

The Use of Dendrochronological Method in Dating of Illegal Tree Cuttings in Turkey: A Case Study

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Abstract

Every year many illegal tree cuttings occur in Turkey, and due to economic value of timber, the species such as *Pinus nigra* Arn. (Black pine) and *Pinus sylvestris* L. (Scots pine) are sometimes subject to illegal cuttings. On the basis of cross-dating results, the case study aims to date the cutting years of pine trees, maker(s) of which is unknown, in Metristepe site (Bafra-Turkey). The master chronology of the 13 samples, which were dated, significantly matched to the reference chronology from the same forest (Gleichläufigkeit Value: 81 %, correlation coefficient 0.82, $P < 0.001$). The dating results indicate that the illegal cuttings in the scene occur mainly between the years 1990-2000. Thus, in terms of neglect of duty, the forest enterprisers, engineers and guards on duty in the period of 1990-2000 might be under criminal proceedings.

Key words: dendrochronology, forensic evidence, illegal cutting, pine, tree ring, dating

Introduction

Dendrochronology is the most effective tool in dating archaeological wood (Kuniholm 1977, Kuniholm 1988, Akkemik *et al.* 2004), historical wooden buildings (Kuniholm 2000, Akkemik and Dagdeviren 2004), past droughts (Stahle *et al.* 2000, Knapp *et al.* 2004, Akkemik *et al.* 2005, Akkemik and Aras 2005, Akkemik *et al.* 2008, Touchan *et al.* 2003, 2005 and 2007), huge earthquakes (Yamaguchi *et al.* 1997), volcanic eruptions (Scuderi 1990, Jones *et al.* 1995), lake formations (Aytug and Kılıç 1993, Stasytytė *et al.* 2005), streamflow (George and Nielsen 2000, Akkemik *et al.* 2008), forest fires (McBride 1983, Baisan and Swetnam 1990, Lafon 2005), forest cuts (Cherubini and Schweingruber 1996), precious violins (Grissino-Mayer *et al.* 2003 and 2004), wood-part paintings (Klein and Bauch 1981, Baillie *et al.* 1985, Eckstein *et al.* 1986, Läänelaid and Nurkse 2006) and illegal tree cuttings (Aytug *et al.* 1991, Wolodarsky-Franke and Lara 2005).

Dendrochronology, however, can be utilized in forest offences. Every year many different forest offences occur in Turkey, and the most of them are in the matter of illegal cuttings. General Directorate of Forestry in Turkey reports that in 2006 the number of cutting offences is 5,956, and that the volume of trees cut illegally is 30,779 m³ (Anonymous 2006). *Pinus nigra* Arn. and *Pinus sylvestris* L. form a great part

among the most outstanding tree species of Turkey's forests, due to economic value of their timber. Thus, these species are sometimes subject to illegal cuttings.

On the strength of the inspector report of Turkey's Ministry of Environment and Forestry, public prosecutor indicts that there is a neglect of duty for forest enterprisers, forest engineers and guards served in the period of 1995-2000 due to illegal tree cuttings, maker(s) of which is unknown, on Metristepe site of Inozu territorial division of Bafra Forest Enterprise, Turkey. It is specified in indictment that total 1,333 trees of *Pinus nigra* Arn. and *Pinus sylvestris* L., with total standing volume 394,525 m³, were cut illegally in this period. After reports of three different expert witness boards in 2002 and 2006 on this case, we were asked by the judge in 2007 to determine and report whether pine trees cut illegally on the site were cut between 1995 and 2000.

In determining the exact cutting year of illegally cut trees, stumps with well-preserved sapwood and bark are extremely important. The presence of spring/summer wood of the last rings in the stumps and its dating enables us to decide the season and the year when each tree was cut (Akkemik 2004, Wolodarsky-Franke and Lara 2005). This is a very powerful method to date the trees cut illegally in Turkey. On the basis of dating of the stumps in the scene, the aim of the present study is to find the dates of the illegal

cuttings of pine trees by using dendrochronological methods.

Materials and methods

The scene of forest offence is located at Metristepe site in Inozu territorial division of Bafra Forest Enterprise in Middle Black Sea Region of Turkey (Figure 1). The longitude and latitude of the site are 35° 40' 38" E and 41° 16' 37" N, respectively, and its elevation is 1100 m a.s.l., and the climate is humid. The area has a mixed forest composed of mainly natural *Pinus nigra* Arn. and *Pinus sylvestris* L. stands. The slope of the area is 0-30% and the aspect is south-southwest.

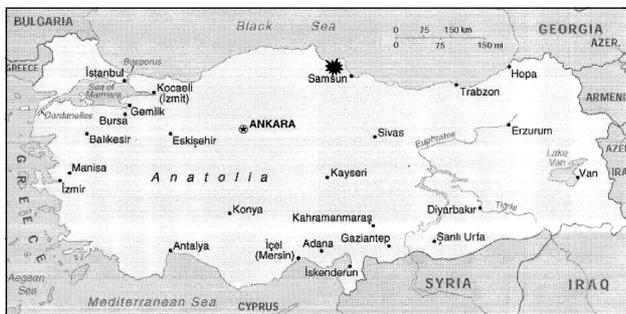


Figure 1. Location of the sampled site, Samsun-Bafra-Metristepe in Turkey, shown by an asterisk

We selected the samples to find their exact cutting dates based on the following features: the wood must have (1) at least 30 tree rings, (2) the outermost ring and especially bark, and (3) they must not be decayed or rotten. Because most of the stumps were decomposed either in their central part or outer part, and have not enough number of tree rings, only 13 stumps could be found having these features in the field, and one stem disc per stump was cut using a chainsaw.

To construct a reference chronology for cross-dating, 20 increment cores, two per tree, were obtained at breast height of 10 living black pine trees on the same site by using an increment borer.

At the laboratory the transverse surfaces of all cores and stem discs were smoothed using sandpaper, and their tree rings were measured to a precision of 0.01 mm using VIAS Time Table. Tree-ring widths were measured in two directions of each stem disc and living tree. While using the ARSTAN Program, an individual chronology for each living tree and a floating chronology for each stem disc were constructed. The residual version was selected in all chronologies

to eliminate non-climatic trends due to age, size, and stand dynamics. Then a reference chronology covering the time span from 1947 to 2006 was built from the individual chronologies of the living trees by using the ARSTAN Program. PAST4Lt program (www.sciem.com) was used for cross-dating of the floating chronologies of the stem discs on the reference chronology. As in most studies, it is considered a level of confidence of 95% of Gleichläufigkeit value (GI) and correlation coefficient (r) between each individual chronology and the reference chronology (Schweingruber 1988). After dating these 13 individual chronologies, GI values and correlation coefficients between the reference chronology and dated individual chronologies were calculated to check the dating, then a master chronology was built for the dated individual chronologies. Finally, the reference chronology and the master chronology of the samples were compared calculating GI and correlation coefficient between them.

Results

According to the dating results, Gleichläufigkeit values (GI) were statistically significant ($P < 0.05$) except for samples 4, 7 and 13. While the highest GI value between the chronologies under study and the reference chronology appeared for sample 10 (GI: 82 %), its lowest value occurred for sample 7 (GI: 57 %). Although GI values were not significant in samples 7 and 13, correlation coefficients were significant at the 99.9% level ($P < 0.001$). The correlation coefficients are significant except samples 4 and 6. Only the sample 4 revealed both low correlation and GI value. However, GI value is high. The highest correlation is 0.65 ($P < 0.001$) in sample 13 (Table 1). Dating of all samples was confirmed by visual comparison of graphs (Figure 2).

Because of very similar wood anatomical features, wood identifications of the samples could not be performed at the species level. Schweingruber (1990) also stated that *Pinus nigra* Arn. cannot always be distinguished from *Pinus sylvestris* L.

According to cross-dating results of samples examined, the illegal cutting dates were ranging from 1988 to 2005; one of 13 stem discs (number 5) was dated to 1988; four of them (number 3, 7, 10, 12) to 1990-1995; seven of them (number 1, 2, 4, 6, 8, 9, 11) to 1995-2000, and one (number 13) to 2005 (Figure 2). Master chronology of these 13 samples significantly matched to the reference chronology (GI: 81 %, correlation coefficient 0.82, $P < 0.001$) (Figure 2). This delivers another confirmation of the dating.

Table 1. Cutting dates/seasons and Gleichläufigkeit values (Gl) and correlation coefficients (r) between the individual chronologies (samples) and the reference chronology

Sample Number	Time Span	Mean Sensitivity	Cutting Dates	Cutting Season*	Gleichläufigkeit Values (%)	Correlation Coefficient (r)
1	1967-1996	0.234	1996	+	74**	0.64***
2	1970-1998	0.171	1998	+	78**	0.60***
3	1963-1992	0.196	1992	+	68*	0.40*
4	1969-1998	0.261	1998	+	61NS	0.16NS
5	1959-1988	0.253	1988	±	70*	0.42*
6	1970-1999	0.223	1999	-	68*	0.29NS
7	1963-1992	0.267	1992	-	57NS	0.58***
8	1969-1998	0.191	1998	+	78**	0.36*
9	1969-1998	0.230	1998	+	64*	0.41*
10	1964-1993	0.171	1993	±	82***	0.34*
11	1964-1998	0.235	1998	-	67*	0.53***
12	1956-1990	0.303	1990	+	66*	0.43**
13	1971-2005	0.341	2005	±	61NS	0.65***
Master Chronology of the Samples	1956-2005	0.227			81***	0.82***

P < 0.05 *, P < 0.01 **, P < 0.001 ***, NS: Not significant
 *) (+) includes entire last ring and cutting season may be after summer; (±) includes partial late wood of the last ring and cutting season may be late spring/early summer; (-) includes only early wood of the last ring and cutting season may be spring/late spring.

Discussion and conclusions

The dating results indicate that the illegal cuttings in the scene occurred before 1995 as well as during 1995-2000. Thereby, the forest enterprisers, forest engineers and guards served not only in the period of 1995-2000 but also in the years 1990-1995 might be under criminal proceedings in terms of neglect of duty. Moreover, sample 13 showed that illegal pine cuttings have occurred in recent years. Forestry Service also considers that there were illegal cuttings during this time period, but their exact years were unknown. However, due to decaying most of pine stumps in the scene, the results based on 13 samples were not able to present how many cubic meters of pine trees were cut illegally in tenure of office for each person.

Decaying degree, less number of tree rings and lacking of bark and outermost ring of the wood decrease the ratio of usage to find exact date of the stumps. Because of these, many of the stumps could not be used in this study. However, 13 stumps could give valuable information about the long-term illegal cuttings for studied area. As a consequence, we can conclude that dendrochronological dating was the most effective method to date the illegal cuttings as indicated by Wolodarsky-Franke and Lara (2005). As a very powerful method, dendrochronological dating can widely be used in the cases like this throughout Turkey.

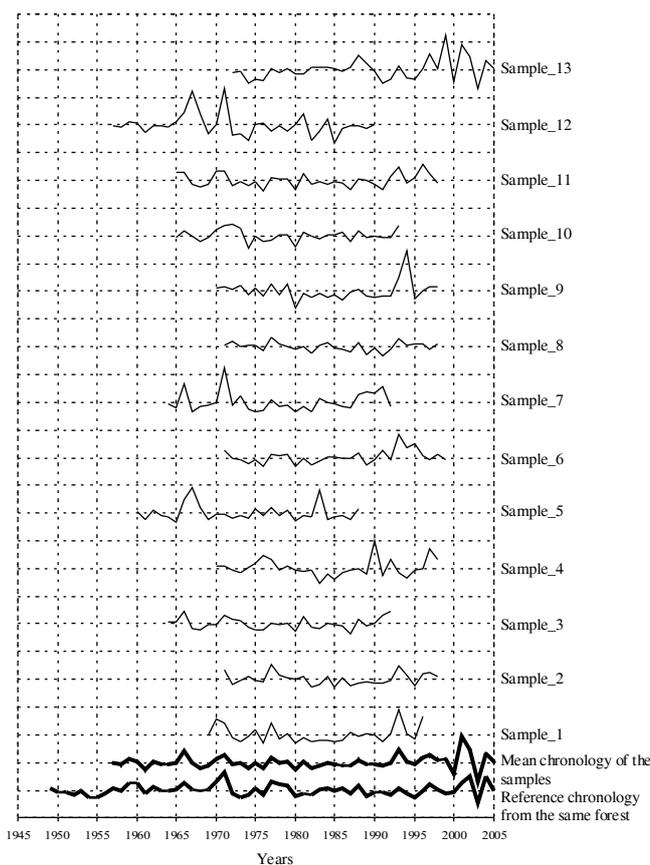


Figure 2. Dating of the floating chronologies of the samples 1-13 and their mean (bold with dot) with the reference chronology (bold-face)

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ИСПОЛЬЗОВАНИЕ ДЕНДРОХРОНОЛОГИЧЕСКОГО МЕТОДА ПРИ ДАТИРОВКЕ НЕЗАКОННОЙ ВЫРУБКИ ДЕРЕВЬЕВ В ТУРЦИИ: ИССЛЕДОВАНИЕ ПРОБЛЕМЫ

Б. Яман и У. Аккемик

Резюме

Ежегодно в Турции проводится множество незаконных вырубок деревьев, что связано с экономическим значением таких древесных пород, как например *Pinus nigra* Agn. (Сосна черная австрийская) и *Pinus sylvestris* L. (Сосна обыкновенная), которые довольно часто подвергаются незаконной вырубке. На базе результатов перекрестной датировки исследование ставит перед собой цель датировать год вырубки сосновых деревьев на участке Метристеппе (Бафра-Турция), образование которых неизвестно. Основная хронология 13 датированных образцов в большей мере соответствовала нормативной мастер-хронологии из этого же леса (значение *Gleichläufigkeit*: 81 %, коэффициент корреляции 0.82, $P < 0.001$). Результаты датирования показывают, что незаконная вырубка деревьев в основном осуществлялась в период 1990-2000 г. Таким образом, из-за халатного отношения к обязанностям в отношении предпринимателей, инженеров и охранников лесного хозяйства, которые находились при исполнении служебных обязанностей в период с 1990 по 2000 г., могло быть начато уголовное судопроизводство.

Ключевые слова: дендрохронология, судебный, незаконная вырубка, сосна, годичное кольцо, датировка