ORAL PRESENTATION

Seasonal Pattern of Leaf Area Index (LAI) for *Pinus pinaster* plantation in Bartın Urban Forest

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**Abstract:**

Leaf Area Index (LAI) is a key parameter indicating one-sided area of the leaves over the projected crown area. LAI parameter is widely used in the scientific researches extending from forestry to hydrology, from botany to landscape architecture. There is broad perspective of LAI measurement involving the direct methods such as leaf harvesting and indirect methods of hemispherical photographing and remote sensing. Although the common analyses of the LAI concentrate on the instant measurements together with other data collections such as soil and forest floor, analysis of the seasonal pattern of LAI has recently gained importance particularly for the deciduous vegetation. However, the number of these analyses for coniferous vegetation is relatively scarce. In this study, seasonal change of the LAI for the *Pinus pinaster* plantation in Bartın Urban Forest, which was opened for public usage in 2010, is discussed. Selective removal of some trees was carried out for the generation of recreational sites within the urban forest. Consequently, closure of the urban forest diminished. Measurement of the LAI is based on the hemispherical photographing using fisheye objective mounted on a digital SLR camera. Hemispherical photographs taken were analyzed with Hemisfer Software version 1.5.3. Six fixed points out of each recreation and control sites were determined in the urban forest. In total 5 measurements were conducted with 3 weeks intervals between March 23rd and June 17th of 2012. According to the results of the study, mean LAI ranges between 1.43 and 1.54 for the recreation site whereas it ranges between 1.72 and 1.84 for the control site. The LAI values are relatively low for coniferous trees.

**Key Terms:** Leaf Area Index (LAI), *pinus pinaster*, bartın urban forest, hemispherical photographs, seasonal pattern.

**Introduction:**

Leaf Area Index (LAI) is the one sided surface area of the leaves over the projected crown area for the broadleaf trees (Bonan 2008). On the other hand, it is defined as the one half of the total leaf area over the unit ground surface area considering also the non-flat leaves (Jonckheere et al. 2004). LAI is a significant parameter, which is applicable for many sciences ranging from ecosystem modeling (Mazzoleni et al. 2004) to hydrological modeling (Waring and Running 2007; Öztürk et al. 2013) and from forest dynamics (Pretzsch 2009) to climate dynamics (Bonan 2008).

Many researchers have analyzed the seasonal change in the LAI of the temperate forests (Bréda and Granier 1996; Campioli et al. 2011; Bequet et al. 2011). However, most of them concentrated on the deciduous trees. The seasonal change in the temperate deciduous LAI is more apparent compared to the coniferous. Hence the foliation and defoliation are the temporally dynamic processes for the temperate deciduous trees. Although they demonstrate spatial variations, part of the leaves of the coniferous trees fall in the winter (Fang et al. 2008). New foliation starts in the spring. They never become leafless unless they turn to die.

In this study, we examined the seasonal pattern of a coniferous tree, *Pinus pinaster* that is in the form of plantation. The *Pinus pinaster* plantation was first established about 15 years ago (TGDF 2011). The plantation site was then converted to a recreation site. This study does involve the investigation of seasonal LAI both for the recreational and the control sites.

*Pinus pinaster* is a coniferous tree with 20-25 m height (Yaltırık and Efe 2000), which grows up to 40 m in maximum. The bark is deeply fissured and reddish brown (Tutin et al. 1993). The tree has gray-green leaves up to 25 cm length and 2 mm diameter. The cones are ovoid-conical with 8-22 × 5-8 cm dimensions (Tutin et al. 1993). They grow well in dry and sandy soils (Yaltrirık and Efe 2000).
Materials and Methods:

The *Pinus pinaster* forest site covering about 22.7 hectares is located in the province of Bartın at the northwest of Turkey (Figure 1). The altitude changes between 80 and 195 m with an average of 138 m whereas the average slope is 16% with the dominant aspect oriented south-west. Moderate deep (50-90 cm) brown forest soil (TMFAL 2005) has formed on calcareous parent material (TGDMRE 2007). Based on the statistics of the 30 years (between 1982 and 2011) meteorological data (TSMS 2013), average annual precipitation is 1044 mm; mainly in the form of rainfall whereas average annual temperature of the site is 12.6°C. The mean temperatures of the summer months; June, July and August are 19.7°C, 22.2°C and 21.9°C respectively (TSMS 2013). The dominant wind direction is from north and north-west.

![Figure 1. Location of Pinus pinaster forest within Bartın watershed and Turkey.](image)

The height of the *Pinus pinaster* trees varies between 8 and 11 m. The mean diameter at breast height (DBH) of the trees is 28 cm (TGDF 2011). Shrubs are the understory vegetation mainly the composed of prickly juniper (*Juniperus oxycedrus*), smoke tree (*Cotinus coggyria*) and green olive (*Phyllrea latifolia*) (Yılmaz 2001). The site is about 6.5 km away from the city center (Öztürk and Bolat 2012) and neighboring to the peripheral settlements. A major part of the *Pinus pinaster* forest covering 18.7 hectares (about 82% of the total experimental forest) was transformed to a recreation site under the name of ‘Bartın Urban Forest (BUF)’. Thinning was applied to the trees in the recreation site. On the other hand, only 4 hectares (almost 18%) of the *Pinus pinaster* forest site is occupied by the control site where thinning has not been applied.
Hemispherical photographing technique was used for the determination of LAI. The hemispherical photographs (180°) were taken using 8 mm fisheye objective (Sigma F3.5 EX DG Circular Fisheye-Sigma Corporation) mounted on a digital SLR camera (Canon EOS 5D Mark II-Canon Corporation). Continuous photographing was conducted with, in average three weeks intervals. Sunny days were not preferred for photographing to avoid exposure to direct sunlight. Six points were defined for hemispherical photographing in each recreational and control sites. In total, 60 photographs as a result of five field visits were taken. The dates of the field visits are March 23rd, April 15th, May 6th, May 25th and June 17th of the 2012 sequentially.

The digital photographs taken were analyzed using hemispherical photograph analysis technique with Hemisfer software 1.5.3 version (Swiss Federal Institute for Forest, Snow and Landscape Research (Schleppi et al. 2007). Automatic thresholding based on the study of Nobis and Hunziker (2005) and method of Lang (1987) was used during the digital photograph analysis. To avoid the effects of the stems and branches on the LAI values, corrections of both Schleppi et al. (2007) for the non-linearity and slope and Chen and Cihlar (2005) for the clumping effect were integrated into calculations.

Results and Discussion:

Figure 2 shows the hemispherical views of the six points in each of the recreation and control sites for the beginning of the monitoring period; March 23rd. Figure 3 presents the change in the LAI values along for the monitoring period between March 23rd and June 17th. According to the results of the study, LAI values continuously increase between

![Figure 2. Hemispherical views from the recreation (left) and control (right) sites in March 23rd of 2012.]
March 23rd and May 6th. LAI values generally stabilize after May reaching approximately the maximum in June. This situation is valid both for the recreation and control sites. After the stabilization, LAI decreased only 0.01 for the sixth point of the recreation site in June.

The mean values for the recreation site are 1.43, 1.47, 1.52, 1.53 and 1.54 sequentially from March 23rd to June 17th. The mean values for the control site are 1.72, 1.76, 1.81, 1.84 and 1.84 sequentially for the same period. The mean LAI values of the control site are slightly higher than the recreation site particularly due to the removal of the trees from the recreation site. The mean increase in the LAI of the recreation site is about 7.7% ranging between 4.0% and 13.4%. The mean increase in the LAI of the control site is about 7.2% ranging between 6.0% and 8.1%.

For a temperate coniferous forest, Leaf Area Index of Pinus pinaster begins to ascend after March. Based on the analysis of the satellite images, Heiskanen et al. (2012) report that the increment of LAI of a boreal forest starts in May where the LAI development lasts until about mid-July and descends afterwards. On the other hand, for evergreen needleleaf trees dominated by relatively warmer climate of North America, Fang et al. (2008) state that LAI increases in mid-April continuing to develop until mid-July and then smoothly decreases.
Conclusions:

In the study area, the monitoring process had to be finished since new removal of trees occurred both in the recreation and control sites after the last monitoring in June 17th. However, subsequent studies should be concentrated on this field investigating both consequences of LAI change and the environmental impacts of forest transformation.

Although Leaf Area Index is a key parameter for many crucial subjects such as, botany, forestry, agriculture, meteorology and hydrology, and find a widespread area of study in the world, particularly for the forestry, it is restricted to few studies in forest ecology (e.g. by Kara et al. 2008) and forest hydrology (Altunkaynak and Aydin 2012; Öztürk et al. 2013). The number of the studies which deal with the LAI parameter must increase indicating the variety of this LAI parameter within Turkey where both coniferous and deciduous forests and mixture of those forests cover large areas.

References


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