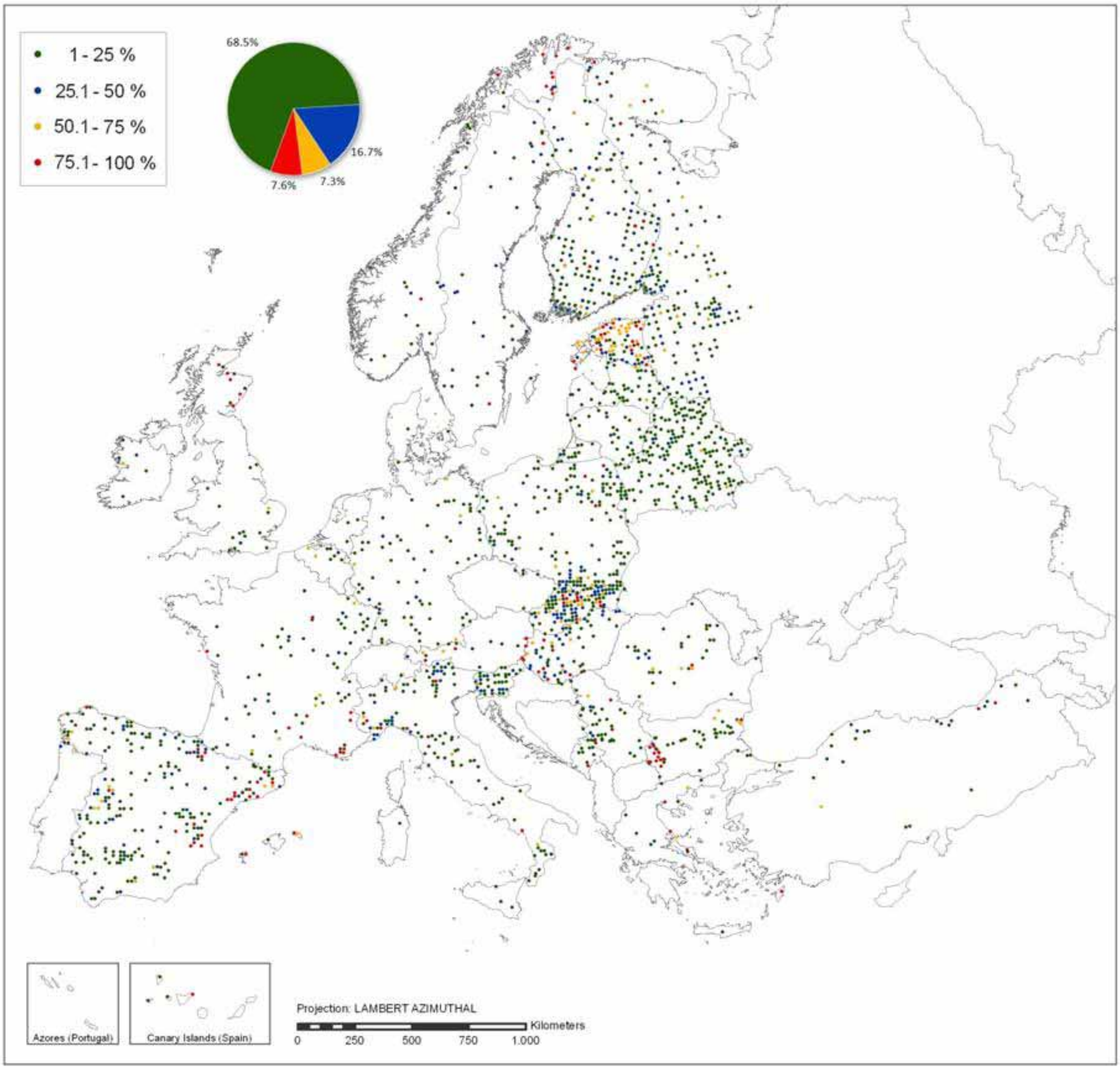

Figure 3-40: Shares of trees per plot with recorded agent group "fungi", 2010

Agent Group "Abiotic agents"

In 2010, the share of trees with damage caused by "abiotic agents" was 12.5%. The most frequent causes were drought, frost/snow, and wind. 72.9% of all affected plots showed a small share of damaged trees. Plots with a higher share of damaged trees were found mainly in Mediterranean areas of Europe. In particular, these plots occured at the eastern edge of the Pyrenean Mountains and in southern France (Fig. 3-41).

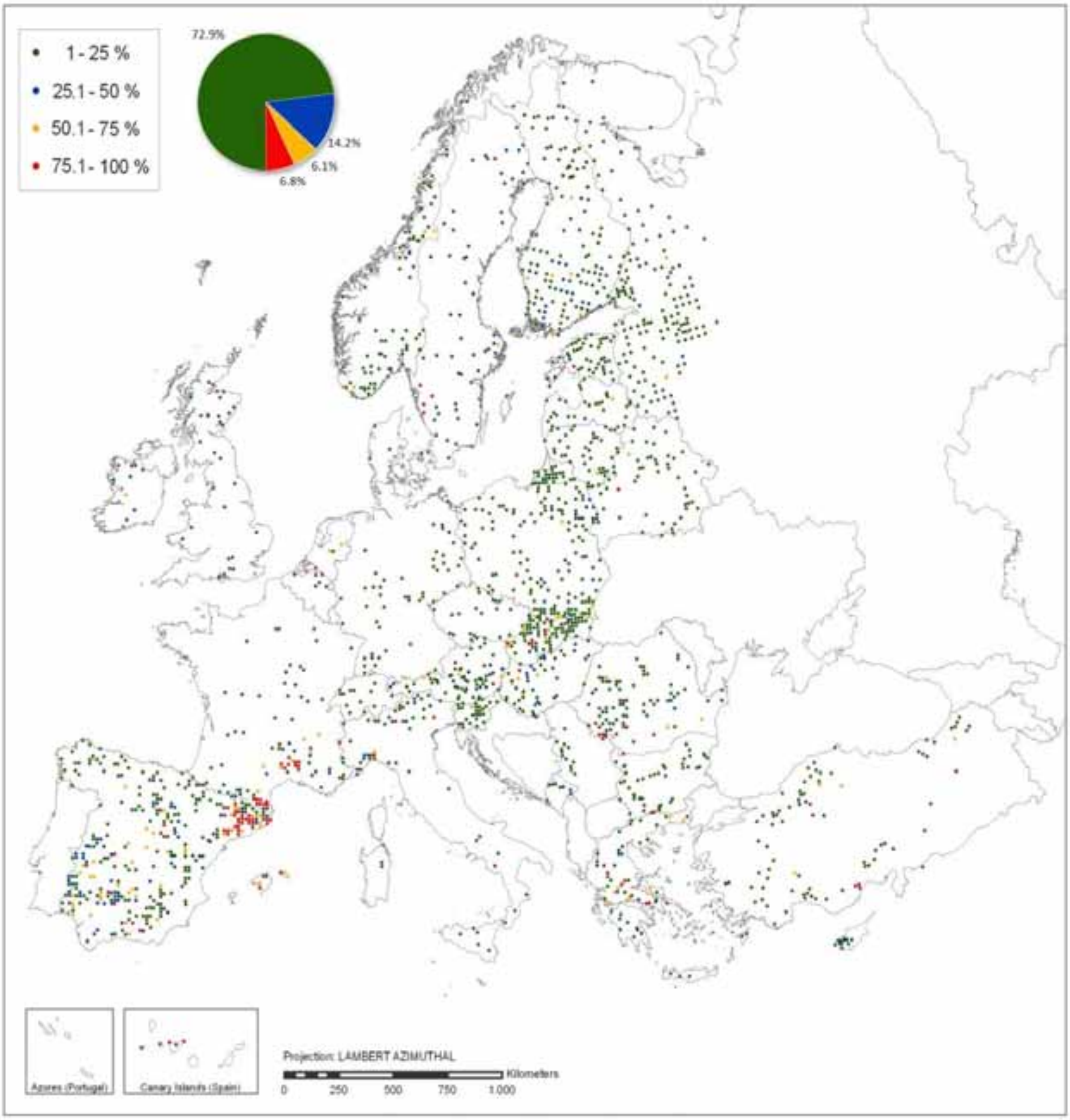

Figure 3-41: Shares of trees per plot with recorded agent group "abiotic agents", 2010

Agent Group "Direct action of men"

The agent group "direct action of men" was recorded on 5.9% of all damaged trees in 2010. The agent group includes mechanical damage e.g. through harvesting operations or road construction. Over 80% of all affected plots displayed only a small number of damaged trees. (Fig. 3-42).

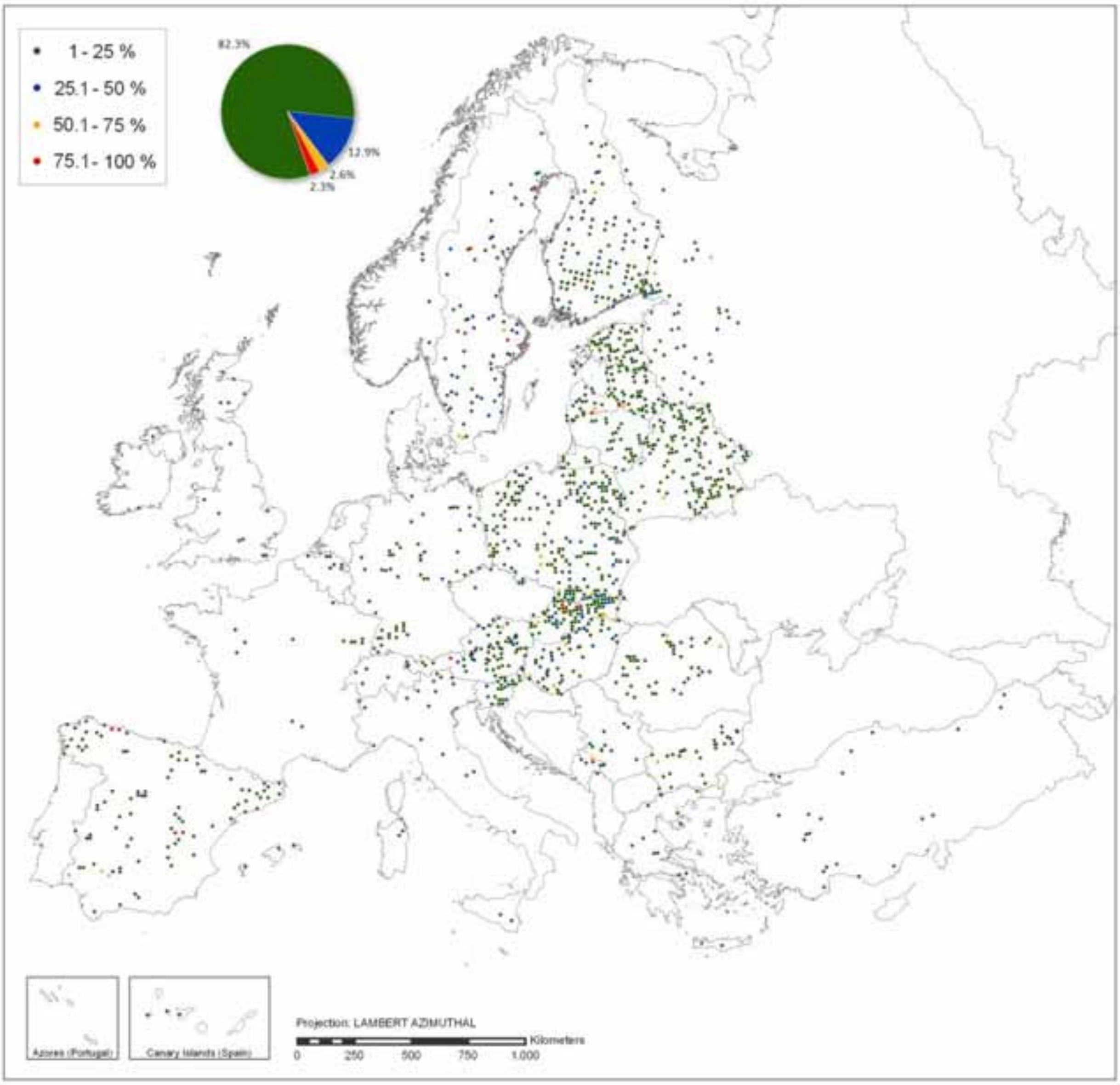

Figure 3-42: Shares of trees per plot with recorded agent group "direct action of man", 2010

Agent Group "Fire"

A share of 0.7% of all damages in 2010 was attributed to the agent group "fire". Damage caused by fire occured relatively infrequently, but often involved several trees on one plot. On over one third of the affected plots, roughly 25% of the trees were damaged (Fig. 3-43). The data provide a good basis for assessing the importance of fire induced damages in relation to other agents. For time near monitoring of forest fire occurrence the terrestrial survey and the related data processing is not appropriate. Such surveys are possible based on satellite imagery yielding spatially higher resoluted information.

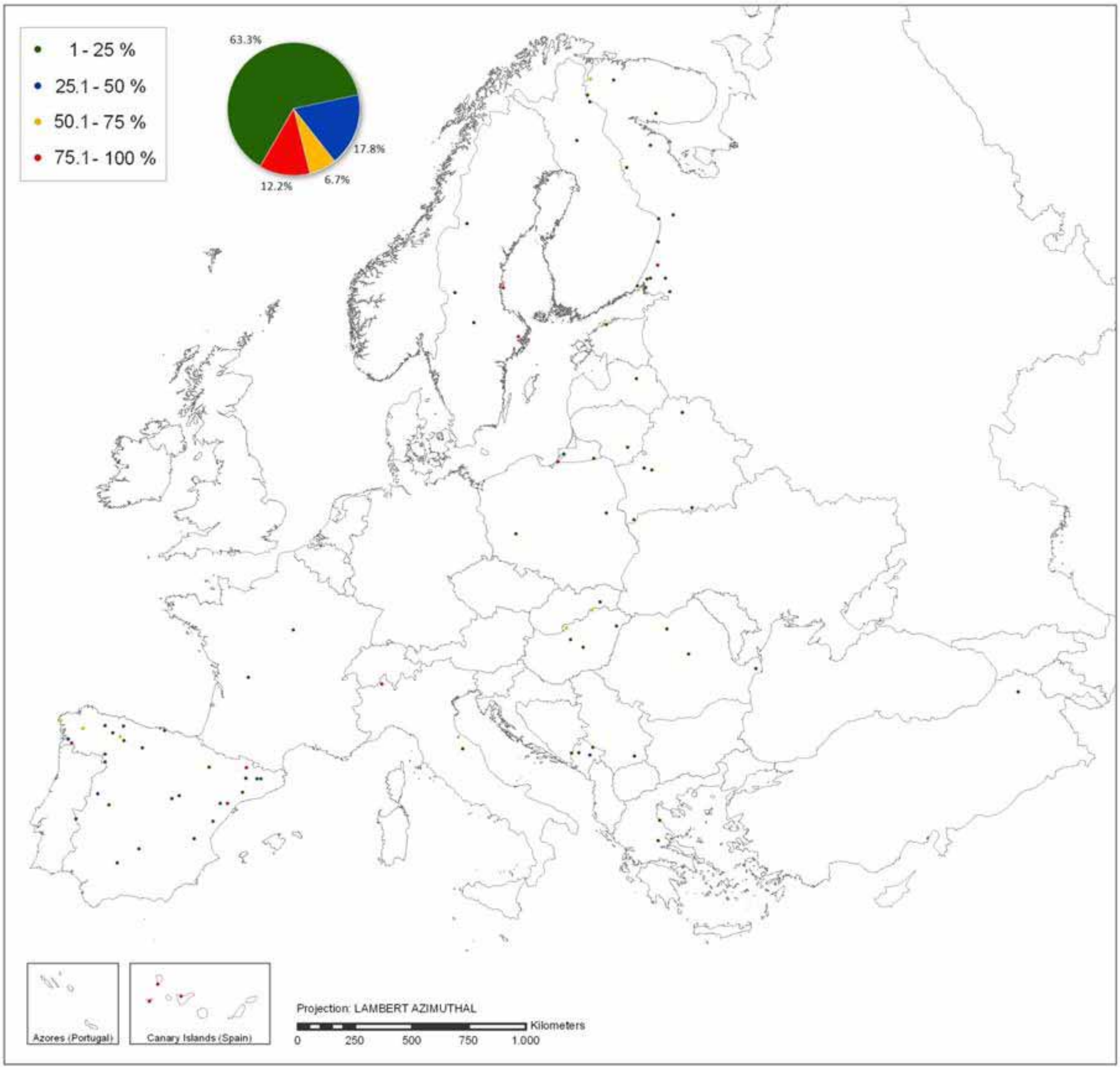

Figure 3-43: Shares of trees per plot with recorded agent group "fire", 2010

3.4 Conclusions

The 2010 large scale health and vitality survey was based on over 7 500 plots and 145 000 trees in 33 participating countries, including 26 EU member states. It was thus the most comprehensive survey that has ever been carried out on the Level I network. The increase is due to the co-financing through the FutMon project under the EU LIFE+ regulation which lead to the participation of Austria, Greece, The Netherlands, Romania and United Kingdom. These countries had not assessed forest health in the year before the start of the project. As concerns non-EU countries, Montenegro for the first time assessed forest condition in 2010 and Turkey as well as the Russian Federation have only very recently started the survey.

In 2010, the evaluation of defoliation was extended to 7 species (-groups) in order to take into account the extended geographical scope of the surveys. It also included the first comprehensive, even though descriptive, presentation of results from damage cause assessments. These assessments had been started in 2005. The continuously updated manual (ICP Forests 2010) provided the methodological basis and is an important cornerstone for the implementation of harmonized assessments. Whereas for the health and vitality assessments of the trees the manual gives explicit prescriptions, plot and tree selection allow for national approaches, requiring, however, that plots and trees selected must provide the basis for country representative results (Chapt. 1). The differing national approaches are reflected in the different numbers of trees selected per Level I plot (Fig. 3-1).

Defoliation results show slightly higher mean defoliation for broadleaves as compared to the conifers assessed. Taking into account the wide coverage of the assessments, these overall means need to be analysed species and region wise. Deciduous temperate oaks had the highest mean defoliation, followed by the south European tree species groups. *Picea abies* and *Pinus sylvestris* showed lowest mean defoliation. There are spatial clusters of plots with above and below average defoliated trees. The Mediterranean coast in southern France and northern Spain is a hot spot with specifically high defoliation in several species groups. Most of the spatial trends are, however, species specific. High defoliation of Mediterranean lowland pines was observed in southwestern Turkey and a cluster of plots with above average defoliation of *Picea abies* occured in Slovak Republic. *Pinus sylvestris* showed comparatively low defoliation on plots in northern Europe, in the Baltic States and Belarus.

Over the last five years temporal trends show some recuperation for evergreen oaks and a continuously increasing defoliation of *Pinus sylvestris*. For the other species/-goups there is no pronounced trend in the most recent years. In general, the extreme heat and drought in summer 2003 is reflected in defoliation of the tree species occurring in temperate Europe, with the exception of *Pinus sylvestris*. The sharp increase of defoliation for four species /-groups at the beginning of the study and the continued fluctuation at comparatively high defoliation levels since then show that the development of tree health and vitality in terms of tree crown defoliation still requires further attention. Through the increasing number of trees in the survey regional developments are more and more levelled off in European mean values. This points to the increasing importance of national and regional studies.

Defoliation reflects a variety of natural and human induced environmental influences. Weather and site conditions as well as tree age influence tree health. The newly introduced damage cause assessment is thus of importance to show the extent of such factors. Insects and fungi are the most widespread agents that were assessed on the trees within the survey. The occurrence of these factors shows clear regional trends like plots with high insect occurrence in north-eastern Spain, Italy or Hungary or high occurrence of trees with fungal infestations in Estonia. The occurrence of insects and fungi is of high relevance for forest health and vitality as well as for forest management (Requardt et al 2009). Forest damage is one of the four indicators under the criteria of the Forest Europe Ministerial Conference on the Protection of Forests in Europe. The ICP Forests and FutMon data base offers the only transnational, harmonized and plotbased information system for such information in Europe. The descriptive evaluations need to be continued and integrated evaluations with other data sets on weather and site conditions are needed as insects and fungi themselves reflect changes in environmental conditions.

The continuation of the time series and the further implementation of related quality assurance measures like field intercomparison courses and quality checks in the data base (Chapt. 2) are of importance to ensure an early warning system for tree health and vitality in the future and to provide the basis for further integrated statistical evaluations which need to be supported by research projects.

3.5 References

Chappelka, A.H., Freer-Smith, P.H. (1995): Predeposition of trees by air pollutants to low temperatures and moisture stress. Environmental Pollution 87: 105-117.

Cronan, C.S., Grigal, D.F. (1995): Use of calcium/aluminium ratios as indicators of stress in forest ecosystems. Journal of Environmental Quality 24: 209-226.

EEA (2007): European forest types. Categories and types for sustainable forest management reporting and policy. European Environment Agency (EEA) Technical Report 9/2006, 2nd edition, May 2007, 111 pp. ISBN 978-92-9167-926-3, Copenhagen.

Freer-Smith, P.H. (1998): Do pollutant-related forest declines threaten the sustainability of forests. Ambio 27: 123-131.

ICP Forests (2010). Manual on methods and criteria for harmonized sampling, assessment, monitoring and analysis of the effects of air pollution on forests. UNECE, ICP Forests, Hamburg. ISBN: 978-3-926301-03-1. [http://www.icp-forests.org/Manual.htm]

Lorenz, M., Becher, G. (1994): Forest Condition in Europe. 1994 Technical Report. UNECE and EC, Geneva and Brussels, 174 pp.

Requardt A, Schuck A, Köhl M (2009). Means of combating forest dieback - EU support for maintaining forest health and vitality. iForest 2: 38-42. [online 2009-01-21] URL: http://www.sisef.it/iforest/contents/?ifor0480-002

3.6 Annexes

Annex I: Broadleaves and conifers

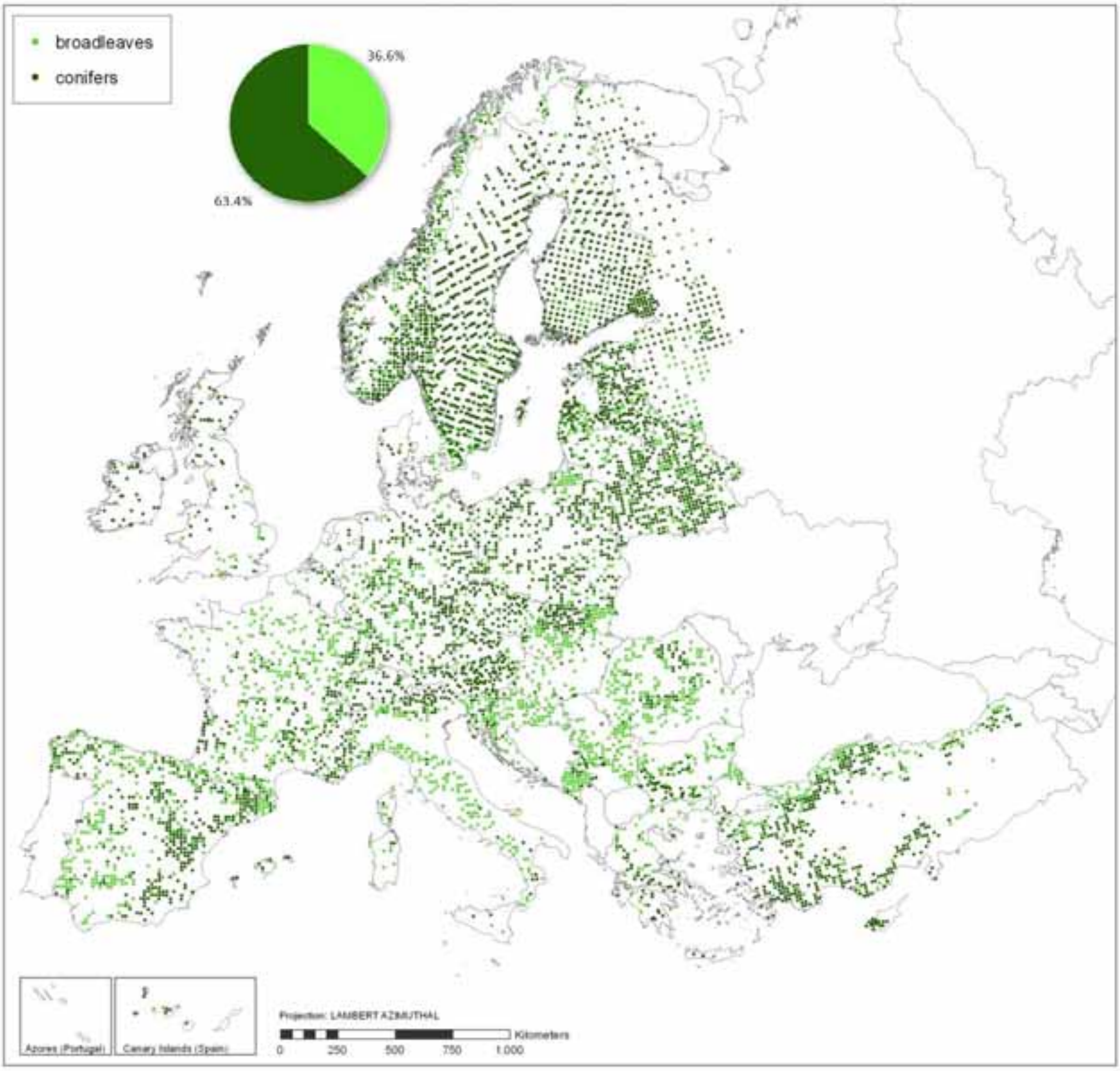

Figure 3-47: Shares of broadleaves and conifers assessed on Level I plots in 2010

Annex II: Number of tree species per plot (Forest Europe classification) (2010)

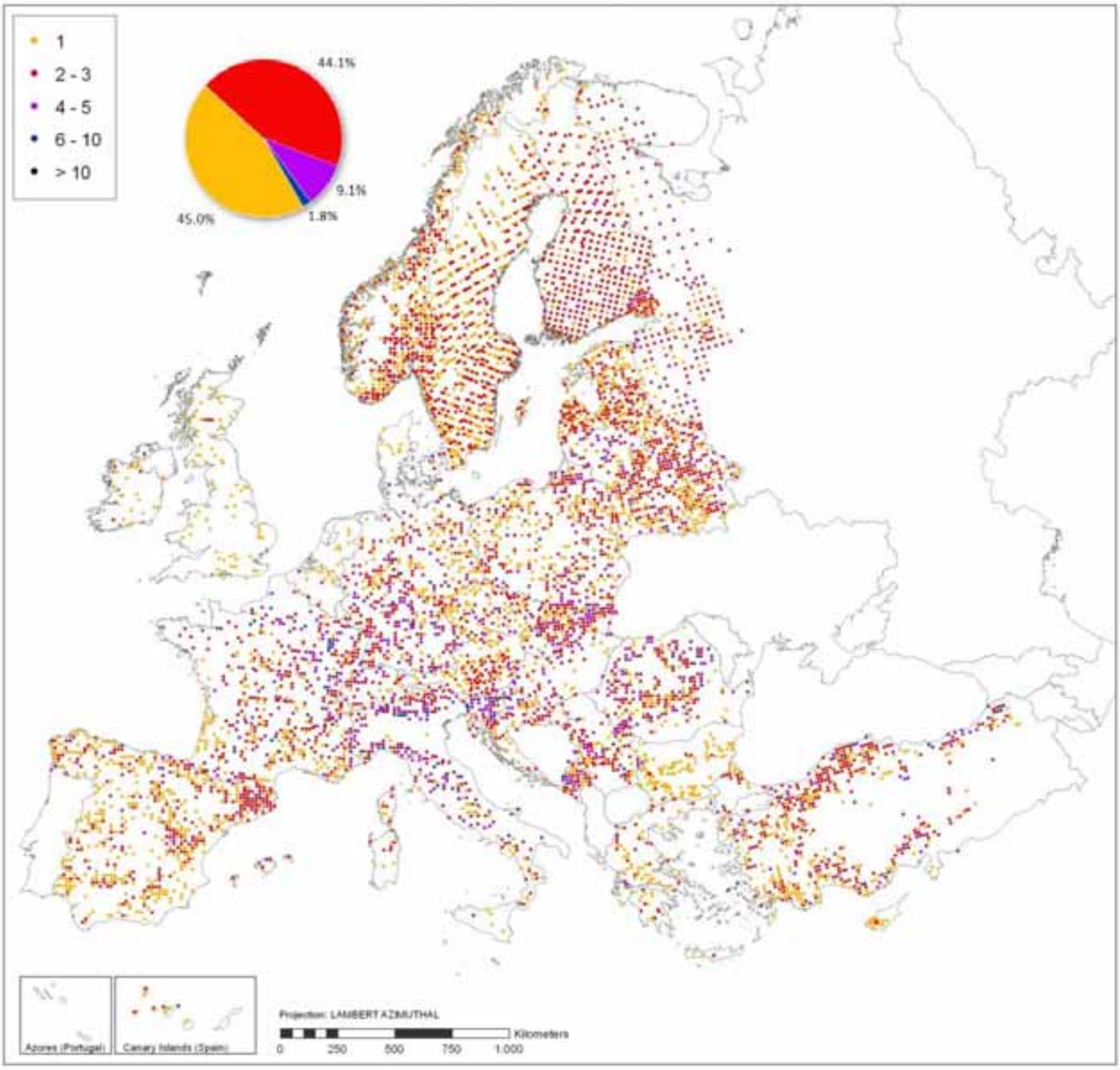

Figure 3-48: Number of tree species assessed on Level I plots in 2010

Annex III: Percentage of trees damaged (2010)

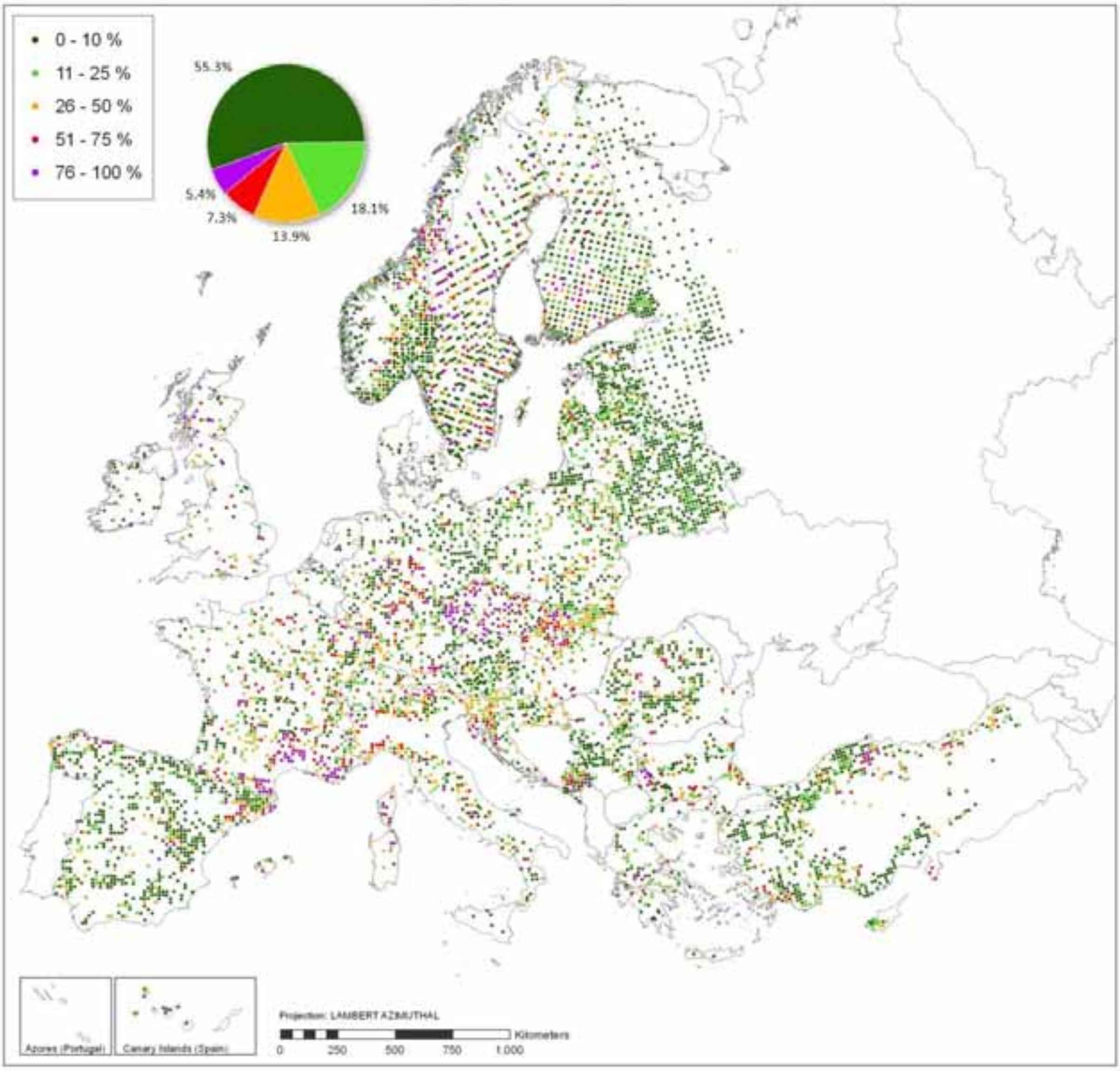

Figure 3-49: Percentage of trees assessed as damaged (defoliartion >25%) on Level I plots in 2010

Annex IV: Mean plot defoliation of all species (2010)

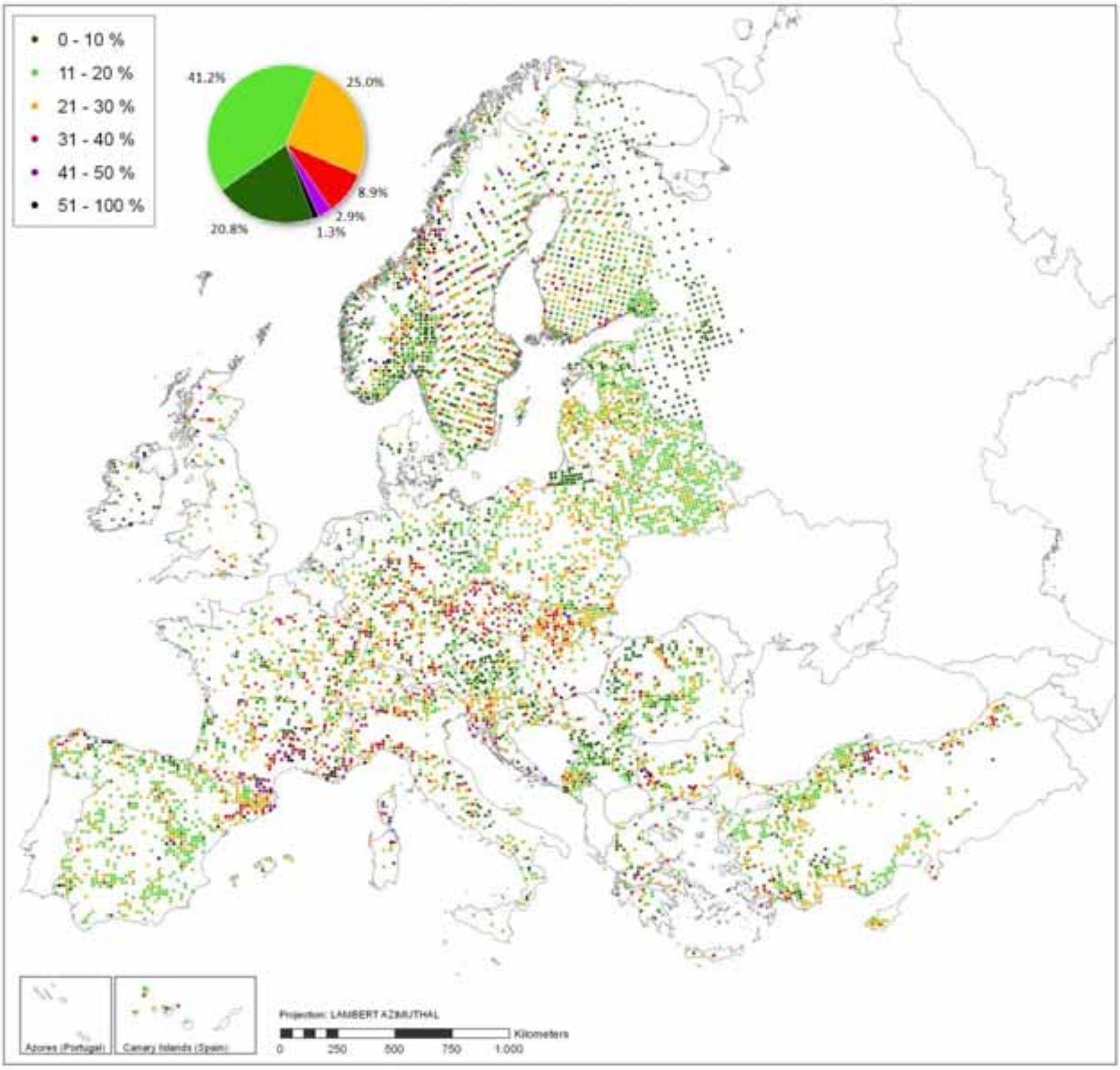

Figure 3-50: Mean defoliation of all trees assessed per Level I plot in 2010

Annex V: Changes in mean plot defoliation (2009 - 2010)

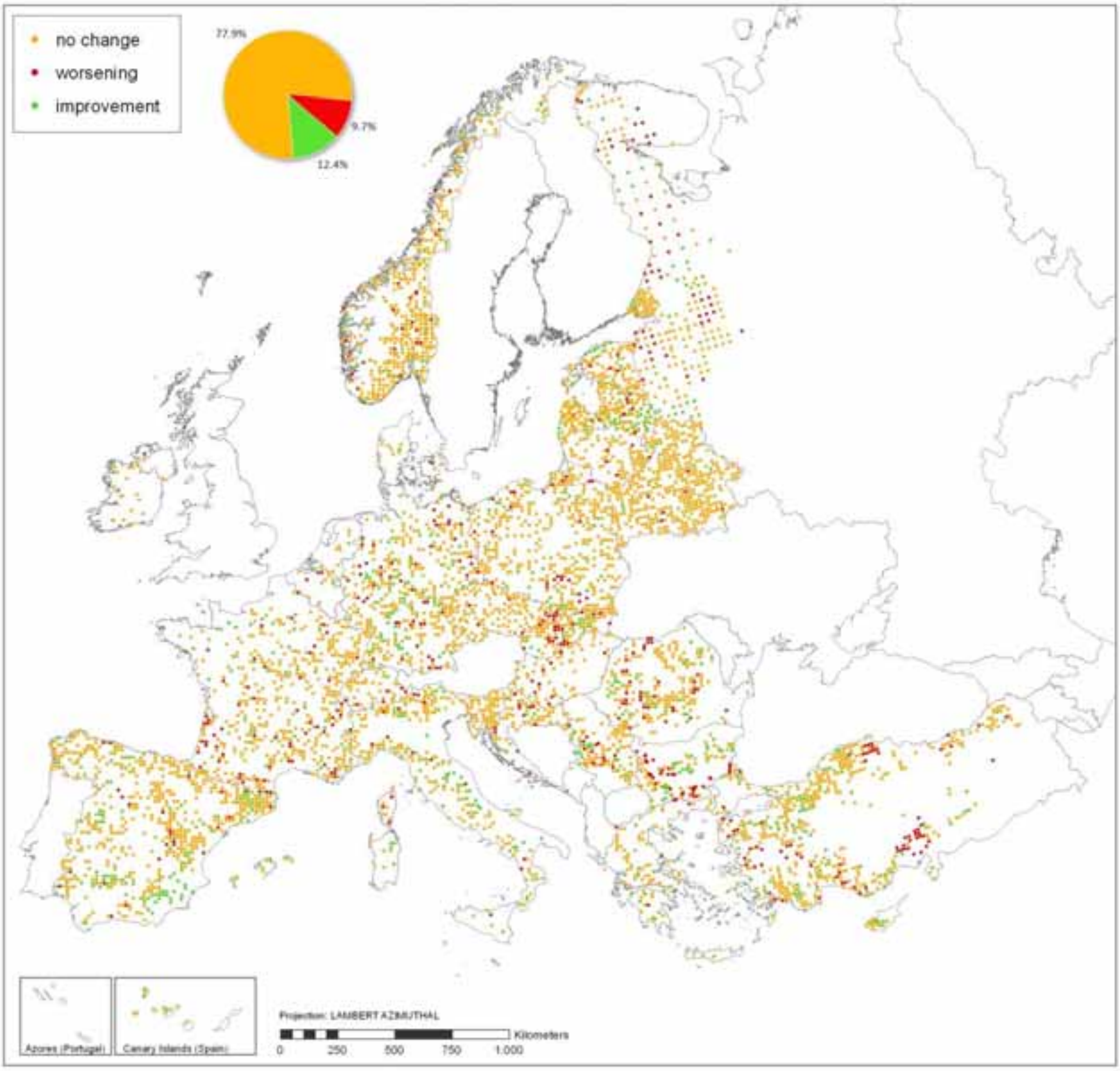

Figure 3-51: Changes in mean defoliation of all trees assessed per Level I plot from 2009 to 2010