Criterion 2

MAINTENANCE OF FOREST ECOSYSTEM HEALTH AND VITALITY

Indicator 2.1

Deposition of air pollutants on forest and other wooded land, classified by elements: nitrogen (N), sulphur (S) and base cations

The deposition of air pollutants is one of the factors responsible for forest damage. Sulphur dioxide (SO_2) is an acidification agent (sulphuric acid). Nitrogen oxides (NOx) are ecosystem inputs that induce acidification (nitric acid) and are responsible for the formation of ozone (O_3) through a reaction involving non-methane volatile organic compounds (NMVOC). Ammonium (NH_3) contributes to the atmospheric nitrogen input and to soil acidification.

Air pollutant depositions in forests are obviously directly dependent on emissions. Although the declining rate over the last 3 decades is encouraging (cf. table below)—because of the shutdown of thermal power plants, the desulphurization of industrial emissions, the use of low-sulphur fuels and the increase in vehicles equipped with catalytic converters—the trend varies depending on the pollutants concerned. Ammonium emission (NH_3) has not markedly decreased. Variations in this pollutant, which was mostly (98%) of agricultural origin in 2008, are mainly due to livestock production changes (76%) and the use of synthetic fertilizers (21%).

	1980	1985	1990	1995	2000	2005	2007	2008	2009 estimate	Variation 1980-2008[1]
	Volume (1000 t)									
SO_2	3 157	1 491	1 335	976	621	471	415	358	324	-89
NO_x	2 009	1 794	1 922	1 775	1 642	1 489	1 362	1 272	1 215	-37
NH_3	793	790	791	773	797	746	740	754	746	-5
COVNM			2 726	2 320	1 865	1 386	1 179	1 086	1 002	-60
	in acid equivalents (Aeq)									
acidification and eutrophication (SO_2, NO_x and NH_3)	189	132	130	115	102	91	86	83	80	-56

(1) 1990-2008 for NMVOC.
Source: CITEPA/SECTEN format - April 2010.

The acid equivalent index is designed to assess the overall amount of substances emitted into the atmosphere. At different spatiotemporal scales, these substances contribute to the acidification and eutrophication of soil, air and the aquatic environment. Its level has declined by over 50% since 1980 due to the marked reduction in SO_2 emissions. Ammonium currently represents 53% of the contribution to this index, as compared to 25% in 1980.

Estimate of atmospheric deposition under the forest canopy (throughfall) in the CATAENAT sub-network stations - 2004-2007 averages*

	H+	Cl	S-SO_4	N-NO_3	Na	N-NH_4	K	Mg	Ca	Fe	Al	Mn	Mean precipitation under the forest canopy
Placette	*g/ha*	*kg/ha*	*kg/ha*	*kg/ha*	*kg/ha*	*kg/ha*	*kg/ha*	*kg/ha*	*kg/ha*	*g/ha*	*g/ha*	*g/ha*	*mm*
CHP 40	11.5	47.8	7.3	2.7	23.1	3.2	41.7	5.1	9.5	54.9	96.0	658.8	615.8
CHP 59	28.7	24.5	7.7	2.5	11.9	6.6	37.2	4.1	8.9	77.3	108.8	1 320.3	720.4
CHS 35	10.5	32.2	4.3	2.8	14.9	7.7	29.1	3.6	4.7	58.0	63.7	2 033.6	533.1
CHS 41	12.1	15.3	2.9	2.0	6.5	4.3	19.2	2.6	6.1	33.9	54.7	1 504.4	433.4
CPS 77	11.1	13.9	3.4	2.9	5.9	3.8	13.7	2.9	8.5	52.3	70.4	1 313.7	397.0
DOU 71	107.1	21.4	5.5	8.3	12.7	4.4	12.5	3.0	7.2	36.8	233.4	704.0	959.5
EPC 08	107.3	30.5	11.3	7.3	16.1	7.9	25.0	2.9	8.0	85.6	372.7	1 524.3	1 016.6
EPC 63	39.6	16.3	4.1	4.7	8.7	2.8	16.4	2.6	8.1	84.7	241.1	610.9	686.5
EPC 74	64.0	7.8	4.5	6.9	3.3	6.7	15.6	1.6	10.9	108.1	192.1	262.4	984.6
EPC 87	53.0	25.5	5.2	5.8	13.1	3.3	22.4	3.0	6.6	58.6	239.7	400.1	836.1
HET 30	60.5	26.5	10.9	8.0	15.4	6.4	17.2	3.0	22.3	45.4	219.0	516.5	1 669.8
HET 64	22.0	27.2	8.4	4.9	13.9	4.0	19.5	2.8	10.0	21.5	94.0	505.3	853.5
PL 20	46.8	106.1	9.9	4.0	58.4	0.8	14.5	9.1	19.6	121.5	749.6	388.5	845.0
PM 17	76.4	141.3	9.6	4.7	77.7	2.8	8.0	10.8	11.8	40.1	101.1	142.8	576.1
PM 40c	76.6	36.2	4.4	3.0	16.5	2.7	13.9	4.8	9.7	57.7	299.8	91.1	589.8
PM 72	16.3	36.9	4.8	6.1	18.7	9.2	12.7	3.3	6.3	57.2	191.5	497.8	542.0
PM 85	68.1	204.9	12.8	4.6	120.7	2.7	13.0	15.4	10.8	58.1	77.2	69.1	488.1
PS 44	46.4	70.8	6.9	4.3	37.6	9.3	13.5	4.5	4.9	59.0	203.1	159.1	558.4
PS 67a	65.6	9.1	4.1	4.9	4.8	5.5	8.0	1.4	4.9	30.3	329.3	809.5	507.0
PS 76	164.9	63.6	14.2	5.6	34.4	7.6	15.7	5.3	9.6	51.3	262.9	1 507.3	593.1
SP 05	1.3	4.5	2.4	0.5	1.1	0.4	27.0	1.7	11.4	70.6	195.7	154.3	386.1
SP 11	19.0	26.7	7.4	3.6	12.9	1.9	43.7	2.8	12.4	120.6	314.5	245.2	863.5
SP 25	40.2	14.5	5.5	6.1	7.3	4.1	21.6	2.2	12.2	65.6	185.9	438.9	1 317.5
SP 38	28.2	5.8	4.3	2.1	2.2	2.3	18.0	1.6	7.9	47.1	218.9	1 117.3	981.0
SP 57	85.5	14.0	6.1	4.6	6.8	2.2	20.1	1.9	6.2	74.8	186.3	2 428.4	715.9
SP 68	45.8	9.6	3.9	5.6	4.7	4.0	21.8	1.6	5.4	46.6	176.7	314.2	709.0
Mean 2004-2007	50.3	39.7	6.6	4.6	21.1	4.5	20.0	4.0	9.4	62.2	210.7	758.4	745.3
Mean 1999-2003*	63.6	41.9	8.0	4.8	22.3	5.0	20.1	4.1	10.3	96.4	190.6	733.1	857.8
Mean 1993-1998	113.0	43.6	11.0	4.8	23.0	4.8	21.5	4.2	11.3	62.7	234.9	853.8	812.5
Variation since 1999-2003	-0.2	-0.1	-0.2	-0.1	-0.1	-0.1	-0.0	-0.0	-0.1	-0.4	0.1	0.0	-0.1
Variation since 1993-1998	-0.6	-0.1	-0.4	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.0	-0.1	-0.1	-0.1

*Because of incomplete measurements, year 2000 is excluded from the calculations for PS 67a, as well as year 2003 for SP 11.

Source: ONF, manager of the French RENECOFOR network (Réseau National de suivi à long terme des Écosystèmes Forestiers) and the CATAENAT sub-network (Charge Acide Totale d'origine Atmosphérique dans les Écosystèmes Naturels Terrestres); the plots are identified by their predominant species - CHS for sessile oak, CHP for pedunculate oak, CPS for pedunculate and sessile oak combined, HET for beech, EPC for Norway spruce, PS for Scots pine, PM for maritime pine, PL for Corsican pine, DOU for Douglas fir, SP for silver fir – followed by the department number of the plot.

The main purpose of the CATAENAT sub-network, set up by the French Office national des forêts (ONF) in late 1992, is to analyse the impact of atmospheric deposition on forest ecosystems. The network consists of 27 sites in open fields and 26 sites within forests located throughout metropolitan France, varying in terms of both the predominant species in the stand and its geographical location, without claiming to be statistically representative. A time-series of 15 years of measurements of annual precipitation and atmospheric deposition in the open field and under the forest canopy (throughfall deposition) is now available for the 1993-2007 period. As an in-depth specialised analysis of these results will soon be published, only the main trends reported in the ONF scientific reports are discussed here.
Details on the 2004-2007 comparisons with the previous 1993-1998 and 1999-2003 periods are given in Appendix XIV.

Throughfall deposition differs clearly from open field deposition levels (not under forest cover). This is firstly due to aerosols and mist and cloud droplets deposited on the tree crowns, as well as precipitation deposition. There is also ion exchange between the precipitation and foliage—trees are thus able to take up certain elements, such as nitrogen, via leaf absorption while discharging others via canopy leaching, especially potassium, calcium and magnesium. Throughfall deposition is generally higher than open field deposition for most elements, except for nitrogen which is sometimes taken up by the foliage, and protons.
Furthermore, throughfall deposition is often greater under conifers—except for larch—than under broadleaved species in the same forest area owing to the persistence of conifer foliage in winter:

a) Acid deposition induced by protons (direct acidity, H^+) in open field precipitation and throughfall is mostly low, i.e. in all plots they are under 1 kg (Keq)/ha/year. It had already greatly decreased on average between 1993 and 1998, and between 1999 and 2003 (-43.7%) and further decreased between 1999-2003 and 2004-2007 (-20.8%). Sites with the greatest throughfall values over the 1993-1998 period were those where the decrease was most marked over the 15 year period: -75.9 % in Seine-Maritime (PS 76), -72.4% in Ardennes (EPC 08) and -79.1% on Mont Aigoual (HET 30). This drop in proton deposition is mainly linked to sulphur fallout.

b) Sulphur deposition ($S-SO_4$) is from two main sources. Part is ocean-derived, which is much greater in coastal areas and has no acidification impact because these depositions are associated with alkaline cations (calcium, magnesium, potassium). Secondly, human-induced emissions of SO_2 are responsible for acidic sulphur fallout as they are partially associated with protons. Over the last 15 years, apart from coastal sites (PM 17 and PM 85), atmospheric sulphur depositions have dropped sharply (-39.8% on average), concomitantly with proton depositions (direct acidity). Sites initially most affected by this pollution are also where the greatest decreases are noted, i.e. especially -59.4% in Seine-Maritime (PS 76), -54.3 % in Ardennes (EPC 08) and -41.1% on Mont Aigoual (HET 30). The policy to reduce SO_2 emissions that was imposed in 1980 thus seems to be yielding encouraging results, even though the decline slowed down between 1999-2003 and 2004-2007. Nitrogen ($N-NO_3$ and $N-NH_4$) is gradually surpassing sulphur as the main acidifying compound since its deposition levels have been declining at a much slower rate.

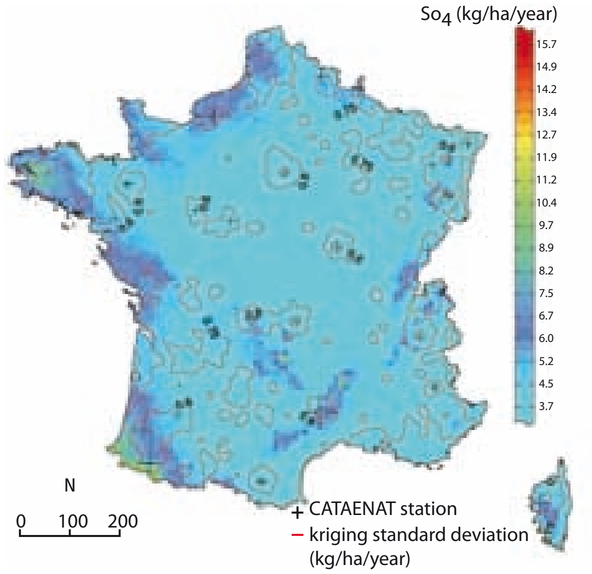
c) Nitrogen deposition (in the form of ammonium and nitrates) has a fertilisation impact on trees, but can also have negative ecosystem acidification (as these compounds are associated with protons) and eutrophication impacts. These depositions are highly spatially variable and mainly derived from agricultural activities (livestock production and fertilisation) for ammonium and vehicle emissions for nitrates. However, depositions sometimes occur very far from the emission site, especially on mountain ranges (e.g. in Vosges and Jura regions) where precipitation is more substantial than in lowland areas.
Total average nitrogen ($N-NO_3$+$N-NH_4$) throughfall was 9 kg/ha/year over the 2004-2007 period. As compared to the 1999-2003 period, there was a relatively marked 8% decrease in this average but with contrasting trends, i.e. declining at 15 sites (2-42%), increasing at eight other sites (2-36%) and steady at three other sites.

d) Calcium, magnesium and potassium are major nutrient cations and their atmospheric deposition is an important nutrient source for barren soils. These depositions are from different sources. Magnesium (Mg), which is mainly derived from the marine environment, shows a very marked gradient between the coast and inland areas, with no average throughfall deposition noted since 1993. Calcium (Ca) is mainly borne by Saharan wind currents, but depositions are also partly from industrial emissions. On average, there has been a relatively marked decrease in throughfall depositions since 1993 (-16.9%), but this trend is noted especially at sites where declines in sulphur deposition are sharpest: -44.8% in Seine Maritime (PS 76), - 46.7% in Ardennes (EPC 08) and -47.3% in the vicinity of Strasbourg (PS 67a). Hence, although the reduction in sulphur pollution has led to a considerable reduction in the direct acidity of atmospheric deposition in forests, it also seems to have led to a considerable reduction in calcium inputs.

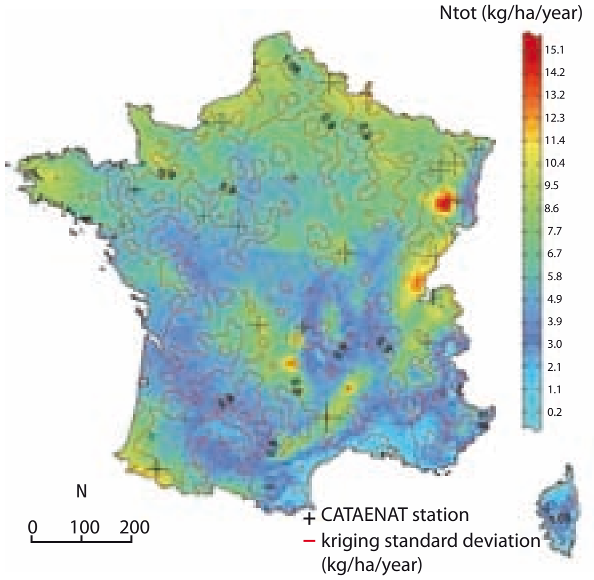
e) Sodium (Na) and chloride (Cl) depositions are essentially derived from the oceans. When elevated (PM 17, PM 85), trees may be subject to extreme salinity conditions.

The overall marked decrease in acidifying depositions of sulphur and protons is beneficial for ecosystems and evidence of the efficiency of the proactive policies imposed in 1980 to reduce SO_2 emissions. However, the deposition acidity still sometimes surpasses the critical load for the most barren soils. Decreasing atmospheric pollution is still a major challenge, especially with respect to nitrogen deposition levels, which have remained relatively steady in the last 15 years and whose accumulation in ecosystems can have negative effects in terms of both acidification and eutrophication.
The findings of the soil analysis study under way (2009-2012) on plots in the RENECOFOR network (cf. p.47) should enable a more accurate assessment of the real impact of these depositions on forest ecosystems.

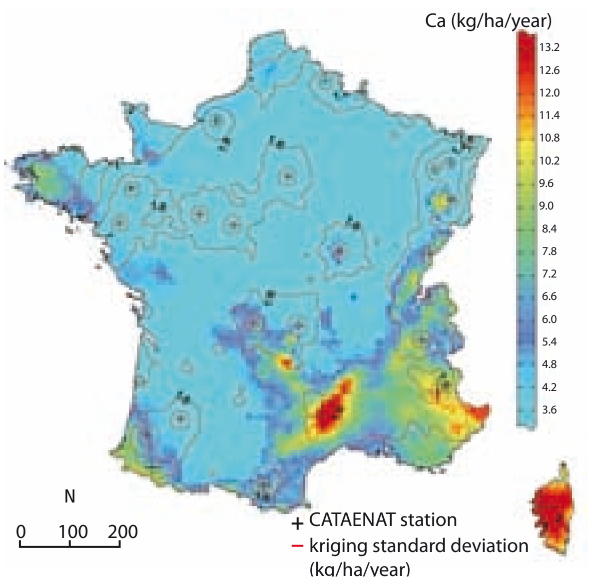
RENECOFOR - CATAENAT
Spatialization of annual atmospheric open field deposition of sulfate ($S\text{-}SO_4$) over the 1999-2004 period.



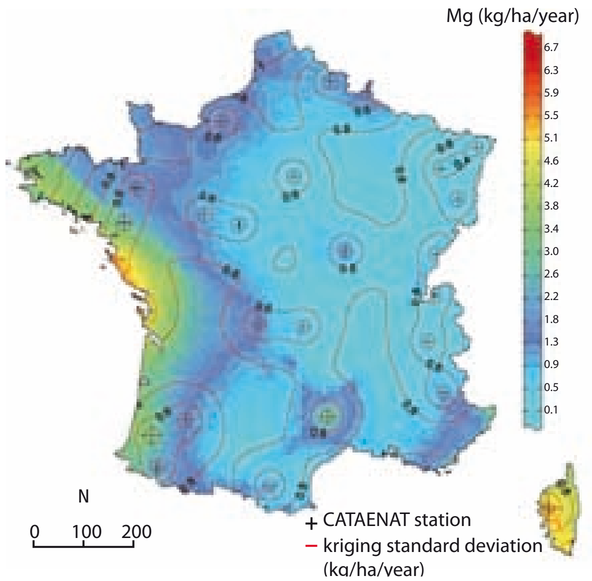
RENECOFOR - CATAENAT
Spatialization of annual atmospheric open field deposition of total nitrogen ($N\text{-}NO_3 + N\text{-}NH_4$) over the 1999-2004 period.



RENECOFOR - CATAENAT
Spatialization of annual atmospheric open field deposition of calcium (Ca) over the 1999-2004 period.



RENECOFOR - CATAENAT
Spatialization of annual atmospheric open field deposition of magnesium (Mg) over the 1999-2004 period.



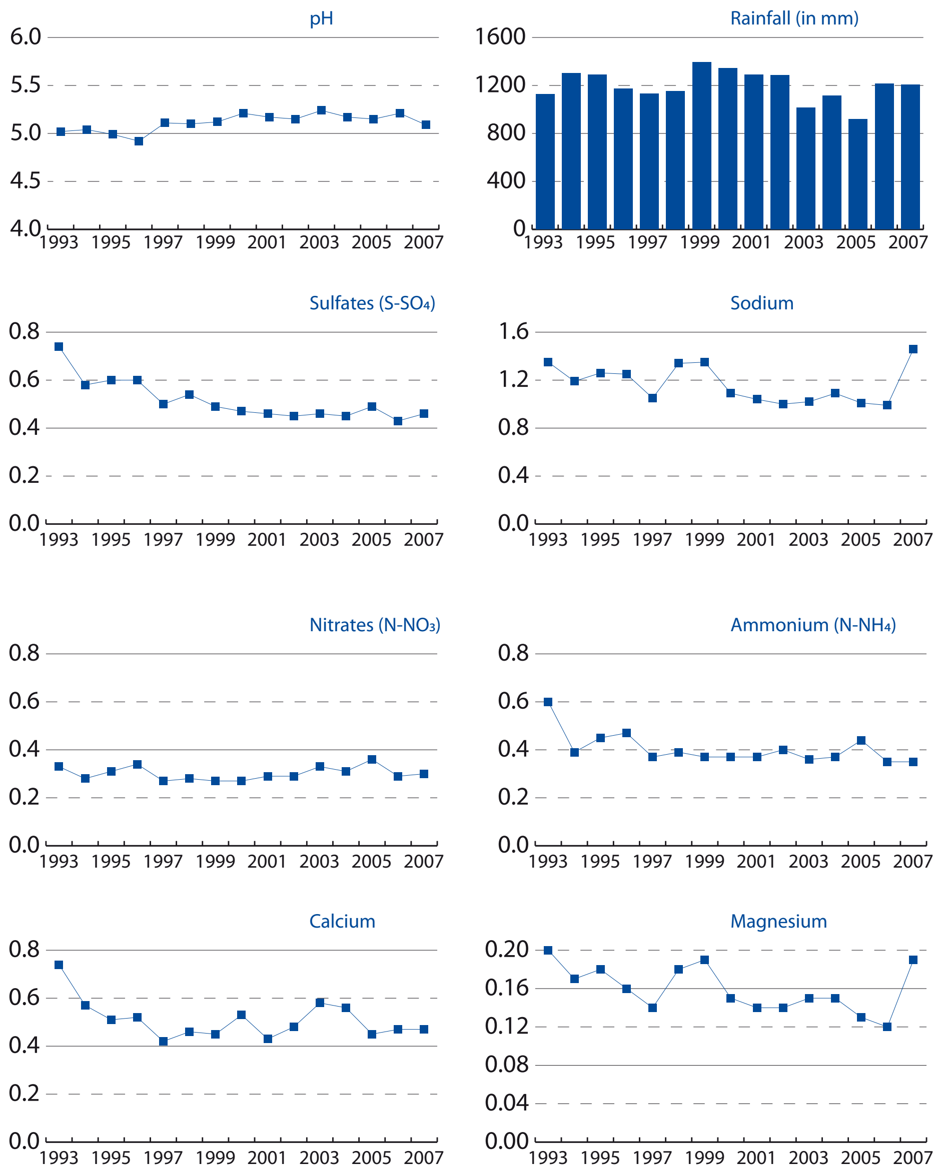
Map 9: Spatialization of annual atmospheric open field deposition of sulfate, total nitrogen, calcium and magnesium in precipitation from 1999 to 2004 at 27 sites in the CATAENAT sub-network.

Source: ONF. Method developed by Croisé et al. (2005).

Variations in overall precipitation quality in open fields in the CATAENAT sub-network from 1993 to 2007 (mean national concentrations weighed by precipitations)

Indicators of the mean overall precipitation quality in France can be calculated simply by dividing the sum of annual depositions at all sites by the sum of their precipitations. The result is the mean annual concentration per mm of precipitation for all 27 sites located in the open field. From a scientific standpoint, this is the only national indicator for monitoring long-term precipitation quality trends.

The direct precipitation acidity has decreased over the last 15 years: the mean pH has generally increased since 1993 despite a stagnation since 2000. This could be partially explained by the 37% decrease in sulfate concentrations during the same period. Nitrate concentrations have been highly stable, along with ammonium levels, apart from an initial peak in 1993. With respect to alkaline cations (calcium, magnesium, sodium), magnesium levels closely match sodium patterns, clearly reflecting its main oceanic origin. However their annual variations are too marked to be able to determine the trends.



Units (per mm of precipitation in mg/mm, with pH)

Figure 12: Variations in overall precipitation quality in open fields in the CATAENAT sub-network from 1993 to 2007.

Source: ONF.

Reference:

Croisé L., Ulrich E., Duplat P., Jaquet O., 2005
Two independent methods for mapping bulk deposition in France. Atmospheric Environment, 39: 3923-3941.

Indicator 2.2

Chemical soil properties of forest and other wooded land (pH, CEC, C/N, organic C, base saturation) related to soil acidity and eutrophication, by main soil types

ISFM 2005 Edition: 508 plots monitored

Soil type		Water pH	Cation exchange capacity (CEC=T)	Base saturation rate (S/T)	Organic carbon content	Carbon/ nitrogen ratio (C/N)
WRB classification	*Number of plots monitored*		*meg/100 g*	*%*	*%*	*%*
Cambisol	222	5.5	11.5	57.6	36.0	14.9
Leptosol	123	7.0	27.0	93.5	47.1	14.1
Luvisol	72	4.8	5.6	47.6	27.5	16.5
Podzol	47	4.7	3.3	32.6	26.5	24.5
Arenosol	2	5.3	1.4	60.1	12.5	25.5
Gleysol	10	5.8	19.2	75.4	41.2	13.0
Regosol	3	6.7	13.6	82.6	37.3	17.8
Others	29	5.8	8.7	70.2	34.8	16.3

Source: Département de la santé des forêts - Inventaire des sols forestiers européens (16 km x 16 km). Means for 1993-94 in the 0-20 cm horizon.
WRB: World Reference Base of Soil Resources

ISFM 2010 Edition: 543 plots monitored

Soil type		Water pH		Cation exchange capacity (CEC=T)		Base saturation rate (S/T)		Organic carbon content		Carbon/ nitrogen ratio (C/N)	
WRB classification	*Number of plots monitored*			*meg/100 g*		*%*		*%*		*%*	
		cm									
		0-10	*0-20*	*0-10*	*0-20*	*0-10*	*0-20*	*0-10*	*0-20*	*0-10*	*0-20*
Cambisol	288	5.6	5.7	17.9	16.0	71.9	68.7	54.3	42.3	16.4	16.0
Leptosol	37	7.0	7.0	35.0	32.3	97.1	96.4	72.7	59.3	16.8	16.2
Luvisol	48	4.8	4.8	6.1	5.3	56.1	49.1	32.8	24.1	17.5	17.4
Podzol	27	4.3	4.3	3.9	3.2	39.6	32.3	37.8	30.7	29.9	30.5
Arenosol	27	4.6	4.6	2.7	2.2	51.4	47.1	23.9	18.1	25.5	25.0
Stagnosol	28	4.9	5.0	8.3	7.4	58.0	52.4	36.3	26.5	17.8	17.5
Phaeozem	28	7.3	7.4	42.3	39.0	99.5	99.4	88.1	74.0	16.8	16.0
Umbrisol	25	4.6	4.6	8.8	7.1	34.6	30.7	83.7	69.2	18.1	18.1
Others	35	5.3	5.4	13.1	11.9	71.2	66.7	43.2	32.1	17.9	17.6

Source: Département de la santé des forêts – Programme BioSoil: Inventaire des sols et de la biodiversité pour le réseau européen de surveillance des forêts (16 km × 16 km), 2007; means in the 0-10 and 0-20 cm horizons.
WRB: World Reference Base of Soil Resources

Forest soils were first analysed in 1994-1995 in French plots of the European network for forest damage monitoring (European network level 1) that were set up in 1989 on the basis of a 16 x 16 km square grid. In France, this network is extended to non-forest areas through a soil quality measurement network (RMQS) with plots set up as of 2001 according to the same square grid and managed by the 'Gis Sol' scientific interest group. Variations in soil quality, according to 2000 assessment points, are thus being monitored throughout metropolitan France via these networks. A second analysis of soils in plots of the European network for forest damage monitoring (level 1) was carried out in 2007 within the framework of the BioSoil programme (cf. below).

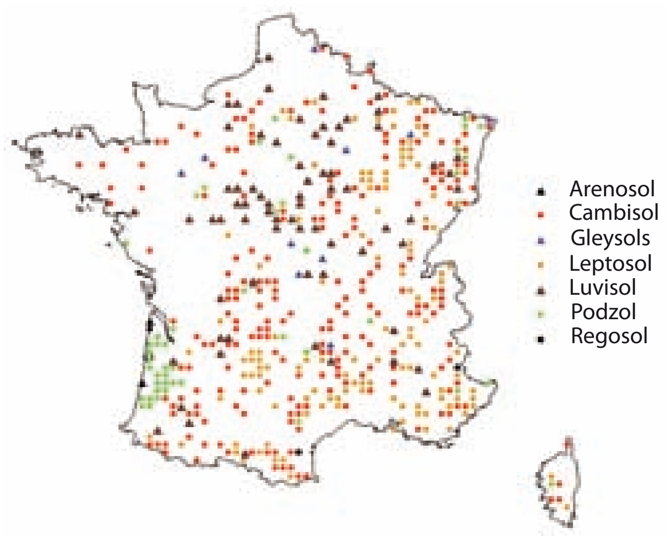
Another French forest network, i.e. the RÉseau National de suivi à long terme des ÉCOsystèmes FORestiers (RENECOFOR), managed by the French Office national des forêts, aims to gain insight into changes in forest ecosystems induced by environmental changes (air pollution, meteorological events). This network is not based on a systematic square grid but on 102 study areas distributed throughout metropolitan France and covering a wide range of FAWS ecosystems (sessile oak, pedunculate oak, Douglas fir, spruce, beech, larch, Scots pine, maritime pine, Corsican pine and silver fir). The physicochemical properties of soils at these 102 sites are monitored using a comparable procedure over time, with five analytical repetitions per layer to 40 cm depth. The first surveys were conducted in 1993-95, while the second is currently under way. The first temporal variations will be analysed in 2013.

Since late 2006, NFI, the INRA InfoSol research unit at Orléans and Laboratoire d'analyse des sols (LAS) at Arras have been jointly addressing a request from the Joint Research Centre (JRC) of the European Commission (Ispra, Italy) within the framework of the European BioSoil programme. This programme is designed to produce a soil and biodiversity inventory for the European forest monitoring network. BioSoil involves 22 European countries and around 4,500 sites, including 548 in France, with Europe partitioned systematically over a 16 x 16 km grid.

Unfortunately it is not possible just to present a comparison between the 2006-2007 (BioSoil) and the previous (1994-1995) surveys because:

- The 1994 procedure was not tailored for a comparison between successive surveys with respect to the plots (a single sample per plot, whereas the BioSoil survey involved a composite sample from five samplings);
- The soil classification differs, according to the French soil reference base for the 1994-1995 survey and the World Reference Base for Soil Resources (WRB) classification for the BioSoil survey—hence Umbrisols are Organosols, Stagnosols correspond to Reductisols, etc.;
- Apart from this difference in nomenclature, identical profiles were classified differently in the two surveys;
- The number of plots increased and some of them were moved.

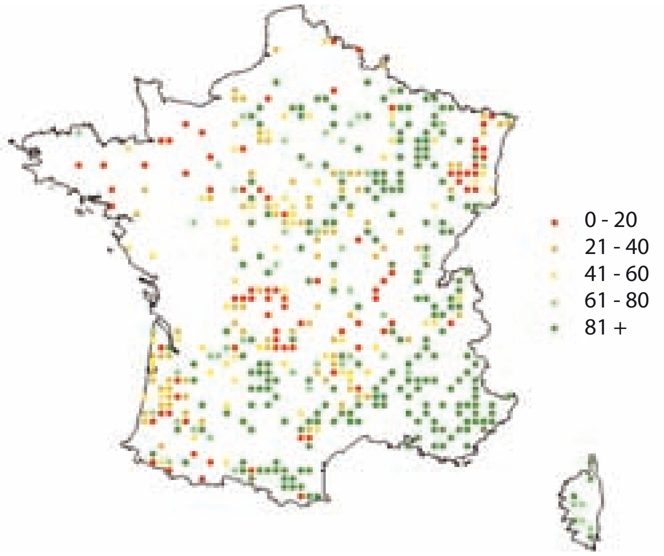
A comparison by plot groups would therefore not be an easy task. In-depth studies on this issue are under way or planned.



Map 10: Types of soils found in the plots of the European monitoring network over a 16 ×16 km grid.
Source: DSF, 1994-95 and 2007.

Forest soils are much more acidic and unsaturated (low proportion of base cations in the cation exchange complex) than agricultural soils. The differences could be explained by the fact that forest stands often grow on barren soils (mountain, hydromorphic and superficial soils, etc.), without any inputs (fertilisers and other soil conditioners). Moreover, mineral losses regularly occur as a result of silvicultural nutrient export without subsequent mineral restoration, litter extraction and increased leaching of minerals by acidic atmospheric depositions.

Within the European network, 45% of soils have a base saturation rate (S/T) of the nutrient cationic complex (calcium, magnesium, potassium) in the 0-20 cm horizon of over 80%, whereas 16% of soils have a low S/T, less than 20%. No precise minimum thresholds have been set, below which forest trees would have mineral nutrition problems, but it is known that the risks increase considerably when the base saturation rate is under 10% (6% of soils). The most unsaturated soils are mainly found in Vosges, the northwestern regions (Normandie, Bretagne), Massif Central and the Landes massif.



Map 11: Base saturation rates recorded in plots of the European monitoring network over a 16 × 16 km grid.

Source: DSF, 1994-95 and 2007.

Indicator 2.3

Defoliation of one or more main tree species on forest and other wooded land in each of the defoliation classes: 'moderate', 'severe' and 'dead'

Data prior to 1994 could not be compared to those collected after 1997 because of the change of method that took place during the 1995-1997 period. Hence, defoliation of a tree is assessed relative to a reference tree (zero defoliation), and references are delineated for each species, region and stand. For this reason it is hard to make comparisons between trees or general categories (broadleaved, conifers). It is therefore necessary to assess variations in this defoliation criterion rather than its absolute value during a given year.

The defoliation status generally reflects the vitality of the tree, and is the result of various factors: tree age, silvicultural history, pathogenic presence, climatic stress, atmospheric pollution, mineral deficiency, etc. The great number of defoliation factors and their difficult interpretation generally complicate determination of the symptom cause.

The climate was marked by a long-term drought from 2003 to 2006 (and until 2007 in the southeastern Mediterranean region) and by cyclone Klaus in January 2009 which, although it did not affect France overall, caused severe damage in the Landes massif. This climatic event did not, however, upset the network nearly as much as the storms of Christmas 1999 since only a few monitoring plots were shut down or moved.

Over the 2005-2010 period, for many forest species there was an improvement in the extent of their defoliation and thus in their health status. This trend tends to indicate that the situation is returning to normal after two major successive crises that affected the French forests, i.e. the Christmas 1999 storms and the 2003 drought. This improvement was further enhanced by cool summers with considerable precipitation in 2007 and 2008, which was highly beneficial for forest vegetation growth.

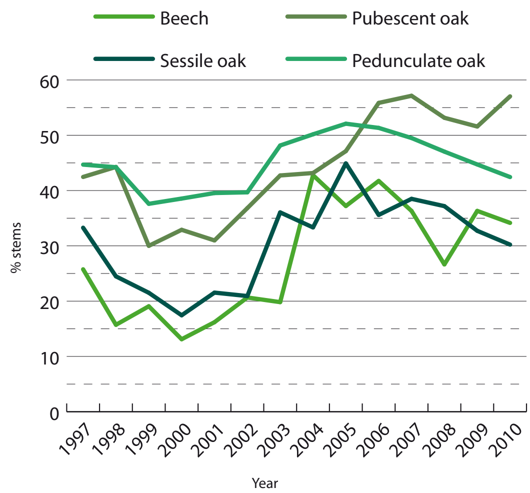


Figure 13: Variation in the percentage of stems of the main broadleaved species with a defoliation rate above 25%.

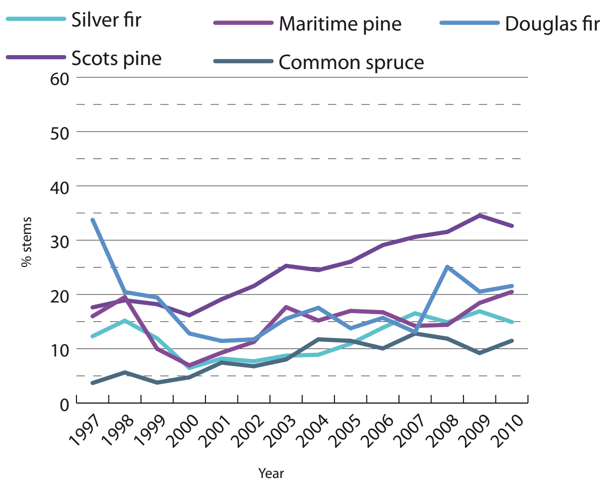


Figure 14: Variation in the percentage of stems of some conifer species with a defoliation rate above 25%.

Source : Département de la santé des forêts – Réseau systématique de suivi des dommages forestiers.

Maritime pine tree windbreaks resulting from cyclone Klaus in January 2009.

This trend was especially marked for broadleaved species (sessile oak, pedunculate oak and beech, with the exception of pubescent oak). However, it was not for conifers, i.e. there was little change, a slight increase (maritime pine, common spruce, silver fir), or even a very sharp increase for Scots pine for which the defoliation situation worsened, generally resulting in the deterioration of its health status in southeastern France.

The level of trees with moderate to average defoliation has been high since 2003 as compared to previous years. The poor health of broadleaved trees is the result of the high defoliation rates of oaks (especially pedunculate oak) and also of more marginal species such as wild cherry, which is susceptible to cylindrosporiosis, elm, which is chronically affected by Dutch elm disease, alder and birch, or trees with little commercial value, such as holm oak or pubescent oak.
After the peak in conifer mortality in 2004, mainly only affecting spruce trees weakened by the 2003 drought and bark beetle infestations, the percentage of deadwood in the grid network returned to a more normal level for both broadleaved and conifer species.

Dead chestnut stand.

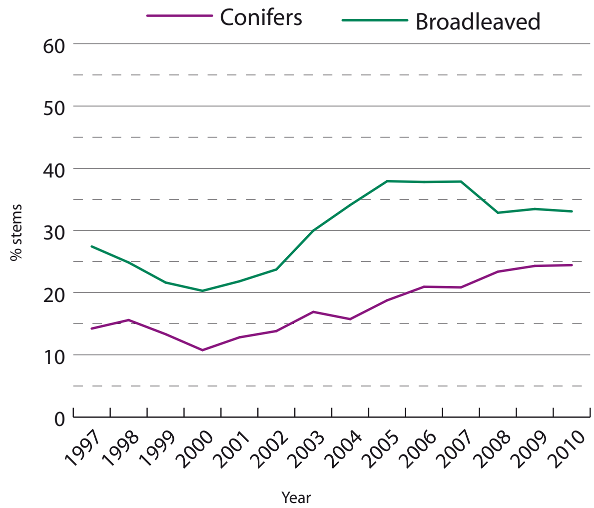


Figure 15: Percentage of trees affected by moderate defoliation (25 to 60%).

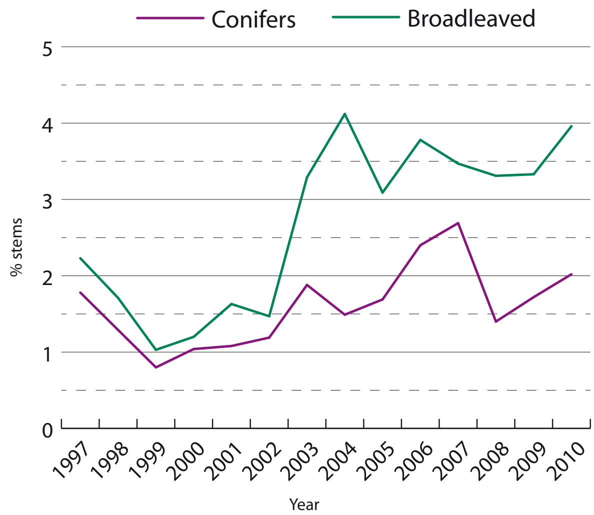


Figure 16: Percentage of trees affected by severe defoliation (more than 60%).

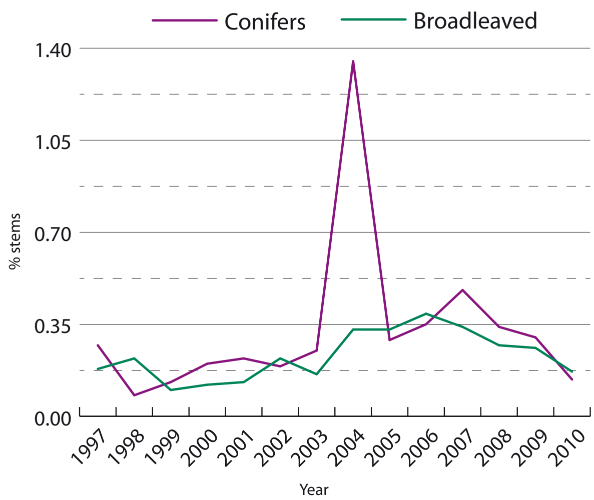


Figure 17: Percentage of dead trees.

Indicator 2.4

Forest and other wooded land with damage, classified by primary damaging agents (abiotic, biotic and human induced) and by forest type

Cause of damage	Main species	% of damaged plots			% of damaged trees		
		1995-1999	2000-2004	2005-2009	1995-1999	2000-2004	2005-2009
Pest insects	Broadleaved	40.3	39.9	39.9	17.9	18.0	16.6
	Conifers	9.5	8.6	11.2	3.4	1.8	4.1
	All species	34.7	34.2	34.7	12.8	12.3	12.2
Fungal diseases	Broadleaved	13.4	13.0	19.4	3.7	3.6	6.4
	Conifers	9.3	14.6	12.9	4.5	7.3	8.4
	All species	14.2	16.0	20.4	4.0	4.9	7.0
Climatic stress	Broadleaved	15.4	10.3	16.5	5.6	3.8	9.7
	Conifers	8.2	8.1	11.2	4.5	2.3	6.3
	All species	15.1	10.5	16.2	5.2	3.3	8.5

Source: Département Santé des Forêts (DSF).

National data are available on damage caused by pest insects, fungal diseases, climatic stress, fires and storms. For the first three factors, the reliable data can only be expressed according to the number of plots and trees affected, but not in terms of area, contrary to the fire and storm damage data. An in-depth analysis of this damage is provided hereafter.

Damage caused by pest insects, fungal diseases and abiotic stress

An assessment of the concerned area has been conducted for the first two editions of the present report (1995 and 2000), based on the main pest and disease events reported during the 5 previous years and by using a multiplicative correction factor to account for non-inventoried situations. However, considering the error level, it was decided to not record the estimations previously carried out. It is not possible to clearly determine exactly how the areas would have changed relative to the previous period.

It is hard to set up a reliable system for monitoring this indicator because of several factors:

- damage symptoms due to pest insects (e.g. defoliators) and fungal diseases are often temporally limited and thus a suitable statistical system has to be available to be able to quantify the damage at the right time;
- some pathogenic fungi (e.g. conifer polypores) are very hard to detect if there is no mortality in the affected trees or if they are not logged;
- relations between the extent of symptoms and the extent of increment losses are often unknown;
- trees can die several months or even years after being damaged by pest insects or fungal diseases. These trees are often scattered throughout the stands and the mortality threshold beyond which the stand may be rehabilitated can vary markedly depending on the forest manager's priorities.

Stand damaged by cyclone Klaus in Aquitaine region.

Damage caused by pest insects, fungal diseases and abiotic stress, such as spring frost and summer drought, varies widely from year to year: it can be limited to 1 year or fluctuate over several years, depending on the specific dynamics of these pest populations, and in interaction with the climatic stress factors (particularly water stress). Mortality is often the ultimate stage of progressive weakening (ageing, root rot fungi, etc.). Tree death can occasionally become more frequent due to a combination of unfavourable factors (e.g. drought and insect defoliators) or outbreaks of bark beetles after storms or droughts.

Because of the lack of an operational measurement instrument capable of supplying reliable quantitative data at the national level on the impact of different biotic and abiotic factors, the question is covered here from two complementary angles:

– **the proportion of trees and plots in the European network affected by 'known causes**': the sampling density is sufficient to reflect major health problems, but probably not more localised problems. Moreover, the summer rating underestimates the damage symptoms and causes because the factors of spring stress (insects, frosts, etc.) are not always identifiable in summer and certain problems (e.g. root problems) are difficult to diagnose;

– **assessment of the severity of serious pest and disease problems on the basis of observations made by the correspondents-observers of the Département santé des forêts** (several thousands observations per year): these problems have been documented, but the proportion of stands affected in a given region is unknown. The observations collected enable us to monitor fluctuations in the main pests affecting French forests.

NB: Recent data cannot be compared to those of the initial 1990-1994 period because the training level of the observers has considerably improved.

Damage of known origin in the European network for forest damage monitoring (mean frequency of problems linked with attacks by pest insects and fungal diseases and with abiotic factors)

For all species, the three most frequent stress factors during the 2005-2009 period are:

– pest insect attacks: 35% of plots and 12% of trees;

– attacks by pathogenic fungi: 20% of plots and 7% of trees;

– abiotic stress (climatic and silvicultural damage, mineral deficiencies, etc.): 16% of plots and 8% of trees.

A dead pine tree as a result of heavy bark beetle attacks.

Species	Number of plots with at least one tree of the species	Number of plots in which were reported					
		Insect pests		Pathogenic fungi (and related)		Damage due to an abiotic factor	
	mean 2005-2009	*mean 2005-2009*	*%*	*mean 2005-2009*	*%*	*mean 2005-2009*	*%*
Sessile oak	130.4	44.8	34.4	14.6	11.2	7.0	5.4
Pedunculate oak	148.2	48.0	32.4	34.6	23.3	11.6	7.8
Holm oak	27.2	9.8	36.0	3.0	11.0	10.2	37.5
Pubescent oak	68.2	35.8	52.5	9.0	13.2	16.6	24.3
Beech	131.8	30.0	22.8	2.8	2.1	11.4	8.6
Maple	59.6	4.8	8.1	1.6	2.7	3.0	5.0
Birch	36.8	1.5	4.1	0.0	0.0	3.2	8.7
Hornbeam	53.8	5.2	9.7	1.3	2.3	4.0	7.4
Chestnut	52.6	2.0	3.8	10.4	19.8	6.8	12.9
Common ash	62.4	6.8	10.9	1.4	2.2	4.4	7.1
Poplar	30.2	1.8	6.0	2.4	7.9	4.0	13.2
Wild cherry	37.8	4.0	10.6	4.0	10.6	2.2	5.8
Other broadleaved	84.4	10.0	11.8	3.6	4.3	7.8	9.2
Total broadleaved	**380.8**	**151.8**	**39.9**	**74.0**	**19.4**	**62.4**	**16.5**
Common spruce	48.0	1.3	2.6	1.0	2.1	1.8	3.6
Silver fir	49.2	2.0	4.1	11.0	22.4	4.4	8.9
Scots pine	66.2	5.2	7.9	9.4	14.2	6.4	9.7
Maritime pine	51.4	10.2	19.8	1.0	1.9	4.0	7.8
Austrian pine	22.4	1.8	8.0	1.3	5.6	4.3	19.0
Aleppo pine	14.4	2.3	16.2	5.6	38.9	3.2	22.2
Douglas fir	20.0	1.6	8.0	2.2	11.0	2.0	10.0
Larch	13.6	2.8	20.2	1.0	7.4	2.4	17.6
Other conifers	10.8	1.0	9.3	1.0	9.3	1.3	11.6
Total conifers	**231.2**	**25.8**	**11.2**	**30.0**	**12.9**	**26.2**	**11.2**
Total all species	**503.8**	**174.8**	**34.7**	**103.0**	**20.4**	**81.4**	**16.2**

Source: DSF.

The degree of damage is difficult to interpret, as it can be over- and under-estimated, and it is very hard to differentiate their respective impacts. The above table only presents the various tree damage factors without accounting for the extent of damage caused. Finally, very spatially large phenomena can be monitored via the square grid network, but it is not tailored for assessing localised and temporarily heavy damage or for detecting emerging pests such as *Chalara fraxinea*, which was first identified in eastern France in 2008.

However, the hierarchy of the different types of problem and the percentage of trees damaged has generally remained unchanged in recent years. The variations could be readily explained, e.g. by the recrudescence of pests and diseases on oaks and by more virulent powdery mildew attacks in recent years.

Species	Number of stems	Number of stems in which were reported					
		Insect pests		Pathogenic fungi (and related)		Damage due to an abiotic factor	
	mean 2005-2009	*mean 2005-2009*	*%*	*mean 2005-2009*	*%*	*mean 2005-2009*	*%*
Sessile oak	1 225.0	213.4	17.4	40.6	3.3	23.6	1.9
Pedunculate oak	1 128.0	240.8	21.3	170.0	15.1	34.8	3.1
Holm oak	368.6	64.6	17.5	38.0	10.3	160.6	43.6
Pubescent oak	852.6	199.0	23.3	28.0	3.3	157.4	18.5
Beech	1 086.6	261.6	24.1	16.6	1.5	90.0	8.3
Maple	149.4	7.2	4.8	4.2	2.8	6.8	4.5
Birch	146.8	2.0	1.4	0.0	0.0	40.0	27.2
Hornbeam	222.0	14.0	6.3	2.0	0.9	11.8	5.3
Chestnut	431.6	9.0	2.1	83.0	19.2	40.8	9.5
Common ash	281.4	31.4	11.2	6.0	2.1	6.4	2.3
Poplar	149.0	3.6	2.4	37.2	25.0	25.8	17.3
Wild cherry	92.0	6.6	7.2	8.5	9.2	3.8	4.1
Other broadleaved	415.8	44.2	10.6	9.0	2.2	35.0	8.4
Total broadleaved	**6 548.8**	**1 089.0**	**16.6**	**418.2**	**6.4**	**635.4**	**9.7**
Common spruce	482.6	10.3	2.1	1.0	0.2	3.8	0.8
Silver fir	498.8	5.8	1.2	35.6	7.1	54.6	10.9
Scots pine	664.8	10.2	1.5	105.0	15.8	70.6	10.6
Maritime pine	844.8	35.8	4.2	2.0	0.2	19.2	2.3
Austrian pine	227.4	20.4	9.0	8.3	3.6	14.0	6.2
Aleppo pine	225.2	9.0	4.0	123.4	54.8	31.8	14.1
Douglas fir	306.2	9.8	3.2	20.2	6.6	14.3	4.7
Larch	149.4	56.5	37.8	3.0	2.0	17.2	11.5
Other conifers	95.4	3.0	3.1	1.0	1.0	4.0	4.2
Total conifers	**3 494.6**	**143.2**	**4.1**	**292.4**	**8.4**	**219.4**	**6.3**
Total all species	**10 100.4**	**1 232.2**	**12.2**	**710.6**	**7.0**	**854.8**	**8.5**

Source: DSF.

The usual trends are noted and they depend on the characteristics of the species and pests:

– oaks and larch are more affected by insects, especially defoliating caterpillars;
– poplars and chestnut for broadleaved species, Aleppo pine for conifers have recurrent fungal disease problems;
– mistletoe is the main problem affecting Scots pine;
– some species show symptoms that can be interpreted as being due to drought: holm oak and pubescent oak, birch, Scots pine and Aleppo pine, etc.

Severity of the 10 major pest and disease problems affecting French forests from 1989 to 2009

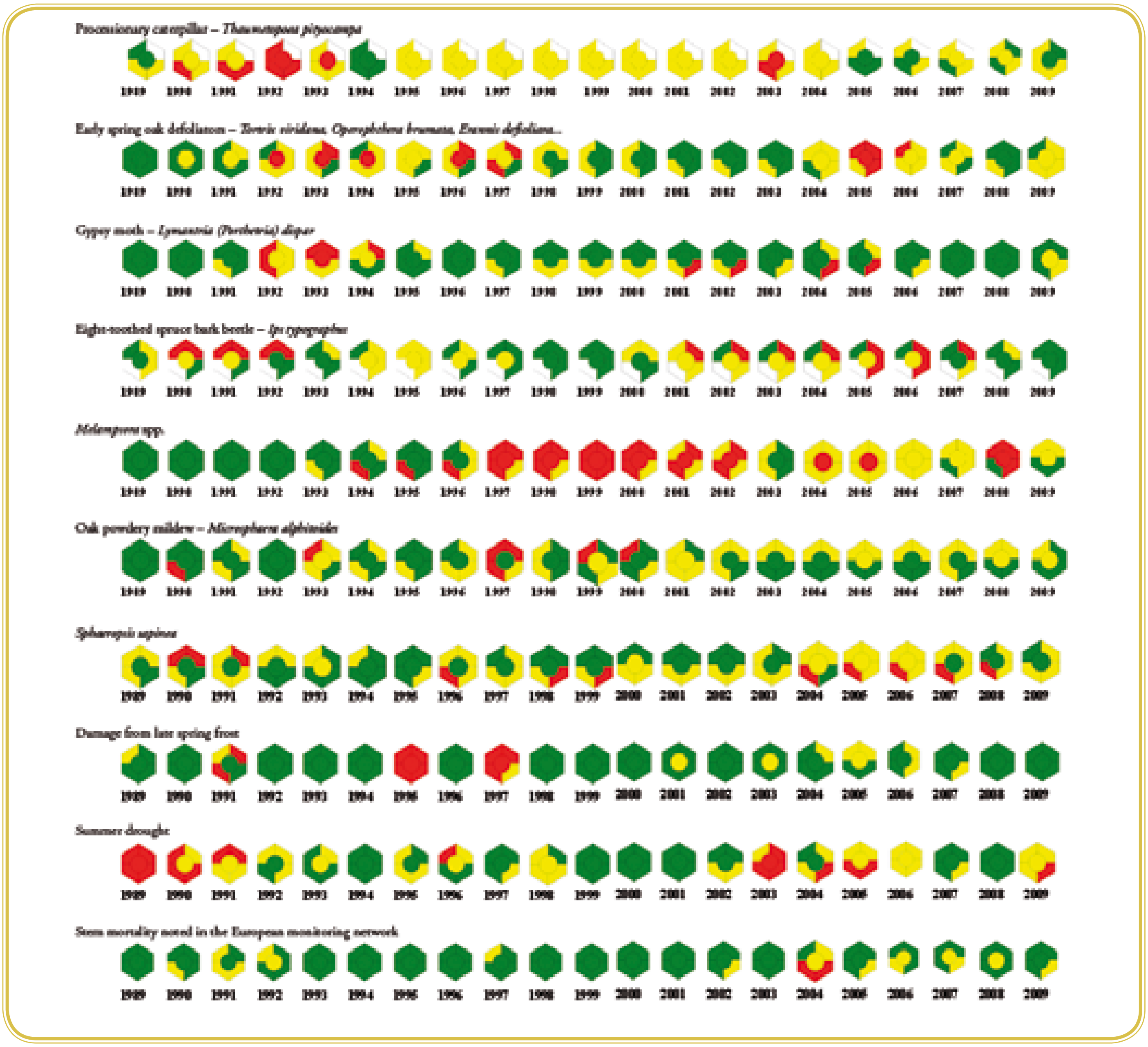
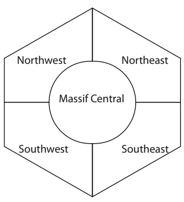


Figure 18: Severity of the 10 major pest and disease problems affecting French forests from 1989 to 2009.
Source: DSF.

The hexagons represent France:
Northwest
Northeast
Massif Central
Southwest
Southeast



Severity of problems:
- green: absence, trace, slight, endemic
- yellow: moderate
- red: marked, epidemic

The white part of some hexagons indicate that the pest mentioned is (or was) absent from the concerned regions.

The 2005-2009 period was marked by continued bark beetle infestations on spruce trees following outbreaks initiated by windfalls caused by the Christmas 1999 storm and the 2003 drought-heat wave. These infestations gradually diminished in the Alps and eastern France in 2008 as a result of the heavy precipitation in 2007 and 2008 and the introduction of bark beetle parasitoids. Despite this, several hundreds of thousands of cubic metres of spruce were still destroyed by bark beetle outbreaks.
Epidemics of broadleaved defoliating caterpillars occurred in 2005, without major consequences, and then the situation very quickly returned to endemic levels. In 2008, *Melampsora* spp. benefitted from mild humid climatic conditions, leading to their proliferation.

Fires observed in forests and other wooded lands

Year	Area destroyed by fire (ha)				Number of fires
	Outside of Mediterranean region	Mediterranean region [1]		Total	
			%		
1979	6 376	53 351	89	59 727	5 507
1980	5 988	16 188	73	22 176	5 040
1981	4 233	23 478	85	27 711	5 173
1982	6 486	48 659	88	55 145	5 308
1983	5 239	48 490	90	53 729	4 659
1984	12 507	14 696	54	27 203	5 672
1985	9 861	47 507	83	57 368	6 249
1986	4 460	47 400	91	51 860	4 353
1987	3 714	10 395	74	14 109	3 043
1988	1 494	5 208	78	6 702	2 837
1989	18 695	56 871	75	75 566	6 743
1990	18 728	53 897	74	72 625	5 881
1991	3 581	6 549	65	10 130	3 888
1992	3 828	12 765	77	16 593	4 002
1993	4 797	11 901	71	16 698	4 769
1994	2 390	22 605	90	24 995	4 618
1995	8 149	9 988	55	18 137	6 563
1996	8 281	3 119	27	11 400	6 401
1997	9 331	12 250	57	21 581	8 005
1998	7 837	11 243	59	19 080	6 288
1999	3 123	12 782	80	15 905	4 960
2000	5 162	18 864	79	24 026	4 553
2001	2 502	17 970	88	20 472	4 260
2002	23 860	6 299	21	30 159	4 097
2003	11 771	61 507	84	73 278	7 023
2004	3 114	10 596	77	13 710	3 767
2005	4 779	17 356	78	22 135	4 698
2006	2 410	5 483	69	7 893	4 608
2007	2 086	6 486	76	8 572	3 382
2008	2 260	3 746	62	6 006	2 793
2009	5 888	11 112	65	17 000	4 870
(1) Languedoc-Roussillon, Provence-Alpes-Côte d'Azur, Corsica, Drôme, Ardèche					
Mean 1980-84 (ha/year)	6 891	30 302	81	37 193	5 170
% total forest area	nd	nd		0.23	
Mean 1985-89 (ha/year)	7 645	33 476	81	41 121	4 645
% total forest area	nd	nd		0.25	
Mean 1990-94 (ha/year)	6 665	21 543	76	28 208	4 632
% total forest area	0.05	0.63		0.18	
Mean 1995-99 (ha/year)	7 344	9876	57	17 221	6 443
% total forest area	0.06	0.24		0.10	
Mean 2000-2004 (ha/year)	9 282	23 047	71	32 329	4 740
% total forest area	0.07	0.54		0.19	
Mean 2005-2009 (ha/year)	3 485	8 837	72	12 321	4 070
% total forest area	0.02	0.20		0.08	

Source: MAAPRAT and the French Ministry of the Interior, based on the Prométhée files for the Mediterranean region, the Association régionale DFCI for the Aquitaine region and DRAAF statements for the other regions. Burnt areas are relative to forest areas and other wooded lands from the Teruti-Lucas survey of SSP: Indicator 1.1.

From 1991 to 2002, the areas affected by fires in France ranged from 10,000 to 30,000 ha per year, which differed markedly from the trend of the previous decade.
These encouraging results were upset by the drought-heat wave of 2003, when there was a record number of more than 7,000 fires with 73,300 ha burnt. The Mediterranean region was especially affected, with more than 60,000 ha burnt in 2003, including 27,400 ha in Corsica and 18,800 in the Var region, thus surpassing the losses of 1989 and 1990. The mean burnt area per fire was more than 10 ha throughout France, as was also the case in 1989 and 1990. These mean results conceal the marked variations between regions, with the largest forest fires recorded in the Mediterranean region.
Another unique feature in recent years concerns the peak in burnt areas recorded in 2002 outside of the Mediterranean area, corresponding to very large forest fires that occurred in the Aquitaine and Midi-Pyrénées regions. The situation returned to normal in 2004, with less than 14,000 ha burnt throughout France.
Despite the peaks in 2005 and 2009 associated with the hot dry summer climatic conditions, destroyed areas decreased substantially between 2006 and 2008 to under 10,000 ha, with a historical minimum of 6,000 ha and less than 3,000 fires ignited in 2008.

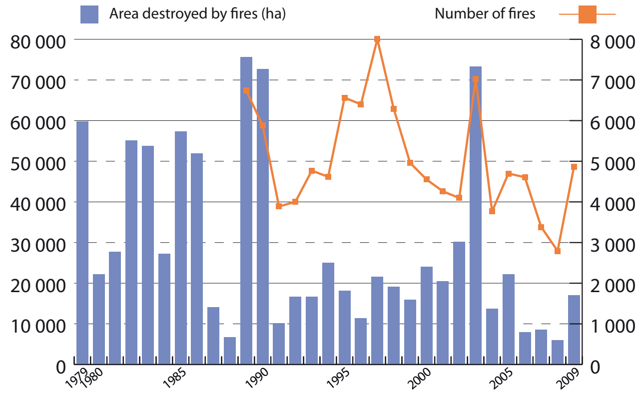


Figure 19: Variations in the number of fires and burnt areas in forests and other wooded lands from 1979 to 2009.

Source: MAAPRAT and Ministry of the Interior.

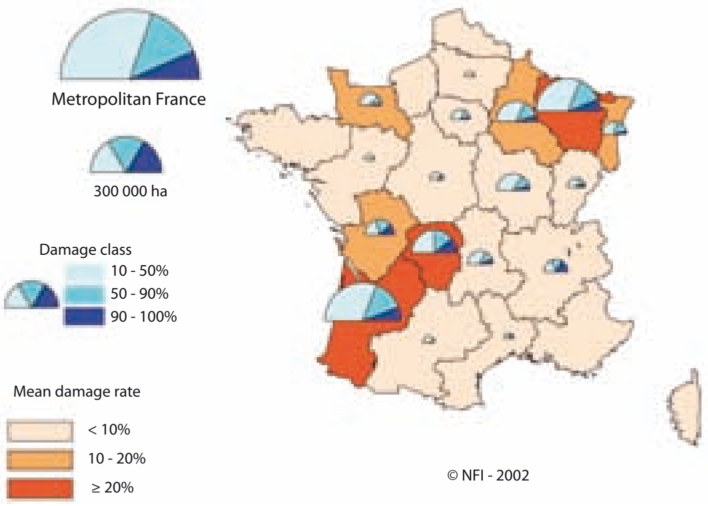
This improvement is the result of several factors, including:
- better adaptation of the system to extreme climatic conditions;
- better control of urbanisation in forest areas and better self-protection of homes;
- regular clearing maintenance in collaboration with crop and livestock farmers when possible;
- more effective coordination of stakeholders;
- enhanced public awareness on forest fire prevention.

Storms

	1965-1974	1975-1984	1985-1994	1995-2004	2005-2009**
Volume in state-owned forest (Mm^3)	3.0	3.6	9.7	61.7	2.3
Volume in private forest (Mm^3)	0.7	12.0	6.5	115.4	41.0
Total volume (Mm^3)	**3.7**	**15.6**	**16.2**	**177.1**	**43.3**
% of growing stock	0.2	1.0	0.9	8.3	1.8
% of production of the corresponding period	-	2.6	2.2	20.0	nd
Mean volume per ha of metropolitan forest per year	0.0	0.1	0.1	1.1	0.6
Destroyed stands (in ha)*	about 2 500	about 9 800	about 9 300	about 115 300	about 70 000

*From 1965 to 1998: area-equivalent of volumes destroyed; 1999: NFI estimation of stand areas in which more than 10% of the cover is destroyed; 2005-2009: NFI estimation of stand areas in which more than 20% of the cover is destroyed.
** As these figures just account for cyclone Klaus in 2009, they are presented for information only, while awaiting a relevant supplement to this table for the 2005-2014 period.
Source: from 1965 to 1998: ONF and French Ministry of Agriculture and Fisheries, only for exceptional windfalls, thus not taking into account windfall volumes regularly removed in mountains at the end of winter; for private forests, most of the figures come from M. Doll's thesis \`Disastrous Meteorological Events in Forests´ 1988; the area-equivalent of the volumes destroyed per year is calculated from the mean volume per hectare of regular high forest, the type of stand most often affected by windfalls. For the 1999 and 2009 storms, NFI estimations were based on analyses of aerial photos and field surveys after the storms (see details below); the exceptional windfall volume between year 2000 and 2008 was zero.

Following the December 1999 storms, which caused considerable damage to a large part of the French forest (176 Mm^3 destroyed, Map 12), the 2005-2009 period was only affected by the exceptionally severe storm of January 2009 in southwestern France (cf. below).



Map 12: Area of stands damaged by more than 10%, ranked by damage class and mean damage rate per administrative region.

Source: NFI, 2002.

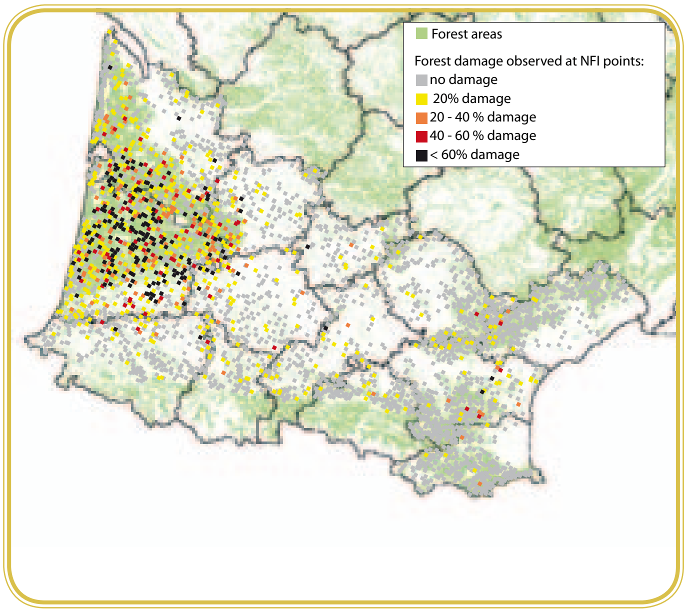
The January 2009 storm

Cyclone Klaus of 24 January 2009 had a major impact on the Aquitaine forest massif and on scattered parts of other massifs in southwestern France. The damage was assessed in Aquitaine, Midi-Pyrénées and Languedoc-Roussillon regions by the National forest inventory using two complementary methods:

– mapping of storm damage to the Aquitaine massif from cloud-free SPOT satellite images at decametric accuracy—these images were acquired in February 2009, spanning almost the entire damaged area (except for the southwestern tip of the Landes massif);

– joint estimation of forest areas and stem volumes affected, based on:

- monitoring of over 3,000 points already inventoried during the four previous annual inventories by all field staff during February 2009;
- photo-interpretation of aerial photographs acquired directly over the sampling points. Low altitude aerial photographs guided the survey teams when they assessed the damage in Pyrénées-Orientales region.



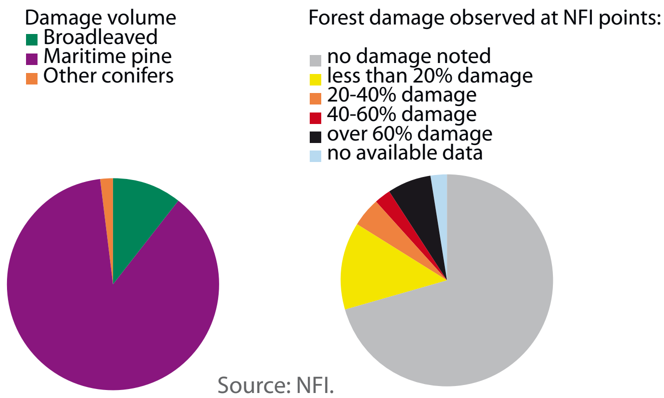
Map 13: Evaluation of forest damage by surveys and photo-interpretation at NFI sampling points during the last four inventories.

Source: NFI, 2009.

The total area monitored in the zone was 7.3 Mha, with forests available for wood supply (FAWS) covering 35% of this area (2.5 Mha).

A total of 690,000 ha was damaged by the storm, representing 29% of the total forest area.

	Forest available for wood supply area (ha)	Area concerned (%)
No damage noted	1 788 000	71
Less than 20% damage	338 000	13
20-40% damage	117 000	5
40-60% damage	63 000	3
Over 60% damage	170 000	7
No available data	58 000	2
Total	**2 535 000**	**100**



Source: NFI.

	Damage volume (Mm^3)	Volume concerned (%)
Broadleaved	4.6	11
Conifers	38.7	89
including maritime pine	37.9	87
including other conifers	0.8	2
Total	**43.3**	**100**

Indicator 2.4.1

Simultaneous presence of several ungulate species

The following graph shows the joint presence of several wild ungulates (red deer, roe deer, wild boar, fallow deer, sika deer, chamois, Cantabrian chamois, ibex and mountain sheep) in the French forest in 2005.

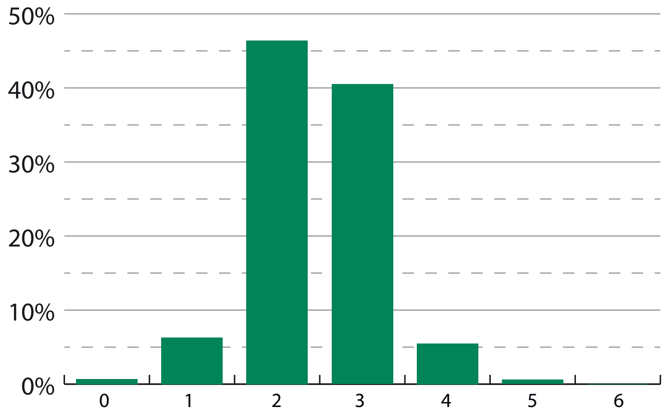


Figure 20: Distribution of ungulate species, in terms of numbers, throughout the French forest area (including Corsica) in 2005 (including wild boar).

Source: Réseau ongulés sauvages ONCFS-FNC-FDC.

	Area (1 000 ha)	% of the French forest
0 species	111.6	0.7
1 species	952.9	6.3
2 species	7 024.7	46.4
3 species	6 123.4	40.5
4 species	836.2	5.5
5 species	83.4	0.6
6 species	0.2	0.0
French forest	15 132.4	100.0

Source: Réseau ongulés sauvages ONCFS-FNC-FDC, SSP for the reference forest area.

Note: The calculations were based on data from the 5-year 'red deer massif' survey (2010 data currently being processed) and the 5-year mountain ungulate survey (latest conducted in 2011). The roe deer data are from the 5-year 'communal roe deer hunting bag' survey (latest conducted in 2007). The wild boar data are from the annual 'communal wild boar hunting bag' survey. Data on two marginal species, i.e. fallow deer and sika deer, are from the 5-year survey of 2006.

Red deer have expanded their distribution range mostly in mountain regions. Numbers of mountain ungulates have also increased to a similar extent (chamois and ibex numbers have almost doubled in 10 years), but they have colonised lowland areas. Roe deer and wild boar are also increasing in highland areas, even at elevations of over 2,500 m. Situations in which different species are living in the same area are thus becoming very common, especially in forest environments, with forests representing 40% of the area occupied by these animals on average.

Red deer (*Cervus elaphus*) with growing antlers (June 2010 in Alsace region).

Indicator 2.4.2

Progression of wild ungulates in forest areas

Big game is a key component of forest ecosystems. As part of its activities, ONCFS has been monitoring big game populations for over 30 years. The Réseau ongulés sauvages ONCFS-FNC-FDC currently monitors all wild ungulate species inhabiting lowland and mountain regions in France. Hunting bag samples of all hunted species per department are collected annually. Red deer, fallow deer, sika deer, chamois, Cantabrian chamois, mountain sheep and ibex are the focus of periodic surveys on the basis of which their spatial distribution ranges are mapped and numbers estimated. Roe deer and wild boar numbers are estimated on the basis of hunting bag data.
Variations noted in the hunting bags of all hunted ungulates in France highlight the major increase in these species over the last 20 years. This increase is more marked for lowland ungulates as compared to those inhabiting mountain regions.

	2009-2010 survey numbers	Progress over 20 years
Red deer	49 075	× 3.8
Roe deer	507 148	3.2
Wild boar	491 762	4.7
Chamois	14 066	2.8
Cantabrian chamois	3 388	1.6
Mountain sheep	4 322	3.8
Fallow deer	2 334	6.1
Sika deer	164	6.6

Source: Réseau ongulés sauvages ONCFS-FNC-FDC.

Ungulate hunting bag patterns over 20 years in France

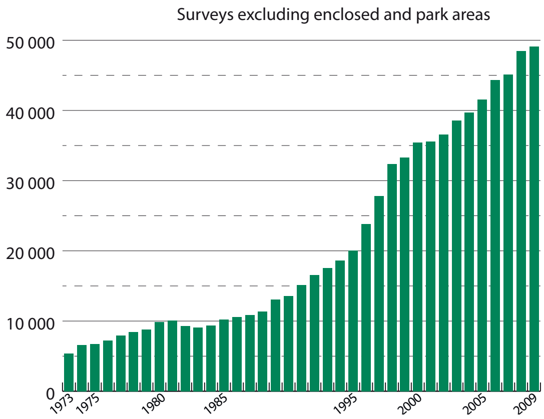


Figure 21: Annual red deer sampling patterns from 1973 to 2009 in France.

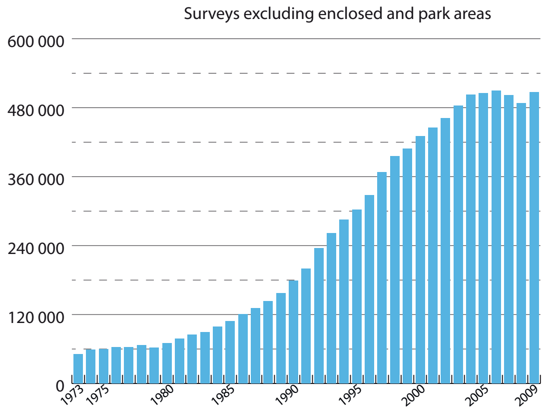


Figure 22: Annual roe deer sampling patterns from 1973 to 2009 in France.

Source: Réseau ongulés sauvages ONCFS-FNC-FDC.

The area colonised by red deer has doubled in 20 years and the estimated numbers have quadrupled.
In contrast, the rise in roe deer numbers has clearly slowed down in recent years, with density-dependence phenomena noted in some areas.

Red deer

Figure 23: Distribution of forest areas inhabited by red deer in France (excluding Corsica) according to red deer density classes per 100 ha of woodland.

In 1985, red deer inhabited 26% of the French forest area, 31% in 1995, 39% in 2000 and 45% in 2005. Over a 20 year period, there has been a clear reduction in forest area with low red deer densities, whereas forest massifs with very high red deer densities are now being noted.

Note: As the ONCFS surveys are carried out every 5 years, the 2010 data were not available for this edition but, as of late 2011, they can be accessed on the ONCFS website at: www.oncfs.gouv.fr.

Forest area inhabited by red deer in France

	1985		1995		2000		2005	
Red deer density classes	*Inhabited forest area*	*% forêt*	*Inhabited forest area*	*% forêt*	*Inhabited forest area*	*% forêt*	*Inhabited forest area*	*% forêt*
]0;0.25]	985.6	25.1	979.9	20.9	663.4	11.4	782.1	11.5
]0.25;0.5]	791.3	20.2	637.2	13.6	818.9	14.0	417.1	6.1
]0.5;1]	813.4	20.7	908.4	19.4	1094.8	18.8	1509.9	22.3
]1;1.5]	495.4	12.6	612.5	13.1	652.9	11.2	745.0	11.0
]1.5;2]	281.1	7.2	338.6	7.2	589.8	10.1	901.8	13.3
]2;3]	354.9	9.1	603.4	12.9	690.9	11.9	833.4	12.3
]3;4]	128.8	3.3	262.0	5.6	549.9	9.4	507.5	7.5
]4;5]	10.9	0.3	197.2	4.2	282.0	4.8	334.4	4.9
]5;10]	56.2	1.4	133.1	2.8	369.7	6.3	654.4	9.6
> 10	4.0	0.1	10.8	0.2	117.8	2.0	99.4	1.5
Total	**3921.6**	**100.0**	**4683.1**	**100.0**	**5830.1**	**100.0**	**6785.0**	**100.0**

Source : Réseau ongulés sauvages ONCFS-FNC-FDC.

Roe deer

In 1985, roe deer inhabited 94% of the French forest area, and 99% since 1995. It is not found in Corsica.

Over a 20 year period, there has been a clear reduction in the percentage of forest area with low roe deer densities, whereas areas with high density classes have been increasing.

Estimated roe deer densities per 100 ha of woodland are, however, a less relevant indicator than for red deer because roe deer are present to an increasing extent in all types of habitat (hedgerows, large grasslands, etc.).

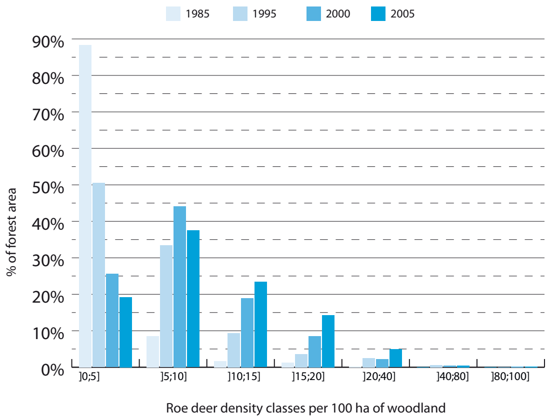


Figure 24: Distribution of forest areas inhabited by red deer in France (excluding Corsica) according to red deer density classes per 100 ha of woodland estimated on the basis of the number of hunting kills.

Source : Réseau ongulés sauvages ONCFS-FNC-FDC.

Note: As the ONCFS surveys are carried out every 5 years, the 2010 data were not available for this edition but, as of late 2011, they can be accessed on the ONCFS website at: www.oncfs.gouv.fr.

Forest area inhabited by roe deer in France

	1985		1995		2000		2005	
Roe deer density classes	*Inhabited forest area*	*% forêt*	*Inhabited forest area*	*% forêt*	*Inhabited forest area*	*% forêt*	*Inhabited forest area*	*% forêt*
]0 ; 5]	12 568.5	88.4	7 533.6	50.5	3 823.4	25.6	2 862.3	19.2
]5 ; 10]	1 203.2	8.5	4 990.7	33.4	6 586.7	44.1	5 596.5	37.5
]10 ; 15]	236.5	1.7	1 400.5	9.4	2 824.4	18.9	3 492.4	23.4
]15 ; 20]	180.3	1.3	540.6	3.6	1 273.5	8.5	2 139.0	14.3
]20 ; 40]	32.6	0.2	368.7	2.5	326.0	2.2	733.1	4.9
]40 ; 80]	0.0	0.0	91.5	0.6	60.9	0.4	71.6	0.5
]80 ; 100]	0.0	0.0	0.0	0.0	30.7	0.2	30.7	0.2
Total	**14 221.2**	**100.0**	**14 925.6**	**100.0**	**14 925.6**	**100.0**	**14 925.6**	**100.0**

Source: Réseau ongulés sauvages ONCFS-FNC-FDC.