Convention on Long-Range Transboundary Air Pollution

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

Results of the International Cross-calibration Courses 2003

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BFH

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1 Introduction

As in the year 2002 only 2 courses could be implemented: The International Cross-calibration Course on Norway spruce and Common beech in Germany in August 10 to 13and the International Cross-calibration Course on Scots pine and Silver birch in Estonia in August 19-22. A third course in Greece on Black pine and Aleppo pine had to be cancelled mainly due to organizational problems.

Each year the host country is focussing on a special issue. In the year 2003 during the ICC in Germany e.g. a relatively high number of stands with varying stand density and tree age were prepared to enable an evaluation on aspects related with these variables. In Estonia the participants were asked to make two estimates based on the upper third of the crown and on the entire crown, respectively, or at least to note which part of the crown was assessed. This aimed on possible differences between assessments due to differences in the assessable crown.

2 Data and Methods

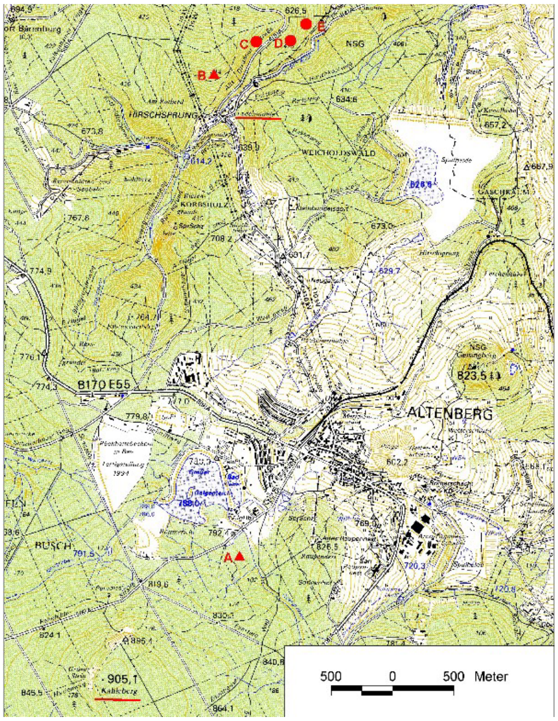
2.1 International Cross-Calibration Course for Crown Condition Assessment – Black pine and Aleppo pine – Greece

The ICC in Greece was cancelled due to organizational problems.

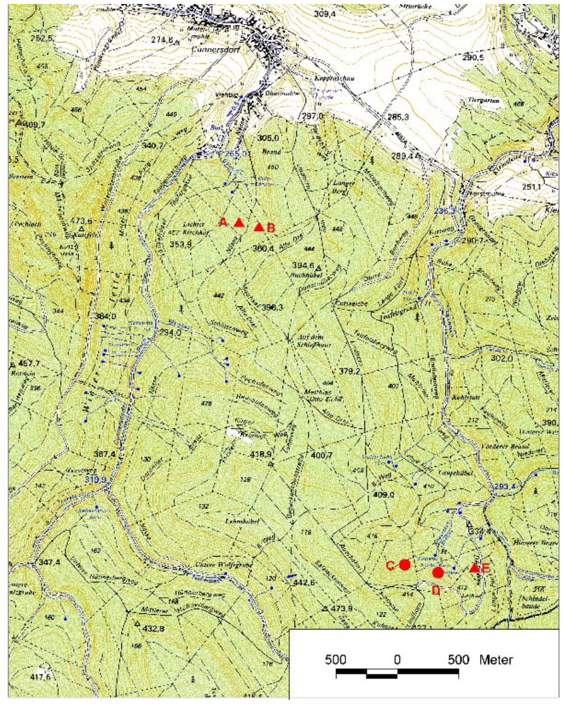
2.2 International Cross-Calibration Course for Crown Condition Assessment – Norway spruce and Common beech – August 10-13, Bad Gottleuba, Saxony, Germany

For both tree species 4 plots were prepared. These 8 plots are located in two survey areas south and east of Bad Gottleuba in the south of Dresden the capital of Saxony. The two areas were named “Altenberg”, located in the Ore Mountains, and “Cunnersdorf”, Elbe Sandstone Mountains. The plots were selected in a way that almost no transportation of the participants was necessary between the plot assessments (Map 1 and). Because of the time efficient location of the plots all trees could be assessed by most of the participants. Nevertheless, some of them could not do all assessments in time. Perhaps this could be used as an indication that even with respect to a time efficient organization two pure assessment days are too short for the assessment of 8 plots or 4 plots a day are too much to assess in time, respectively. A further plot in Cunnersdorf which was prepared in addition for the assessment of Norway spruce was not assessed during the course at all.

Map 1: Area Altenberg[1]; Norway spruce (triangle) and beech plots (circle)



Map 2: Area Cunnersdorf; Norway spruce (triangle) and beech plots (circle)



The plots in area "Altenberg" are located in the Ore Mountains and are expected to be exposed to relatively high deposition loads, especially in the past. Namely, plot p0401, Alt_A, is located in direct neighborhood to a region were forest decline was from the seventies on. Trees on this plot showed typical crowns for the extreme site and deposition conditions.

Table 1: Test range plots ICC 2003 in Bad Gottleuba; stand and site parameters as provided during the course.

Code evaluation	code course	area	tree species	age	density	altitude [m a.s.l.]	prec. [mm]	temp. [°C]
p0401	Alt_A[I)]	Altenberg	Norway spruce	46	0,6	800	1000	4,3
p0402	Alt_B	Altenberg	Norway spruce	119	0,8	675	830	6,4
p0403	Alt_C[)]_D	Altenberg	Europ. beech	147/168	1,1/0,8	575-650	830	6,4
p0404	Alt_E	Altenberg	Europ. beech	168	1,0	575-625	830	6,4
p0405	Cun_A[I)]	Cunnersdorf	Norway spruce	93/106	0,8	325	790	7,8
p0406	Cun_B	Cunnersdorf	Norway spruce	93	0,9	325	790	7,8
p0407	Cun_C	Cunnersdorf	Europ. beech	153	0,9	370-425	800	7,5
p0408	Cun_D[I)]	Cunnersdorf	Europ. beech	83	1,0	390	800	7,5
	Cun_E	Cunnersdorf	Norway spruce			not assessed		

[I)] real Level I or national assessment plot

[1] Topografische Karte 1:25000 herausgegeben vom Landesforstpräsidium Sachsen mit Erlaubnis des Landesvermessungsamtes Sachsen; Erlaubnis-Nr.: 12/04-B

Information on site characteristics (altitude, orographic description, mean annual air temperature and sum of precipitation, climatic zone, nutrient status, and soil moisture) and stand information (tree species, age, top height, top diameter, timber volume, and density) was provided to the participants for each plot. Additionally, common information about the region, its forest and their history was given. The location of the plots and the position of the individual trees was documented on maps which facilitated the work of the participants. For each tree also a fixed position from where the first assessment had to be done was marked in the maps and in the field to increase the comparability of the assessments. Participants were asked to make a second assessment following their implemented national method in case that it would have led to another assessment due to different views on a tree crown.

Some descriptive statistics are listed in Table 2 in order to give an overview about the level and range of defoliation assessments during the course. In general, the range of the assessments is wide but e.g. for plot p0408 the range was only 45%.The highest standard deviation was found for the plots p0401 and p0407. These plots showed also the highest median and mean values together with plot p0403.

Table 2: Plot specific statistics of the defoliation assessments in Bad Gottleuba.

plot	n obs	mean	median	std	min	max
p0401	297	26.5	25	18.4	0	95
p0402	300	17.5	15	14.2	0	85
p0403	300	33.2	30	15.0	5	85
p0404	253	18.0	15	10.4	0	50
p0405	300	17.6	15	11.3	0	70
p0406	196	11.7	10	11.4	0	60
p0407	300	35.8	35	17.4	0	85
p0408	298	14.5	15	10.3	0	45

In all, 18 experts from 9 countries participated in the course (Table 3). Mr. Haußmann and Mr. Fischer from the ICP Forests were mostly involved in organizational issues and not directly in the crown condition assessments. According to the national procedures some participants built teams leading to a maximum number of 11 assessment values for each tree. The assessments of Mr. Gibas are not taken into account producing any statistic in this report because of his low experience.

Table 3: Participants ICC 2003 in Bad Gottleuba; shaded names indicate the participation in the ICC 2000 in Saxony.

Country	Name	code course	code evaluation
ICP Forests	Mr Thomas Haußmann		
PCC of ICP Forests	Mr Richard Fischer		
Austria	Mr Günter Rössler	AU	GER01
Czech Republic	Mr Lukas Neuman	CZ1	GER02
Czech Republic	Ms Ludmila Bohacova		
Denmark	Ms Iben M. Thomsen	DK	GER03
Denmark	Mr Mogens Egebjerg Pedersen		
Hungary	Mr János Kapcsándi	HU	GER04
Hungary	Mr Pál Kovácsevics		

Country	Name	code course	code evaluation
Ireland	Mr Pat Neville	IRL	GER05
Italy	Mr Alberto Cozzi	IT	GER06
Italy	Mr Jacopo Ristori		
Sweden	Mr Stefan Anderson	SW	GER07
Switzerland	Mr Alfred Potzinger	CH	GER08
Switzerland	Mr Raphael Siegrist		
Germany	Mr Milan Gibas	DE Gibas / DE1	GER09 [I)]
Germany	Mr Alexander Böttiger	DE Böttiger / DE2	GER10
Germany	Mr Henry Barthold	DE Sachsen	GER11
Germany	Mr Mario Helbig		
Germany	Mr Arnd Schöndube		

[I)] Mr Gibas was doing his practical course, his assessments are of no interest for the ICP Forests and will not be evaluated in this report.

Table 4 shows that some of the participants did not assess all trees or all plots, respectively.

Table 4: Number of assessments ICC 2003 in Bad Gottleuba.

	GER 01	GER 02	GER 03	GER 04	GER 05	GER 06	GER 07	GER 08	GER 10	GER 11
p0401	30	30	30	*29*	30	30	30	30	*28*	30
p0402	30	30	30	30	30	30	30	30	30	30
p0403	30	30	30	30	30	30	30	30	30	30
p0404	30	30	30	*15*	*28*	30	30	30	*0*	30
p0405	30	30	30	30	30	30	30	30	30	30
p0406	*0*	30	*0*	*16*	30	30	30	30	*0*	30
p0407	30	30	30	30	30	30	30	30	30	30
p0408	30	30	30	30	30	*28*	30	30	30	30

2.3 International Cross-Calibration Course for Crown Condition Assessment – Scots pine and Silver birch – August 19-22, Pühajärve, Estonia

During the ICC 2003 in Estonia four plots built the test range. On each plot 30 trees were assessed. These 4 plots were located in the forests around Pühajärve, south of Tartu in the southern part of Estonia.

Table 5: Test range plots ICC 2003 in Pühajärve.

code evaluation	code course	tree species	age	note	height [m]	silviculture
p5901	plot 1	Scots pine	100/110	Harznutzung (resin (?)), eher licht		thinning ~ 5 years ago
p5902	plot 2	Scots pine	60	with Norway spruce	~17 ten years ago	
p5903	plot 3	Silver birch	-	with spruce and pine	22-23	thinning 2 years ago
p5904	plot 4	Silver birch	75	with spruce and pine (mostly smaller); strong wind during assessment		

The participant on behalf of the PCC of ICP Forests did not make own assessments (Table 7). The data of 14 national experts from 8 countries were collected. Because of the possibility that two values were given by some experts for the same tree the maximum number of 20 assessments per tree was made during the course. Which of the assessments is following the Level I assessments in the respective country is documented in Table 10.

Some plot specific descriptive statistics of the assessments done during the course in Pühajärve are presented in Table 6. All plots show a satisfying wide range of assessment values. Whereas the Scots pine plots (p5901 and p5902) are of different level of defoliation on the plots p5903 and p5904 with Silver birch mean and median values of the assessments are relatively similar. However, standard deviation and range for plot p5904 are lowest of all plots in Pühajärve.

Table 6: Plot specific statistics of the defoliation assessments in Pühajärve.

plot	n obs	mean	median	std	min	max
p5901	600	28.4	25	18.6	5	95
p5902	480	22.0	15	16.7	5	95
p5903	450	25.3	20	14.3	5	80
p5904	450	23.4	20	9.5	0	55

Table 7: Participants ICC 2003 in Pühajärve.

Country	Name	assessed part of crown	code evaluation
PCC of ICP Forests	Mr Volker Mues		
Belgium	Mr Gert Sioen	varying	EST01
Estonia	Mr Enn Kaljula	upper third	EST02
		entire crown	EST03
Estonia	Mr Heino Ounap	upper third	EST04
		entire crown	EST05
Finland	Mr Kimmo Siuruainen	varying	EST06
Finland	Mr Hannu Autio	varying	
Germany	Mr Mario Helbig	varying	EST07
Latvia	Mr Ieva Zadeika	upper third	EST08
		entire crown	EST09
Lithuania	Mr Ricardas Beniusis	upper third	EST10
		entire crown	EST11
Lithuania	Mr Vaidas Grigaitis	upper third	EST12
		entire crown	EST13
Lithuania	Mr Raimundas Lavrenovas	upper third	EST14
		entire crown	EST15
Lithuania	Mr Vidas Stakenas	upper third	EST16
		entire crown	EST17
Norway	Mr Rune Eriksen	varying	EST18
Norway	Mr Volkmar Timmermann	varying	EST19
Sweden	Mr Soren Wulff	varying	EST20

Table 8 shows the number of assessments of all teams per plot. The lack of assessments from the teams 9, 11, 13, 15, and 17 on some plots is because the teams from Latvia and Lithuania made some additional assessments for the entire crown for the plots p5901 and p5902 which were not done at the other plots. Thus, all teams made at least one assessment per tree on all plots following their national method. The additional values were done to detect possible differences with other teams caused by differences in the assessed part of the crown.

Table 8: Number of assessments per plot and team ICC 2003 in Pühajärve.

	EST 01	EST 02	EST 03	EST 04	EST 05	EST 06	EST 07	EST 08	EST 09	EST 10	EST 11	EST 12	EST 13	EST 14	EST 15	EST 16	EST 17	EST 18	EST 19	EST 20
p5901	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
p5902	30	30	30	30	30	30	30	30	30	30	*0*	30	*0*	30	*0*	30	*0*	30	30	30
p5903	30	30	30	30	30	30	30	30	*0*	30	*0*	30	*0*	30	*0*	30	*0*	30	30	30
p5904	30	30	30	30	30	30	30	30	*0*	30	*0*	30	*0*	30	*0*	30	*0*	30	30	30

2.4 Statistics

In general, the evaluation of the 2003 ICCs focussed on the same issues as the evaluation of the 2002 and 2001 ICCs (MUES & SEIDLING 2002). The correlation between the assessments of two paired teams were calculated as Spearman rank correlation coefficients instead of Pearson correlation coefficient (PROC CORR, SAS 1999). PROC CORR computes the Spearman's correlation by ranking the data and using the ranks in the Pearson product-moment correlation formula. In case of ties, the averaged ranks are used. Significant correlations are printed bold in this report.

The difference between the assessments of two paired teams was evaluated as relative frequency (PROC FREQ, SAS 1999) of those absolute differences which were lower than 5%, 10%, or 20%, respectively. This descriptive statistic was chosen instead of the percentage of absolute agreement which was used in the evaluation of the courses in 2001 and 2002 in order to get more reasonable shares of satisfying values (e.g. +/-5%). Additionally, the null hypothesis that there is no difference in location for defoliation among the teams was tested using the Kruskal-Wallis test (PROC NPAR1WAY, SAS 1999).

3 Results

The results of evaluations are presented in the same order for all tree species: Firstly, the plot specific **distributions** of the assessments of each participant are described. Secondly, the percentages of assessment **differences** within a range of 5%, 10%, or 20% for pairs of teams are presented followed by the results of the Kruskal-Wallis test in order to describe differences in the level of assessments and thirdly, the SPEARMAN **correlation coefficients** describe the coherency with respect to the ranking of the trees among two teams. It is a non parametric statistic and was tested for significance.

3.1 ICC 2003 on Norway spruce and Common beech in Germany

3.1.1 Norway spruce

In order to describe the plot specific **distribution** of the assessments minimum, maximum, mean, median, and standard deviation were (as error index of mean value) were used to produce graphics (Annex 1). These show that especially at p0401 and p0402 at least some trees of higher defoliation are part of the test range. The range of defoliation values at the both other plot are lower, especially in case of plot p0406 for which not all teams made assessments. At all plots some teams (GER01, GER03, and GER08) tend to make relatively low defoliation assessments while others make relatively high assessments (GER04 and GER11). This “ranking” among the teams is relatively consistent. E.g. the assessments of GER02 are higher than those of GER01 and GER03. In addition, the teams mostly had the same ranking of the plot levels of defoliation as described by mean and median values in Table 2. An exception of the general order def(p0406) < def(p0405) < def(p0402) < def(p0401) can be observed for GER04. This is probably because of this team is not used in assessing defoliation of Norway spruce which is not a main tree species in the respective home country. In addition the extraordinary situation at plot p0401, recuperating Norway spruce after very strong defoliation, must be recognized.

The **differences** between the assessments of two participants can be calculated easily. The frequency of absolute differences lower or equal 5%, 10% and 20% are presented in Annex 5. The interpretation of the tables is demonstrated by the pair GER02-GER03: 49% of all Norway spruce trees which were assessed by both teams had absolute differences lower or equal 5%, 76% are lower or equal 10% and for 98% of the trees absolute difference lower or equal 20% were found. In Annex 5 percentages below a specific level which is indicated at the upper left of each of the three tables are written bold and red to facilitate the finding of pairs which show stronger deviations. The tables show that assessments of the teams GER01, GER08, GER11, and especially GER04 deviate relatively strong from the assessments of the other teams. For almost all pairs significant differences of the level of defoliation were found by the Kruskal-Wallis test (Annex 6). Only within the group GER02, GER10, and GER11 and within the group GER03, GER05, GER06, and GER07 the levels are not significantly different.

The SPEARMAN **correlation** coefficient describes the coherency of the assessments of two teams with respect to their ranking. The correlation coefficients for the Norway spruce assessments are presented in Annex 7. The values are between 0.4 (teams 2 and 4) and 0.87 (teams 7 and 11). All correlation coefficients are significant at a significance level of 5%. Also all correlation coefficients which are calculated plot specific (not figured) are statistically significant.

3.1.2 Common beech

The graphics of the plot specific **distributions** in Annex 2 are produced in the way described for Norway spruce in 3.1.1. The range of defoliation assessments is wide at the plots p0403 and p0407. In general, the ranking of the plots following Table 2 is def(p0408) < def(p0404) < def(p0403) < def(p0407). This order is not the same for all teams. Again GER04 deviates with relatively low assessments at plot p0407 and high assessments at p0403. GER07 and GER11 made the highest assessments at most plots while GER01, GER02, GER03, and GER08 made relatively low assessments.

For Common beech the frequencies of absolute differences lower or equal the three limits 5%, 10%, and 20% are presented in Annex 8. The assessments of GER03 and GER04 showed higher deviations from the assessments of the other teams. In addition GER07 and GER11 deviated from the assessments of GER01-GER04. Many pairs of teams made assessments at significantly different levels (Annex 9). Only within the group GER05, GER06, GER07, GER10, and GER11 and within the group GER01, GER02, GER03, GER04, and GER08 the levels are not all significantly different.

The SPEARMAN **correlation** coefficients for Common beech are presented in Annex 10. All correlation coefficients (between 0.52 and 0.90) are significant (α=0.05). If calculated plot specific some correlation coefficients are not significant (not figured). Almost all not significant correlation coefficients are calculated for pairs with participation of team ger04 or ger01 as indicated in Table 9. Perhaps more important could be the observation that all but one not significant correlation were found at plot p0404.

Table 9: Not significant correlation coefficients (SPEARMAN) for plot specific calculation on Common beech assessments; most frequent teams in italic format.

plot	team A	team B	$r_{Spearman}$
p0404	ger03	*ger01*	0.24
p0404	*ger04*	*ger01*	0.44
p0404	*ger04*	ger02	0.15
p0404	*ger04*	ger03	0.30
p0404	*ger04*	ger05	0.33
p0404	*ger04*	ger07	0.50
p0404	*ger04*	ger11	0.38
p0404	ger06	ger02	0.34
p0404	ger08	*ger01*	0.32
p0408	ger05	*ger01*	0.28

3.2 ICC 2003 on Scots pine and Silver birch in Estonia

3.2.1 Scots pine

The range of the assessments for Scots pine (p5901 and p5902) are wide as presented by the **distribution** graphics (Annex 3). Mean of all assessments as well as median (Table 6) show that defoliation assessments at p5902 were lower than those at p5901. Especially at p5901 the level of defoliation is very similar as it is described by the graphic in Annex 3. However, as it is shown also for p5903 EST03, EST05, EST06, and EST09 tend to make lower defoliation assessments. At both plots EST02 and EST07 are of the higher assessing participants. EST09 made the only assessments for p5901 which were lower than those for p5902.

The pair wise **differences** (Annex 11) show that groups of participants can be distinguished: EST01, EST02, EST04, EST07, and EST08 on one hand made very similar assessments with deviations to the assessments of a group consisting of EST03, EST05, and EST06. No other grouping were found but for pairs with EST09 relatively low shares of differences to assessments of other participants lower or equal +/- 20% were found which indicates that there is were some bigger differences. The Kruskal-Wallis test (Annex 12) for Scots pine shows again that there are groups of participants with significant differences in level of assessed defoliation: EST03, EST05, EST06, EST09, EST18, and EST20 on one hand and the other participants on the other hand.

All **correlation** coefficients for Scots pine in Annex 13 are significant (α=0.05) and reach values from 0.47 to 0.96 and also the plot specific correlation coefficients for all pairs are significant.

3.2.2 Silver birch

The **distributions** of the assessments for silver birch as presented in Annex 4 show a wider range for p5903 than for p5904. This confirms the results of Table 6. The level of defoliation of both plots does not deviate so much over all teams. The assessments of

EST06 are relatively low whereas those of EST03, EST05 and EST07 tend to be relatively high.

The **differences** between the paired assessments as presented in Annex 14 for Silver birch are very low. Correspondingly, the Kruskal-Wallis test (Annex 15) indicated only few pairs with significantly different level of assessed defoliation, mostly pairs with EST05, EST06, EST07, EST10, EST19, or EST20.

The **correlation** coefficients for Silver birch in Annex 16 reach values from 0.53 to 0.92 and all are significant (α=0.05). Also the plot specific calculation (not figured) leads to significant correlations for all pairs of teams.

3.3 Comparison with ICC 2000 in Germany

In the year 2000 the last ICC in Germany was organized by the same people and many of the participants in 2003 already participated this ICC. In 2000, beneath other plots one plot for Norway spruce and another for Common beech were assessed, each of them with 20 trees. In order to get values for a comparison with the assessments from 2000 those two plots were prepared for the ICC 2003 (Norway spruce on p0405 and Common beech on p0407) in the same stands. Only the plot specific distributions from 2000 and 2003 are compared, a tree specific comparison could not be done in this first evaluation due to temporal limitations.

The interpretation of the comparison results must not be over interpreted! It must be kept in mind that not only the trees were not really the same in both years but also that the aim of the 2000 course in Saxony was not the recording of possible differences but the calibration of the participants in order to get more similar results. This former approach aimed on the “adaptation” of the assessment methodology of the participants and it is possible that relatively high assessments on the first plot which was assessed in 2000 gave a participant the feeling that he should make lower assessments on the next plot and tree species although deviating from his national methodology. Thus, a comparison with assessments made before the implementation of the new ICC strategy in the test phase 2001/2002 could lead to misleading results.

3.3.1 Norway spruce, p0405 – Cun_A

The distributions for the Norway spruce assessments of the participants in 2000 (Figure 1) and in 2003 (Figure 2) show some similar and some less similar features. E.g. in both years teams 4 and 11 made rather high assessments whereas teams 1 and 8 made rather lower ones. On the other hand, teams 3 and 5 made in relation to the other teams lower assessments in 2003 than in 2000.

Figure 1: Distribution of Norway spruce assessments in 2000.

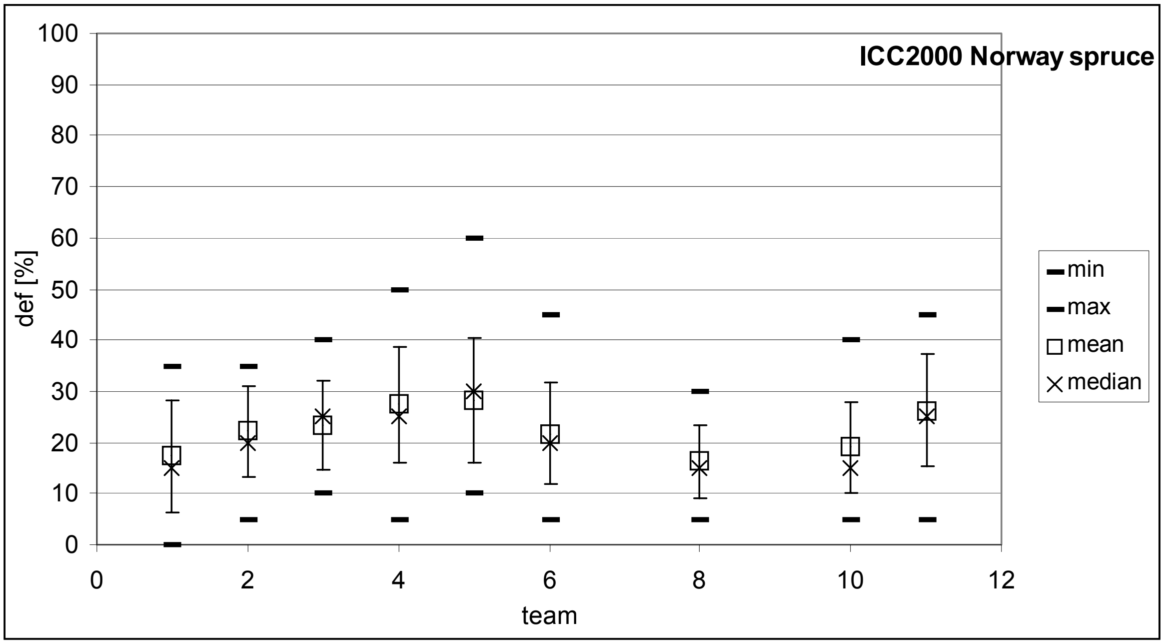
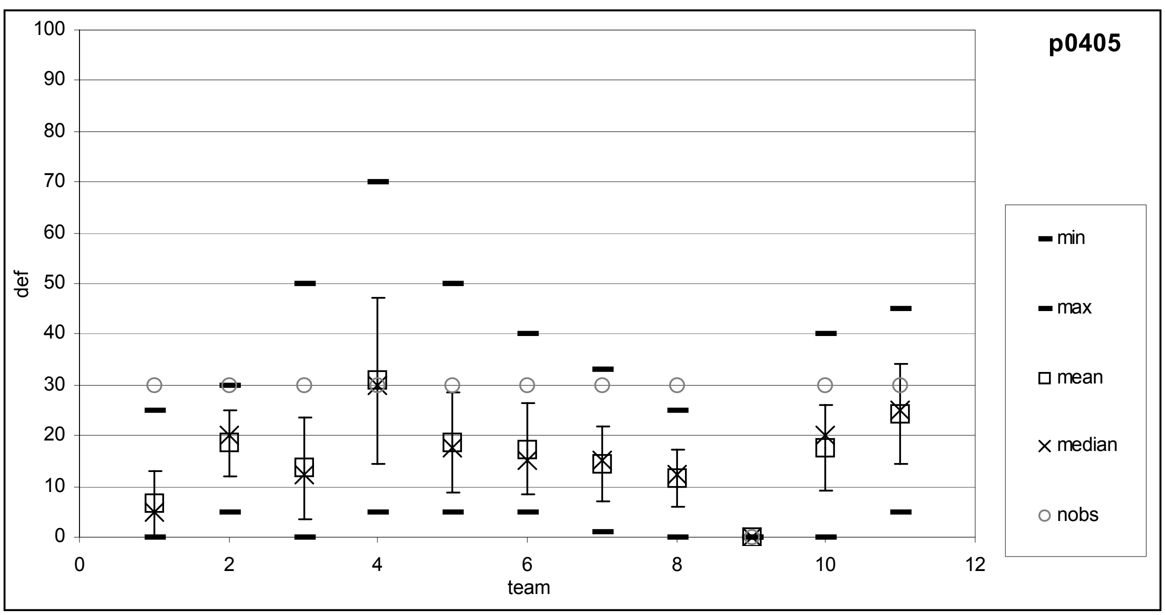


Figure 2: Distribution of assessments 2003 on plot p0405.



3.3.2 Common beech, p0407 – Cun_C

The comparison of the assessment distributions for Common beech in 2000 (Figure 3) and in 2003 (Figure 4) show that in both years team 11 made relatively high assessments whereas team 1 made rather high assessments in 2000 and average ones in 2003, the assessments of team 3 were lower than those of team 4 in 2000 while in 2003 the relation was the opposite. Similar differences can be observed for other pairs of teams.

Figure 3: Distribution of Common beech assessments in 2000.

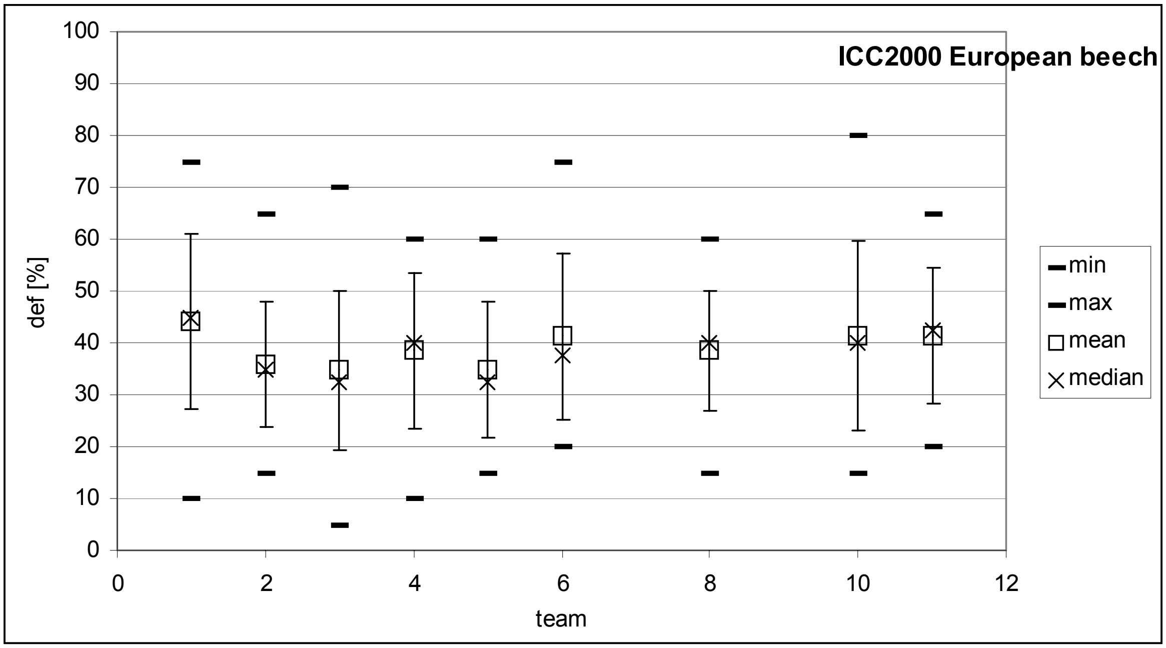
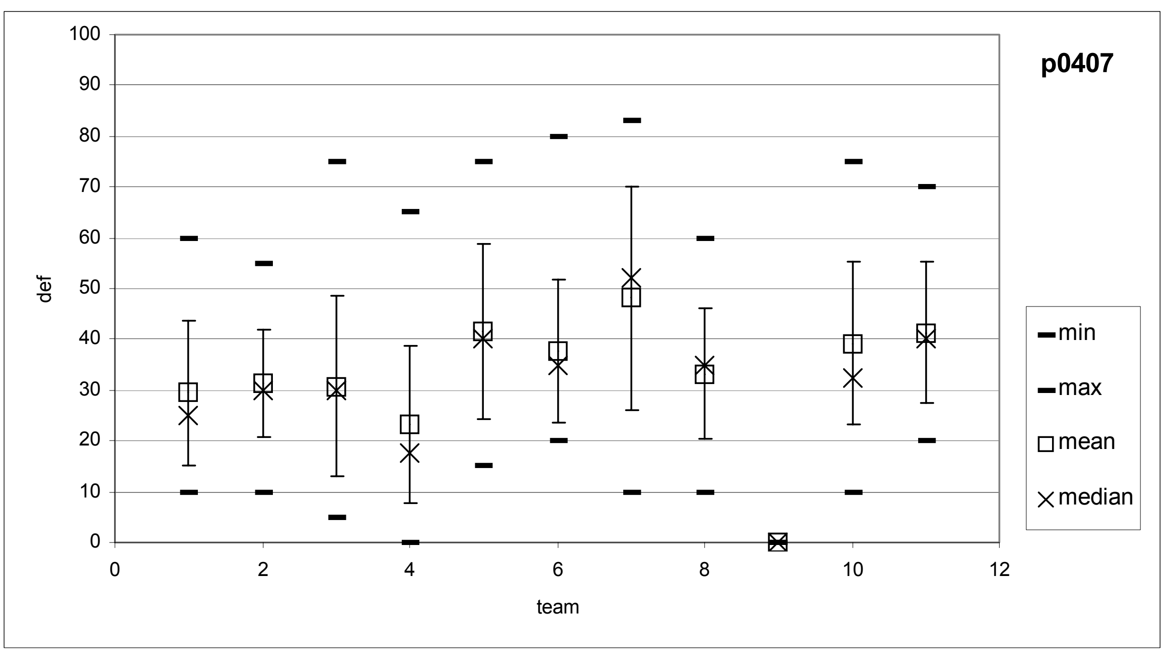


Figure 4: Distribution of assessments 2003 on plot p0407.



4 Discussions during the courses

4.1 ICC 2003 in Germany

Following the guidelines for International Cross-calibration Courses (FERRETTI et al., 2003) during the field exercises of the ICC 2003 in Germany there were no discussions of the assessments or the crown condition of single trees. A general discussion was held at the end of the course. Points which were discussed:

- does the leaf size influence the assessments?
- if branches and twigs are missing, because they have never developed or have later fallen off, is this defoliation?
- how many needle years can be expected for Norway spruce under different conditions?
- if the top died several years ago, is this defoliation?
- where does the crown start and which part of it is assessed?
- how did fructification influence the assessments?

There were deviating opinions to most of the discussed points. The statistics presented in 3 may be used to get a rough impression of how strong deviations between the participants are. For studying the reasons for the deviations a more comprehensive database will be needed.

4.2 ICC 2003 in Estonia

During the ICC 2003 in Estonia the results of the participants was discussed at the end of each field exercise to get a better impression of possible reasons for deviations between the assessments of participants. This procedure deviates from that described in the guidelines for International Cross-calibration Courses (Ferretti et al., 2003) and at least some participants indicated that they were not sure to be not influenced by those discussion when doing the next assessments. The earliest time for discussion should be after finishing the last plot of the tree species. To avoid any bias of the assessments any discussion and comparing presentation of the defoliation assessments should be done after the last field assessment. Especially for less experienced participants the discussions after each plot assessments could be very helpful to understand the proceeding of the participants but the ICCs no longer aim on a training effect of the participating National Reference Teams (NRTs).

The relatively strong differences in defoliation between the upper and the lower part of the crowns, especially in case of Silver birch, was pointed out at several plots/trees. If this had an influence on the similarity of the assessments done by the participating teams will be discussed in 5.1. To get an impression of the differences the assessed parts of the crowns are listed in the following Table 10 as given by the participants during the final discussion:

Table 10: Assessed part of the crown.

country	Scots pine	Silver birch
Lativia	upper third / entire excepted competition influenced [I)]	same as Scots pine
Norway	upper 2/3	The whole assessable crown
Sweden	upper 2/3 at most	same as Scots pine
Germany	crown not being influenced by competition (in present and past)	same as Scots pine
Lithuania	whole crown (excluding competition zone) = assessable crown	same as Scots pine
Finland	upper 2/3	same as Scots pine
Estonia	upper 1/3 [I)] and whole crown	same as Scots pine
Belgium/Flanders	whole crown	same as Scots pine

[I)] sent to PCC

Some differences could be explained by differences in how the assessable crown is defined in the participating countries. E.g. even if the “entire (living) crown” is assessed by two participants it can not mean exactly the same part of the crown. In addition, the heavy flowering in this year was

The following additional points were discussed at the end of the course:

- selection of stands and trees, the visibility of the crowns
- need for fixed positions
- need for definition of reference trees by the host country

In general, the selection of stands by the Estonian hosts was stated to be very useful. The stands were more or less typical ones but not those of highest density. The selection of trees should follow an objective methodology and not be done in a subjective way to enable for getting general conclusions by statistical evaluations. The visibility of the crowns was one of the criteria chosen for the selection of test range trees and therefor given in most cases.

There were no fixed positions marked in the field from where the single trees had to be assessed for the first assessment. The discussions on some special trees with relatively high differences in defoliation assessments showed that varying positions from where the assessments were made were caused the most differences. This underlined the position which was made already on the ICC 2002 in Norway and in the ICC annex of the ICP Forests manual (under preparation) that at least the first assessment for a tree should be made from a fixed position in order to increase comparability of the assessments. A second one can be made after following a probably country specific deviating individual procedure.

No reference trees were given by the host country as recommended in the ICC guidelines and the participants did not miss it. If they use local reference trees they defined it by themselves.

5 Concluding Remarks and Recommendations

For the reasons described in 3.3 the comparison with the 2000 assessments are not interpreted further and only the results of the ICC 2003 are basis of the following remarks and recommendations. The availability of assessments for the same trees will increase with the repetition of ICCs at the test range implemented since 2001. Respective analysis shall lead to reliable results on temporal consistency.

5.1 Evaluation of assessments

The results of the ICCs 2003 according to tree specific differences, differences in location of the assessment distributions and to the pair wise correlation coefficients are presented in 3.1 and 3.2. The rank correlations show clearly that the methodologies the participants follow lead to a consistent ranking of the trees. This is this most important result and basic for a common evaluation and presentation of the European monitoring data on forest condition.

The comparison of the location of the assessment distributions shows for many pairs of teams significant differences. In most cases these differences are of low level as the tree specific differences show: For most pairs of participants a huge part of the tree specific differences are within a range of +/-5%, or at least +/-10%, respectively. Relatively high frequencies of differences of more than +/-20% are exceptions which can be explained by environmental or stand conditions of the test range plots, the respective participants are not used to work with. Those effects of low experience with special conditions or certain tree species which are less frequent in the country of a participant, however, are not expected to be important concerning the outcomes of the ICP Forests monitoring system.

5.2 Evaluation of course structures

In 2003 both courses, in general, followed the guidelines for International Cross-calibration Courses (FERRETTI et al., 2003). Some departures from the guidelines were made and will be discussed as well as recognized advantages and disadvantages of the guidelines themselves.

The implementation of long term test ranges leads to a relatively high efforts for the host countries. Both host countries of the ICCs 2003 as well as those of the years before made a very good job in managing the organizational tasks. However, the re- assessment of the same trees and plots will save time in the future and, thus, will be an important advantage of the new ICC concept. The most time consuming preparation in the field will be to re-allocate and mark the trees and fixed positions.

The principle to use fixed positions for the first assessment of a tree was used in Germany 2003. It is very likely that the fixed positions on one hand led to a higher comparability of the assessments and that this procedure saved time in the field. On the other hand there were made no second assessments by the participants following further and probably other positions and views of the crown which would be used following the pure national methodology. Because of this, the comparability of the results with the field assessments made in the respective home countries during the survey period can be reduced. For the future we clearly need a second assessment for each tree where the prepared fixed position deviates from the position(s) which would be used following the respective national methodology. To make this second assessment more time will be needed and 4 plots each with 30 trees could be too much to assess within the given time. On the other hand, 3 plots for each of two tree species per ICC should be assessable and give enough possibilities to assess trees under varying stand and site conditions.

The test range in Germany consists of real Level I or national plots. This guaranties an objective tree selection as well as the assessment under real Level I conditions. On the other hand the selection of the plots remains subjective and must be the decision of the host country in order to allow for a effective course organization. For the same reason it must be underlined that the selection of real Level I plots is of advantage for the interpretation of the course results but more important is a time effective structure of the test ranges.

With respect to the variation of stand and site conditions it can be stated that a reduction of the distance between the test range plots allows for a very time effective field work and reduces noise caused by too much variation in site conditions. If e.g. 3 test range plots of a certain tree species vary with respect to 8 site parameters which could influence the assessments of at least some of the participants a reliable evaluation of cause-effect relationships is not possible. If the differences between two teams change from one plot to the next the reason for this change will not be identifiable in case that too much parameters are different between both plots.

A clear statement can and must be made about the discussions during the field exercises. Although discussions during the field survey or before the finalization of the last plot can help the participants - and in particular the participating staff who is engaged in the evaluation of defoliation assessments - to understand which reasons can probably cause different assessments for the same tree the possible disadvantage of biased assessments at the following plots is much more important. The ICCs aim at reporting assessment values which are as close to the nationally used methodology as it is possible. Any adaptation to the assessments of other participants would lead to a bias of the assessments.

The selection of trees should follow objective criteria to assure the reliability of the found results. In any case it would be good to document the used methods.

6 References

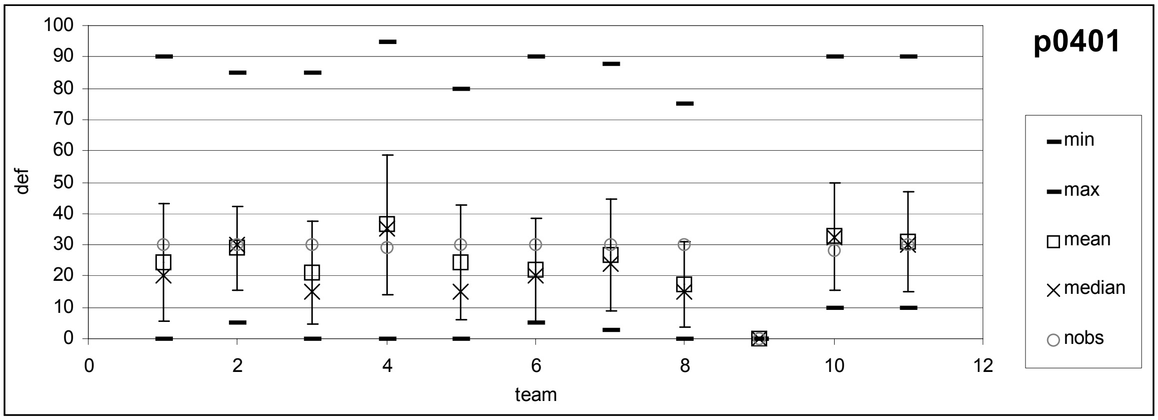
Ferretti, M., Mues, V., Durrant, D., Eichhorn, J., Lorenz, M., and Szepesi, A. 2003: New Design of International Cross-Calibration Courses of ICP Forests and the EU Scheme. Guidelines ICP Forests, BFH, Germany.

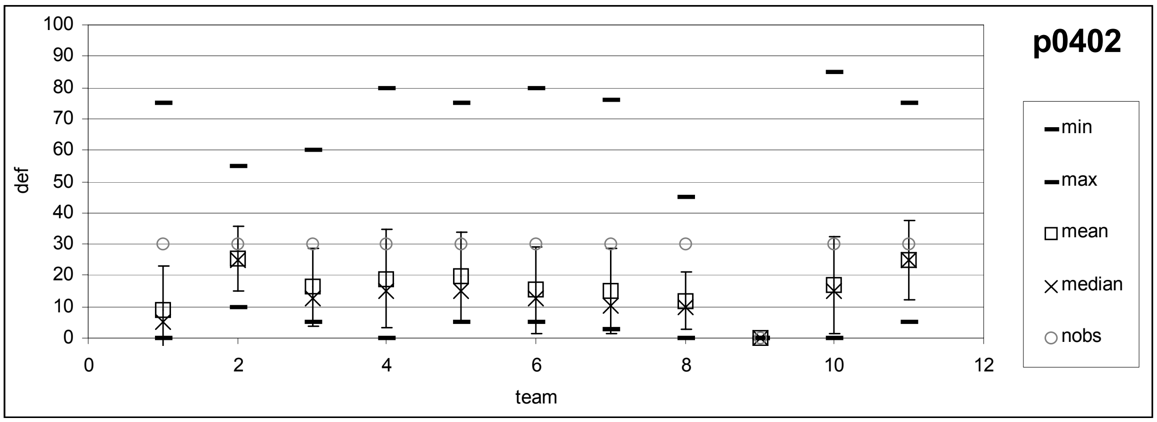
Mues, V. and Seidling, W. 2002: Evaluations of the International Cross-calibration Courses 2001 and 2002. BFH, Germany.

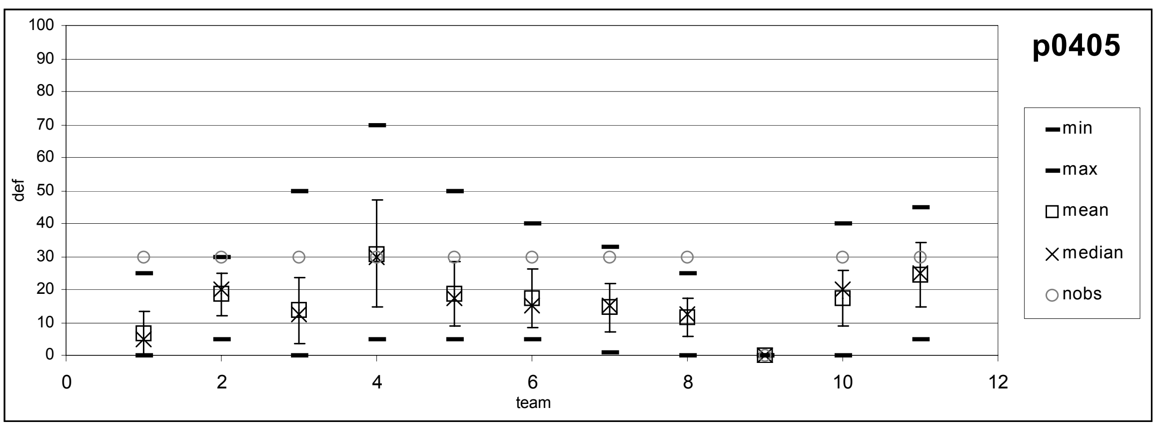
SAS 1999: SAS OnlineDoc, Version Eight. SAS Institute Inc., Cary, NC, USA

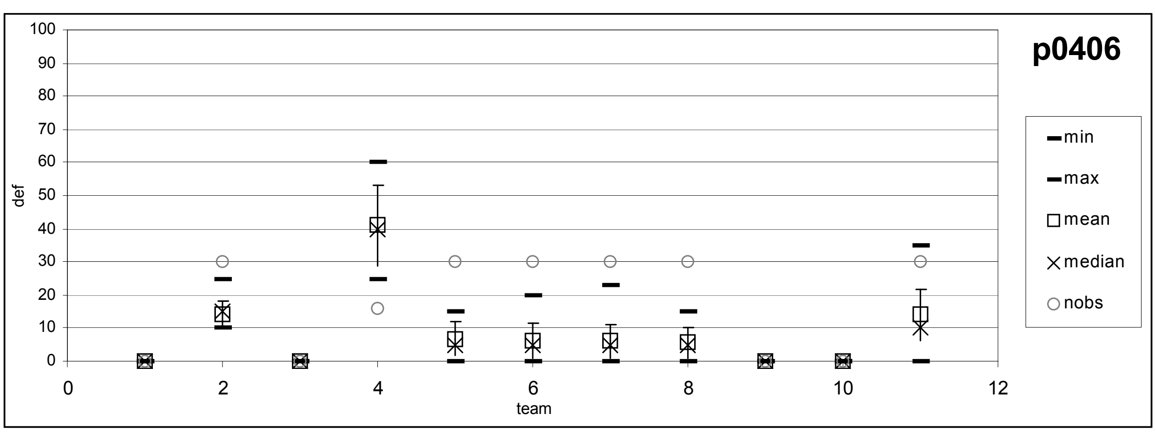
Annexes

Annex 1: Distribution of assessments for Norway spruce.

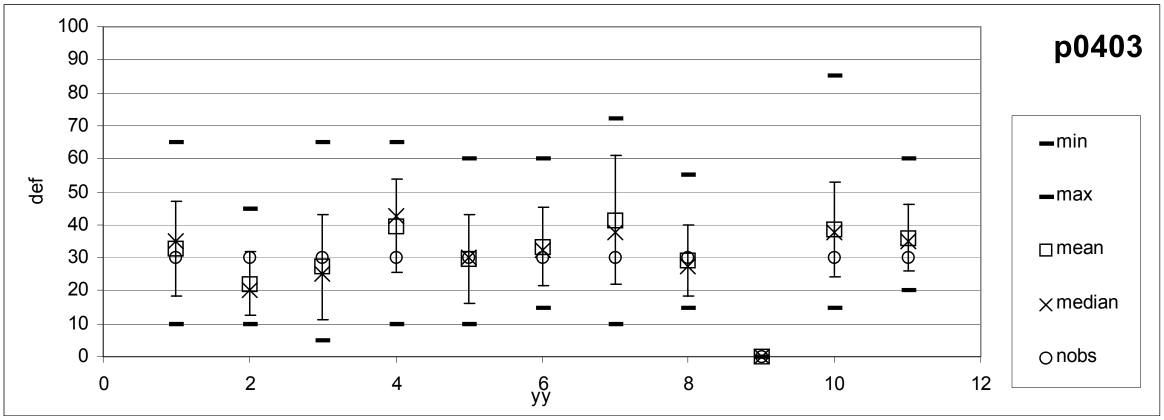


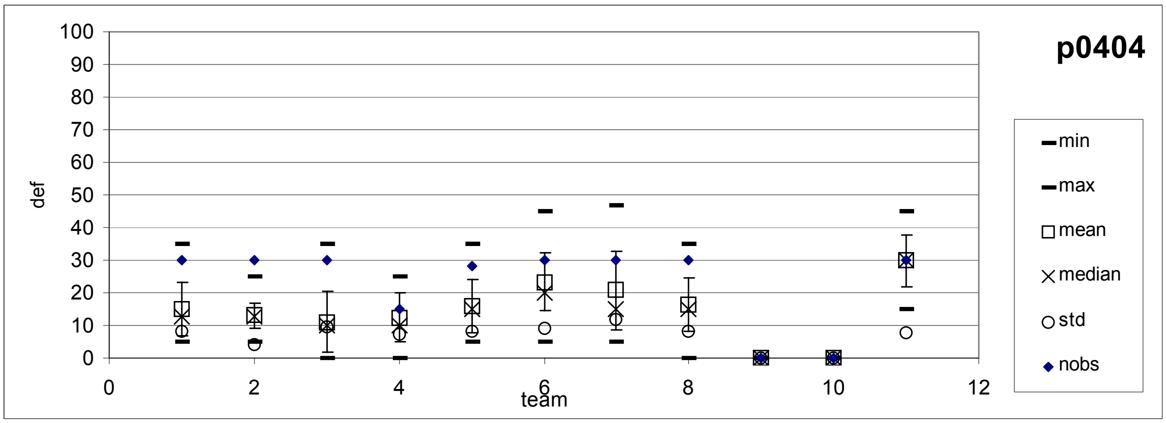


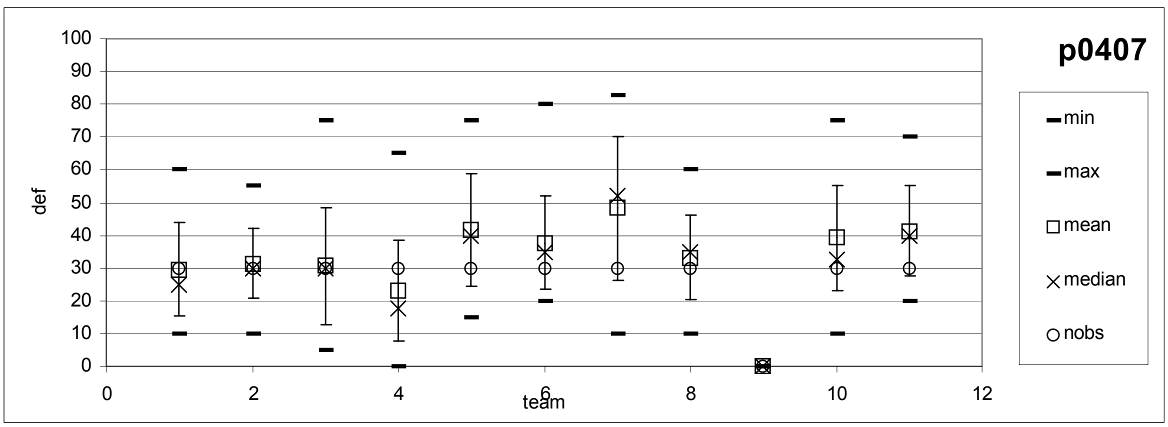


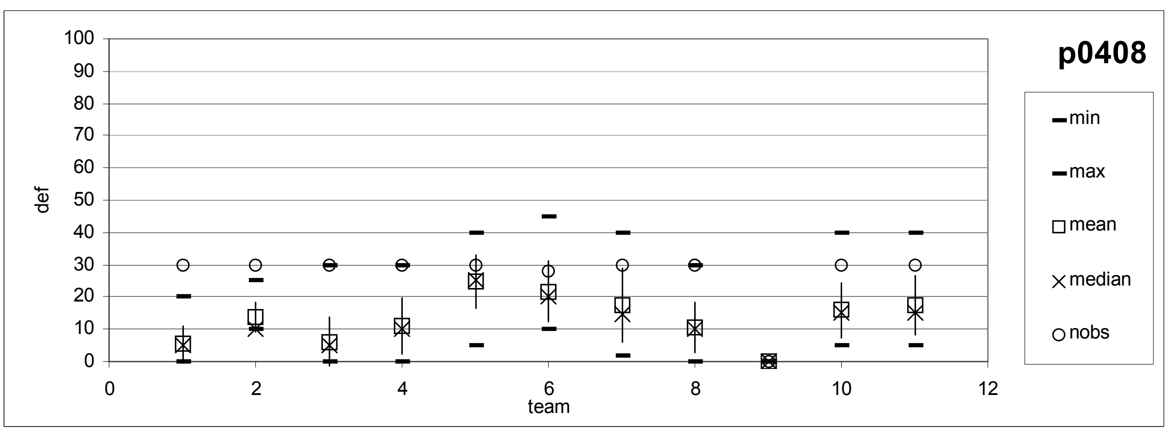


Annex 2: Distribution of assessments for Common beech.

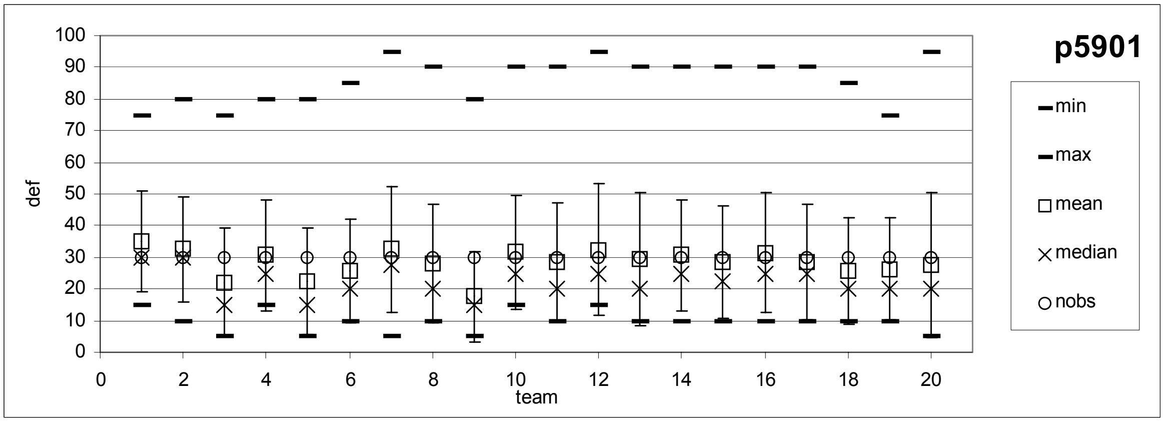


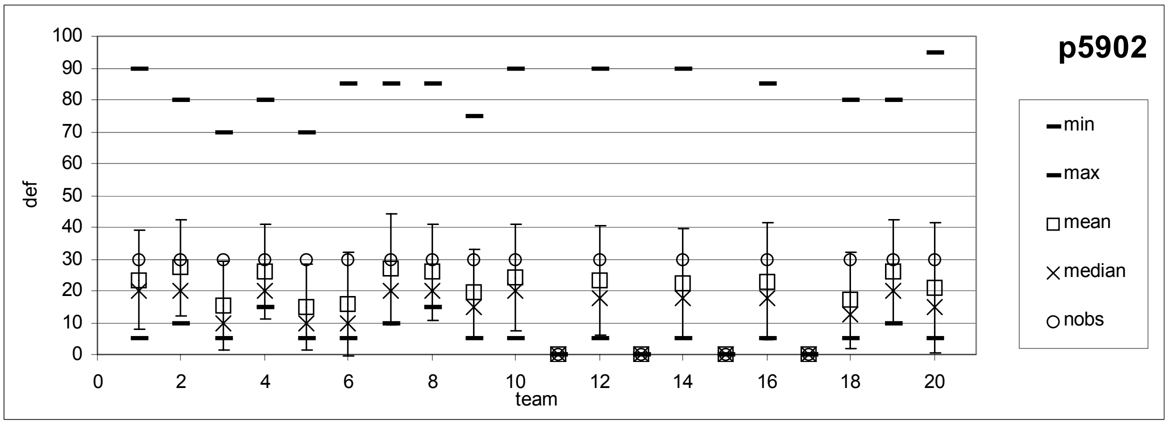




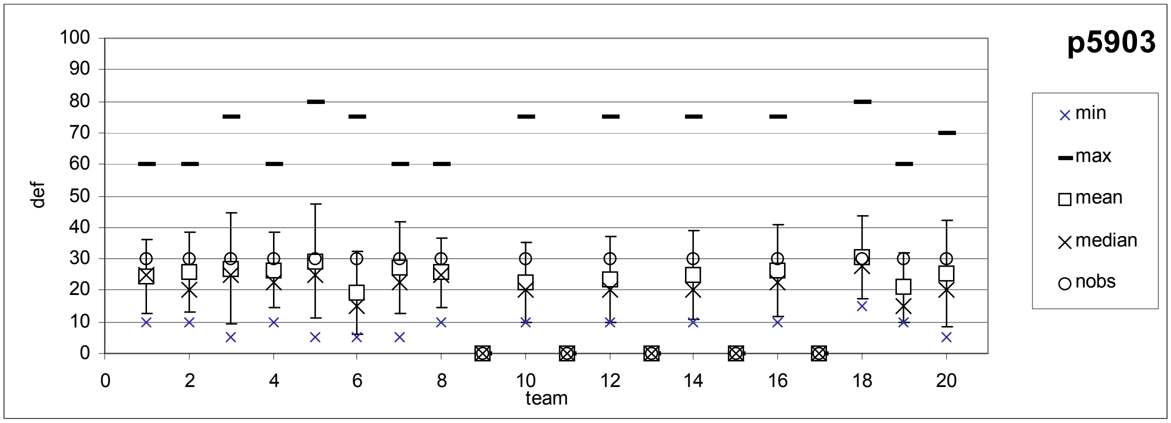


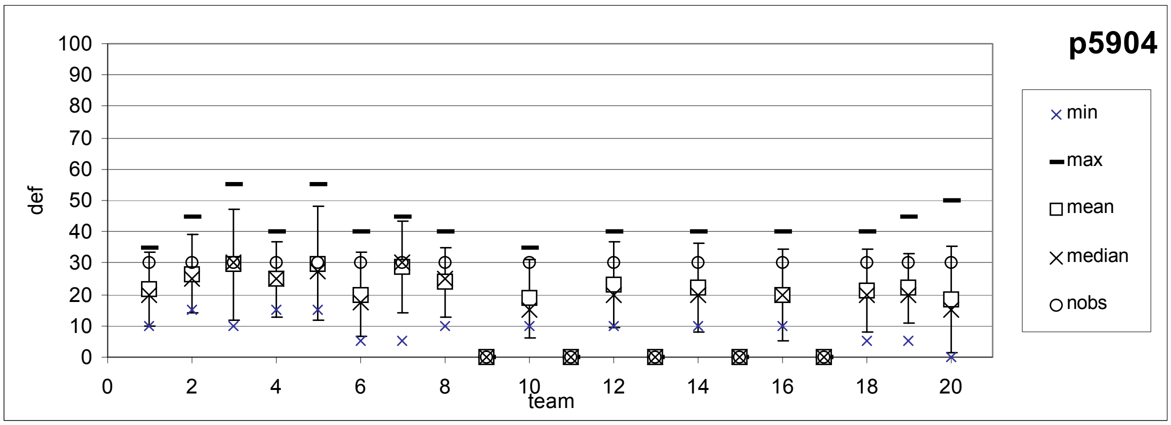
Annex 3: Distribution of assessments for Scots pine.





Annex 4: Distribution of assessments for Silver birch.





Annex 5: Frequency of absolute differences lower or equal 5%, 10%, and 20% for Norway spruce.

40					team					
absdif +/-5	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
2	**20**									
3	62	49								
4	**30**	**33**	**37**							
5	40	57	62	**37**						
6	54	48	72	40	78					
7	46	56	70	42	70	87				
8	69	**33**	69	**26**	67	72	66			
9										
10	**31**	59	58	45	59	66	77	50		
11	**26**	72	**34**	41	53	43	53	**27**		51

60										
absdif +/-10	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
2	**48**									
3	84	76								
4	**45**	**56**	**52**							
5	73	83	86	60						
6	81	78	89	**55**	92					
7	79	83	88	**58**	91	96				
8	88	71	83	**41**	83	92	88			
9										
10	73	82	78	64	84	84	93	75		
11	**38**	91	66	63	79	79	86	**53**		86

90										
absdif +/-20	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
2	93									
3	94	98								
4	**73**	**78**	**76**							
5	96	98	94	**78**						
6	98	98	98	**72**	100					
7	99	99	96	**73**	100	99				
8	97	97	97	**65**	97	99	98			
9										
10	97	97	93	91	98	97	97	92		
11	91	99	97	**82**	99	98	100	98		100

Annex 6: Kruskal-Wallis test for Norway spruce; chi-Values which indicate significant differences between the assessments of two teams are shaded (α=0.05).

chi	1	2	3	4	5	6	7	8	9	10
2	43.6									
3	10.4	16.1								
4	49.6	12.9	30.3							
5	11.2	18.4	0.0	33.6						
6	5.7	30.1	1.4	45.7	1.4					
7	11.3	19.4	0.0	35.3	0.0	1.3				
8	0.7	67.0	11.1	70.3	12.0	4.8	11.3			
9										
10	27.1	0.4	7.9	11.3	9.1	16.0	9.6	39.4		
11	43.9	1.1	19.2	7.7	21.4	33.5	22.5	66.2		2.2

Annex 7: Correlation coefficient for Norway spruce; significant correlation coefficients are shaded (α=0.05).

	1	2	3	4	5	6	7	8	9	10
2	0.75									
3	0.77	0.74								
4	0.68	0.40	0.62							
5	0.70	0.74	0.76	0.52						
6	0.73	0.70	0.79	0.52	0.82					
7	0.78	0.71	0.76	0.54	0.77	0.84				
8	0.75	0.73	0.70	0.59	0.77	0.78	0.80			
9										
10	0.84	0.68	0.74	0.72	0.72	0.74	0.83	0.73		
11	0.79	0.76	0.83	0.53	0.77	0.85	0.87	0.83		0.79

Annex 8: Frequency of absolute differences lower or equal 5%, 10%, and 20% for Common beech.

40					team					
absdif +/-5	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
2	53									
3	61	51								
4	49	41	**38**							
5	43	52	**33**	**31**						
6	42	46	**26**	**34**	55					
7	**34**	**36**	**22**	**30**	41	49				
8	65	63	57	49	49	50	42			
9										
10	43	50	**29**	40	**38**	58	**39**	47		
11	**34**	**32**	**23**	**35**	43	66	48	43		70

60										
absdif +/-10	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
2	77									
3	85	81								
4	73	67	69							
5	60	65	**53**	**50**						
6	69	70	**52**	60	78					
7	**49**	**48**	**41**	**52**	61	65				
8	87	88	85	65	69	77	**58**			
9										
10	70	64	**58**	66	67	84	63	78		
11	**57**	**53**	**43**	**55**	71	93	72	69		87

90										
absdif +/-20	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
2	97									
3	98	97								
4	96	**87**	**90**							
5	**85**	92	**84**	**86**						
6	93	92	92	92	97					
7	**79**	**73**	**77**	**78**	**87**	**90**				
8	99	99	98	92	94	95	**85**			
9										
10	99	91	94	**84**	94	97	90	97		
11	95	93	92	**88**	96	99	94	98		99

Annex 9: Kruskal-Wallis test for Common beech; chi-Values which indicate significant differences between the assessments of two teams are shaded (α=0.05).

chi	1	2	3	4	5	6	7	8	9	10
2	0.3									
3	1.7	4.3								
4	0.7	0.3	4.3							
5	15.3	19.2	25.0	7.5						
6	24.0	34.3	34.6	13.3	1.0					
7	23.1	24.5	33.2	14.1	2.1	0.4				
8	1.7	1.3	6.9	0.1	8.0	15.5	15.1			
9										
10	20.5	25.8	29.3	11.9	1.6	0.3	0.1	14.0		
11	31.1	44.0	41.7	18.3	4.7	1.9	0.0	23.5		0.2

Annex 10: Correlation coefficient for Common beech; significant correlation coefficients are shaded (α=0.05).

	1	2	3	4	5	6	7	8	9	10
2	0.72									
3	0.80	0.76								
4	0.73	0.52	0.66							
5	0.58	0.69	0.65	0.55						
6	0.78	0.70	0.76	0.68	0.73					
7	0.81	0.77	0.85	0.71	0.72	0.83				
8	0.83	0.77	0.90	0.69	0.70	0.79	0.89			
9										
10	0.90	0.81	0.88	0.71	0.64	0.80	0.86	0.89		
11	0.84	0.70	0.87	0.70	0.64	0.80	0.86	0.89		0.88

Annex 11: Frequency of absolute differences lower or equal 5%, 10%, and 20% for Scots pine.

40									team										
+/-5	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
2	75																		
3	**28**	**15**																	
4	75	92	**23**																
5	**32**	**17**	97	**27**															
6	**35**	**33**	77	48	73														
7	72	68	**37**	73	**35**	**38**													
8	67	72	**37**	80	**33**	53	75												
9	42	**37**	67	42	67	57	**38**	47											
10	83	70	42	77	42	58	78	77	45										
11	50	53	53	60	63	70	57	70	43	90									
12	67	60	48	60	47	58	67	68	55	77	60								
13	47	53	57	60	47	70	57	80	50	67	67	80							
14	72	68	55	67	52	68	73	75	52	92	83	83	73						
15	50	53	63	53	53	77	63	70	**37**	77	87	67	77	93					
16	70	53	48	63	48	63	65	68	47	85	80	73	63	87	83				
17	**33**	50	57	50	53	80	67	80	**33**	70	77	67	70	87	97	80			
18	48	42	75	55	70	88	52	58	62	55	63	52	67	65	77	63	70		
19	55	72	40	73	43	53	67	75	55	67	53	52	50	68	63	57	57	55	
20	50	43	70	48	67	70	60	52	65	67	60	67	70	68	67	63	70	65	57

60																			
+/-10	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
2	88																		
3	67	63																	
4	92	98	80																
5	67	**57**	98	82															
6	78	75	93	82	95														
7	93	93	63	90	62	68													
8	87	88	73	92	78	80	90												
9	**57**	**58**	85	73	87	88	63	87											
10	95	93	75	90	73	87	92	90	67										
11	80	80	83	80	80	87	83	83	70	100									
12	83	80	73	85	75	80	87	92	72	90	80								
13	70	80	73	83	73	90	70	90	60	97	97	93							
14	93	88	83	87	80	87	95	95	73	97	97	92	87						
15	77	87	80	77	77	90	90	90	67	100	97	80	87	100					
16	90	90	75	90	75	83	95	90	70	97	93	92	97	98	97				
17	83	87	77	87	73	93	87	90	70	97	93	73	87	100	100	100			
18	80	77	93	85	88	98	70	87	87	85	83	80	87	90	87	87	93		
19	85	90	75	90	75	82	88	88	75	87	70	80	73	85	77	83	80	85	
20	72	73	83	82	82	90	87	88	82	85	80	87	80	92	87	88	93	88	82

90																			
+/-20	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
2	100																		
3	98	100																	
4	98	100	100																
5	97	98	100	98															
6	98	95	100	97	100														
7	98	100	90	97	**88**	95													
8	98	98	100	100	100	100	97												
9	**88**	90	97	90	97	97	**88**	97											
10	100	98	95	100	93	98	100	100	92										
11	100	97	90	97	**87**	97	97	100	**87**	100									
12	98	95	93	97	93	93	97	95	**88**	100	97								
13	97	93	93	93	93	90	100	93	**83**	100	100	100							
14	100	98	95	100	95	100	98	100	95	100	100	100	100						
15	100	100	93	100	93	100	97	100	93	100	100	100	100	100					
16	98	100	92	98	93	97	100	100	90	100	100	100	100	100	100				
17	100	97	97	100	100	100	100	100	**87**	100	100	93	100	100	100	100			
18	97	97	100	97	100	98	95	98	97	97	97	93	90	97	97	97	97		
19	95	98	97	98	95	98	98	98	93	100	100	93	93	98	100	100	100	98	
20	98	100	93	98	92	93	100	98	90	98	93	93	93	98	97	100	93	97	98

Annex 12: Kruskal-Wallis test for Scots pine; chi-Values which indicate significant differences between the assessments of two teams are shaded (α=0.05).

chi	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
2	0.1																		
3	23.3	29.0																	
4	0.4	1.1	26.3																
5	23.3	29.0	0.0	25.9															
6	16.9	21.1	1.5	17.0	1.2														
7	0.1	0.4	21.1	0.1	20.8	14.1													
8	2.0	3.5	23.0	0.5	22.2	13.9	0.9												
9	23.2	29.1	0.7	25.0	0.4	0.3	19.9	21.0											
10	1.1	2.3	21.7	0.3	21.0	12.9	0.4	0.0	19.6										
11	0.8	1.7	15.1	0.3	14.5	8.8	0.3	0.0	13.4	0.0									
12	2.3	3.8	17.4	1.3	16.6	9.3	1.2	0.3	14.7	0.3	0.2								
13	0.8	1.6	12.6	0.5	11.8	6.8	0.4	0.1	10.4	0.1	0.0	0.0							
14	2.5	4.1	15.2	1.5	14.6	8.0	1.5	0.4	12.9	0.5	0.3	0.0	0.1						
15	0.3	0.9	14.3	0.1	13.6	8.4	0.1	0.0	12.8	0.0	0.0	0.2	0.1	0.4					
16	1.9	3.2	12.2	1.2	11.7	6.5	1.2	0.2	10.1	0.4	0.3	0.0	0.2	0.0	0.4				
17	0.3	0.7	12.8	0.0	12.3	7.9	0.1	0.1	11.5	0.0	0.0	0.3	0.1	0.4	0.0	0.4			
18	14.1	18.1	3.0	14.3	2.5	0.2	11.5	11.3	1.2	10.7	7.4	7.1	5.2	6.0	6.8	4.7	6.1		
19	2.8	4.7	16.9	2.2	15.6	8.1	1.7	0.8	13.6	0.8	0.6	0.1	0.2	0.0	0.5	0.0	0.5	6.0	
20	9.8	12.8	2.8	9.9	2.4	0.3	8.2	7.5	1.1	7.1	4.9	4.9	3.9	4.0	4.9	3.2	4.5	0.0	4.3

Annex 13: Correlation coefficient for Scots pine; significant correlation coefficients are shaded (α=0.05).

	est01	est02	est03	est04	est05	est06	est07	est08	est09	est10	est11	est12	est13	est14	est15	est16	est17	est18	est19
est02	0.83																		
est03	0.87	0.93																	
est04	0.82	0.90	0.88																
est05	0.85	0.83	0.91	0.88															
est06	0.87	0.74	0.77	0.74	0.80														
est07	0.87	0.83	0.82	0.83	0.75	0.75													
est08	0.74	0.77	0.74	0.81	0.72	0.62	0.83												
est09	0.58	0.60	0.57	0.61	0.59	0.47	0.69	0.79											
est10	0.91	0.83	0.82	0.81	0.84	0.82	0.87	0.73	0.67										
est11	0.81	0.80	0.79	0.76	0.80	0.68	0.77	0.71	0.87	0.91									
est12	0.85	0.76	0.78	0.71	0.72	0.76	0.86	0.73	0.64	0.83	0.71								
est13	0.73	0.79	0.77	0.71	0.67	0.68	0.76	0.80	0.75	0.78	0.78	0.91							
est14	0.90	0.84	0.83	0.82	0.81	0.83	0.89	0.76	0.67	0.89	0.85	0.88	0.84						
est15	0.83	0.86	0.82	0.80	0.75	0.83	0.84	0.83	0.87	0.88	0.88	0.81	0.89	0.96					
est16	0.88	0.81	0.79	0.82	0.82	0.84	0.84	0.80	0.68	0.86	0.84	0.84	0.84	0.92	0.91				
est17	0.84	0.82	0.79	0.80	0.79	0.90	0.86	0.79	0.80	0.87	0.86	0.76	0.80	0.92	0.93	0.95			
est18	0.83	0.81	0.79	0.78	0.77	0.87	0.76	0.69	0.47	0.76	0.68	0.72	0.72	0.82	0.84	0.82	0.84		
est19	0.65	0.74	0.68	0.76	0.65	0.62	0.76	0.76	0.59	0.67	0.56	0.62	0.66	0.70	0.69	0.70	0.72	0.71	
est20	0.88	0.82	0.85	0.82	0.83	0.80	0.90	0.82	0.74	0.88	0.82	0.87	0.84	0.89	0.91	0.86	0.92	0.74	0.76

Annex 14: Frequency of absolute differences lower or equal 5%, 10%, and 20% for Silver birch.

40

+/-5	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
2	60																		
3	45	88																	
4	82	80	55																
5	52	63	82	68															
6	63	55	40	43	**33**														
7	50	67	67	53	70	43													
8	82	68	65	75	62	65	62												
9	.	.	.	.	.	.	.	.											
10	85	55	47	62	45	78	**38**	68	.										
11	.	.	.	.	.	.	.	.	.	.									
12	80	58	58	70	63	70	67	77	.	80	.								
13	.	.	.	.	.	.	.	.	.	.	.	.							
14	73	73	55	72	55	75	55	80	.	78	.	83	.						
15	.	.	.	.	.	.	.	.	.	.	.	.	.	.					
16	80	52	47	65	45	68	50	77	.	80	.	78	.	90	.				
17	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
18	57	55	42	57	43	57	48	68	.	67	.	70	.	70	.	72	.		
19	67	62	45	68	45	72	45	73	.	72	.	77	.	72	.	68	.	62	
20	62	50	40	42	42	73	53	53	.	70	.	60	.	62	.	68	.	57	72

60

+/-10	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
2	87																		
3	67	97																	
4	93	95	80																
5	80	90	93	92															
6	90	78	72	82	68														
7	88	90	83	90	85	67													
8	98	93	75	98	82	85	88												
9	.	.	.	.	.	.	.	.											
10	98	80	67	88	63	97	68	90	.										
11	.	.	.	.	.	.	.	.	.	.									
12	93	87	77	87	83	90	78	88	.	93	.								
13	.	.	.	.	.	.	.	.	.	.	.	.							
14	97	92	82	95	82	90	83	95	.	97	.	95	.						
15	.	.	.	.	.	.	.	.	.	.	.	.	.	.					
16	95	92	63	92	77	85	72	93	.	97	.	92	.	97	.				
17	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
18	83	83	70	82	73	82	78	90	.	80	.	80	.	88	.	87	.		
19	93	90	77	92	80	97	75	93	.	90	.	88	.	90	.	88	.	78	
20	87	80	73	83	67	87	72	87	.	87	.	85	.	92	.	92	.	82	85

90

+/-20	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
2	100																		
3	97	100																	
4	100	100	98																
5	95	100	100	100															
6	100	100	93	98	93														
7	98	100	100	100	100	95													
8	100	100	97	100	95	100	98												
9	.	.	.	.	.	.	.	.											
10	100	97	93	98	95	100	98	98	.										
11	.	.	.	.	.	.	.	.	.	.									
12	100	98	97	98	95	98	98	100	.	100	.								
13	.	.	.	.	.	.	.	.	.	.	.	.							
14	100	100	100	100	98	100	98	100	.	100	.	100	.						
15	.	.	.	.	.	.	.	.	.	.	.	.	.	.					
16	100	100	98	100	97	100	98	98	.	98	.	100	.	100	.				
17	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
18	100	100	93	100	93	93	100	100	.	100	.	100	.	100	.	100	.		
19	100	97	95	98	92	97	98	100	.	98	.	95	.	97	.	95	.	95	
20	100	100	98	100	95	95	97	98	.	97	.	100	.	100	.	100	.	97	95

Annex 15: Kruskal-Wallis test for Silver birch; chi-Values which indicate significant differences between the assessments of two teams are shaded (α=0.05).

chi	1	2	3	4	5	6	7	8	10	12	14	16	18	19
2	1.1													
3	3.3	0.4												
4	1.6	0.1	0.5											
5	7.7	2.3	0.3	2.9										
6	5.5	11.9	11.8	13.5	18.9									
7	5.3	1.1	0.1	1.5	0.1	15.9								
8	0.8	0.1	1.1	0.2	3.6	9.5	2.3							
10	4.6	9.5	9.6	13.9	19.2	0.7	15.0	8.1						
12	0.4	2.6	3.9	4.0	9.2	4.2	6.7	1.8	2.3					
14	0.2	2.1	3.3	3.4	8.3	5.0	5.8	1.4	2.9	0.0				
16	0.5	3.2	4.4	4.3	9.4	2.8	6.8	2.3	1.1	0.1	0.2			
18	1.5	0.0	0.5	0.0	1.9	10.4	1.3	0.1	7.8	2.1	1.6	2.8		
19	1.8	6.2	6.6	8.2	13.4	1.5	10.7	4.5	0.2	0.9	1.3	0.3	5.0	
20	2.6	6.7	7.1	7.5	11.5	0.1	9.3	5.0	0.2	2.0	2.5	1.2	5.7	0.5

Annex 16: Correlation coefficient for Silver birch; significant correlation coefficients are shaded (α=0.05).

	est01	est02	est03	est04	est05	est06	est07	est08	est10	est12	est14	est16	est18	est19
est02	0.55													
est03	0.62	0.92												
est04	0.69	0.70	0.70											
est05	0.70	0.81	0.87	0.83										
est06	0.70	0.76	0.80	0.63	0.81									
est07	0.76	0.77	0.79	0.70	0.83	0.78								
est08	0.73	0.70	0.78	0.73	0.77	0.82	0.74							
est10	0.82	0.56	0.61	0.60	0.67	0.76	0.70	0.72						
est12	0.75	0.61	0.70	0.67	0.81	0.76	0.77	0.75	0.74					
est14	0.68	0.71	0.77	0.65	0.79	0.82	0.72	0.85	0.78	0.76				
est16	0.79	0.57	0.61	0.59	0.66	0.72	0.64	0.77	0.80	0.70	0.78			
est18	0.60	0.56	0.56	0.53	0.58	0.65	0.62	0.68	0.70	0.64	0.70	0.74		
est19	0.62	0.76	0.78	0.72	0.79	0.74	0.71	0.72	0.60	0.69	0.66	0.64	0.59	
est20	0.80	0.67	0.70	0.68	0.77	0.75	0.69	0.76	0.84	0.77	0.75	0.77	0.77	0.73