Collection: IUFRO RG 7.01 (2010) - Antalya (Turkey)
Adaptation of Forest Ecosystems to Air Pollution and Climate Change
Guest Editors: Elena Paoletti, Yusuf Serengil

First results of a nation-wide systematic forest condition survey in Turkey

Tolunay D [(1)], Karabiyik B [(2)], Temerit A [(3)]

Monitoring of forest condition in Turkey started in 2006 when a 16x16 km grid of Level I plots was established. In 2007, the first 48 *Pinus brutia* plots were surveyed for crown condition. In 2008 and 2009, the plots were 398 and 563, respectively. In 2007, the mean defoliation for *P. brutia* was 13.0 %. In 2008-2009, the mean defoliation was 19.5-19.8 % and 27.0-23.0 % for coniferous and broadleaved species, respectively. Defoliation was higher than 25 % on 24.6-18.7 % of the monitored trees. The species with the highest defoliation were *Carpinus betulus* and *Juniperus foetidissima* in 2008, and *Quercus pubescens* and *Juniperus communis* in 2009. The slight improvement in forest health in 2009 may be attributed to better weather conditions than in 2008 (higher precipitation). The forests along the Black Sea coast of Thrace showed the highest defoliation in both 2008 and 2009. This may be due to transboundary air pollution from Istanbul, where sources of sulphate and nitrate pollution occur. Elevated defoliation rates were also observed in the Black Sea region; they were most probably caused by biotic factors in plots subject to industrial pollution.

Keywords: Forest monitoring, ICP forests, Air pollution, Health status, Defoliation, Turkey

Introduction

Since the '70s, monitoring of forest ecosystems has been considered as a prerequisite for investigating forest decline (Badea et al. 2004). At the very beginning, the causes were unknown and thus the decline was defined as "new-type". Later on, it became clear that air pollution was one of the main causes. Standardized methods of inventory and monitoring were established in Europe in 1985 on behalf of the International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) by the United Nations Economic Commission for Europe (UNECE), working under the Convention on Long-range Transboundary Air Pollution (CLRTAP - UNECE 2004). ICP Forests is a forest monitoring programme to collect data from permanent plots installed in most countries of Europe at two levels of intensity. Level I plots are systematically selected to assess tree crown condition. Level II plots represent widespread forest ecosystems to study cause–effect relationships. The integration of National Forest Inventories and ICP Forests Level I Plots and the development of new and more intensive assessments are supported by FutMon, a Life+ project established in 2007. Forty-one countries including Turkey participate in the ICP Forests programme. Data on tree crown condition in 2009 for more than 126 000 trees on 6791 Level I Plots in Europe are summarised in Fischer et al. (2010).

Turkey has about 21.2 million ha forest area accounting for about 27 % of the country's total land area. Although forest is usually defined as land spanning more than 0.5 ha with trees higher than 5 m and a canopy cover of more than 10 % or trees able to reach these thresholds in situ based on the FRA 2010 Categories and Definitions, the forest area of Turkey is classified into two main groups on the basis of crown coverage. Forest area with a crown coverage of 11-100 % is defined as productive forest area and covers about 50 % of the country's forest area. Forest area with crown coverage of 1-10 % is considered as degraded forest area which covers the remaining 50 % of Turkish forest lands. Sixty percent of the country's forest areas is dominated by coniferous species, especially *Pinus brutia* and *Pinus nigra* while broadleaved species, particularly oaks, represent the remaining 40 %. Although biotic and abiotic stressors affecting forest ecosystems have always been a concern for Turkish forestry, the first study on air pollution effects on forests was conducted by academicians in 1950 (Irmak and Huş 1951). After the '70s, the number of research projects have been increasing. Even if national permanent monitoring plots could not be established, applied research projects were carried out in forest lands around pollution sources. Mostly, sulphur content in needles or leaves was investigated. In the 1990s, the first plots were installed in some regions on a 16x16 km grid in line with ICP Forests; tree crown condition was assessed and foliage was sampled to analyze sulphur content (Karakaş et al. 2007, Koray et al. 2007). However, this work was discontinued due to limitation of funding and lack of qualified staff .A field-based monitoring system on a 16 x 16 km grid network covering the whole country's forest ecosystems started in 2006 in the project "Development of Forestry Information System in Sustainable Forest Management" that was conducted and coordinated by the Turkish Forest Service in collaboration with the Department of Research and Development of the Turkish Ministry and with EVD-Ministry of Economic Affairs of the Netherlands.

This paper aims at presenting the findings of the tree crown condition assessments in 2007-2009 concerning the impact of changing environmental conditions on the health status of Turkey's forests.

Material and methods

The transnational Level I survey is based on a large scale grid with one plot every 256 km². The methods defined in "Manual on methods and criteria for harmonized sampling, assessment, monitoring and analysis of the effects of air pollution on forests" (UNECE 2004) are strictly followed by the countries participating in the ICP Forests, including Turkey.

In Turkey, the Level I network is a systematic grid of 16x16 km where all the cross points that fall in forest ecosystems are iden-

(1) Istanbul University, Faculty of Forestry, Soil Science and Ecology Department, 34473 Bahceköy, Istanbul (Turkey); (2) General Directorate of Forestry, Department of Forest Management and Planning, Gazi Tesisleri 7 nolu Bina 06560 Bestepe, Ankara (Turkey); (3) General Directorate of Forestry, Department of Forest Management and Planning, Gazi Tesisleri 7 nolu Bina 06560 Bestepe, Ankara (Turkey).

@ Banu Karabiyik (uomturkiye@ogm.gov.tr)

Received: Jun 10, 2010 - Accepted: Oct 15, 2010

Citation: Tolunay D, Karabiyik B, Temerit A, 2011. First results of a nation-wide systematic forest condition survey in Turkey. iForest 4: 145-149 [online 2011-06-01] URL: http://www.sisef.it/iforest/show.php?id=567

Tab. 1 - Defoliation classes according to UNECE and EU classification (UNECE 2004).

Defoliation class	Needle/leaf loss (%)	Degree of Defolation
0	Up to 10	None
1	11-25	Slight (warning)
2	26-60	Moderate
3	61-99	Severe
4	100	Dead

Tab. 2 - Number of plots and trees assessed in Turkey from 2007 to 2009.

Years	Number of plots assessed	Number of trees assessed
2007	48	911
2008	398	9318
2009	563	13219

tified as Level I plots. Since the forest area in the country is approximately 21.2 million ha and one grid point represents 256 km², a total of 828 plots can be installed and assessed. 400 additional grid points represented the forest boundaries (500 m from the forest edge) and were allocated using existing digitized forest maps. These grid points were installed when the point fell in a forest area. In case the grid point fell in other land use areas (< 25 m from the forest area), the point was moved towards the closest forest area (< 100 m). Plots at grid point in forest lands were not assessed when there were less than 10 trees with > 5 cm dbh. The Level I plot installation started in 2007 and continued in 2008 and 2009.

In each plot, four clusters with six trees were selected at 25 m from the plot center along the North, East, South and West directions. Trees with > 5 cm diameter at breast height (dbh) and Kraft classes 1-3 (1 = dominant; 2 = co-dominant; 3 = subdominant) were permanently selected to assess crown condition and in particular defoliation and discoloration.

At the end of 2009, 815 Level I plots were installed while only 48 Level I plots in *Pinus brutia* stands had been installed in 2007. Besides defoliation and discoloration, tree number, tree species and identified damage types as well as other stand and site parameters including country, plot number, plot coordinates, date, altitude, aspect, water availability, humus type, forest type and mean age of dominant storey were recorded according to Fischer et al. (2010). In assessing defoliation, the UNECE and EU classification was used (Tab. 1). Crown condition was assessed in 398 and 563 Level I plots in 2008 and 2009, including 9318 and 13 219 trees, respectively (Tab. 2).

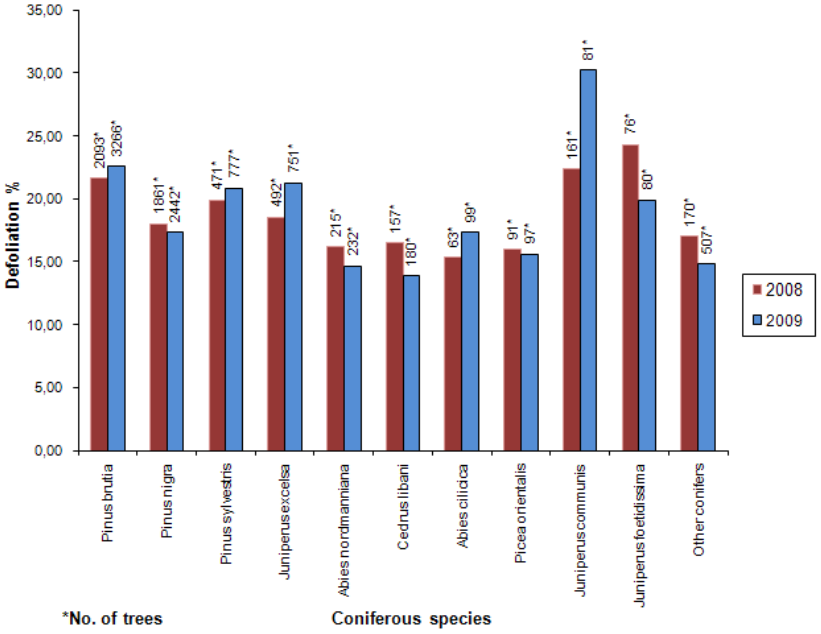

Fig. 1 - Mean defoliation of coniferous species in 2008 and 2009.

Results and discussion

Among conifers, *Juniperus foetidissima*, *Juniperus communis* and *Pinus brutia* showed the highest defoliation rates (24.3%, 22.4% and 21.6%, respectively) in 2008 and *Juniperus communis*, *Pinus brutia* and *Juniperus excelsa* in 2009 (30.2%, 22.6% and 21.2%, respectively). The mean defoliation of conifers did not change in 2008 (19.5%) and 2009 (19.8% - Fig. 1, Tab. 3).

As only 48 Level I plots dominated with *Pinus brutia* (911 trees) were assessed in 2007, the temporal development of defoliation for conifers and broadleaves was evaluated only on the data of 2008 and 2009. Both conifers and broadleaves showed lower percentages of trees in defoliation class 0 to 1 in 2008 than in 2009, and higher values in class 2 to 4 (Tab. 3), suggesting an improvement of forest health in Turkey in 2009.

Among broadleaved tree species, *Carpinus betulus* (34.3%), *Quercus petraea* (33.1%) and *Carpinus orientalis* (31.2%) were the most affected by defoliation in 2008 while *Quercus pubescens* (33.5%), *Carpinus orientalis* (27.9%) and *Quercus petraea* (25.8%) were the species with higher defoliation in 2009. Defoliation for all broadleaved species excluding *Quercus pubescens* and *Quercus coccifera* decreased in 2009 as compared to 2008. However, the mean defoliation of broadleaves in 2009 (23.0 %) was still higher than the mean defoliation of conifers in 2008 and 2009 (Fig. 2, Tab. 3).

In Europe, the deciduous oak species *Quercus robur* and *Quercus petraea* showed the highest defoliation during the last decade (Fischer et al. 2009). Defoliation peaked after the extremely dry and warm summer in 2003 and has been recovering slowly since 2007. In 2009 the overall defoliation of ICP-Forests trees was 19.3% (Fischer et al. 2010). Of all trees assessed, 20.2 % was scored as damaged (class 2 to 4). Damaged broadleaves were 22.4 % and damaged conifers were 18.3 % (Fischer et al. 2010). When comparing European averages in 2009 with Turkish results in 2008 and 2009, the percentage of damaged broadleaves is higher (23.4%), while the percentage of damaged conifers is lower (16 %) in Turkey. A comparison of forest condition in Turkey and in countries with similar forest ecosystems for the years 2008 and 2009 showed very variable trends (Tab. 4).

Tab. 3 - Health status of species types on the basis of defoliation in Turkey from 2008 to 2009.

Species Type	% trees defoliated					
	Class 0 to 1		Class 2 to 4		Mean defoliation	
	2008	2009	2008	2009	2008	2009
Conifers	83.7	84.0	16.2	16.0	19.5	19.8
Broadleaves	61.7	76.6	38.3	23.4	27.0	23.0
All species	75.4	81.3	24.6	18.7	22.3	20.9

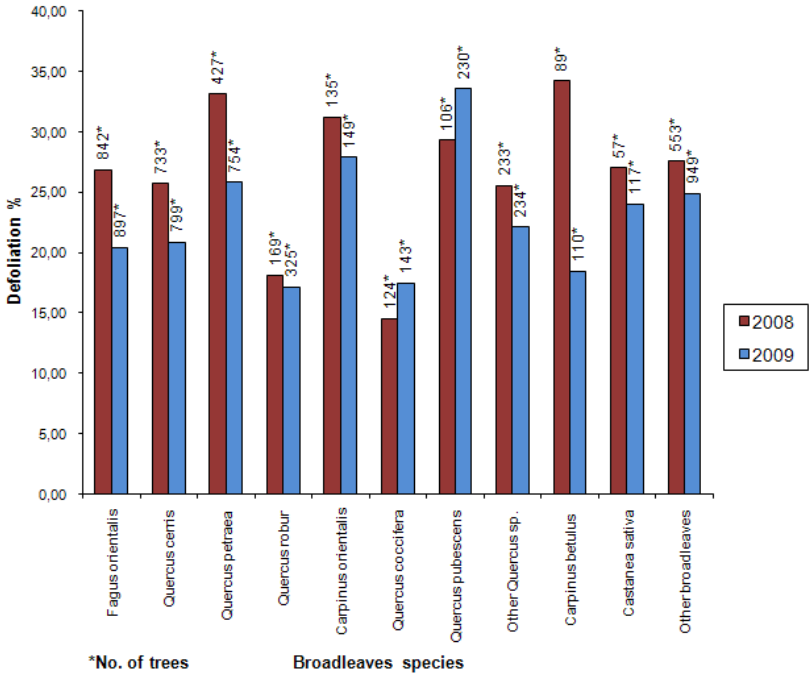

Fig. 2 - Mean defoliation of broadleaved species in 2008 and 2009.

Tab. 4 - Percent of damaged conifers, broadleaves and trees of all species (2008-2009, Fischer et al. 2010).

Countries	Defoliation Classes 2-4								
	Conifers			Broadleaves			All Species		
	2008	2009	Change Points 08/09	2008	2009	Change Points 08/09	2008	2009	Change Points 08/09
Bulgaria	45.6	33.0	-12.6	17.8	12.2	-5.6	31.9	21.1	-10.8
Crotia	59.1	66.5	7.4	19.1	20.7	1.6	23.9	26.3	2.4
France	25.1	26.8	1.7	36.5	37.1	0.6	32.4	33.5	1.1
Italy	24.0	31.6	7.6	35.8	36.8	1.0	32.8	35.8	3.0
Spain	12.9	14.9	2.0	18.4	20.7	2.3	15.6	17.7	2.1
Turkey	16.2	16.0	-0.2	38.3	23.4	-14.9	24.6	18.7	-5.9

Higher defoliation of coniferous and broadleaved species in southern Europe is mostly attributed to summer drought events (Fischer et al. 2010). The dry year 2008 followed by the wet year 2009 (Tab. 5) enabled us to preliminarily investigate the effect on crown condition in Turkey. A clear decrease in the rates of damaged broadleaved trees was observed in 2009 (Tab. 2), as a likely recovery after water stress.

In addition to drought effect, the pests *Thaumetopoea pityocampa* for *Pinus brutia* in Aegean and Mediterranean regions, *Dendroctonus micans* and *Ips typgraphus* for *Picea orientalis*, and *Lymantria dispar* for oak species in Black Sea Region are worth to be mentioned here. Intensive training programmes on pests are needed for a proper assessment in the Turkish plots.

Furthermore, more detailed analyses are required about air pollution. Out of the 200 coal-fired power plants with higher SO_2 emissions in Europe (Barrett 2004), six are in Turkey. Thus, local polluting sources, such as the coal-fired power plant in Muğla province in south-western Mediterranean region and the industrial plants in Iskenderun province in south-eastern Mediterranean region, may contribute to the higher mean defoliation for all species in 2009 (Fig. 3, Fig. 4).

In Turkey, the assessment of wet and dry deposition has been carried out mostly in or nearby urban areas in 1990s. In and around Istanbul, the concentration of sulphate and nitrate was high, although high calcium level neutralized the deposition pH (Gülsoy et al. 1999, Akkoyunlu & Tayanç 2003). Both local heating systems for houses and polluting sources in Balkans and Eastern Europe were suggested as a cause of the pollution in Istanbul (Okay et al. 2002, Akkoyunlu & Tayanç 2003), where rapid industrialization is still continuing. Slightly higher mean defoliation for all species in northern Anatolia region than in the other regions may suggest an effect of pollution from Istanbul (Fig. 3). In EMEP (European Monitoring and Evaluation Programme) stations, Tuncel (2003) reported that values of sulphate, nitrate and ammonia were higher in Amasra, Menemen and Antalya stations, *i.e.*, along Black Sea, Aegean and Mediterranean coasts, than in Ankara and Uludag, *i.e.*, in the inner Anatolian regions (Fig. 4). It was argued that air pollution decreased from coasts to inland.

The causes of change in forest ecosystems can be understood only by intensive monitoring. Twelve Level II plots representing the major forest ecosystems have been recently installed in Turkey. Moreover, ICP Forests Laboratory in line with international standard has been establishing at Aegean Forest Research Directorate in Izmir. Data on crown condition, soil condition, soil solution chemistry, needles/leaves chemistry, tree growth and yield, deposition, meteorology, ground vegetation, tree phenology, air quality, plant ozone injury and plant litterfall are included. Crown condition, ground vegetation, tree phenology and plant ozone injury are currently assessed; further activities will start soon. Further Level II plots should be also installed following the results from Level I plots.

Conclusions

Results from forest condition Level I monitoring in 2008-2009 in Turkey suggest that broadleaves are more affected than conifers. Likely causes of damage are air pollution (in particular along the Black Sea coast) and drought. As defoliation cannot be attributable to a single factor, an intensive Level II monitoring is recommended, with focus on areas where airborne deposition may exceed critical loads. All efforts in providing the information required for a sustainable forest management - as defined by the Ministerial Conference on the Protection of Forests in

Tab. 5 - Annual average temperature and annual total precipitation by years (TSMS 2010).

Year	Annual average temperature (°C)	Annual total precipitation (mm)
1971-2000	12.8	652.2
2007	13.8	616.2
2008	13.6	504.1
2009	13.7	815.7

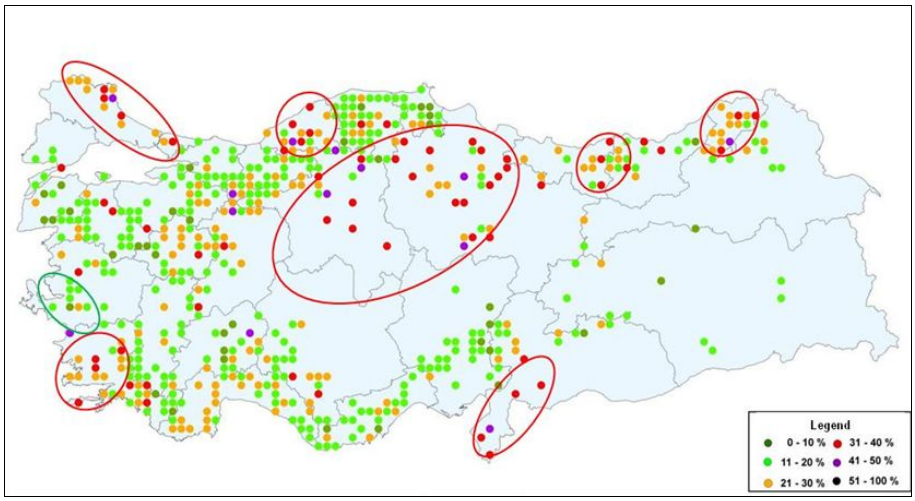

Fig. 3 - Mean plot defoliation for all species in 2009 (GDF 2010).

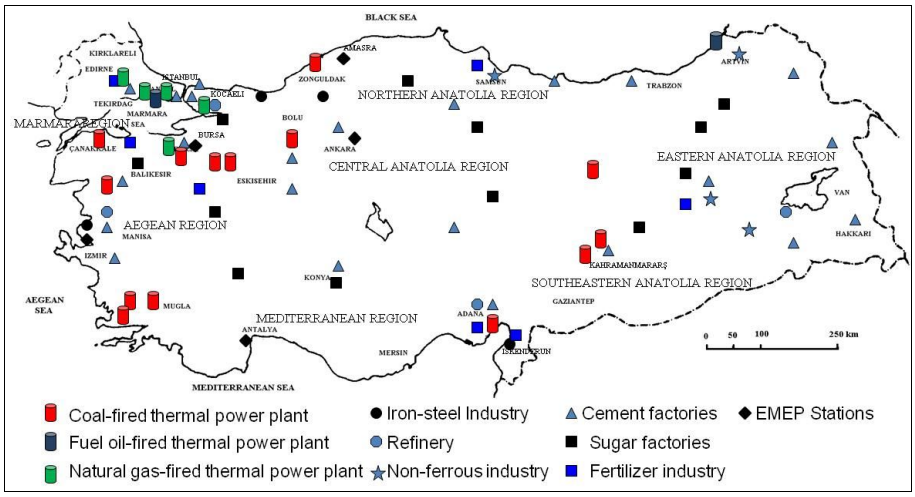

Fig. 4 - Locations of some air pollutant sources and five EMEP stations in Turkey (modified after Avci 2005 and Say 2006).

Europe (MCPFE) and promoted by United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD) - may help in drafting policy and strategy to better maintain and develop forest ecosystems with special attention to forest health and vitality. The region of Turkey is thought to face higher temperature and lower precipitation in the coming decades (IPCC 2007), so that natural stressors - in particular pests and forest fires - may seriously harm forest ecosystems. Turkish Forest Ecosystems Monitoring Programme linked with ICP Forests makes a concerted effort to provide data and information for this collaborative network.

Acknowledgements

We thank: all team members who assessed the tree crown condition for data submission to National Focal Centre of Forest Ecosystems Monitoring Programme coordinated by Department of Forest Management and Planning of Turkish Forest Service incorporating with Department of Research and Development of the Ministry of Environment and Forestry; Umut Adiguzel for graphics; Prof. Zeki Kaya for his kind help in proof-reading the English text; and Dr. Elena Paoletti for editorial support in English translation.

References

Akkoyunlu BO, Tayanç M (2003). Analyses of wet and bulk deposition in four different regions of Istanbul, Turkey. Atmospheric Environment 37: 3571-3579. - doi: 10.1016/S1352-2310(03)00349-2

Avci S (2005). Türkiye' de termik santraller ve çevresel etkileri. Istanbul Üniversitesi Edebiyat Fakültesi. Cografya Bölümü Dergisi 13: 1-26.

Badea O, Tanase M, Georgeta J, Anisoara L, Peiov A, Uhlirova H, Pajtik J, Wawrzoniak J, Shparyk Y (2004). Forest health status in the Carpathian Mountains over the period 1997-2001. Environmental Pollution 130: 93-98. - doi: 10.1016/j.envpol.2003.10.024

Barrett M (2004). Atmospheric emissions from large point sources in Europe. The Swedish NGO Secretariat on Acid Rain, Sweden, pp. 50.

Fischer R, Lorenz M, Köhl M, Becher G, Granke O, Bobrinsky A, Braslavskaya T, de Vries W, Dobbertin M, Kraft P, Laubhann D, Lukina N, Nagel HD, Reinds GJ, Sterba H, Solberg S, Stofer S, Seidling W (2009). The condition of forests in Europe 2009 Executive Report. UN-ECE / EC, Geneva, Brussels, pp. 12.

Fischer R, Lorenz M, Mues V, Iost S, Granke O, Becher G, van Dobben H, Reinds GJ, de Vries W (2010). Forest condition in Europe. 2010 Technical Report of ICP Forests, pp. 178.

GDF (2010). General directorate of forestry, web page of Turkish forest ecosystems monitoring programme. [online] URL: http://web.ogm.gov.tr/diger/icp2/Sayfalar/haritalar.aspx

Gülsoy G, Tayanç M, Ertürk F (1999). Chemical analyses of the major ions in the precipitation of Istanbul, Turkey. Environmental Pollution 105: 273-280. - doi: 10.1016/S0269-7491(98)00186-9

IPCC (2007). Climate change 2007: synthesis report. Contribution of working groups I, II and III to the fourth assessment report of the intergovernmental panel on climate change (Pachauri RK, Reisinger A eds). IPCC, Geneva, Switzerland, pp. 104.

Irmak A, Hus S (1951). Murgul bakir fabrikasinin ormanlara yapacagi zararlar ve orman idaresince alinmasi lazim gelen tedbirler hakkinda teklif. I.U. Orman Fakültesi Dergisi 1: 44-48.

Karakas A, Zengin M, Sarigül M, Özay FS, Uluer K (2007). Bati karadeniz ve marmara bölgesinde

hava kirliliginden (SO_2) kaynaklanan orman zararlarinin belirlenmesi. kavak ve hizli gelisen orman agaclari arastirma enstitüsü, Teknik Bülten, No. 206, Izmit, Turkey.

Koray ES, Güner ST, Cömez A, Çelik N, Karatas R, Karakas A (2007). Eskisehir, sakarya, bilecik, bolu yörelerinde hava kirliliginin ormanlar Üzerine etkisinin belirlenmesi, Cevre ve orman bakanligi arastirma projesi, Proje Nu ESK-02.8302/2002-2007.

Okay C, Akkoyunlu BO, Tayanc M (2002). Composition of wet deposition in Kaynarca, Turkey. Environmental Pollution 118: 401-410. - doi: 10.1016/S0269-7491(01)00292-5

Say N (2006). Lignite-fired thermal power plants and SO_2 pollution in Turkey. Energy Policy 34: 2690-2701. - doi: 10.1016/j.enpol.2005.03.006

TSMS (2010). 2009 Yili iklim verilerinin degerlendirmesi. (Turkish state meteorological service) [online] URL: http://www.dmi.gov.tr/FILES/verideger/2009-iklim-verileri.pdf

Tuncel G (2003). Türkiye' de asit yagmurlari. In: III. "Atmosfer bilimleri sempozyumu bildiri kitabi", pp. 1-16.

UNECE (2004). Manual on methodologies and criteria for harmonized sampling, assessments, monitoring and analysis of effects of air pollution on forests. Programme Co-ordinating Center, UN/ECE, Hamburg, Germany and Geneva, Switzerland.