RESULTS OF THE LARGE-SCALE FOREST CONDITION MONITORING IN SPAIN

Centre of a Level I plot in Spain

2014 REPORT

GOBIERNO DE ESPAÑA
MINISTERIO DE AGRICULTURA, ALIMENTACIÓN Y MEDIO AMBIENTE

Forest Inventory and Statistics Area
Ministry of Agriculture, Food and Environment

LIST OF CONTENTS

Coordination: SILCO SL

SUMMARY

This paper summarizes the results obtained in the Forest Damage Inventory (IDF), carried out in Spain in the framework of the large-scale forest monitoring network (Level I of ICP-Forests) following a common methodology in all participant European countries. Data corresponding to the 2014 assessment, as well as its evolution comparing to previous years, are shown here.
The large-scale forest monitoring network (Level I) was established in Spain in 1987 in order to monitor forest damages, particularly those related to Air Pollution, by means of the assessment plots of a systematic and random grid net of 16 x 16 Km located throughout European forest area.

Results obtained from the 2014 Inventory show a slight improvement in the general health condition of trees, comparing to previous year. In 2014, a percentage of 85,1% of the assessed trees looked healthy (compared to the percentage of 83,4% of healthy trees obtained in 2013) although still far from the levels of year 2011 (88,2%).
A percentage of 13,3% of all trees were included in defoliation classes "2" and "3" (indicating defoliation levels higher than 25%) whereas in 2013 this percentage was 15.9%.

The number of dead trees decreases as well (1,6% in 2014 whereas in 2013 this percentage was 2,4%).

Recovery is more evident in the case of broadleaves (with a percentage of 81,6% compared to the 79.4% of last year). In the case of conifers, percentage of healthy trees also increases, although slightly (88.6% this year and 87.4% in 2013).

The mortality of trees is mainly due to felling operations, like sanitary cuts and forest harvesting processes, as well as to decline processes related to isolated water shortages.

The periodic assessment of plots of the Large Scale Forest Monitoring Network (Level I) is a very simple and useful method in order to know the apparent health condition of trees and the evolution of existing forest formations. In Spain defoliation assessment is a useful tool, besides being one of the indicators of sustainable forest management of Forest Europe. The parameter defoliation is also used for the evaluation of the processes of forest degradation caused in most cases by a combination of factors acting together, being air pollution one of these factors.

BACKGROUND

In the decade of the 70s of last century, a decline process which affected most of the forest in industrialized countries started to be noticed in Europe. Its origin is still uncertain.

This decline process could affect forests of very different geographical and ecological conditions and its symptoms were defoliation, discoloration of leaves and needles as well as the proliferation of harmful agents considered as saprophytes or semi-saprophytes. This way, the decline situation ends up favoring the appearance of damaging factors such as pests, diseases or other agents which can disturb the forest ecosystem.

As a result of this growing concern, the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests operating under the Convention on Long-range Transboundary Air Pollution (CLRTAP) of the United Nations Economic Commission for Europe (UNECE) was launched in 1985.

In 1986 the EEC Regulation number 3528/86 on "Protection of Forests against Atmospheric Pollution Effects", set up the basis of a common strategy for forest monitoring in all EU countries. From 1987 on, systematic assessments for the evaluation of the forest health condition are performed annually covering the whole community forest area.

Subsequently, this action was supported by the Ministerial Conferences for the Protection of Forests, held in Strasbourg (1990) and Helsinki (1993).

The joint work of the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP-Forests) of the United Nations Economic Commission for Europe (UNECE) and the European Union Programme for Protection of Forests against Atmospheric Pollution resulted in the analysis of the health condition of European forests which has been performed since 1987 until nowadays.

Within the so called European Forest Monitoring Programme (EFMP), a series of projects which constitute the future of forest monitoring in Europe were launched under EC Instrument "Life +". Among all of them, the FutMon project was selected by the European Union to continue the forest monitoring activities carried out from January 2009 to June 2011, also allowing the possibility of some EU funding which ensured the continuity of the work.

After the end of FutMon, the European Union financial support ended as well, although temporarily, in wait of another legal framework which re-enables a return of funds to EU countries. Nevertheless, almost all participating countries have continued with the forest monitoring works based on their own national budgets.

Almost all European countries have implemented the Forest Monitoring Networks since mid 80s.

In 2013 the large-scale forest condition monitoring Network (Level I) (16 x 16 km grid net.) and other sampling schemes with similar methodology and purposes covered 25 countries (being 18 of them EU countries).

MONITORING SCHEME AND METHODS

The large-scale forest condition monitoring network (Level I) consists of a network of points distributed in a 16 x 16 grid net of 16 kilometres across Europe. When the nodes of this grid lie in forest area, a sampling point is installed.

The points are assessed annually since 1987.

The Forest Inventory and Statistics Area (hereinafter AIEF) of the Ministry of Agriculture, Food and Environment, is responsible, at present, of the performance of the Forest Damage Inventory (IDF) in Spain, in collaboration with the Forest Services of the different Spanish regions, and in coordination with the rest of forest damage inventories carried out at European level

Once the sampling points are installed, 24 trees are selected following strict criteria. In these sample trees, defoliation and damages are assessed on each tree by means of the assessment of three parameters: description of symptoms, damage causes (diagnosis) and quantification of the damage extent.

Defoliation is assessed using percentage classes, according to the methodology established in the Spanish Manual ("Manual de Campo de la Red de Seguimiento de Daños en los Montes - Red Europea de Nivel I") which is available on the Web page of the Ministry and the European ICP-Forests manual of (which can be downloaded from the Programme´s web site).

The different photoguides published up to the moment: BOSSHARD (1986), CEE (1987) INNES (1990), Cadahía et al. (1991), FERRETTI (1994) and CENNI et al. (1995) as well as the recommendations of international expert panels help in the assessments.

The IDF-2014 was carried out over 620 plots and 14.880 trees in Spain (7.413 of them belonging to different species of conifers and 7.467 of them to broadleaves). ***Figure 1*** shows the grid in the Iberian Peninsula, Balearic Canary Islands.

The assessments were conducted in the summer months (June to September), during which twelve teams of forest engineers and foremen specifically trained for this kind of work visited all the plots.

Conifers
Broadleaves
Mixed Forests

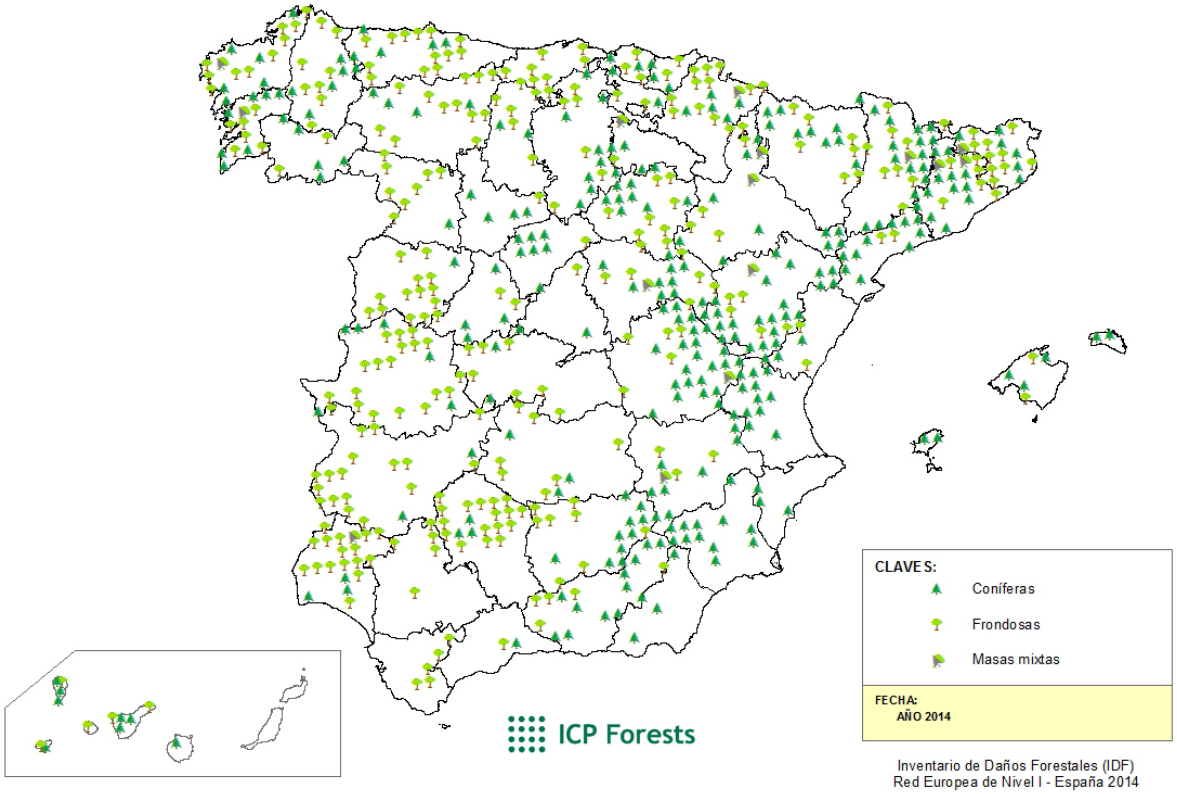

Figure 1. Location of the plots of the European large-scale forest monitoring grid net (Level I) in Spain (conifers, broadleaves and mixed forests). Year 2014

MONITORING RESULTS

DEFOLIATION

Table 1 shows the evolution of defoliation levels for conifers, broadleaves and for all species, between 1987 (first inventory) and 2014, both for the Iberian Peninsula and the Balearic Islands (including, from 1994 on, data obtained in the Canary Islands too). This table serves as reference and basis for all the analyses which are later explained in the text.

The ***Table I of the Annex*** shows the levels of damage to the assessed trees both in absolute values and in percentage; ***Tables II and III of the Annex*** provide a breakdown of the damage percentages for the species of conifers and broadleaves which are most commonly represented in the Inventory. For each one, a differentiation in two age groups has been done: younger and older than 60 years. This subdivision has been made in function of their diameters at breast height (dbh) and the formulas which relate these diameters with the age of trees (for each species), according to the estimates from the National Forest Inventory (1990).

Finally, Table IV of the Annex reflects the intensity of the sampling (plots and trees assessed) and the level of damages in each of the regions, differentiating between conifers and broadleaves.

Table 1. Forest Damage Inventory in Spain, evolution of damages. (IDF Spain, 1987-2014).

Evolution of forest damages. Percentages by defoliation classes (IDF Spain, 1987 - 2014)

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
No. of sample plots	322	388	457	447	436	462	460	456*	454	460	462	465	611	620
Total No. of assessed trees	5.908	9.260	10.968	10.728	10.462	11.088	11.040	10.944	10.896	11.040	11.088	11.160	14.664	14.880
No. of assessed conifers	3.084	4.792	5.371	5.296	5.212	5.521	5.510	5.563	5.367	5.495	5.544	5.576	7.371	7.545
No. of assessed broadleaves	2.824	4.468	5.597	5.432	5.250	5.567	5.530	5.381	5529	5.545	5.544	5.584	7.293	7.335
	DEFOLIATION IN CONIFERS AND BROADLEAVES (%)													
0 to 10% of crown defoliated	63,5	68,5	76,7	78,3	64,2	50,6	44,8	38,5	28,7	29,1	33,6	36,7	36,4	33,3
11 to 25% of crown defoliated	23,6	23,9	18,9	17,0	28,4	37,0	42,2	42,2	47,8	51,4	52,7	49,7	50,7	52,8
26 to 60% of crown defoliated	12,1	6,0	2,9	3,1	5,2	9,5	10,0	13,0	18,9	15,1	10,4	9,6	9,9	10,1
More than 60% of crown defoliated	0,8	1,1	0,5	0,7	1,1	1,0	1,1	2,4	2,6	2,2	1,5	1,3	1,1	0,7
Dead or missing trees	0,0	0,5	1,0	0,9	1,1	1,9	1,9	3,9	2,0	2,2	1,8	2,7	1,9	3,1
	DEFOLIATION IN CONIFERS (%)													
0 to 10% of crown defoliated	67,9	71,1	77,9	77,8	67,8	55,6	49,9	43,9	32,7	33,1	38,9	39,1	41,0	38,1
11 to 25% of crown defoliated	21,5	21,2	17,7	17,7	24,9	30,9	35,4	37,0	49,1	48,9	49,5	48,0	49,2	49,8
26 to 60% of crown defoliated	9,9	6,2	2,8	2,9	5,2	11,0	11,7	13,0	14,9	13,5	8,8	9,1	7,1	7,3
More than 60% of crown defoliated	0,7	1,0	0,6	0,2	0,7	0,7	1,0	1,8	2,0	2,2	1,2	1,3	1,2	0,7
Dead or missing trees	0,0	0,5	1,0	1,4	1,4	1,8	2,0	4,3	1,3	2,3	1,6	2,5	1,5	4,1
	DEFOLIATION IN BROADLEAVES (%)													
0 to 10% of crown defoliated	58,8	65,7	75,4	78,8	60,6	45,7	39,7	32,9	24,8	25,3	28,4	34,2	31,7	28,3
11 to 25% of crown defoliated	26,0	26,8	19,9	16,3	31,9	43,1	48,9	47,5	46,6	54,0	55,8	51,4	52,2	55,9
26 to 60% of crown defoliated	14,5	5,7	2,9	3,3	5,3	8,0	8,3	13,1	22,8	16,6	12,1	10,1	12,8	13,0
More than 60% of crown defoliated	0,7	1,2	0,8	1,1	1,5	1,2	1,2	2,9	3,1	2,1	1,6	1,3	1,0	0,7
Dead or missing trees	0,0	0,6	1,0	0,5	0,7	2,0	1,9	3,6	2,7	2,0	2,1	3,0	2,3	2,1

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
No. of sample plots	620	620	620	620	620	620	620	620	620	620	620	620	620	620
Total No. of assessed trees	14.880	14.880	14.880	14.880	14.880	14.880	14.880	14.880	14.880	14.880	14.880	14.880	14.880	14.880
No. of assessed conifers	7.522	7.532	7.514	7.498	7.511	7.511	7.520	7.502	7.488	7.469	7.439	7.438	7.435	7.413
No. of assessed broadleaves	7.358	7.348	7.366	7.382	7.369	7.369	7.360	7.378	7.392	7.411	7.441	7.442	7.445	7.467
	DEFOLIATION IN CONIFERS AND BROADLEAVES (%)													
0 to 10% of crown defoliated	28,9	24,2	22,7	24,0	17,0	17,2	18,0	19,7	17,8	24,3	28,1	21,8	22,2	21,7
11 to 25% of crown defoliated	58,1	59,4	60,7	61,0	61,7	61,2	64,4	64,7	64,5	61,1	60,1	60,7	61,2	63,4
26 to 60% of crown defoliated	9,7	13,2	13,2	11,8	18,0	18,2	14,6	13,1	14,3	11,1	9,1	13,5	12,1	11,4
More than 60% of crown defoliated	1,0	0,9	1,2	1,2	1,4	1,3	1,2	1,1	1,4	1,2	1,1	2,4	2,1	1,9
Dead or missing trees	2,3	2,3	2,2	2,0	1,9	2,1	1,8	1,4	2,0	2,3	1,6	1,6	2,4	1,6
	DEFOLIATION IN CONIFERS (%)													
0 to 10% of crown defoliated	33,8	28,7	27,0	27,5	20,4	21,2	22,2	23,5	21,6	27,2	32,5	26,0	28,2	25,9
11 to 25% of crown defoliated	54,5	55,7	58,9	58,5	60,2	60,0	62,0	63,6	63,5	59,7	57,1	62,6	59,2	62,7
26 to 60% of crown defoliated	8,6	12,2	11,5	10,2	16,2	15,5	12,9	10,7	11,9	9,5	8,0	8,9	8,4	8,8
More than 60% of crown defoliated	1,1	0,9	1,2	1,3	1,5	1,0	0,8	0,9	1,3	0,8	0,8	1,4	1,1	1,3
Dead or missing trees	2,0	2,5	1,4	2,5	1,7	2,3	2,1	1,3	1,7	2,8	1,6	1,1	3,1	1,3
	DEFOLIATION IN BROADLEAVES (%)													
0 to 10% of crown defoliated	23,9	19,5	18,3	20,3	13,5	13,1	13,7	15,9	13,9	21,4	23,7	17,7	16,1	17,5
11 to 25% of crown defoliated	61,6	63,2	62,6	63,6	63,2	62,5	66,8	65,7	65,4	62,5	63,1	58,8	63,2	64,1
26 to 60% of crown defoliated	10,9	14,3	14,9	13,5	19,9	20,9	16,3	15,7	16,8	12,8	10,3	18,1	15,7	14,0
More than 60% of crown defoliated	1,0	0,9	1,2	1,0	1,4	1,6	1,6	1,2	1,6	1,4	1,3	3,3	3,3	2,4
Dead or missing trees	2,6	2,1	3,0	1,6	2,0	1,9	1,6	1,5	2,3	1,9	1,6	2,1	1,7	2,0

* From 1994 on, the number of sample plots includes the plots assessed in Canary Islands as well.

which are obtained in the assessments, in five classes:

- Class 0 (no defoliation; between 0% and 10%)
- Class 1 (slight defoliation; between 10% and 25%)
- Class 2 (moderate defoliation; mayor de 25% hasta 60%)
- Class 3 (severe defoliation; between 60% and 100%)
- Class 4 (dead or missing tree; 100%)

Before evaluating the results, we should remind that defoliation class "4" (dead trees) includes also the trees which have been cut as a result of forest harvesting and silvicultural operations (important for species such as eucalyptus, poplar or radiata pine in areas such as the Cantabrian or Huelva) and those affected by fire with no ability to regrow. This explains the appearance of plots with all the trees missing.

General results show that in 2014, 85,1 % of the sampled trees looked healthy: they correspond to defoliation classes “0” and” 1 (between 0 and 25% of leaf volume loss). A 13,3 % of the trees are included in classes” 2” and” 3”, with defoliation levels higher than 25%. These values show a slight improvement if compared to previous year (2013).

The historical evolution of parameter defoliation for the whole sample is reflected in ***Figure 2***. A slight overall improvement in the condition of trees is noticed. It shows a slight decrease in the percentage of trees in Class "0" (no damage) and a greater increase in the percentage of trees within the class "1" (slightly damaged).
As regards the trees with defoliation levels higher than 25%, there is a slight decrease in the percentage of trees included in class "2" (moderately damaged) and also in class "3" (severely damaged).
Class “4”, where dead or missing trees are included, also decreases slightly.
Overall evaluation of the 2014 results reflects a recovery if compared to previous year.

Different defoliation levels

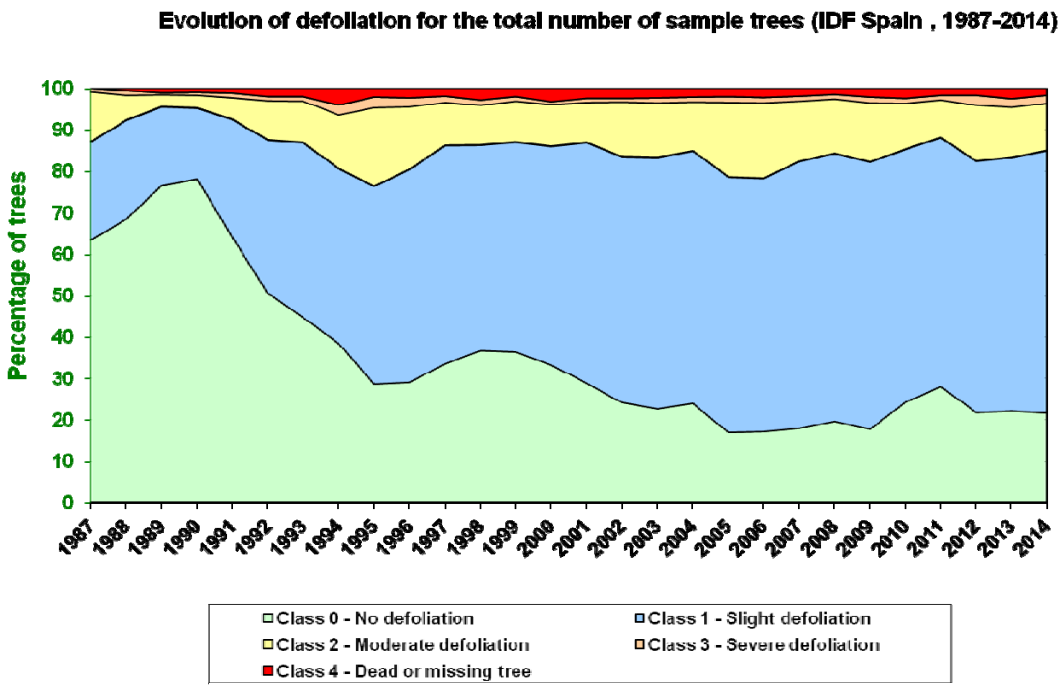

Figure 2. Evolution of defoliation for the total number of sample trees (IDF Spain, 1987-2014)

Figure 3 allows us to appreciate the different evolution of conifers and broadleaves since the beginning of samplings.

The study of the defoliation levels shows that a general decay process started in 1991 (more evident, in principle, for conifers). In 1995 the maximum deterioration was reached, much more acute for broadleaves. In 1996 and 1997 there was a recovery in the condition of trees.

Since 1997, conifers show an erratic behaviour, experiencing slight deterioration periods followed by small improvements, but always presenting a better health condition than broadleaves.

In 2004, a slight recovery was noticed, being more evident for broadleaves. In 2005 there was a significant deterioration for both groups of species related to the strong drought suffered.

A process of improvement started in 2006 and continued until 2011, with a relapse in 2009. In 2012 there was a new deterioration, acuter for the broadleaves.

The values of 2014 show a continuation of the recovery which started in 2013.The improvement seen this year is higher for broadleaves, although in general the health condition is still better for conifers, as this group of species has the highest percentage of healthy trees and a lower number of damaged trees.

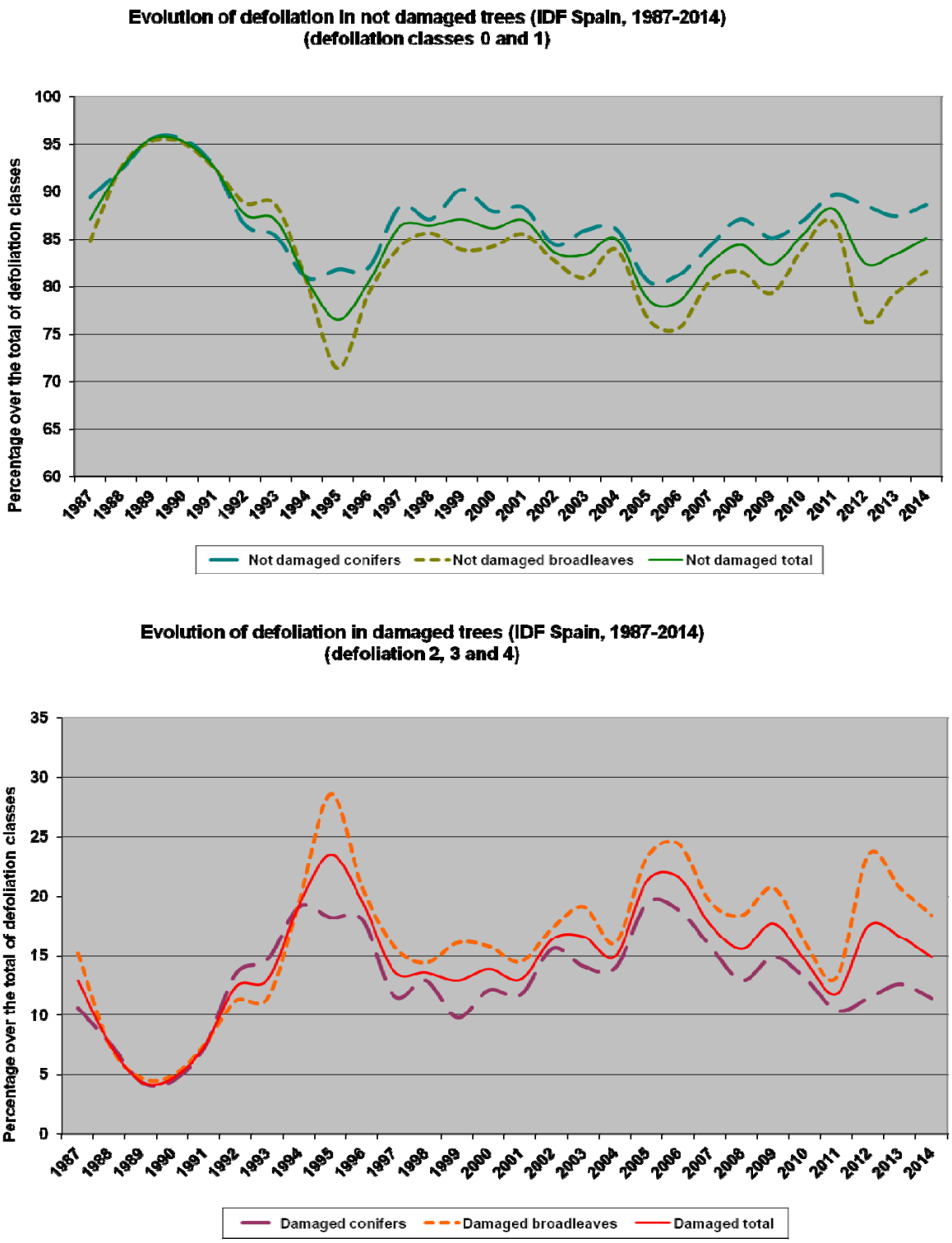

Figure 3. Annual evolution of the defoliation levels for conifers and broadleaves in the different inventories (IDF Spain, 1987-2014).

If we make a differentiation between the two groups of species, we can see that in the case of broadleaves, there is a slight recovery reflected by a 81.6% of healthy trees (versus the 79.3% of last year), together with a similar decrease in the proportion of damaged trees (from 19% in 2013 to 16.4% in 2014). In the case of conifers, the percentage of healthy trees increases, although this increase is somewhat lower, being the percentage of trees included in this category a 88.6%

(versus 87.4% of last year), while the percentage of damaged trees increases slightly (10.1% versus a 9.5% in 2013).

As for the dead trees, the percentage decreases slightly in the case of conifers (from 3.1% to 1.3%) and increases very slightly in the case of broadleaves (from 1.7% to 2%). Most of the times the causes of death are sanitary cuts, forest harvesting and decay processes derived from water shortages.

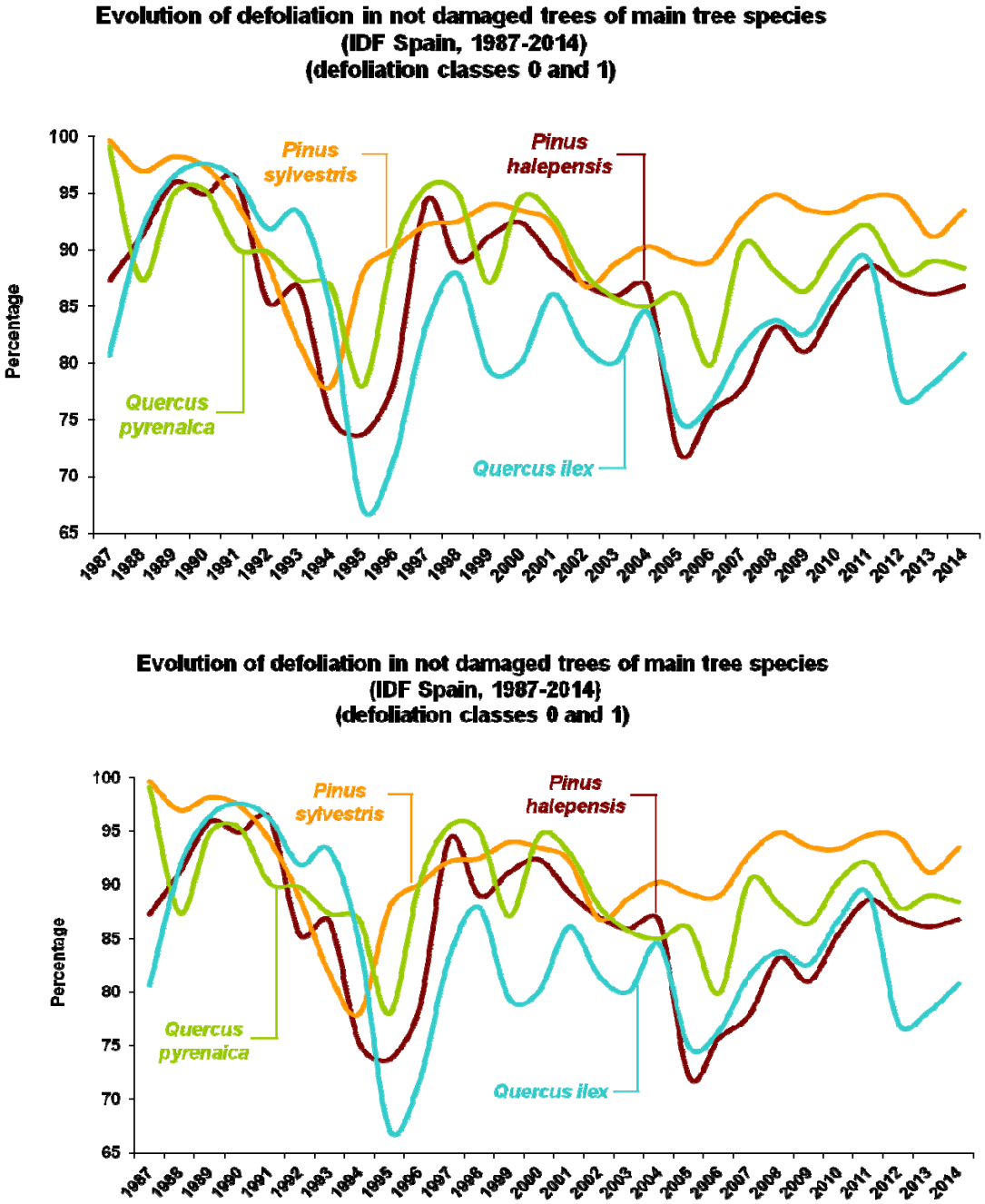

Figure 4. Annual evolution of the defoliation levels of the most relevant forest species in the different inventories. (IDF Spain, 1987-2014).

The analysis of the four forest species more frequently represented in the inventories (two conifers – Scots pine and Aleppo pine - and two broadleaves – Holm oak and Pyrenean oak) and the evolution of their defoliation levels in healthy trees (classes 0+1) and damaged (classes 2 + 3) is shown in ***Figure 4*** showing the following results:

During 2014 the species showing a clearer improvement is Holm oak which increases its percentage of healthy trees and reduces its percentage of damage ones in the same proportion, followed by Scots pine, which increasing its percentage of healthy trees and maintains its percentage of damaged trees in similar levels to previous year. In the case of Pyrenean oak, values remain virtually unchanged, while in the case of Aleppo pine, the percentage of healthy trees increases but the percentage of damaged trees increases in greater proportion.
The percentage of dead trees decreases this year (2014) for the two species of conifers.

We must bear in mind that the average defoliation for Holm oak is always the highest, with over 18% of trees classified as damaged. Then we find the Aleppo pine (almost 13% of trees damaged) and after that, Pyrenean oak, with 11% of damaged trees. Scots pine has less than 6% of trees in the class of damaged trees.

The methodology used in the European Level I grid is based in the comparison of the assessed tree with a reference tree (or ideal tree of the area). This methodology prevents from a direct comparison of the results obtained in different countries which have implemented this inventory. However, it shows the overall trend for whole Europe.

The analysis of results obtained in IDF-2013, indicated that Spain had a lower proportion of damaged trees than the whole Europe, as showed in ***Table 2***, with a percentage of 16,6% of sample trees classified as damaged and a difference of almost 4 percent points if compared to total Europe. We still don´t have transnational data from IDF – 2014, but results from Spain show a slight decrease in the proportion of damaged trees, with a 14,9% of trees in this class.

	Spain 2013	Europe 2013	Spain 2014
No. of sample plots	620	5.672	620
No. of conifers assessed	7.435	53.179	7.413
No. of broadleaves assessed	7.445	48.936	7.467
Total	14.880	102.115	14.880
DEFOLIATION IN CONIFERS %			
0 to 10% of crown	28,2	34,5	25,9
11 to 25% of crown	59,2	49,7	62,7
>25%	12,6	15,8	11,4
DEFOLIATION IN BROADLEAVES %			
0 to 10% of crown	16,1	29,4	17,5
11 to 25% of crown	63,2	45,0	64,1
>25%	20,7	25,6	18,4
DEFOLIATION TOTAL %			
0 to 10% of crown	22,2	32,1	21,7
11 to 25% of crown	61,2	47,4	63,4
>25%	16,6	20,5	14,9

Table2. Defoliation percentages in Spain & Europe. IDF Spain, 2014 and 2013; ICP-Forests 2013

The results obtained in Spain may have a certain geographical interpretation, as can be seen in ***Table 3***, which shows the proportion of damaged trees (classes 2 + 3) during the IDF-2013 and the IDF-2014 as well as the variations between the two inventories for each region in Spain. In Figure 5 all the cumulative scores of all defoliation classes for each region are graphically represented.

Changes in damage percentage by regions (IDF Spain. 2013 y 2014)

	2013		2014		2014 - 2013
	Class 0+1	Class 2+3	Class 0+1	Class 2+3	Class 2+3
Andalusia	85,1	12,7	87,3	11,7	-1,0
Aragon	91,1	8,2	89,1	10,8	2,6
Asturias	81,9	11,2	90,0	8,6	-2,6
Balearic Islands	68,1	29,6	69,9	18,5	-11,1
Canary Islands	79,2	20,8	82,7	16,3	-4,5
Cantabria	95,4	4,1	92,5	7,0	2,9
Castile and La Mancha	81,2	15,9	83,9	16,0	0,1
Castile and Leon	88,4	11,0	87,6	11,2	0,2
Catalonia	76,2	19,0	86,5	10,6	-8,4
Extremadura	79,2	20,6	78,7	19,5	-1,1
Galicia	72,5	22,5	74,9	19,0	-3,5
Madrid	63,9	36,1	68,1	31,9	-4,2
Murcia	96,2	3,8	88,9	11,1	7,3
Navarre	87,3	11,8	88,2	10,2	-1,6
La Rioja	93,7	6,3	76,0	23,0	16,7
Basque Country	88,3	3,9	96,7	3,3	-0,6
Valencia	91,0	5,9	82,2	17,6	11,7
Total Spain	83,4	14,2	85,1	13,3	-0,9

Table 3. Evolution of the different percentages of damages by regions.

As a result of the values obtained, it can be derived that many of the regions show an improvement, highlighting Baleares where the percentage of trees rated as damaged has decreased at a rate of 11.1%, followed by Catalonia (8.4%) and Madrid with a 4 2%.

The regions with worsen results than previous year are: La Rioja, where the percentage of trees classified as damaged has increased by 16.7%, followed by Valencia with 11.7% and third Murcia 7.3%.

In the case of La Rioja, it seems that there is an increase in the populations of *Rhynchaenus fagi*, a mining insect affecting beech, which is the main broadleaved species in La Rioja. This species has also been really affected by late frosts occurred this year. In Valencia, there is an increase in the presence of needle cast and fungal decay, damage caused by drought and insect damages. In Murcia, where most of the trees represented are Aleppo pines, a significant increase in damages due to drought has been recorded.

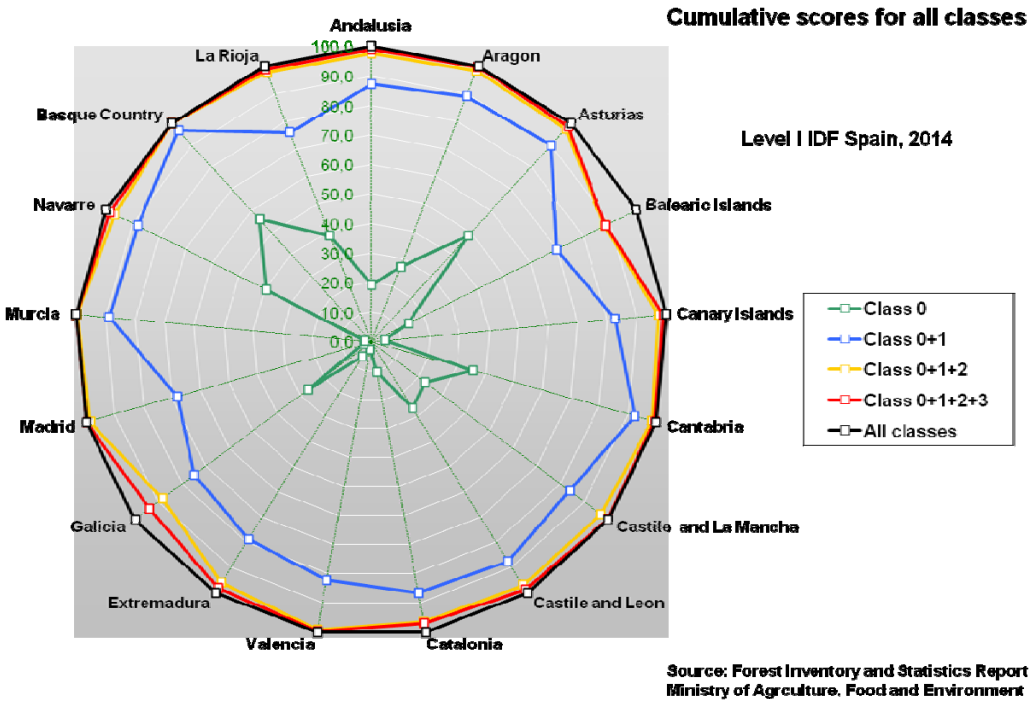

Figure 5. Graphic showing the cumulative scores for all defoliation classes by regions (IDF Spain, 2014).

DAMAGING AGENTS AND CAUSES

In 2005, a new system of damage causes assessment was implemented on all sample plots in order to identify potential damaging agents and their impact on tree condition.
The assessed parameters are classified into three main areas:

1. Description of symptoms: The main objective of symptom description is "describe what you see," indicating both the part of the tree which is affected and the type of symptom that it shows.

2. Identification of the damaging agents (Diagnosis): The identification of the causal agents is crucial for studying the cause – effect mechanisms. The damaging agents are grouped into a number of categories with a hierarchical encoding. The best possible situation is reaching the level of species identification.

3. Quantification of symptoms (Extension): The extent of the damage indicates the amount (percentage) of the total area of the part of the tree we are assessing which is affected by a concrete damaging agent.

Results shown in ***Table 4*** indicate the main damage causes which have been registered and identified in trees presenting a defoliation level higher than 25% (damaged trees) in recent years.

Table 4. Main damage causes identified in damaged trees (defoliation level higher than 25%). IDF, Spain 2005-2014.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Damaged trees	4303	4456	1937	3451	3924	3278	2405	3654	3471	3224
Game and grazing	0.2	0.2	0.3	0.2	0.3	0.3	0.3	0.5	0.6	0.6
Insects	23.3	27.5	40.5	27	26.9	25.5	24.8	25	25.3	25.8
Fungi	8.2	9.4	10.6	10.5	10.2	9	9.5	8.1	8.5	8.3
Abiotic agents	43.9	36.6	21.9	34.7	34.8	32.4	31.5	42.7	39.2	41.5
Direct action of men	5.6	4.9	3.6	5.4	5.9	7.4	9.1	5.8	8.2	5.8
Fires	2.8	3.3	3.5	2.7	3	4	3.7	3.6	3.7	3.8
Other	9.2	10.7	13.9	11.6	11.2	11.8	12.8	10.8	11.7	11.9
Not identified	6.8	7.4	5.7	7.9	7.7	9.6	8.3	3.5	2.8	2.3

Given the difficulty of assessing the damages caused by known local/regional pollutants, no data are recorded.

When analysing the results of these parameters in damaged trees, a slight decrease (if compared to 2013) in the number of damage records is observed (3.471 in 2013 comparing to 3.224 in 2014). Comparing to previous year, a slight increase in the percentage of abiotic damages, mainly caused by drought, is observed; meanwhile, a decrease in the number of damage caused by the direct action of man is detected. The rest of damages does not increase or decrease its share remarkably comparing to previous year. It should be quoted that abiotic damage represent more than 41% of all damages recorded in weakened trees and that damages by insects represent almost a 26%.

Figure 6 shows the damage causes registered in the 2014 Inventory in the total group of trees presenting defoliation levels higher than 25%.

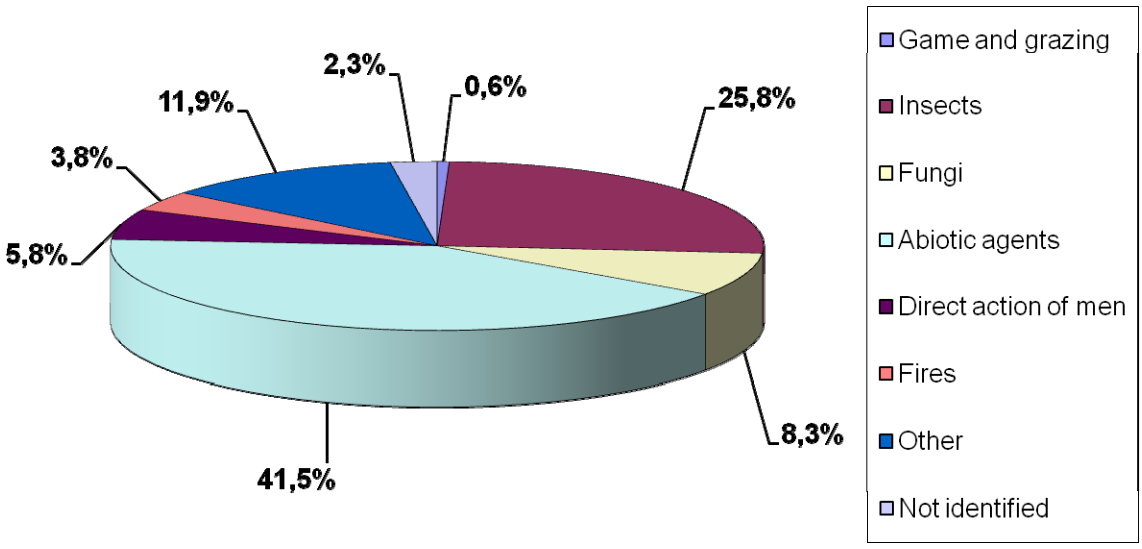

Figure 6. Main damage causes identified in damaged trees (defoliation levels higher than 25%)

TREE MORTALITY

The number of missing trees in IDF-2014 (245 trees) is much lower than in IDF-2013 (359 trees), representing this figure a 1.6% of the total number of sampled trees.

Figure 7 shows the proportion of agents which have been identified in dead trees and ***Figure 8*** its evolution since 2008.

In a 68% of cases, the trees disappearance is caused by human action (mostly cuts), followed by the action of abiotic agents (drought and wind) in more than 9% of cases, nearly an 8% of the total figure of dead and missing trees are damaged by fire, more than 7% is due to other types of damages (competition, presence of *Viscum album*, etc.) while almost 6% of death or disappearance cases are caused by borers (mainly *Phoracantha semipunctata*).

If compared to 2013 there is an increase in the percentage of trees affected by fires and an important decrease of damages caused by human activities.

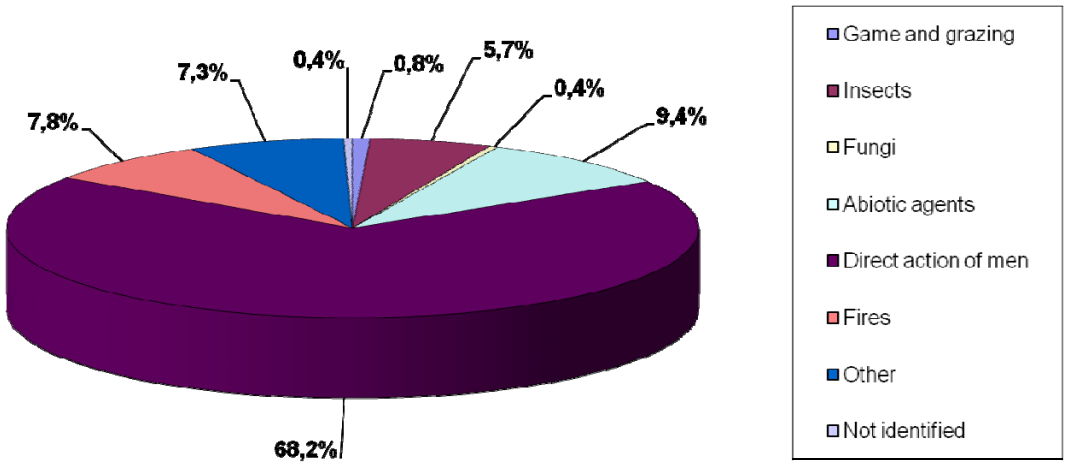

Figure 7. Damaging agents recorded in dead or missing trees. IDF, Spain, 2014.

Therefore, we can conclude that the main reasons for tree death are cuts (as a result of forestry operations), independently that there have previously existed factors that may have put the vegetation in a situation of imbalance which favours the entry of opportunistic or masking damaging agents.

If we consider the species which have more trees in the category "dead", *Pinus pinaster* is clearly the most important (with 25% of the total number of dead trees in 2014 belonging to this species), followed by eucalyptus with more than a 17%, and Holm oak with almost a 15%.

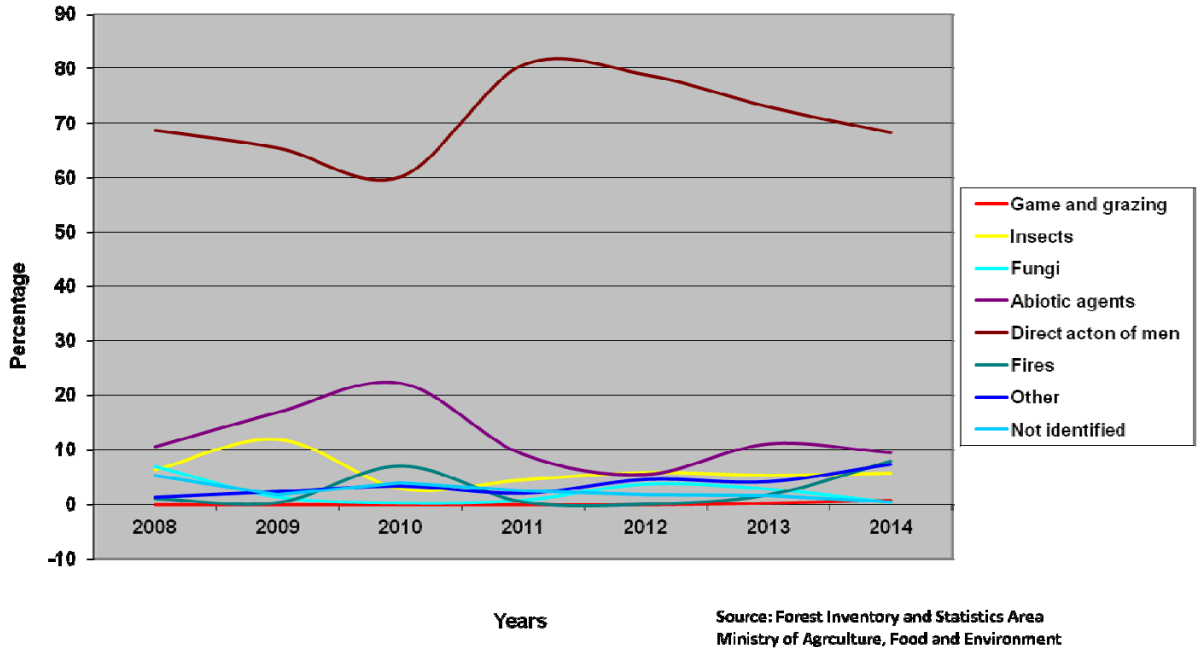

Figure 8. Evolution of the share of damaging agents in dead or missing trees. IDF Spain, 2008-2014.

The main causes of death in the case of *Pinus pinaster* are cuts (in a 61% of the cases) but there is also a large number of trees affected by fire (19%), in the case of eucalyptus, the main causes of death are also cuts (51%) being the second cause in importance the action of boring insects (*Phoracantha semipunctata*) with a 23%, in Holm oak the main cause of death is still the cuts (almost 78%), followed by drought (14% of the cases).

BIBLIOGRAPHY

BOSSHARD W. (Editor) 1986: *Sanasilva, Le chiome degli alberi*. Instituto federale di ricerche forestali. Birmensdorf.

CADAHIA D. *et al*. 1991: *Observación de daños en especies forestales mediterráneas*. CEE-MAPA. Madrid.

CEE 1987: *Diagnóstico y clasificación de nuevos tipos de daños forestales*. Edición especial D.G. VI. División Forestal. Bruselas.

CENNI *et al*. 1995: *Valutazione delle condizioni degli alberi*. Dipartimento Agricoltura e foreste. Regione Toscana. Florencia.

FERRETTI M. (Editor), 1994: *Especies forestales mediterráneas. Guía para la evaluación de las copas*. CEE-UN/ECE. Bruselas, Ginebra.

INNES J.L. 1990: *Assessment of tree condition*. Forestry Commission, HMSO. Londres.

Inventario Forestal Nacional, 1990: Segundo Inventario Forestal Nacional. Explicaciones y métodos (1986-1995). ICONA.

ANNEXES

ANNEX – Table I: Figures (total and percentages) of forest damages by species, according to the different defoliation classes (IDF Spain, 2014).

	Species	CONIFERS						BROADLEAVES								
		P.h.	P.n.	P.pr.	P.pa.	P.s.	Other	Eu.sp.	F.s.	Q.i.	Q.py.	Q.s.	Other	<60 Years	≥60 Years	Total
Defoliation classes	Defoliation percentage	Total number of trees in each class														
0: Not defoliated	0% - 10%	69	431	434	109	610	379	223	192	227	186	24	466	1.821	1.407	3.228
1: Slightly defoliated	11% - 25%	1.783	862	796	269	630	661	319	163	2.408	672	291	1.057	6.696	3.843	9.436
2: Moderately defoliated	26% - 60%	253	66	69	53	57	137	166	34	529	76	74	163	1.167	510	1.697
3: Severely defoliated	61% - 99%	16	12	9	4	12	34	67	0	61	16	6	31	209	69	272
4: Dead or missing tree	100%	7	6	62	10	10	4	43	3	36	6	13	48	179	66	245
Defoliation classes	Defoliation percentage	Percentage of trees in each class														
0: Not defoliated	0% - 10%	2,8	36,9	31,2	26,1	41,8	34,3	27,3	60,3	7,0	21,8	8,0	26,0	20,3	23,9	21,7
1: Slightly defoliated	11% - 25%	84,0	65,9	67,2	69,6	61,7	49,9	39,0	40,1	73,8	66,8	70,3	60,3	62,3	65,2	63,4
2: Moderately defoliated	26% - 60%	12,1	6,7	6,4	12,2	4,7	12,4	20,3	6,8	16,2	8,9	18,6	9,3	13,2	8,7	11,4
3: Severely defoliated	61% - 99%	0,8	1,0	0,7	0,9	1,0	3,0	8,1	0,0	1,9	2,1	1,9	1,8	2,2	1,1	1,9
4: Dead or missing tree	100%	0,3	0,6	4,6	2,3	0,8	0,4	5,3	0,8	1,1	0,6	3,3	2,8	2,0	1,1	1,6

	P.h.	P.n.	P.pr.	P.pa.	P.s.	Other	Eu.sp.	F.s.	Q.i.	Q.py.	Q.s.	Other	<60 Years	≥60 Years	Total
Classes 0+1	86,8	92,8	88,4	84,8	93,5	84,2	88,3	90,4	80,8	88,4	76,3	86,3	82,8	89,1	85,1
Classes 2+3	12,9	6,7	7,1	13,1	5,7	15,4	28,4	6,8	18,1	11,0	20,4	11,1	15,4	9,8	13,3
Classes 2+3+4	13,2	7,2	11,8	15,4	6,6	15,8	33,7	9,6	19,2	11,8	23,7	13,7	17,4	10,9	14,9

ANNEX – Table II: Percentage of forest damages in conifers for the most relevant species (IDF Spain, 2014).

CLASSIFICATION	Species	Trees aged up to 60 years							Trees aged 60 years or more							
		P.h.	P.n.	P.pr.	P.pa.	P.s.	Other	Subtotal	P.h.	P.n.	P.pr.	P.pa.	P.s.	Other	Subtotal	Total conifers
Defoliation classes	Defoliation percentage	Defoliation. Percentage of trees in each class														
0: Not defoliated	0% - 10%	2,8	32,4	39,4	21,8	38,5	28,3	24,1	3,3	46,8	28,1	37,8	48,5	44,3	29,8	25,9
1: Slightly defoliated	11% - 25%	81,9	59,7	55,0	60,8	53,9	60,4	62,7	88,0	47,7	62,4	54,8	47,3	48,9	62,8	62,7
2: Moderately defoliated	26% - 60%	14,4	6,4	7,0	14,0	6,3	16,5	10,4	7,8	4,0	6,0	6,4	3,4	6,8	6,5	8,6
3: Severely defoliated	61% - 99%	0,8	0,7	0,8	1,0	1,3	4,5	1,6	0,5	1,7	0,5	1,1	0,3	0,7	0,7	1,3
4: Dead or missing tree	100%	0,3	0,8	3,8	2,8	1,0	0,3	1,3	0,4	0,0	8,0	1,1	0,5	0,5	1,4	1,3

P.h.: *Pinus halepensis*; P.n.: *Pinus nigra*; P.pr.: *Pinus pinaster*; P.pa.: *Pinus pinea*; P.s.: *Pinus sylvestris*.

ANNEX – Table III: Percentage of forest damages in broadleaves for the most relevant species (IDF Spain, 2014)

CLASSIFICATION	Species	Trees aged up to 60 years							Trees aged 60 years or more							
		Eu.sp.	F.s.	Q.l..	Q.py.	Q.s.	Other	Subtotal	Eu.sp.	F.s.	Q.l.	Q.py.	Q.s.	Other	Subtotal	Total broadleaves
Defoliation classes	Defoliation percentage	Defoliation. Percentage of trees in each class														
0: Not defoliated	0% - 10%		26,6	6,2	20,2	3,6	19,3	16,6	-	62,2	8,7	24,6	6,4	32,1	19,8	17,6
1: Slightly defoliated	11% - 25%	39,0	55,6	72,6	68,4	64,4	61,8	61,7	-	32,3	76,1	67,7	72,9	59,0	68,9	64,1
2: Moderately defoliated	26% - 60%	20,3	17,9	16,8	10,1	28,1	12,9	16,6	-	4,3	14,0	6,4	16,9	6,9	10,8	14,0
3: Severely defoliated	61% - 99%	8,1	0,0	2,0	2,8	1,7	2,2	3,4	-	0,0	1,7	1,0	2,1	1,5	1,5	2,4
4: Dead or missing tree	100%	6,3	0,0	1,7	0,7	12,3	3,8	2,8	-	1,2	0,5	0,4	1,7	1,5	1,0	2,0

Eu.sp.: *Eucalyptus sp*; F.s.: *Fagus sylvatica*; Q.l.: *Quercus ilex*; Q.py.: *Quercus pyrenaica*; Q.s.: *Quercus suber*.

ANNEX – Table IV. Results by regions: Percentages of damages in conifers and broadleaves by regions (IDF Spain, 2014).

	ANDALUSIA			ARAGON		
	Conífers	Broadleaves	Total	Conífers	Broadleaves	Total
Defoliation level						
0	19,3	19,1	19,2	32,2	14,3	27,2
1	68,6	67,8	68,1	59,0	69,5	61,9
2	10,9	9,9	10,3	7,0	15,5	9,3
3	0,7	1,9	1,4	1,6	0,7	1,5
4	0,5	1,3	1,0	0,2	0,0	0,1
Total no. of sample trees ...	773	1.363	2.136	1.093	419	1.512
Total no. of sample plots ...			89			63

	ASTURIAS			BALEARIC ISLANDS		
	Conífers	Broadleaves	Total	Conífers	Broadleaves	Total
Defoliation level						
0	54,5	46,6	48,6	13,0	16,1	13,9
1	42,8	40,9	41,4	65,6	32,3	56,0
2	0,0	10,0	7,4	21,4	9,7	18,1
3	0,0	1,6	1,2	0,0	1,6	0,4
4	2,7	0,9	1,4	0,0	40,3	11,6
Total no. of sample trees ...	112	320	432	154	62	216
Total no. of sample plots ...			18			9

	CANARIAS			CANTABRIA		
	Conífers	Broadleaves	Total	Conífers	Broadleaves	Total
Defoliation level						
0	5,2	3,4	4,5		35,6	35,6
1	81,9	72,3	78,2		56,9	56,9
2	10,9	20,9	14,7		6,0	6,0
3	1,5	1,7	1,6		1,0	1,0
4	0,5	1,7	1,0		0,5	0,5
Total no. of sample trees ...	193	119	312		216	216
Total no. of sample plots ...			13			9

	CASTILE AND LA MANCHA			CASTILE AND LEON		
	Conífers	Broadleaves	Total	Conífers	Broadleaves	Total
Defoliation level						
0	34,1	6,3	22,9	33,3	21,5	26,5
1	57,4	66,3	61,0	53,6	66,5	61,1
2	7,1	22,5	13,3	8,9	10,0	9,5
3	1,4	4,8	2,7	2,3	1,4	1,7
4	0,0	0,1	0,1	1,9	0,6	1,2
Total no. of sample trees ...	1.092	732	1.824	1.005	1.395	2.400
Total no. of sample plots ...			76			100

	CATALONIA			EXTREMADURA		
	Conífers	Broadleaves	Total	Conífers	Broadleaves	Total
Defoliation level						
0	15,2	4,0	10,6	22,4	2,8	6,0
1	74,4	77,9	75,9	63,5	74,5	72,7
2	9,0	11,7	10,1	7,1	19,4	17,4
3	0,4	0,8	0,5	0,5	2,4	2,1
4	1,0	5,6	2,9	6,5	0,9	1,8
Total no. of sample trees ...	1.072	752	1.824	170	886	1.056
Total no. of sample plots ...			76			44

	GALICIA			MADRID		
	Conífers	Broadleaves	Total	Conífers	Broadleaves	Total
Defoliation level						
0	32,8	21,3	26,8	0,0	8,3	2,8
1	53,5	43,0	48,1	58,3	79,2	65,3
2	5,3	21,0	13,4	39,6	12,5	30,6
3	1,8	9,1	5,6	2,1	0,0	1,3
4	6,6	5,6	6,1	0,0	0,0	0,0
Total no. of sample trees ...	604	644	1.248	48	24	72
Total no. of sample plots ...			52			3

	MURCIA			NAVARRE		
	Conífers	Broadleaves	Total	Conífers	Broadleaves	Total
Defoliation level						
0	2,4		2,4	27,3	45,0	39,6
1	86,5		86,5	59,1	44,0	48,6
2	10,8		10,8	9,1	8,3	8,6
3	0,3		0,3	0,0	2,4	1,6
4	0,0		0,0	4,5	0,3	1,6
Total no. of sample trees ...	288		288	132	300	432
Total no. of sample plots ...			12			18

	LA RIOJA			BASQUE COUNTRY		
	Conífers	Broadleaves	Total	Conífers	Broadleaves	Total
Defoliation level						
0	47,0	20,0	38,5	68,1	40,4	56,1
1	40,9	30,0	37,5	30,4	53,8	40,6
2	9,1	50,0	21,9	1,5	5,8	3,3
3	1,5	0,0	1,1	0,0	0,0	0,0
4	1,5	0,0	1,0	0,0	0,0	0,0
Total no. of sample trees ...	66	30	96	204	156	360
Total no. of sample plots ...			4			15

	VALENCIA		
	Conífers	**Broadleaves**	**Total**
Defoliation level			
0	2,7	2,0	2,6
1	80,8	69,4	79,6
2	15,7	28,6	17,1
3	0,6	0,0	0,5
4	0,2	0,0	0,2
Total no. of sample trees ...	407	49	456
Total no. of sample plots ...			19