LIFE07 ENV/DE/000218 "FutMon"

Results of the 11th UNECE/ICP-Forests & FutMon Combined Intercalibration Course on the Assessment of Ozone Visible Injury

Report: Action C1-O3-24 (ES)

Report Prepared by Fundación CEAM
and the Swiss Federal Institute WSL

Course hosted by Fundación CEAM
Valencia, 21-24 September 2010

1. INTRODUCTION

As part of FutMon action C1-O3-24 (ES), a second Intercalibration Course on the Assessment of Ozone Visible Injury was carried out in Valencia on 21-24 September 2010. It was hosted by Instituto Universitario CEAM-UMH (Spain), with the support of WSL (Switzerland). The structure of the course was similar to the one held in Hungary in 2009 (a previous report is available for the results of this course). The Valencia course was the 11th in a series of annual courses on visible injury assessment organized within the activities of ICP-Forests.

A total of 30 participants attended this course, although some Spanish participants contributed only to concrete parts, e.g., the microscopy exercise. Attendees came from 11 countries: Brazil, Bulgaria, Czech Republic, Germany, Greece, Italy, Switzerland, Romania, Slovenia, Slovakia and Spain. All these countries, except Brazil, are involved in the FutMon project. The list of participants and their countries is provided below:

Participant	Country
Carla Z. Sandrin	Brazil
Edenise Segala-Alves	Brazil
Patricia Bulbovas	Brazil
Lora Petrova	Bulgaria
Václav Buriánek	Czech Republic
Stefan Meining	Germany
Konstantina Tsagi	Greece
Martina Pollastrini	Italy
Fabiana Cristofolini	Italy
Rosanna Desotgiu	Italy
Filippo Bussotti	Italy
Elena Gottardini	Italy
Marco Ferretti	Italy
Silvia Ferlazzo	Italy
Stefan Leca	Romania
Diana Silaghi	Romania
Hana Pavlendová	Slovakia
Rupel Matej	Slovenia
Vicent Calatayud	Spain
Gerardo Sánchez-Peña	Spain
Júlia Cerveró	Spain
Carmen Martín	Spain
Agustí Palomares	Spain
Esperanza Calvo	Spain
Germán Cabanillas	Spain
Francisco García-Breijo	Spain
José Reig-Armiñana	Spain
David Lázaro	Spain
José Manuel Gálvez Álvarez	Spain
Marcus Schaub	Switzerland

Table 1: List of participants

Fig. 1: Participants in the course (part)

The course consisted of the following 6 sessions:

Session 1. Opening of the meeting and introductory statements

Session 2. Scientific presentations: report of the activities carried out by the different teams

Session 3. Indoor exercises: Photo Exercise and Fresh Material exercise

Session 4. Microscopy exercise

Session 5. Field exercise

Session 6. Evaluation, future activity and final remarks

This report presents the results and discussions of the sessions. Data analyses of the indoor and field exercises are restricted to the European teams involved in FutMon and/or ICP-Forests.

In session 1, Vicent Calatayud introduced the programme of the course and the agenda was adopted. Then, Marcus Schaub commented on the main changes in the new ICP-Forest manual, which has been completely revised with all the chapters following a common structure. Measuring Quality Objectives (MQO) have been defined for each type of exercise carried out in the intercalibration courses. These MQO have been established on the basis of the experience gained during the FutMon project (e.g., based on results from the 10th UNECE/ICP-Forests & FutMon Combined Intercalibration Course on the Assessment of Ozone Visible Injury held in Hungary), and will be applied in the present intercalibration exercise. The revised manual can be downloaded from: http://www.icp-forests.org/Manual.htm.

2. SCIENTIFIC PRESENTATIONS: REPORT ON THE ACTIVITIES CARRIED OUT BY THE DIFFERENT COUNTRIES

In session 2, the different participants presented the results of their activities related to visible injury assessment and measurement of air pollutants.

E. Gottardini, A. Cristofori, F. Cristofolini, F. Bussotti and M. Ferretti showed the results of a study with *Viburnum lantana*: RESPONSIVENESS OF *VIBURNUM LANTANA* L. TO OZONE IN FIELD CONDITIONS: FIRST RESULTS TO VERIFY IF THIS SPECIES CAN BE USED AS A BIOINDICATOR IN REMOTE AND FORESTED AREAS. The main aim of this study, still ongoing, is to verify whether *Viburnum lantana* could be used as in situ bioindicator of ozone. This species has been selected due to its wide spatial distribution in the study area of Trentino and its specific symptom development in response to ozone.

C. Tsagari and C. Kaoukis presented a report on the ASSESSMENT OF OZONE INJURIES IN GREEK FOREST ECOSYSTEMS. The study involved 4 plots. Increased ozone concentrations were observed during summer. The highest ozone concentrations were measured at Mount Ossa and the lowest values were measured in an urban park in Athens. Ozone injuries were identified and confirmed in *Fagus sylvatica* and *Sorbus torminalis*. Photos of ozone-like symptoms in another 5 species were also shown and discussed.

C. Zuliani Sandrin, E. Segala Alves and P. Bulbovas reported some results of a case study on MONITORING OF VEGETATION SUBMITTED TO AIR POLLUTION IN THE REGION OF PAULÍNIA, SÃO PAULO, BRAZIL. *Psidum guajava* 'Paluma' (guava) and tobacco Bel - W3 plants were used as ozone bio - indicators, and *Lolium multiflorum* as a bioacumulator. Native species of semidecidual forest has been also monitored in six fragments in relation to accumulation of nutrients, increment measurement and chemical and physical soil analysis. Future developments of this network will include bulk deposition, passive samplers and the analyses of visible foliar injury

V. Calatayud, E. Calvo, J. Cerveró, C. Martín and A. Palomares presented results from the AIR QUALITY AND VISIBLE INJURY ASSESSMENT IN SPAIN. Concentrations of NO_2, SO_2 and O_3 since the year 2000 were reported, as well as information on the different species showing symptoms in the field. An example of the estimation of AOT40 based on ozone passive sampler measurements in eastern Spain was also reported. The suitability of using hourly estimates derived from passive samplers to model ozone fluxes under Mediterranean conditions was also discussed.

M. Schaub presented RESULTS FROM SWITZERLAND. He showed examples both of species that frequently show ozone injury in Switzerland and of species with misleading (ozone-like) symptoms. Results of visible injury, AOT40 values and ozone fluxes from several level II plots were presented. Visible injury has been correlated with AOT40 and/or ozone fluxes.

D. Silaghi and Stefan Leca presented their results on the OZONE VISIBLE INJURY ASSESSEMENT STATUS IN ROMANIA. Even though a considerable number of species were observed, no evident ozone symptoms were found in the year 2010. Pictures of different species were presented.

3. MICROSCOPY EXERCISE

Session 4 consisted of a demonstration microscopy exercise at the Botanical Garden (Fig. 2). It was led by Filippo Bussotti and Rosanna Desotgiu, with the support of Francisco García-Breijo, José Reig-Armiñana and David Lázaro, from the Botanical Garden of Valencia.

After listening to a description of the different types of anatomical responses induced by ozone and their localized effects in different parts of the leaves/cells, participants were introduced to the techniques for preparing samples for microscopy observation. Cuttings of leaves of several species were examined individually under the light microscope. The aim of this session was to train teams involved in ozone injury assessment to use simple microscopy tools as a support to discriminate ozone effects form other types of injury.

Fig. 2: Microscopy session

4. INTERCALIBRATION EXERCISES

As in the year 2009, three intercalibration exercises were carried out for the Quality Assurance/Quality Control of the assessment of visible injury under the FutMon project:

1) Photo-exercise with pictures of symptomatic leaves and plants: The participants scored each pictorial sample as to whether the symptoms were: a.) ozone-induced or b.) not ozone-induced.
2) Exercise with fresh plant material: leaves of 26 plants were scored as either ozone-injured or not.
3) Field exercise at a forest edge close to Alcalá de la Selva (Aragón, Spain), applying the FutMon methods for ozone visible injury assessment.

5. RESULTS OF THE PHOTO EXERCISE

For the photo exercise, photos of 63 species were scored as ozone-symptomatic or not by 15 teams. Three of the plants were later removed from the analysis due to problems with the quality of the pictures, so that the analysis presented here covers 60 slides. The control for this exercise was Marcus Schaub (Switzerland), who provided most of the pictures.

Out of the 60 photos scored, 43 were considered to be symptomatic and the remaining 17 were asymptomatic, according to the control. The complete exercise from 2010 can be downloaded from www.ozoneinjury.org. The list and number of the 43 photos with ozone symptoms are provided below:

Fagus sylvatica (1)
Viburnum lantana (3)
Viburnum lantana (4)
Fagus sylvatica (5)
Fagus sylvatica (6)
Viburnum lantana (8)
Populus nigra (10)
Populus nigra (11)
Populus nigra (14)
Laburnum alpinum (16)
Fraxinus ornus (21)
Ulmus glabra (22)
Rhamnus cathartica (23)
Salix daphnoides (24)
Fraxinus angustifolia (25)
Morus alba (26)
Morus alba (27)
Ailanthus altissima (30)
Robinia pseudoacacia (33)
Fraxinus ornus (34)

Ulmus glabra (37)	Alnus glutinosa (50)
Alnus viridis (38)	Carpinus betulus (52)
Salix daphnoides (39)	Prunus serotina (53)
Fagus sylvatica (40)	Fraxinus excelsior (54)
Cornus mas (41)	Fraxinus excelsior (55)
Sambucus nigra (42)	acer campestre (56)
Carpinus betulus (43)	Pinus halepensis (57)
Fraxinus excelsior (44)	Acer pseudoplatanus (58)
Fraxinus excelsior (46)	Alnus glutinosa (59)
Viburnum lantana (47)	Berberis vulgaris (60)
Sambucus ebulus (48)	Hibiscus syriacus (63)
Salix spp. (49)	

Table 2: List of photos assessed in the photo exercise

Fig. 3: Photo exercise

In 10 of the photos, there was 100% agreement with the control (the 15 teams scored the same as the control), while in 26 photos, at least 90% of the teams agreed with the control (Fig. 4). The most problematic pictures were: *Fagus sylvatica* (40), *Prunus serotina* (53), *Fraxinus excelsior* (55) and *Pinus halepensis* (57). Photo 40 showed a leaf with symptoms that were hard to observe. Leaf 53 showed typical ozone symptoms in *Prunus serotina*; however, if one is not familiar with the reddish patches developed by this species in response to ozone, they could be interpreted as being produced by, e.g., fungi. The chlorotic mottle observed in *Pinus halepensis*, induced in controlled conditions (fumigation with ozone in OTCs) is a typical response of conifers. However, symptoms caused by sucking insects can be quite mimetic.

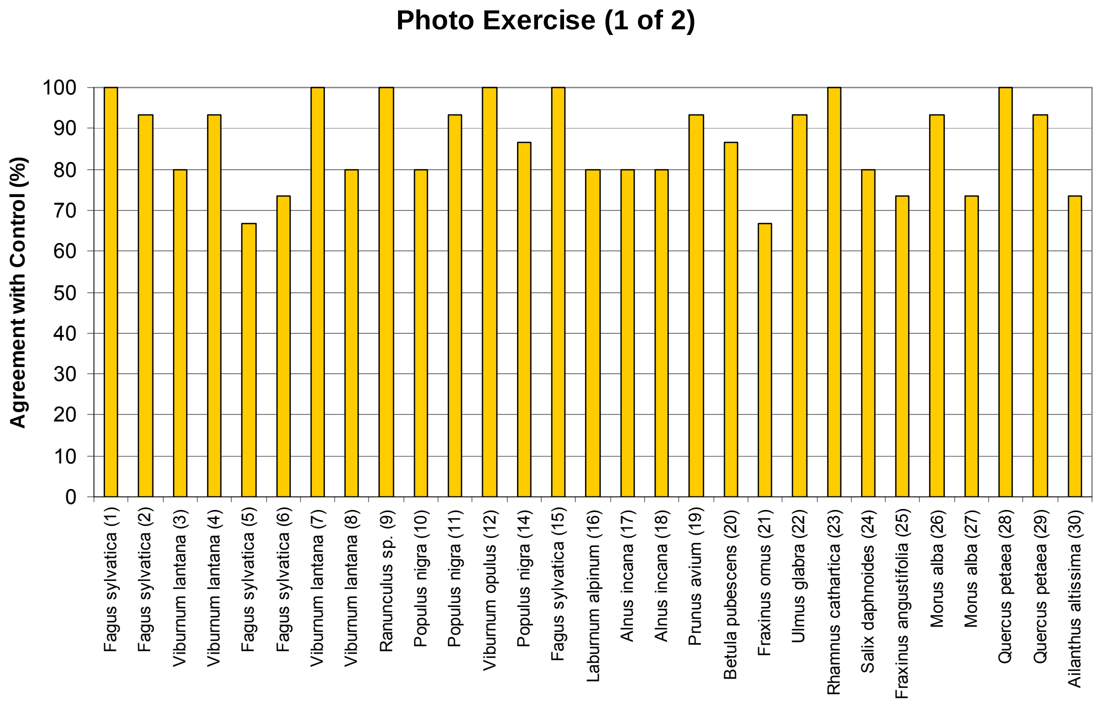

Figure 4 (part 1). Percentage of agreement with the control for the different photos of plants. Teams assessed each picture as ozone-symptomatic or not.

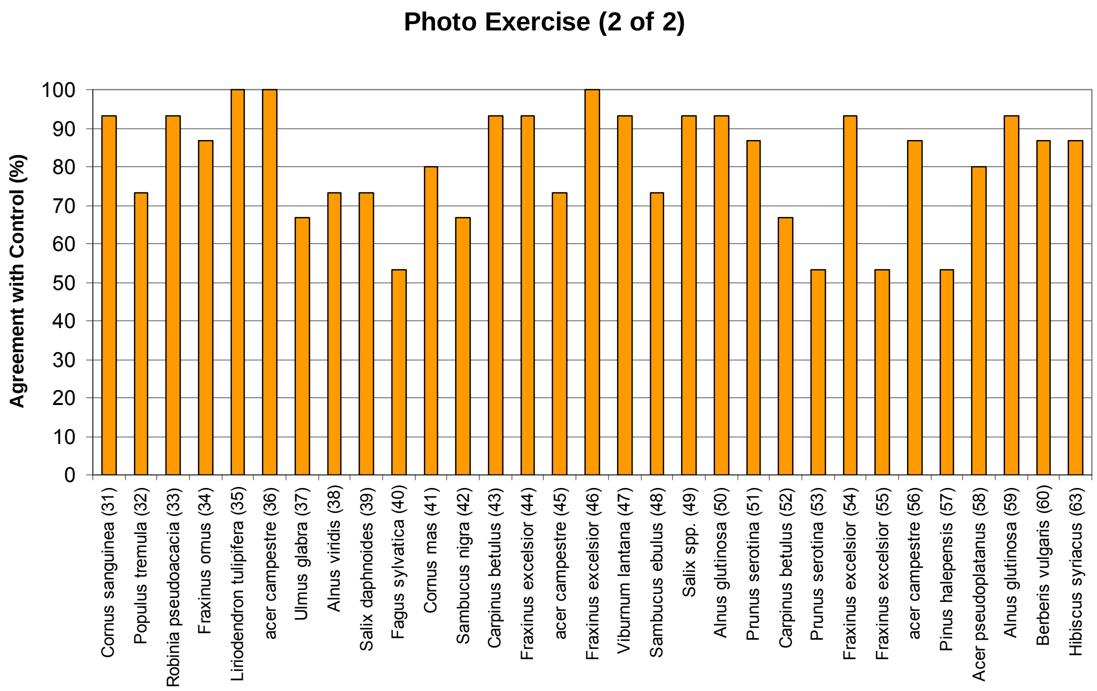

Figure 4 (part 2). Percentage of agreement with the control for the different photos of plants. Teams assessed each picture as ozone-symptomatic or not.

Considering the scores of the 60 photos together, we found that the teams and the control agreed in 85% (on average) of the cases.(Figure 5). 87% of the teams achieved the current objective of agreeing with the control in ≥ 70% of the photos. If the threshold is set at ≥ 80%, 80% of the teams managed to achieve this objective. With regard to a similar exercise in 2009, the results of the present exercise represent an improvement, as in 2009 the percentages of agreement with the control were 81% and 65% for thresholds set at ≥ 70% and at ≥ 80% respectively.

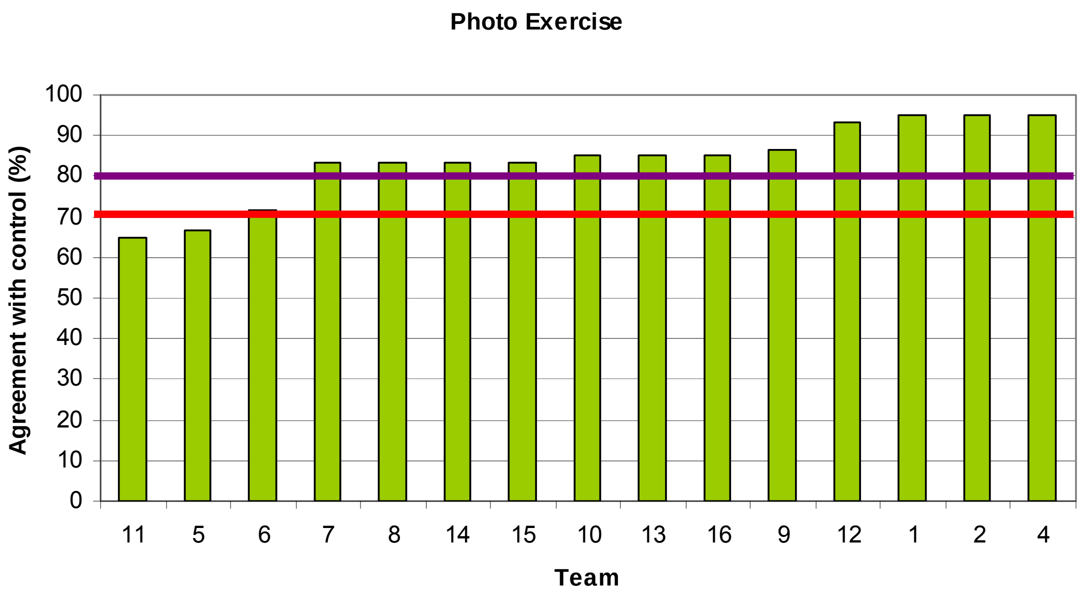

Figure 5. Percentage of agreement of the teams with the control for the 60 slides scored.

6. RESULTS OF THE FRESH MATERIAL EXERCISE

As in the 2009 intercalibration course, a fresh material exercise was also carried out in 2010. This type of exercise is more similar to the assessment of plants in the field because several leaves per plant can be assessed and both sides of the leaves can be checked to identify, for example, possible remnants of insects.

For this exercise, several species were fumigated with ozone for two months in Open Top Chambers in order to induce visible symptoms that could be assigned unequivocally to this pollutant. The Open Top Chambers belong to the Instituto Universitario CEAM-UMH and are located in Benifaió (Valencia, Spain) (Fig. 6).

Figure 6. CEAM-UMH Open Top Chamber facility in Benifaió. Different species of plants were fumigated with enhanced ozone levels in order to induce visible injury in their leaves.

Figure 7. Fresh material exercise.

A total of 26 samples were scored (Fig. 7). The control for this exercise was Vicent Calatayud (Spain), who collected most of the samples and had background information on which samples were fumigated with ozone in the OTCs. There were only two possibilities of scoring: ozone symptomatic (Y) or non-ozone symptomatic (N).

The following samples were symptomatic, while the rest were either asymptomatic or (more frequently) showed symptoms due to agents other than ozone. The list of ozone-symptomatic samples is provided below:

Species/Sample
Acer pseudoplatanus
Ailanthus altissima_1
Ailanthus altissima_2
Alnus glutinosa_1
Fraxinus angustifolia
Fraxinus ornus
Hibiscus syriacum_2
Lonicera etrusca
Pistacia terebinthus
Populus maximowiczii x berolinensis
Prunus mahaleb
Rhamnus cathartica_2
Viburnum lantana_1

Table 3: List of symptomatic species in the fresh material exercise

A total of 14 individual teams scored the 26 fresh samples. On average, there was 87% agreement between the teams and the control for the different samples (Fig. 9). A 100% agreement was observed in the following ozone-asymptomatic samples: *Acer monspessulanum*, *Alnus glutinosa*_2, *Cercis siliquastrum*, *Hibiscus syriacum*_1, *Populus* sp., *Salix eleagnos* and *Sambucus ebulus*. There was also a 100% agreement with the control in three ozone-symptomatic samples: *Hibiscus syriacum*_2, *Populus maximowiczii* x *berolinensis*, *Rhamnus cathartica*_2. In these species, the ozone symptoms were very characteristic (see photos in www.ozoneinjury.org). In contrast, the most problematic samples were: *Fraxinus angustifolia* (50% agreement), *Ailanthus altissima*_2 (57% agreement) and *Fraxinus ornus* (57% agreement). The two Fraxinus species showed yellow stippling, but these ozone symptoms, induced by fumigation in the OTCs, were very “clean” in comparison with symptoms found in the field in Fraxinus species (dark brown stipples that often coalesce to cover large areas), so that they were not recognized as caused by ozone by some of the teams. In *Ailanthus altissima*, the stippling was combined with yellowing, and this was probably the cause of the stippling being overlooked by part of the teams.

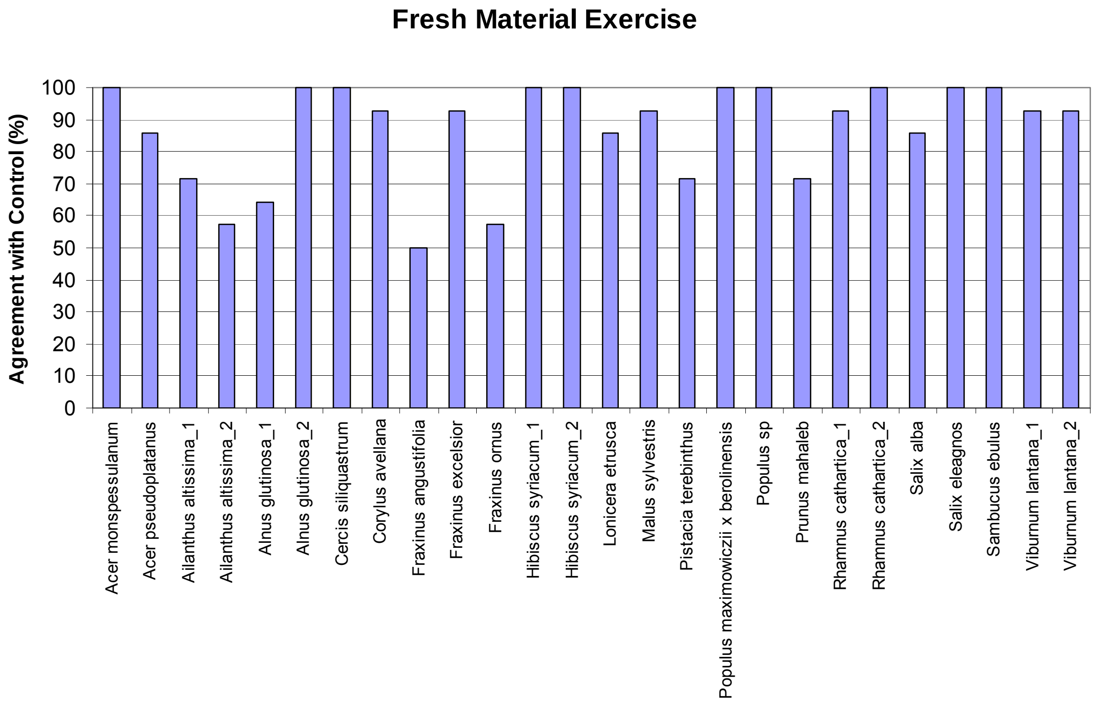

Figure 8. Percentage of agreement with the control for the different samples of plants showing ozone injury and other types of symptoms. Teams assessed each sample as ozone-symptomatic or not.

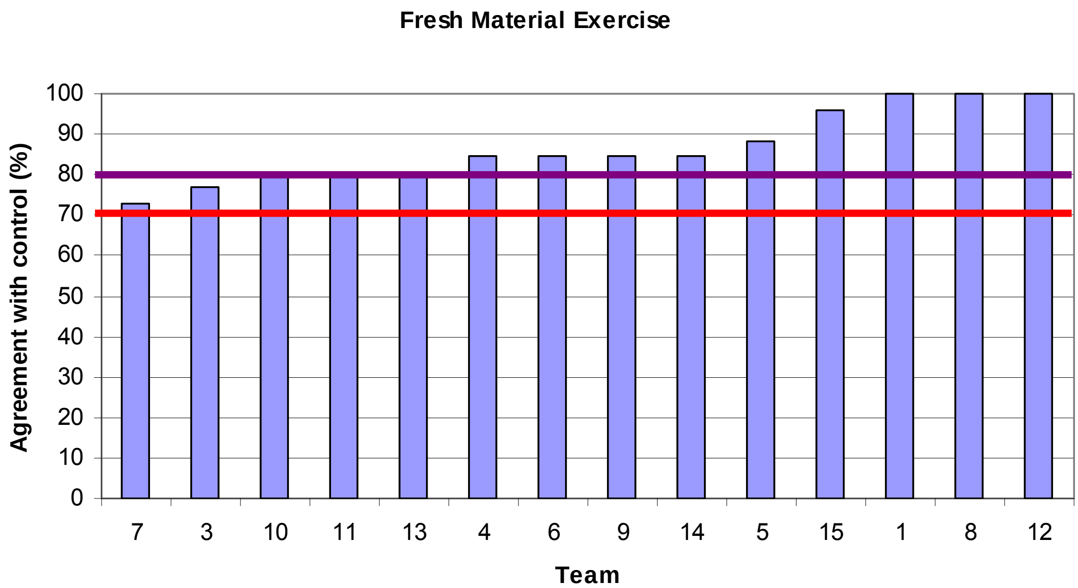

Figure 9. Percentage of agreement of the teams with the control for the 26 samples scored.

All the teams (100%) agreed with the control on ≥ 70% of the samples. A more demanding threshold of ≥ 80% of agreement with the control was reached by 88% of the teams, i.e., it was not reached by 2 of the 14 teams (Fig. 9). These results on the scoring of fresh samples represent an improvement over the results obtained during the 2009 Ozone Injury Intercalibration Course where only 84% of the teams reached the threshold of ≥ 80%, and 92% of the teams reached the threshold of ≥ 70%. Moreover, the fact that the two teams that did not fulfil the requirement of ≥ 80% agreement with the control had only recently begun to attend this type of course, seemed to indicate the importance of repeated attendance at these courses. Again confirming the 2009 results, the agreement with the control in the fresh material exercise was higher than in the photo exercise. The fact that in the former the samples can be observed in much more detail (e.g., the upper and lower sides of several leaves can be examined) than with a single picture, helps in the discrimination of ozone induced injury from injury caused by other types of biotic or abiotic agents.

7. RESULTS OF FIELD EXERCISE

In 2010, a field exercise was carried out at a forest edge close to Alcalá de la Selva (Teruel, Spain). This exercise was complementary to the one carried out in 2009 in Hungary. In the latter, 21 squares were randomly selected along a forest edge by each team (i.e., not all the teams assessed the same quadrates), considering an error of 20% (21 quadrates for 300 m). All plants (woody and non-woody species) within each quadrate were later assessed as symptomatic or not (Yes/No). As an output of this course, it was decided that in order to have more comparable results among countries/participants, only woody species would be assessed in the future. Another output was that, considering the variability in species composition of the quadrates due to random selection, only a 10% error would be accepted: i.e., for a given forest edge length, a higher number of quadrates would be needed.

The exercise carried out in 2010 at a forest edge close to Alcalá de la Selva (Teruel, Spain) was focused on comparison among teams. Twenty 2x1 m quadrates were randomly selected along a forest edge transect. All the teams assessed visible injury within the same quadrates. Only woody species were considered. For each quadrate, each species present was assessed as ozone-symptomatic or not. A total of 11 teams (with 1 to 4 people per team) participated.

Figure 10. Field exercise.

Variations in the number of species (with and without ozone symptoms) assessed per quadrate by the different teams are reported in Table 4. Most of the teams assessed a number of species per quadrate within the range of control ± 1 species. However, some teams found higher discrepancies in concrete quadrates.

		QUADRATE																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Team	CONTROL	4	6	6	6	4	8	4	5	7	5	3	4	8	7	7	7	5	7	3	5
	1	2	5	6	6	3	6	3	3	4	4	3	4	5	3	5	3	3	3	2	4
	2	4	6	5	8	5	8	4	6	7	5	3	3	8	3	9	7	3	6	2	5
	3	4	5	4	4	3	5	3	3	6	4	3	4	7	6	7	5	2	5	3	4
	4	4	5	4	2	4	5	3	5	5	4	3	4	7	5	7	5	2	4	3	4
	5	3	5	5	4	4	6	3	6	7	4	4	4	5	6	6	8	8	8	2	5
	6	3	3	5	6	4	7	3	5	6	4	2	4	5	3	9	5	4	7	5	3
	7	5	6	6	7	5	7	4	6	6	5	3	3	5	4	8	7	3	8	2	5
	8	3	6	5	7	6	7	4	5	7	4	3	3	7	6	10	6	3	6	2	5
	9	4	6	6	8	5	8	4	6	7	5	4	3	6	2	8	8	3	6	2	5
	10	4	6	6	6	4	8	4	5	7	5	3	4	8	7	7	7	5	7	3	5
	11	2	5	4	6	4	4	3	3	6	4	4	3	5	4	7	3	3	3	2	4
	Mean	3.5	5.3	5.2	5.8	4.3	6.6	3.5	4.8	6.3	4.4	3.2	3.6	6.3	4.7	7.5	5.9	3.7	5.8	2.6	4.5
	St. Dev.	0.9	0.9	0.8	1.7	0.9	1.4	0.5	1.2	1.0	0.5	0.6	0.5	1.3	1.7	1.4	1.7	1.7	1.7	0.9	0.7
	Max	5	6	6	8	6	8	4	6	7	5	4	4	8	7	10	8	8	8	5	5
	Min	2	3	4	2	3	4	3	3	4	4	2	3	5	2	5	3	2	3	2	3

Table 4: Number of species (with or without ozone symptoms) assessed by the different teams per quadrate

Results of this exercise were evaluated in terms of number of quadrates with symptomatic species. A deviation from the control team in ± 2 quadrates was considered to fit within the QA/QC requirements. The results of the exercise are reported in Fig. 11. The control team found 4 quadrates with symptoms. Eight of the 11 teams fulfilled the requirement of control ± 2 quadrates. The highest deviation from the control was that of team 9, which reported 13 quadrates with symptoms.

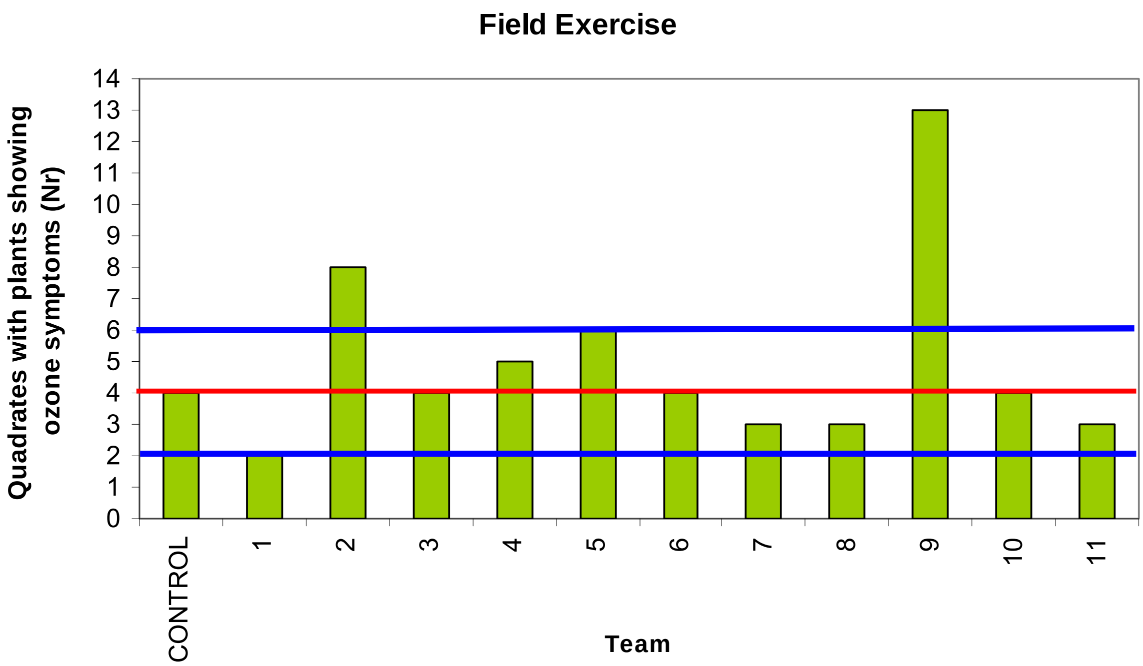

Figure 11. Number of quadrates with symptomatic species according to the assessment of the teams

	TEAM											
	CONTROL	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Ailanthus altissima	1	0	0	1	1	0	1	0	0	1	1	0
Corylus avellana	0	0	1	1	1	1	0	0	0	1	0	1
Crataegus monogyna	0	0	0	0	0	0	0	0	0	3	0	0
Euonymus europaeus	0	0	0	1	0	0	0	0	0	1	0	0
Fraxinus angustifolia	1	1	1	1	1	1	1	1	1	1	1	1
Lonicera etrusca	0	0	0	0	0	0	0	0	0	1	0	0
Prunus spinosa	0	0	1	0	0	0	0	0	0	3	0	0
Viburnum lantana	2	1	6	2	3	5	2	2	2	8	2	1
Symptomatic species (Total Nr)	3	2	4	5	4	3	3	2	2	8	3	3

Table 5: Species considered symptomatic by the different teams, and total number of symptomatic species per team

A total of 21 different woody species were scored by the participants in the field exercise. The control team found 3 species with ozone symptoms: *Ailanthus altissima* (1 quadrate), *Fraxinus angustifolia* (1 quadrate) and *Viburnum lantana* (2 quadrates). Nine of the 11 teams were in the range of control ± 1 symptomatic species (i.e., 2 to 4), and all teams except one were in the range of control ± 2 symptomatic species. The remaining team (team 9) found a total of 8 symptomatic species (Table 5).

All teams consistently found symptoms in *Viburnum lantana*, although differences occurred in the number of symptomatic quadrates: 8 teams considered this species to be symptomatic in 1 to 3 quadrates (control ± 1). Discussion after the exercise showed that, unlike the other teams, team 5 considered some plants with very subtle symptoms to be symptomatic. The presence of plants with a misleading homogeneous reddening, not typical of ozone, could also explain the discrepancy between the control and the two teams with the highest scores for this species. All teams also consistently found ozone symptoms in *Fraxinus angustifolia* in one quadrate. *Ailanthus altissima* was identified as symptomatic by 5 teams, and *Corylus avellana* was reported as symptomatic by 6 teams. In Ailanthus, old leaves of a single plant had to be checked carefully to observe the stippling caused by ozone. In Corylus, although a few leaves presented a faint stippling consistent with the typical pattern of ozone symptoms, we followed the criteria of the control team which, prior to the exercise, scored these plants as being asymptomatic (symptoms too subtle to be considered unequivocally ozone symptoms). Reports of ozone symptoms on the other species were sporadic, with most of them being reported by team 9, but some also from an additional team. According to the criteria of the control team, these symptoms (most of them reddening) were not typical of ozone (e.g., stippling, restricted to interveinial areas of the leaves, and showing an age).

The percentage of symptomatic species per quadrate is presented in Table 6. The mean percentage of symptomatic species per quadrate was low, 3.1% for the control team and up to 8.5% for all teams except one (19.3%)

	QUADRATE																				
Team	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Mean
CONTROL	0	0	17	0	0	13	0	0	0	0	0	0	13	0	0	0	0	0	0	20	3.1
1	0	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	2.1
2	0	0	0	0	0	13	25	17	0	0	0	33	13	0	0	14	0	17	0	40	8.5
3	0	0	0	0	0	20	0	0	0	0	0	0	14	0	0	40	0	0	0	50	6.2
4	0	0	25	0	0	20	0	0	0	0	0	0	14	0	0	40	0	0	0	50	7.5
5	0	0	20	0	0	17	0	17	0	0	0	0	0	0	0	25	13	0	0	20	5.5
6	0	0	20	0	0	14	0	0	0	0	0	0	20	0	0	0	0	0	0	33	4.4
7	0	0	17	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	20	2.5
8	0	0	20	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	20	2.7
9	0	0	17	13	0	38	25	17	0	0	25	67	33	50	13	13	0	17	0	60	19.3
10	0	0	0	0	0	13	0	0	0	0	0	0	13	0	0	0	0	14	0	20	3.0
11	0	0	25	0	0	0	0	0	0	0	0	33	0	0	0	0	0	0	0	25	4.2
Mean	0.0	0.0	14.7	1.0	0.0	14.5	4.2	4.2	0.0	0.0	2.1	11.1	10.0	4.2	1.0	11.0	1.0	4.0	0.0	31.9	5.7
St. Dev.	0.0	0.0	9.3	3.6	0.0	9.7	9.7	7.5	0.0	0.0	7.2	21.7	10.4	14.4	3.6	15.8	3.6	7.2	0.0	14.5	4.7
Max	0	0	25	13	0	38	25	17	0	0	25	67	33	50	13	40	13	17	0	60	19.3
Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	2.1

Table 6: Percentage of symptomatic species per quadrate as scored by the different teams.

8. SUMMARY OF DATA QUALITY CONTROL RESULTS

For the photo and fresh-material exercises, data quality is evaluated on the basis of Measuring Quality Objectives (MQO). Currently, the results of both exercises are considered to fulfill the MQO when there is a minimum of 70% agreement with the control considering all the photos or samples scored. On this basis, 13 out of 15 teams fulfilled the MQO for the photo exercise while all teams (14) reached the MQO for the fresh material exercise (Table 7). If a higher threshold of ≥80% agreement is established for both exercises, 12 teams achieved this MQO for both the photo and the fresh material exercise. These results suggest that a more demanding threshold could be achieved with good training. Nevertheless,, higher percentages of agreement with the control over an 80% threshold would be difficult to reach, as in some species ozone symptoms either are difficult to separate from symptoms caused by other agents or are still a matter of debate.

Investigation	MQO	Type	Number of Teams	Nr of Teams that achieved the MQO
Photo Exercise	≥ 70% agreement with control	Photos	15	13 [12*]
Fresh Material Exercise	≥ 70% agreement with control	Leaves	14	14 [12*]
Field Exercise	Control ± 2 quadrates	Nr. of Symptomatic quadrates in the LESS	11	9 [7+]
Field Exercise	Control ± 2 species	Nr. of Symptomatic species in the LESS	11	10 [9+]

MQO=Measurement Quality Objective [e.g., 70% of a team fit with control team]
In braquets:
* Nr of teams that achieved MQO considering a MQO of ≥80% agreement with control
+ Nr of teams that achieved MQO considering a MQO of control ± 1 quadrate or species

Table 7: Summary of all exercises.

Regarding the field exercise, quality control was applied to the total number of quadrates with symptomatic species and to the total number of symptomatic species per plot (LESS). A deviation from the control team in ± 2 quadrates or species was accepted (Table 7). For these MQO, 9 (for the Nr. of symptomatic quadrates) and 10 (for the Nr. of symptomatic species) out of 11 teams fulfilled these requirements. If a more demanding requirement of ± 1 quadrate or species deviation from the control had been established, it would have been passed by 7 (for the Nr. of symptomatic quadrates) and 9 of the teams (for the Nr. of symptomatic species). Nevertheless, one must bear in mind the possibility of some variability even for teams reporting the same number of symptomatic quadrates or number of species per LESS. For example, both group 5 and group 6 (Table 5) reported that in the LESS there were 3 symptomatic species. Two of the species, *Viburnum lantana* and *Fraxinus angustifolia*, were the same for both, but the third one was different: *Corylus avellana* was considered symptomatic by group 5 and *Ailanthus altissima* by group 6.

CONCLUSIONS

- Participants in the 2010 course presented their results on both air quality measurements and visible injury assessment within the FutMon project. The main changes proposed in the completely revised ICP-Forest manual were discussed. Based on FutMon results and the previous Intercalibration Course on Visible Injury Assessment held in Hungary, Measurement Quality Objectives (MQO) were proposed for air quality measurements and visible injury surveys. For visible injury assessment, these MQO were tested in the present intercalibration course in three types of exercises: photo-exercise, fresh material exercise and field exercise.
- In the Photo exercise, 60 photos of leaves were scored (two possibilities: ozone-symptomatic or not) by 15 teams. The current MQO required a minimum agreement with the control of ≥ 70%. 13 of the 15 teams fulfilled this requirement. If the threshold had been established at ≥ 80%, 12 teams would have fulfilled these MQO.
- For the Fresh Material exercise, 26 samples of leaves from different species were assessed (two possibilities: ozone-symptomatic or not) by 14 teams. Samples were collected from the field or from plants fumigated with enhanced-ozone levels in Open Top Chambers. All the teams were able to fulfill the current MQO of a ≥ 70% agreement with the control. If a higher agreement threshold of ≥ 80% had been considered, 12 teams would have fulfilled this MQO.
- The Field exercise was carried out in Alcalá de la Selva (Teruel, Spain). For this exercise, 11 teams assessed the same 20 quadrates (2x1 m), randomly selected along a forest edge. Two MQO were established for this exercise: 1) for the number of quadrates containing symptomatic species, the MQO was control ± 2 quadrates, and 2) for the number of symptomatic species in the plot (LESS), the MQO was control ± 2 species. For these MQO, 9 (for the Nr. of symptomatic quadrates) and 10 (for the Nr. of symptomatic species) of the 11 teams fulfilled the requirements. If a more demanding requirement of ± 1 quadrate or species deviation from control had been established, it would have been passed by 7 (for the Nr. of symptomatic quadrates) and 9 of the teams (for the Nr. of symptomatic species).