Results of the Forest Condition Survey 2008

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Summary

Compared with 2007, crown condition 2008 does not show significant change if the national average over all tree species is considered. In 2008, **26** % of the forest area were assessed as damaged[1] (damage classes 2 -4), as compared to 25 % in 2007. 31 % were undamaged (2007: 30 %) and 43 % in the warning stage (2007: 45 %). Mean crown defoliation decreased slightly from 20.7 to 20.4 %.

The main tree species show the following development:

-   **Spruce** *(Picea abies)***:** the area percentage of damaged trees is **30 %** (2007: 28 %). Mean crown defoliation was 20.8 % and remained unchanged as compared to the previous year.

-   **Scots pine** *(Pinus sylvestris)*: the area percentage of damaged trees is **18 %** (2007: 13 %). Mean crown defoliation increased from 17.8 to 18.9 %.

-   **Beech** trees *(Fagus sylvatica)* recovered significantly: The area percentage of damaged trees fell from 39 % in 2007 to **30 %** in 2008. Mean crown defoliation decreased from 25.6 to 22.0 %. This decrease has been favoured by the nearly complete absence of fructification in 2008.

-   **Oaks** (*Quercus petraea and Q. robur*): the area percentage of damaged trees further increased from 49 % in 2007 to **52 %** in 2008. This is a new maximum. The poor crown condition of the oak trees is also reflected in mean crown defoliation which reached 28.3 % in 2008. Although damage from insects decreased in comparison with the previous year, oaks are by far most severely affected by crown defoliation in German forests.

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[1]   Survey methods, definition of the damage classes and definition of mean crown defoliation are explained in the annex

Results of the survey 2008

The result 2008 has been calculated based on the crown condition data of 10'347 sample trees which were assessed on 423 sampling plots of the national 16 km x 16 km grid. The assessment covers 38 different tree species. However about 85 % of all trees included in the samples belong to the four main tree species spruce, scots pine, beech and oaks (note that the two oak species *Quercus robur* and *Quercus petraea* are assessed together). The remaining tree species are aggregated to the two species groups "other conifers" and "other broadleaves". For explanations on the assessment methods see Annex: Forest condition survey: assessment and classification methods.

Results of the Forest Condition Survey 2008 are presented in the following figures and tables. The information on the percentage of forest area covered by the respective tree species or species group stem from the National Forest Inventory.

All Tree Species
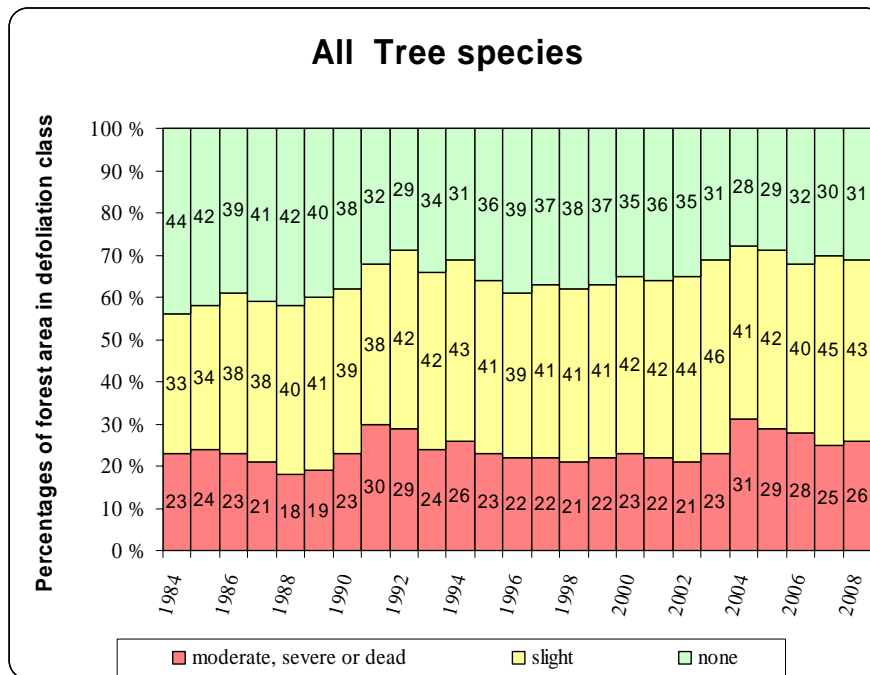
Figure 1:   All Tree Species; development of defoliation classes since 1984 (until 1989 without the new laender; 10'347 trees assessed in 2008)

Table 1:   **All tree species: Development of defoliation classes since 1984 [% of forest area]**

Year	0 (undamaged)	1 (warning stage)	2 – 4 (damaged)
1984	44	33	23
1985	42	34	24
1986	39	38	23
1987	41	38	21
1988	42	40	18
1989	40	41	19
1990	38	39	23
1991	32	38	30
1992	29	42	29
1993	34	42	24
1994	31	43	26
1995	36	41	23
1996	39	39	22
1997	37	41	22
1998	38	41	21
1999	37	41	22
2000	35	42	23
2001	36	42	22
2002	35	44	21
2003	31	46	23
2004	28	41	31
2005	29	42	29
2006	32	40	28
2007	30	45	25
2008	31	43	26

Table 2:   **Mean defoliation in percent by tree species or species groups**

Year	Total/ all species	Spruce	Scots pine	Beech	Oaks	other conifers	other broadleaves
1984	18.9	21.3	18.0	17.0	15.9	22.2	9.9
1985	17.7	20.0	16.5	15.2	17.5	24.3	10.3
1986	18.1	19.7	16.6	16.6	19.2	25.2	11.9
1987	17.7	17.2	17.2	20.1	19.2	21.7	12.1
1988	16.8	16.9	16.6	17.2	18.8	19.6	12.0
1989	17.2	17.6	16.1	17.0	20.9	19.5	13.3
1990	18.3	18.1	17.6	20.3	19.8	20.1	16.1
1991	21.1	19.9	22.8	20.7	23.4	20.4	19.0
1992	21.2	20.8	19.7	24.8	22.8	20.6	21.4
1993	19.7	20.0	17.0	22.9	25.4	21.8	17.5
1994	20.4	20.6	19.0	21.7	26.7	22.0	17.5
1995	19.2	19.1	16.6	23.9	25.0	21.3	16.2
1996	18.4	17.8	15.8	22.0	28.0	20.3	16.1
1997	18.8	18.7	16.2	22.7	28.2	18.8	15.8
1998	18.3	19.4	15.0	22.0	24.9	18.8	15.1
1999	18.6	19.0	15.9	23.2	26.2	18.4	14.7
2000	19.3	19.7	16.6	25.6	24.4	18.7	14.5

Year	Total/ all species	Spruce	Scots pine	Beech	Oaks	other conifers	other broadleaves
2001	18.8	20.1	16.4	22.8	24.0	18.1	13.5
2002	19.1	20.2	16.9	22.3	22.5	18.9	15.8
2003	19.9	20.8	17.5	22.7	25.4	19.9	17.6
2004	22.8	23.6	18.5	30.5	28.5	21.0	19.7
2005	21.5	21.8	18.6	27.0	28.1	19.8	18.2
2006	21.0	19.7	18.7	27.7	26.6	19.9	18.2
2007	20.7	20.8	17.6	25.6	28.0	20.3	17.8
2008	20.4	20.8	18.9	22.0	28.3	22.2	16.5

Conifers

Mean defoliation
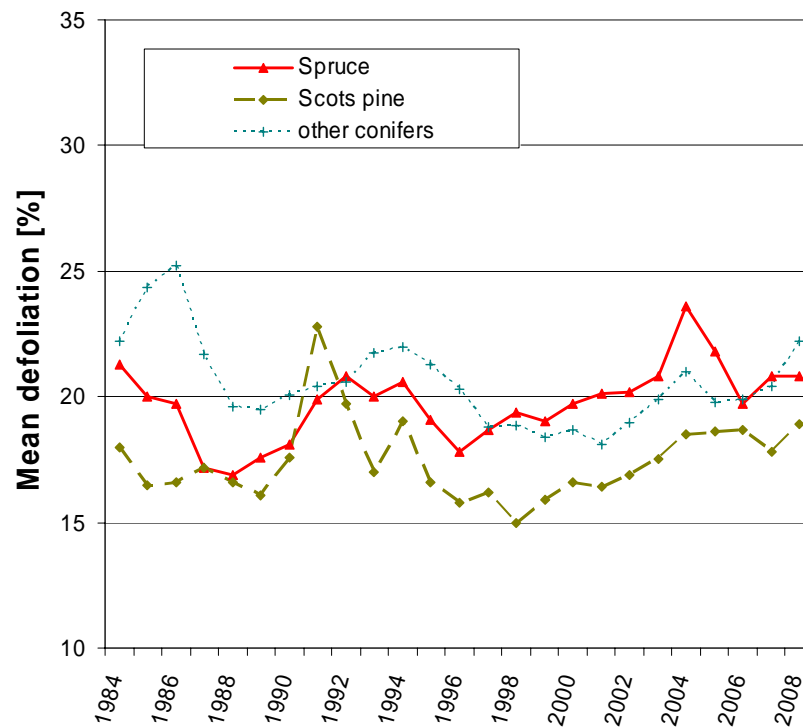
Figure 2   Development of mean defoliation since 1984 for Spruce, Scots pine and other conifers

Spruce

Scientific name: *Picea abies*

Percentage of forest area: 28 %

Figure 3:   Spruce; Development of defoliation classes since 1984
(until 1989 without new laender; 2'702 sample trees in 2008)

Table 3:   Spruce: Development of defoliation classes since 1984 [% of area]

Year	0 (undamaged)	1 (warning stage)	2 − 4 (damaged)
1984	36	34	30
1985	36	31	33
1986	33	37	30
1987	40	36	24
1988	39	42	19
1989	38	41	21
1990	36	41	23
1991	34	37	29
1992	28	42	30
1993	34	40	26
1994	32	39	29
1995	38	38	24
1996	43	35	22
1997	37	40	23
1998	36	38	26
1999	36	39	25
2000	34	41	25
2001	31	43	26
2002	33	41	26

Year	0 (undamaged)	1 (warning stage)	2 – 4 (damaged)
2003	30	43	27
2004	26	39	35
2005	27	42	31
2006	39	34	27
2007	33	39	28
2008	34	36	30

Figure 4:   *Spruce: Distribution of defoliation assessed in 5 %-steps in 2007 and 2008 (defoliation class 0 green, defoliation class 1 yellow, defoliation classes 2 – 4 red)*

Scots pine

Scientific Name: *Pinus sylvestris*

Percentage of forest area: 23 %

Figure 5:   *Scots pine; Development of defoliation classes since 1984*
     (until 1989 without new laender; 3'135 sample trees in 2008)

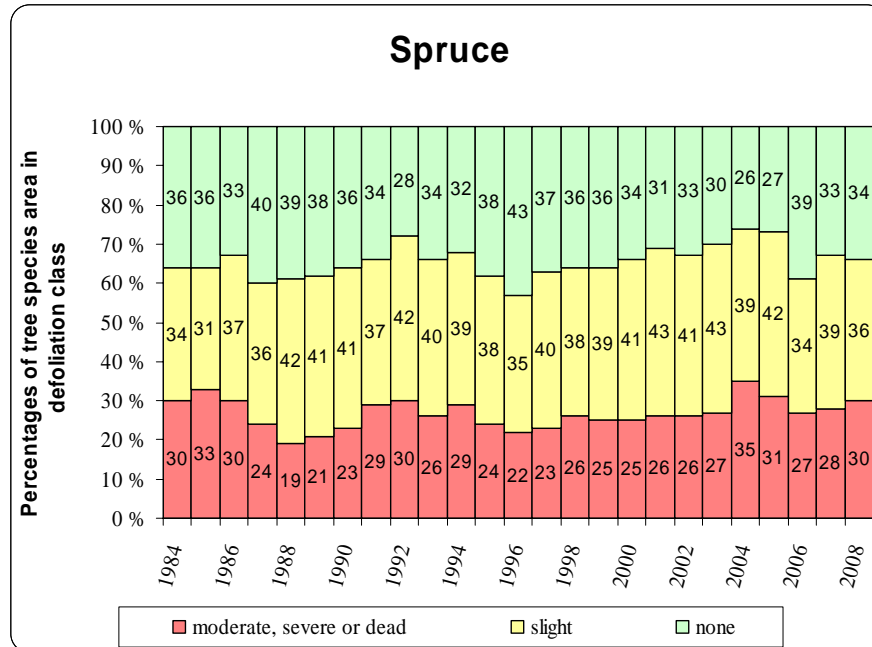**Table 4:**   **Scots pine: Development of defoliation classes since 1984 [% of area]**

Year	0 (undamaged)	1 (warning stage)	2 – 4 (damaged)
1984	39	38	23
1985	42	41	17
1986	42	43	15
1987	45	43	12
1988	48	41	11
1989	41	45	14
1990	39	40	21
1991	28	39	33
1992	31	45	24
1993	40	44	16
1994	33	48	19
1995	41	45	14
1996	44	43	13
1997	43	44	13
1998	45	45	10
1999	42	45	13
2000	39	48	13
2001	40	46	14
2002	38	49	13
2003	34	53	13

Year	0 (undamaged)	1 (warning stage)	2 – 4 (damaged)
2004	34	49	17
2005	34	47	19
2006	31	51	18
2007	33	54	13
2008	29	53	18

The share of damaged scots pine trees has increased compared to 2007. Mean crown defoliation increased too. When comparing the frequency distribution of the crown defoliation assessed in 5 %-steps in 2007 and 2008, the 5 %-classes up to 15 % defoliation have decreased while the classes 20 % and more have increased.
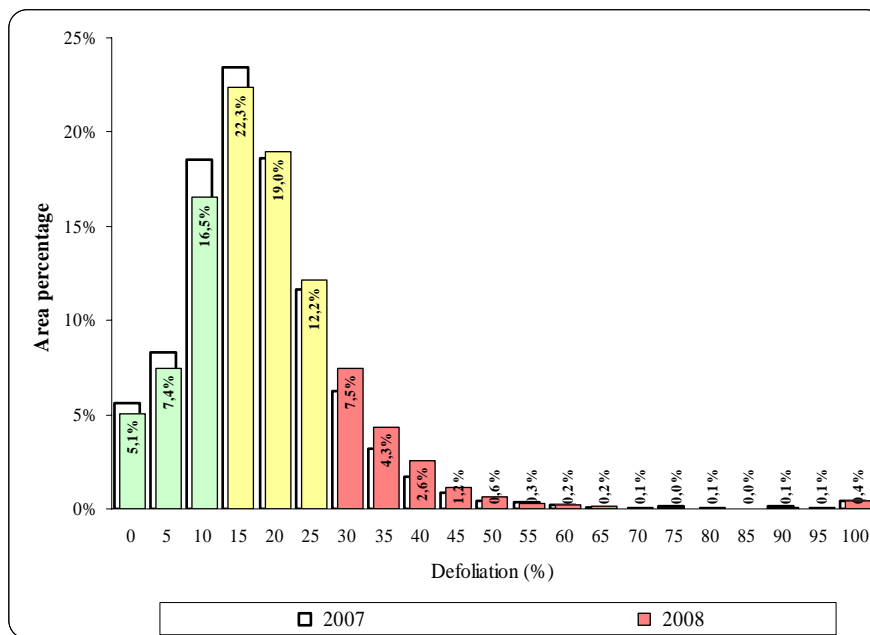
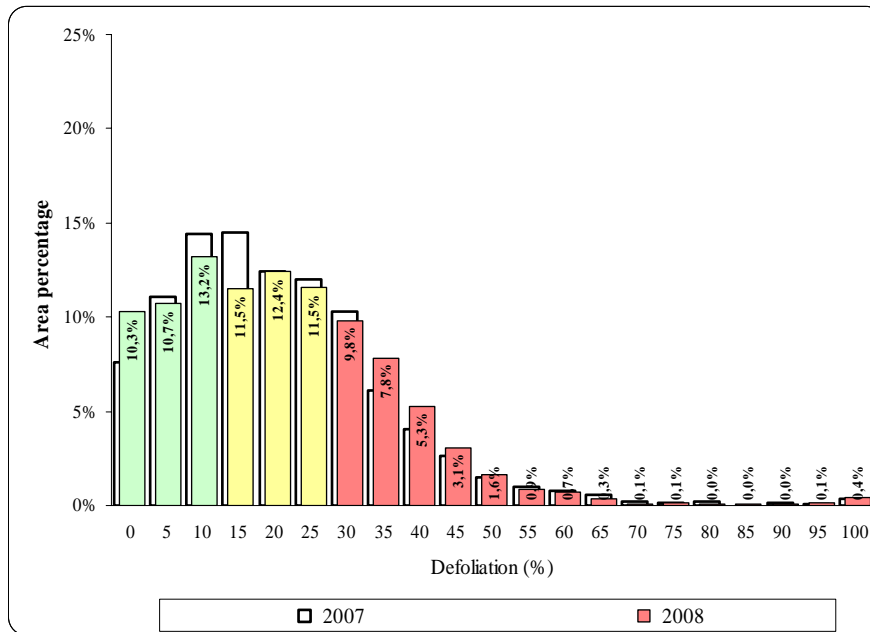*Figure 6:   Scots pine: Distribution of defoliation assessed in 5 %-steps in 2007 and 2008 (defoliation class 0 green, defoliation class 1 yellow, defoliation classes 2 – 4 red)*

Other conifers

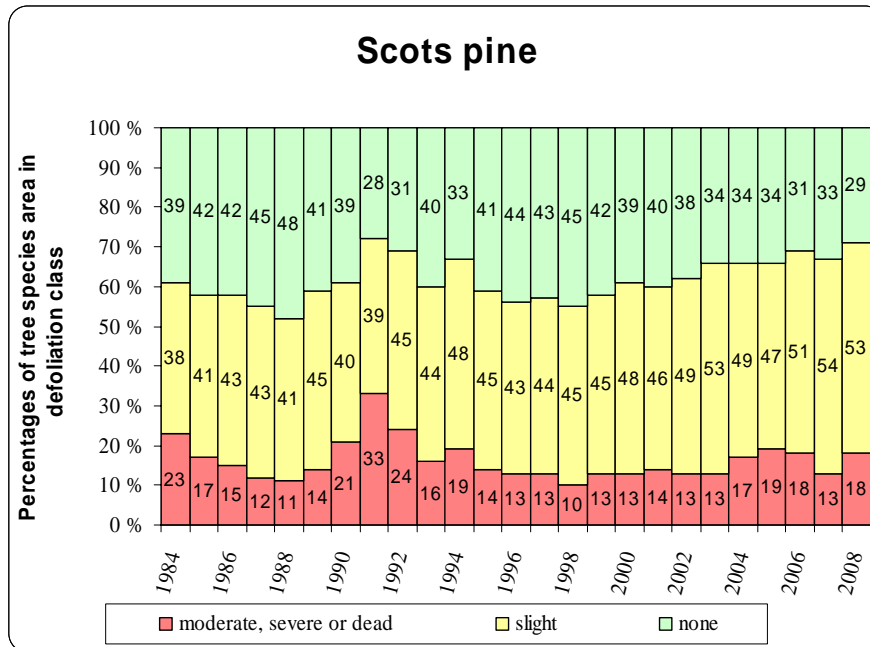Percentage of forest area: 6 %.

Figure 7:   Other conifers; Development of defoliation classes since 1984
(until 1989 without new laender; 653 sample trees in 2008)

Table 5:   Other conifers: Development of defoliation classes since 1984 [% of area]

Year	0 (undamaged)	1 (warning stage)	2 – 4 (damaged)
1984	46	18	36
1985	40	20	40
1986	42	16	42
1987	42	25	33
1988	44	27	29
1989	42	32	26
1990	41	30	29
1991	38	31	31
1992	39	31	30
1993	33	36	31
1994	31	39	30
1995	37	31	32
1996	41	30	29
1997	39	39	22
1998	40	35	25
1999	43	33	24
2000	42	33	25
2001	42	33	25
2002	42	34	24

| Year	0 (undamaged)	1 (warning stage)	2 – 4 (damaged)
2003	35	39	26
2004	32	39	29
2005	35	40	25
2006	42	32	26
2007	34	44	22
2008	32	37	31

Figure 8:   *Other conifers: Distribution of defoliation assessed in 5 %-steps in 2007 and 2008*
(defoliation class 0 green, defoliation class 1 yellow, defoliation classes 2 – 4 red)

Broadleaves

Mean defoliation
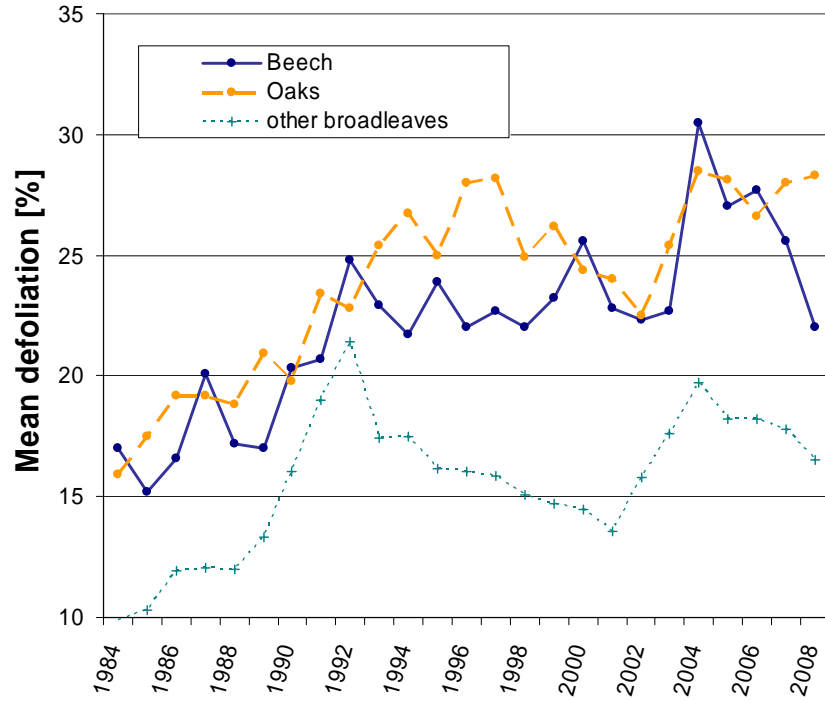
Figure 9:   *Development of mean defoliation since 1984 for Beech, Oaks and other broadleaves*

Beech

Scientific Name: *Fagus sylvatica*

Percentage of forest area: 15 %
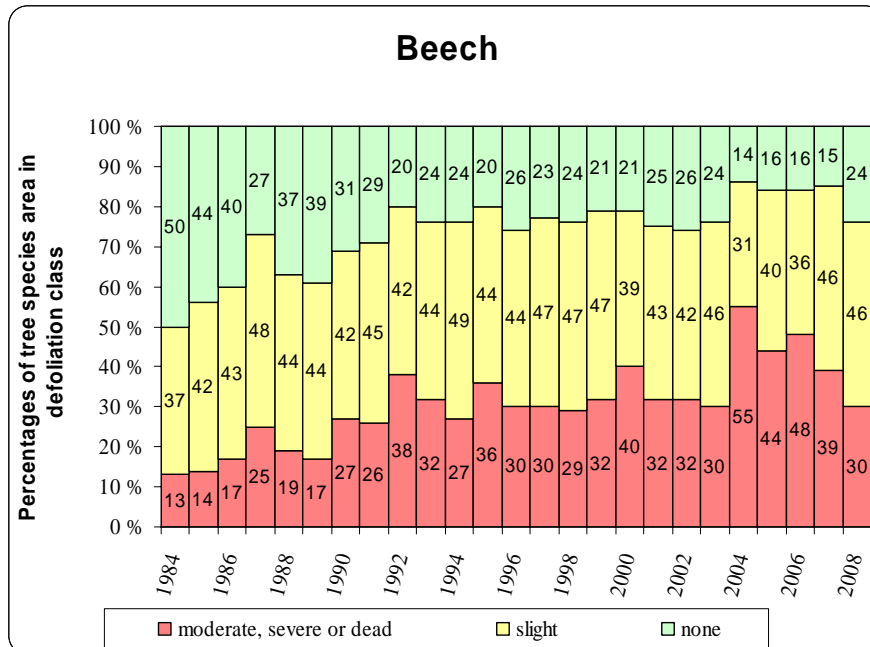
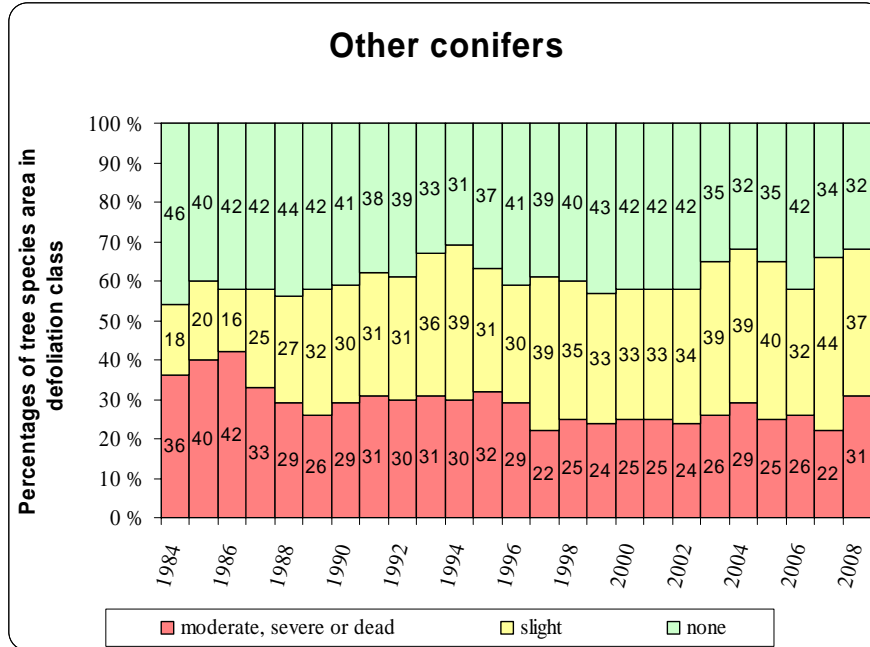*Figure 10:   Beech; Development of defoliation classes since 1984*
(until 1989 without new laender; 1'825 sample trees in 2008)

Table 6:   Beech: Development of defoliation classes since 1984 [% of area]

Year	0 (undamaged)	1 (warning stage)	2 – 4 (damaged)
1984	50	37	13
1985	44	42	14
1986	40	43	17
1987	27	48	25
1988	37	44	19
1989	39	44	17
1990	31	42	27
1991	29	45	26
1992	20	42	38
1993	24	44	32
1994	24	49	27
1995	20	44	36
1996	26	44	30
1997	23	47	30
1998	24	47	29
1999	21	47	32
2000	21	39	40
2001	25	43	32
2002	26	42	32

Year	0 (undamaged)	1 (warning stage)	2 – 4 (damaged)
2003	24	46	30
2004	14	31	55
2005	16	40	44
2006	16	36	48
2007	15	46	39
2008	24	46	30

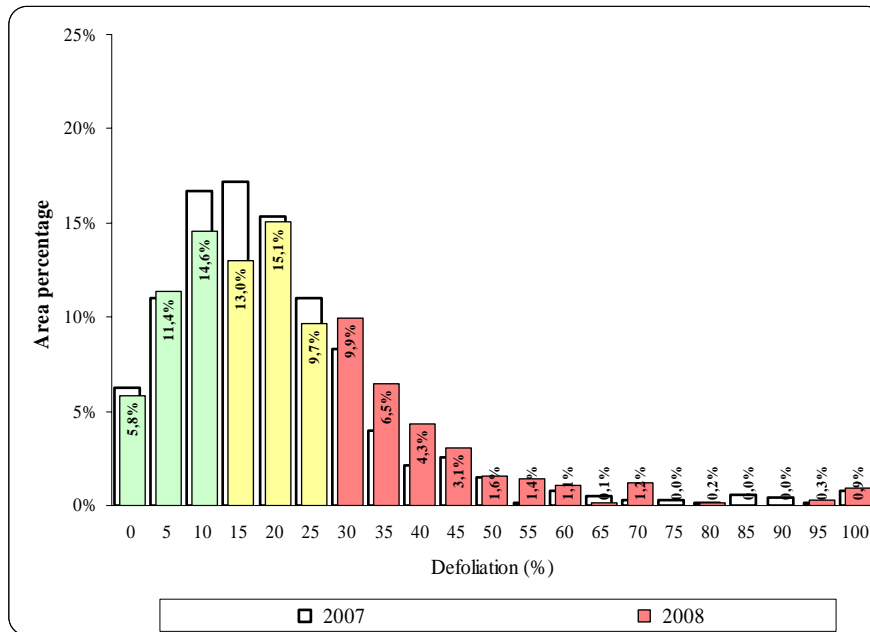*Figure 11:*   *Beech: Distribution of defoliation assessed in 5 %-steps in 2007 and 2008 (defoliation class 0 green, defoliation class 1 yellow, defoliation classes 2 – 4 red)*

Beech trees significantly recovered: the area percentage of the defoliation classes 2 – 4 decreased by 9 percentage points and amount now to 30 %; the share of trees without defoliation (defoliation class 0) increased accordingly. Mean crown defoliation also decreased. The favourable development is also evident when considering the frequency distribution of crown defoliation assessed in 5 %-steps.

Only few trees were fruiting in 2008. This helped the trees to recover, since beech shows a strong relationship between fruiting and crown defoliation.

Beech: Relationship between fruiting and crown defoliation
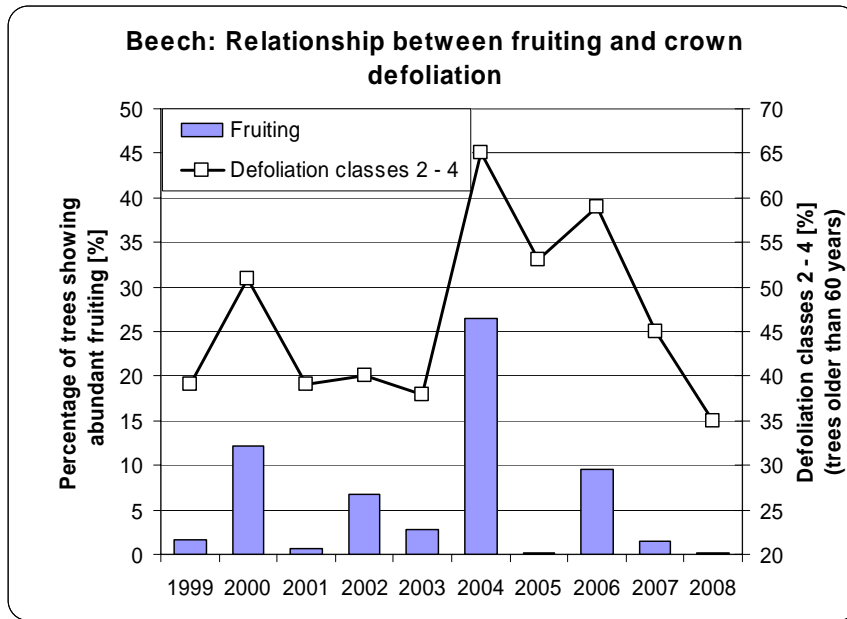
Figure 12: Beech: Relationship between fruiting and crown defoliation

Oaks

Includes European and Sessile oak; the North American Red oak (*Quercus rubra)* is included under „Other broadleaves".

Scientific names: *Quercus robur, Quercus petraea*

Percentage of forest area (both oak species together): 10 %
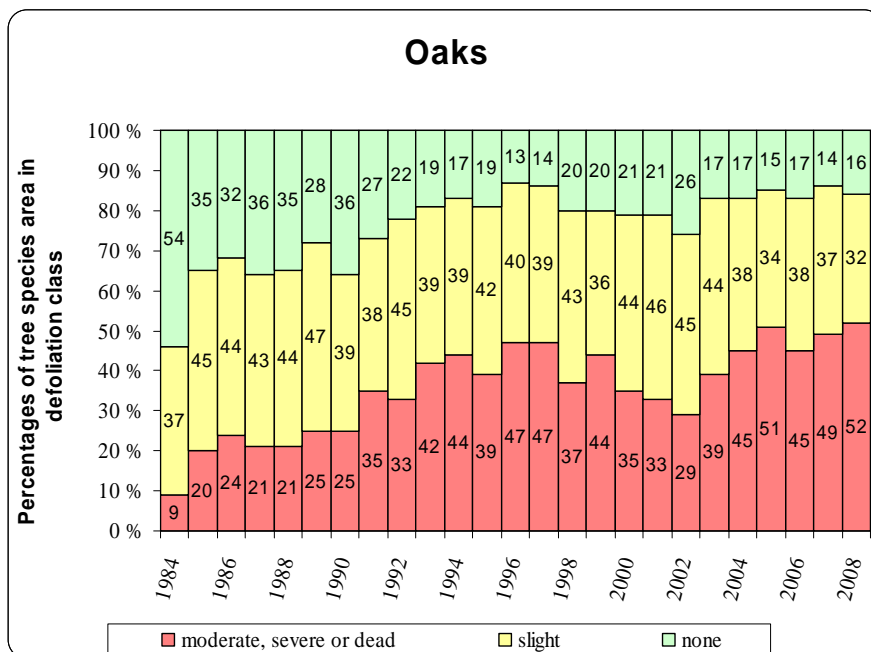
Oaks

Figure 13: Oaks; Development of defoliation classes since 1984
(until 1989 without new laender; 682 sample trees in 2008)

Table 7:   **Oaks: Development of defoliation classes since 1984 [% of area]**

Year	0 (undamaged)	1 (warning stage)	2 – 4 (damaged)
1984	54	37	9
1985	35	45	20
1986	32	44	24
1987	36	43	21
1988	35	44	21
1989	28	47	25
1990	36	39	25
1991	27	38	35
1992	22	45	33
1993	19	39	42
1994	17	39	44
1995	19	42	39
1996	13	40	47
1997	14	39	47
1998	20	43	37
1999	20	36	44
2000	21	44	35
2001	21	46	33
2002	26	45	29
2003	17	44	39
2004	17	38	45
2005	15	34	51
2006	17	38	45
2007	14	37	49
2008	16	32	52

The share of damaged oak trees further increased compared to 2007. Mean defoliation increased less because the percentage of undamaged trees also slightly increased. But oaks remain the most damaged trees in German forests: half of the trees show more than 25 % defoliation.
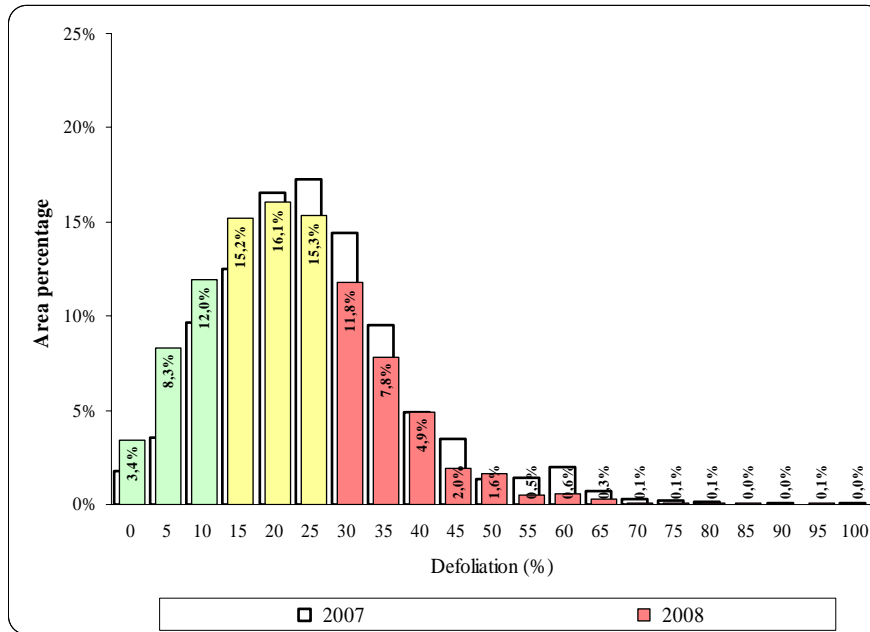
Figure 14:   *Oaks: Distribution of defoliation assessed in 5 %-steps in 2007 and 2008 (defoliation class 0 green, defoliation class 1 yellow, defoliation classes 2 – 4 red)*

Other broadleaves
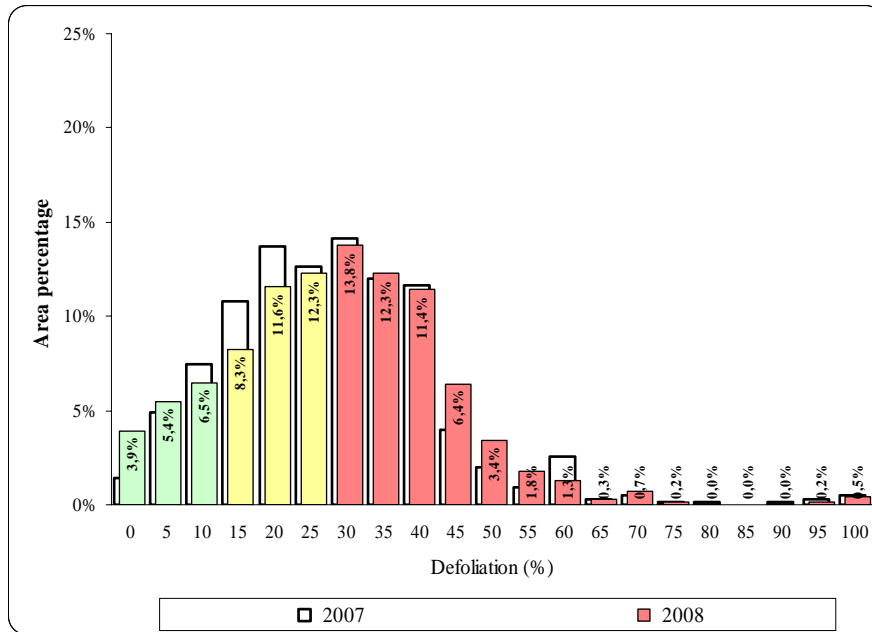
Percentage of forest area: about 16 %
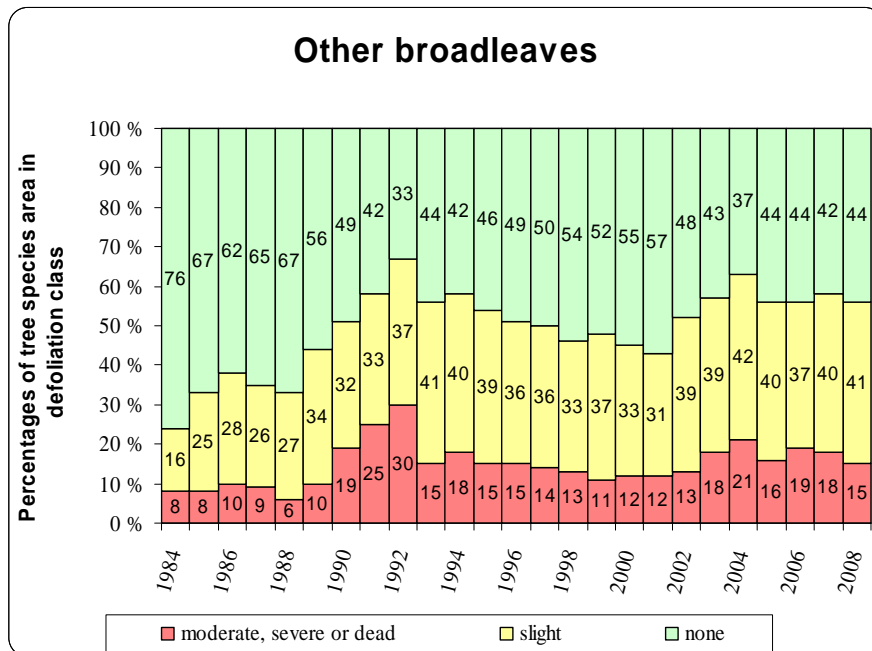
Figure 15:   *Other broadleaves; Development of defoliation classes since 1984 (until 1989 without new laender; 1'350 sample trees in 2008)*

Table 8:   **Other broadleaves: Development of defoliation classes since 1984 [% of area]**

Year	0 (undamaged)	1 (warning stage)	2 – 4 (damaged)
1984	76	16	8
1985	67	25	8
1986	62	28	10
1987	65	26	9
1988	67	27	6
1989	56	34	10
1990	49	32	19
1991	42	33	25
1992	33	37	30
1993	44	41	15
1994	42	40	18
1995	46	39	15
1996	49	36	15
1997	50	36	14
1998	54	33	13
1999	52	37	11
2000	55	33	12
2001	57	31	12
2002	48	39	13
2003	43	39	18
2004	37	42	21
2005	44	40	16
2006	44	37	19
2007	42	40	18
2008	44	41	15
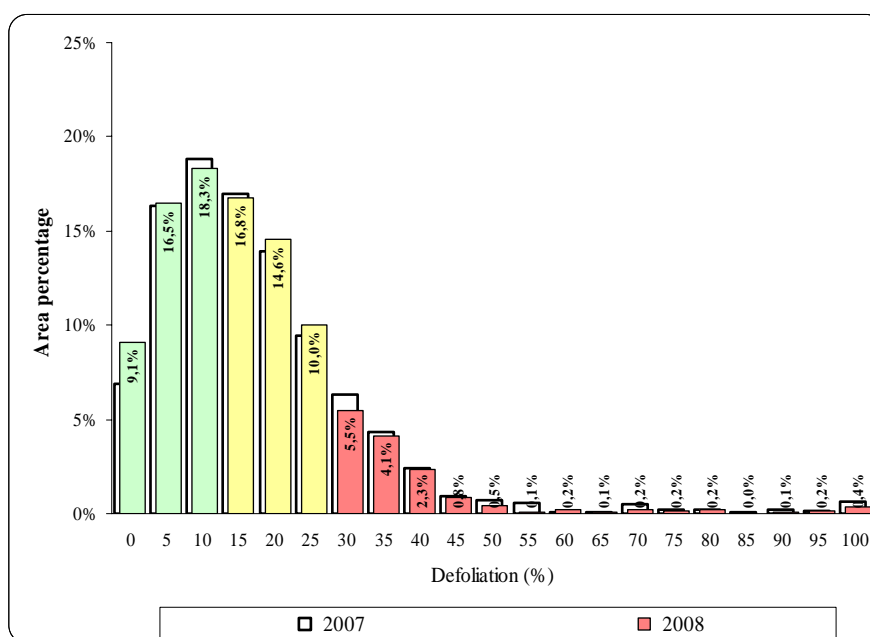
Figure 16:   *Other broadleaves: Distribution of defoliation assessed in 5 %-steps in 2007 and 2008*

(defoliation class 0 green, defoliation class 1 yellow, defoliation classes 2 – 4 red)

Influence of tree age on defoliation

Older trees are in general more affected by defoliation than younger ones. The following figure shows the percentages of defoliation classes 2 – 4 separately for young trees (up to 60 years) and older trees.

Figure 17:   Development of the percentage of damaged trees (defoliation classes 2 – 4) by tree species and age classes

Forest Condition in the German laender

While the national results are based on the data from the national 16kmx16km-grid, the *laender* use denser grids to gain reliable information at the regional scale. The following table shows the main results as communicated by the *laender* to the Federal Ministry of Food, Agriculture and Consumer Protection.

Table 9:   Forest condition in the German *laender* 2008

Percentage of defoliation classes 2 to 4 and change compared with 2007

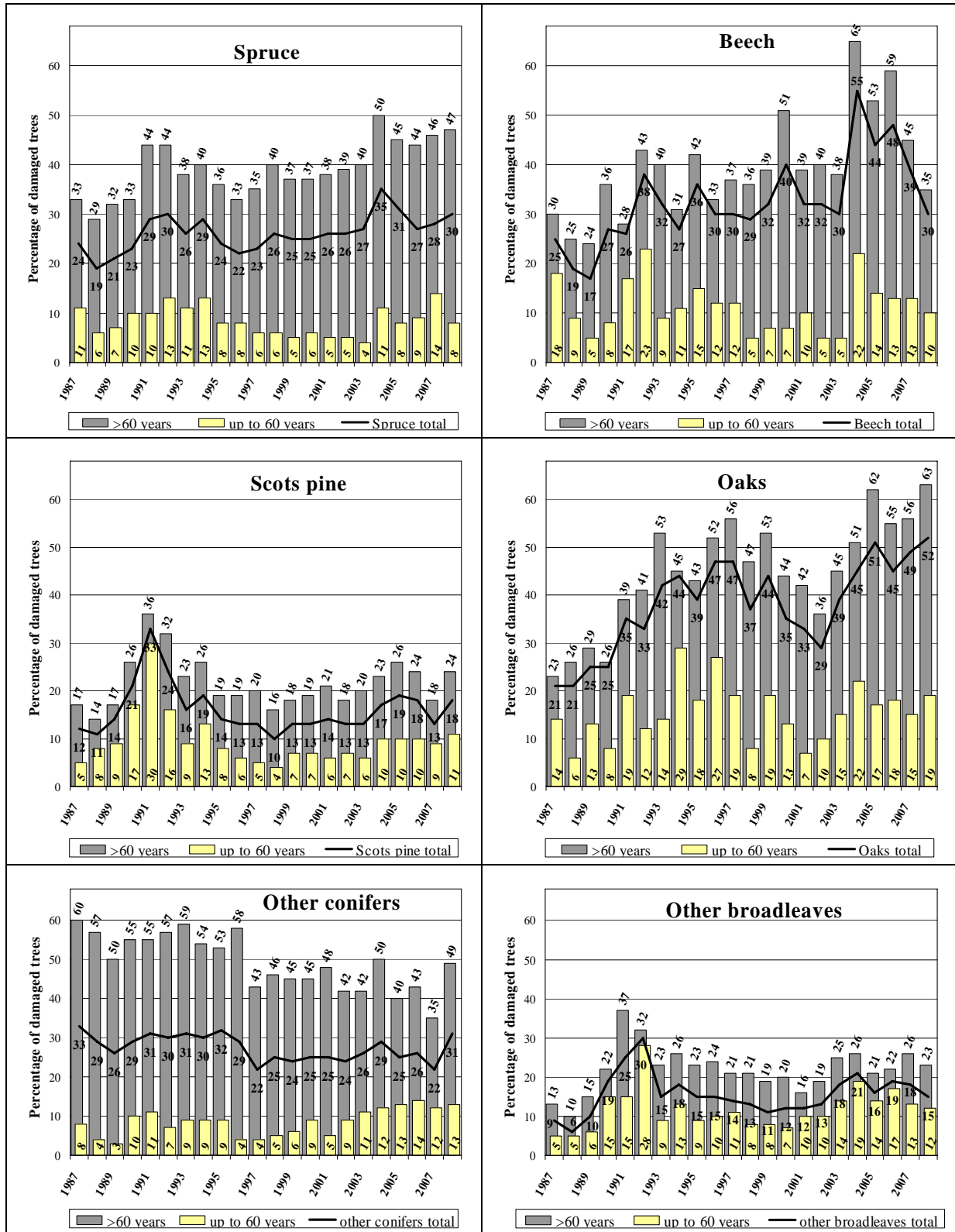| Land	All Tree species Area percentage [%] (*Change in percentage points*)	Spruce Area percentage [%] (*Change in percentage points*)	Scots Pine Area percentage [%] (*Change in percentage points*)	Beech Area percentage [%] (*Change in percentage points*)	Oaks Area percentage [%] (*Change in percentage points*)	Grid Grid width [km²]
Baden-Württemberg	**35** *(-5)*	**31** *(-7)*	**41** *(-2)*	**42** *(-3)*	**64** *(-5)*	8x8
Bayern	**28** *(-1)*	**29** *(-1)*	**29** *(+2)*	**23** *(-6)*	**46** *(+5)*	8x8
Berlin	**29** *(-3)*	**o. A.**	**24** *(+4)*	**o. A.**	**57** *(-12)*	2x2
Brandenburg	**16** *(+4)*	**o. A.**	**15** *(+5)*	**27** *(-5)*	**28** *(-6)*	4x4[2]
Bremen	**6** *(+1)*	**15** *(o. A.)*	**2** *(o. A.)*	**10** *(o. A.)*	**10** *(o. A.)*	0,2x0,1
Hamburg	**o. A.**	**o. A.**	**o. A.**	**o. A.**	**o. A.**	16x16
Hessen	**23** *(-13)*	**22** *(-8)*	**23** *(-4)*	**26** *(-12)*	**29** *(-21)*	8x8[3]
Mecklenburg-Vorpommern	**22** *(+5)*	**26** *(-1)*	**21** *(+8)*	**16** *(-7)*	**34** *(-2)*	8x8
Niedersachsen	**16** *(±0)*	**24** *(+2)*	**4** *(+1)*	**31** *(-5)*	**36** *(-4)*	8x8[4]
Nordrhein-Westfalen	**25** *(-2)*	**20** *(-3)*	**20** *(+7)*	**25** *(-17)*	**51** *(+8)*	4x4
Rheinland-Pfalz	**31** *(+3)*	**19** *(-2)*	**20** *(+5)*	**42** *(+6)*	**60** *(+10)*	4x4
Saarland	**38** *(-5)*	**30** *(-3)*	**67** *(+5)*	**33** *(-17)*	**52** *(+2)*	2x4
Sachsen	**17** *(-3)*	**15** *(-3)*	**11** *(-4)*	**31** *(-6)*	**34** *(-8)*	4x4
Sachsen-Anhalt	**18** *(+2)*	**33** *(±0)*	**6** *(+4)*	**38** *(-8)*	**43** *(-3)*	4x4
Schleswig-Holstein	**28** *(-2)*	**44** *(+1)*	**8** *(+4)*	**28** *(-21)*	**27** *(-4)*	8x8
Thüringen	**34** *(-1)*	**29** *(-1)*	**51** *(+10)*	**30** *(-10)*	**52** *(-8)*	4x4

o. A.: no information; sample size too small

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[2] Scots pine: 8x8

[3] denser grid (4x4) in the Rhine-Main-Region

[4] additional plots in a 4x4 km-grid for beech and oak (all plots where at least 6 beech or oak trees can be found)

For more information on forest condition at the *laender* level, the following list of links facilitates the access to the forest condition reports of the *laender*.

Baden-Württemberg: www.fva-bw.de/

Bayern: www.lwf.bayern.de/ ; www.forst.bayern.de

Berlin: http://www.stadtentwicklung.berlin.de/forsten/waldzustand/

Brandenburg: www.lfe.brandenburg.de

Hessen: www.nw-fva.de ; www.hmulv.hessen.de

Mecklenburg-Vorpommern: www.wald-mv.de

Niedersachsen: www.nw-fva.de; www.ml.niedersachsen.de

Nordrhein-Westfalen: http://www.wald-und-
holz.nrw.de/65Wald_und_Umwelt/Waldzustandserhebung/Bericht_2008/index.php

Rheinland-Pfalz: http://www.fawf.wald-rlp.de/

                                  under „Veröffentlichungen, Waldzustandsbericht"

Saarland: http://www.saarland.de/8256.htm

Sachsen: http://www.smul.sachsen.de/sbs/

Sachsen-Anhalt   www.nw-fva.de; www.mlu.sachsen-anhalt.de

Schleswig-Holstein: http://www.schleswig-
holstein.de/UmweltLandwirtschaft/DE/NaturschutzForstJagd/06__Wald/01__Informationen/0
3__Waldzustand/01__Schadensbericht/ein__node.html

Thüringen: www.thueringenforst.de

Annex

Forest condition survey: assessment and classification methods

Forest condition has been assessed annually in the old *laender* since 1984 and in the new *laender* since 1990. The statistical sampling of crown condition on a systematic permanent grid is currently the only method allowing to get large scale and timely information on the vitality of forests at the national level at reasonable costs. Crown condition is considered an indicator for tree vitality. Defoliation is defined as a loss of leaves or needles as compared to a reference tree with full foliage and assessed in 5% steps. The results of the survey can be expressed as **mean defoliation**, i.e. the average of the defoliation found on all sample trees.

The 5 %-classes can also be aggregated to defoliation classes of different width (cf. table 9). A defoliation of more than 25 % is conventionally taken as a threshold for damage. Therefore, defoliation classes 2, 3 and 4 are often presented together and referred to as "damaged".

Table 10:   Definition of defoliation classes

Defoliation class	Needle-/leaf loss	degree of defoliation
0	0 – 10 %	none
1	11 – 25 %	slight (warning stage)
2	26 – 60 %	moderate
3	61 – 99 %	severe
4	100 %	dead

In addition to defoliation, further characteristics of the crown (e. g. the degree of flowering and fruiting) as well as the presence of symptoms of abiotic and biotic damage are assessed.

Environmental monitoring of forest ecosystems

The national forest condition survey is part of a broader **environmental monitoring of forest ecosystems**. It has been developed and established since the 80ies to monitor and describe environmental changes and their impact on forest ecosystems. It includes national large scale assessments on a **systematic grid** (referred to as "**Level I**") and the **intensive monitoring** of various environmental parameters on a number of permanent plots (**Level II**). The German monitoring programme is closely linked to a European programme (ICP-Forests) which is unique in the world by its assessment approach harmonized at the European level and the broad participation of currently 41 countries. More information under www.icp-forests.org . In the 80ies, acidification and eutrophication by air-born pollutants were the main concern. Today, the data and time-series of the monitoring programme gain in importance when assessing the impact of climate change and developing adaptation strategies for forestry.

The **crown condition assessment** takes place every year in July and August on a 16 km x 16 km-grid. At the national scale, it yields reliable representative information on the main tree species. The national grid is a sub-sample of the denser grids established by the laender to gain information at the regional scale. The most common plot design is a 4-point cross-cluster oriented along the main compass directions at a distance of 25 m from the grid point. On each of the four sub-plots, the 6 nearest trees are chosen, resulting in 24 sample trees per plot.[5]

The national **Forest Soil Inventory** takes also place on the Level-I grid, but with four times the plot number of the forest condition survey on the 8 km x 8 km grid points. It is a common project of the Federal Government and the laender aimed to improve the knowledge on the status of forest soils and its changes over time. This knowledge is needed to develop and evaluate measures to prevent soil deterioration. The first national forest soil inventory took place between 1987 and 1993. The second one started in spring 2006 and is still ongoing.

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[5] some laender use sligthly different but comparable plot designs

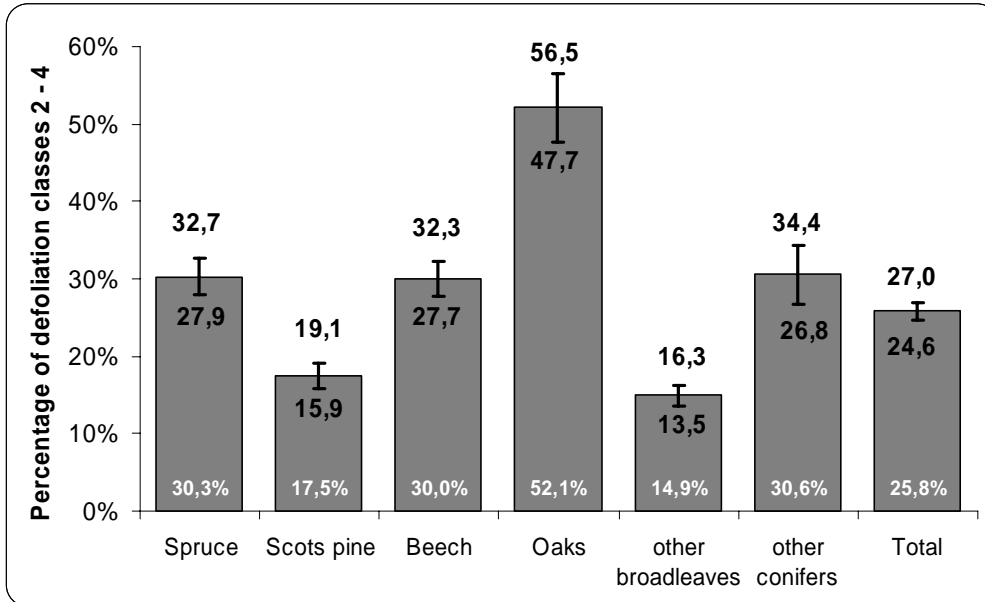## *Accuracy of the forest condition assessment 2008*

Figure 18:   *Percentages of Defoliation classes 2 to 4 by tree species in 2008; the whiskers show the standard error*

The whiskers show the borders within which the true value can be expected with a probability of 68 %.

Table 11:   **Percentages of Defoliation classes 2 to 4 by tree species in 2008: Mean and Standard error**

Tree Species	Mean [%]	Standard error [percentage points]
Spruce *(Picea abies)*	30.3	±2.2
Scots pine *(Pinus sylvestris)*	17.5	±1.6
Beech *(Fagus sylvatica)*	30.0	±2.3
Oaks *(Quercus petraea, Q. robur)*	52.1	±4.4
other broadleaves	14.9	±1.4
other conifers	30.6	±3.8
Total (all tree species)	**25.8**	**±1.2**