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SHADING OF TREE CANOPIES ON INTERTOWN ROADS THROUGHOUT FOREST LANDSCAPES: ABDİPAŞA-OVACUMA GREENWAY OF TURKEY

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Abstract

Greenways are the systems that link both the urban and rural landscapes. Thus, they establish cultural and natural corridors between these landscapes. Being one of the major rural landscapes, forests supply ecosystem services by their recreation potential as well as wood and oxygen production. Hence, forest ecosystems that include roads constitute rural greenways. The canopies of the trees and shrubs supply shading on these road surfaces. These greenways play a significant recreational and safety role within the overall forest landscapes. They provide shading, recreation, and safety for both the drivers and passengers. Thereby, tree and shrub canopy parameters such as the closure and coverage are the determining factors on the safety, shading and recreation potential. Amongst those tree and shrub canopy parameters, the Leaf Area Index (LAI), Light Transmission (LT), Gap Fraction (GF) and Canopy Openness (CO) are the prominent ones. Therefore, the greenway route along the road between Ulus Subprovince (Bartın) and Safranbolu Subprovince (Karabük) at the northwestern Turkey, was chosen as the study and research field in this study. The oriental planes (*Platanus orientalis* L.) are the immediate roadside trees with their canopies shading on the surface of that road. Along 14 km road route, 71 different points were defined for the hemispherical photographing during the summer of 2021. Based on the analyses of these hemispherical photographs using the version 3.2 of the Hemisfer program, the LAI values ranged between 1.89 m^2 m^{-2} and 2.79 m^2 m^{-2}, being 2.34 m^2 m^{-2} on average. However, the average LT and CO percentages were 17.9% and 18.2%, whereas the average GF percentage was 7.7%. According to the overall results of this study, the canopy parameters indicated relatively high canopy closure and coverage values even though with alternating values and percentages for the different sections of the greenway route.

Keywords: Tree Canopy, Rural Landscape, Forest Ecosystem, Road Route, Greenway, Ecosystem Services

1. Introduction

Forest landscapes are the areas which compose the land uses' mosaic where the forest ecosystems predominantly occupy (Turner & Gardner, 2015). Forest landscapes possess social, aesthetic, and recreational dimensions as well as their principle ecological, hydrological, and economical roles (Marsh, 2010). By their social, aesthetic, and recreational services, they particularly offer temporary or permanent accommodation and employment opportunities for the forest villagers and, supply trekking, picnic activities and, entertain road journey throughout these forest landscapes for the local public or the visitors (Öztürk et al., 2019). Hence, an entertaining and safe road journey not only supply recreation for the passengers but also secure the travel for the drivers (Öztürk, 2017). Besides the road pavements and traffic signs, the surrounding environment also plays significant positive or negative roles on both the recreation and safety potential of those travels. Therefore, the forest trees aligned or scattered along the roadside constitute greenway system within the overall surrounding landscape.

Greenways, which are the connections of linear components, and which are composed of trees or shrubs, should be planned, designed, and managed within the concepts of aesthetic, ecological, recreational, and cultural dimensions. Thus, their usages should intend to achieve sustainability. (Ahern, 1995; Öztürk & Gökyer, 2016). Greenway systems sometimes link the urban and rural settlements such as from streets to towns and from districts

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to cities. Namely, within the urban and rural landscapes, they construct aesthetic and ecological corridors (Forman & Godron, 1986; Forman & Alexander, 1998). One of the substantial constituents of the rural landscapes, forest ecosystems offer services by providing recreation potential as well as primarily producing wood and oxygen. Indeed, by means of the forest tree canopies on the roads, forest ecosystems constitute rural greenway systems. Therefore, forest landscapes including the greenways, play significant role in terms of shading supply and associated recreation potential and securing safety for the travellers. Thus, from the point of determining the shading, safety and recreation potential of these greenway systems, canopy analyses are necessary for the immediate surrounding trees. These canopy analyses particularly involving the determination of canopy density, closure, coverage, and also light transmission levels, are very important.

Amongst the canopy parameters, Leaf Area Index (LAI), Light Transmission (LT), Gap Fraction (GF) and Canopy Openness (CO) are the prominent ones which can be directly referred to identify the level of canopy closure and coverage. Thereby, determining the degree of the tree canopy closures and coverages by using these tree canopy parameters within a case intertown greenway system, constitutes the main aim of this study.

Fig. 1. Study field (greenway system) and overall 71 hemispherical photographing points within Turkey

2. Material and Methods

In the northwestern Turkey, at the Western Black Sea Region, there is a road between the Bartın and Karabük Provinces, which involve many greenway systems. Between the Abdipaşa Town (Ulus, Bartın) and the Ovacuma Town (Safranbolu, Karabük), the road route, that carry the greenway system characteristics, was chosen as the study field. Ovacuma tributary of the Ulus Stream is running together with the greenway system. The Abdipaşa side of the greenway system is more fragmented compared to the Ovacuma side. Oriental plane (*Platanus orientalis* L.) trees together with their canopies dominate the greenway as if they have constructed vegetation tunnel on the road itself. Along this road route within the greenway system, the hemispherical photographing points were determined between the 32° 41' 19" and 32° 34' 17" eastern longitudes, and between the 41° 27' 20" and 41° 30' 17" northern latitudes (Fig. 1). The length of the road route is about 14 km whereas its' altitude ranges between 135 m and 300 m above sea levels. In the study region, annual precipitation is 1044 mm on average whereas the annual air temperature is 13°C on average (TSMS, 2013). Thereby, climate regime of the study region can globally be described as mesothermal humid (Atalay, 2011). The surrounding forest ecosystems primarily involve the sessile oaks (*Quercus petraea* [Matt. Liebl.]), European hornbeams (*Carpinus betulus* L.), oriental beeches (*Fagus orientalis* Lipsky) and black pines (*Pinus nigra* L.) (TGDF, 2006). Due to the scenic beauty of the oak and hornbeam trees in particular, the foliage and colours of these forest ecosystems become very spectacular in autumn (Öztürk & Gökyer, 2015).

71 different hemispherical photographing points were selected within this 14 km route in order to determine the canopy parameters of these oriental plane trees along this greenway system (Fig. 1). The 14 km long road was divided into 6 sections, each of which constitutes distinct canopies with different closures. The hemispherical photographs were taken in mid-June of 2021. A digital camera (Canon EOS 5D digital SLR camera, Mark II-Canon Corporation) where an 8 mm fisheye lens (Sigma F3.5 EX DG Circular Fisheye-Sigma Corporation) is mounted, was used to capture these hemispherical photographs. Hemisfer (version 3.2; Swiss Federal Institute for Forest, Snow and Landscape Research) software was used during the analyses of the LAI, LT, GF, and CO parameters (Schleppi et al., 2007). Methodology on LAI-2000 device (LI-COR Biosciences Inc.) was referred during these analyses. The automatic thresholding was based on Nobis & Hunziker (2005) whereas the corrections were applied according to the coupled methods by Chen & Cihlar (1995) and Schleppi et al. (2007).

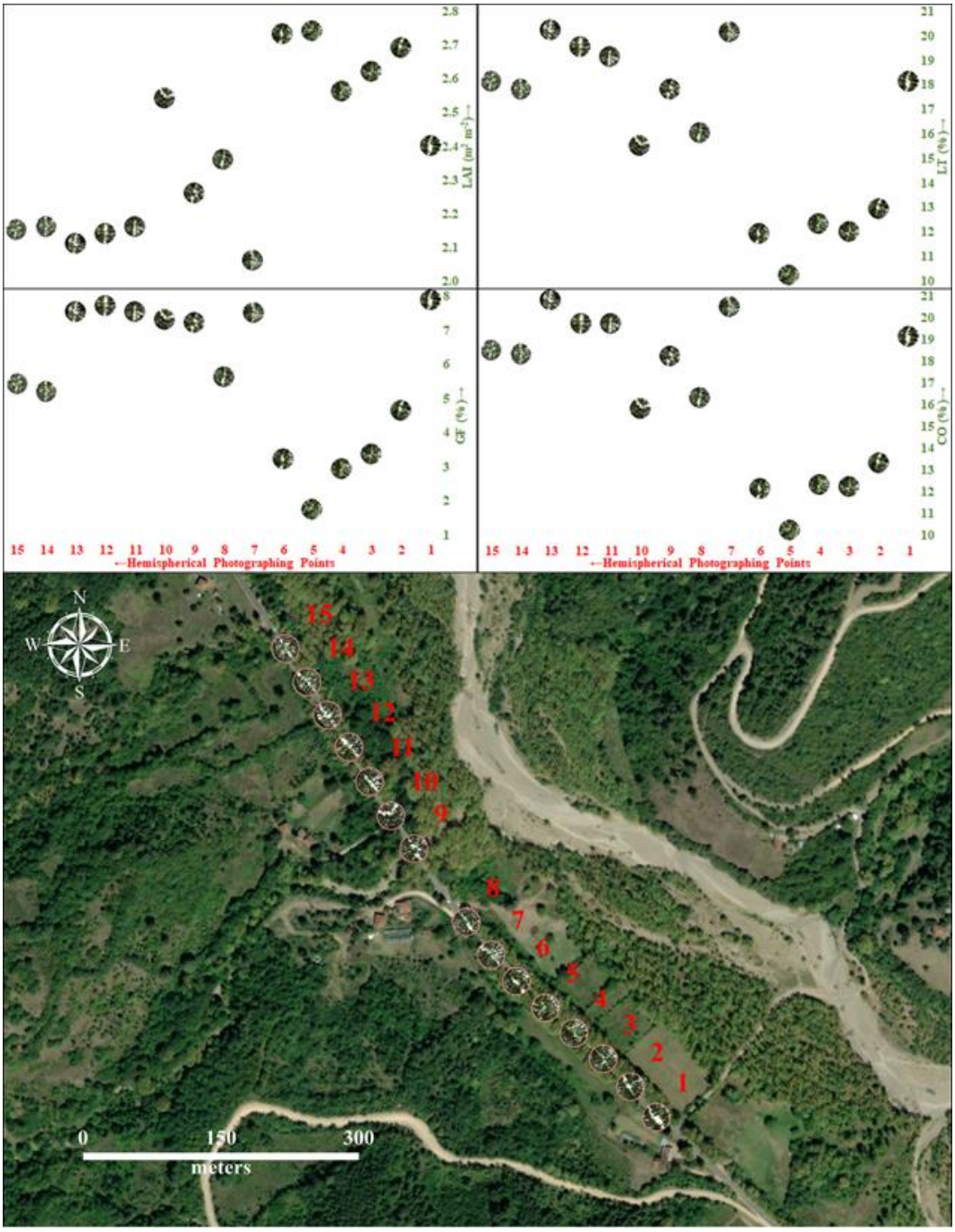

Fig. 2. Location of the first 15 hemispherical photographing points together with their LAI values, and LT, GF, CO percentages in the Section 1

3. Results and Discussion

3.1. Section 1

Regarding to the study results, the LAI ranged between 2.06 m^2 m^{-2} and 2.74 m^2 m^{-2} for the first 15 hemispherical photographing points where the mean LAI was 2.38 m^2 m^{-2} within the Section 1 of the greenway research field (Fig. 2). On the other side, the mean LT was 16.1% ranging between 10.2% and 20.2% whereas the mean GF was 5.6% ranging between 1.7% and 7.9%. Confirming these values, the mean CO was 16.5% varying between 10.2% and 20.8% (Fig. 2). These values indicated that the canopies of the roadside trees were relatively dense and therefore had high shading supply in this Section 1. Indeed, Cackowski & Nasar (2003) roadside vegetation had remedial impacts on the disappointment of the drivers.

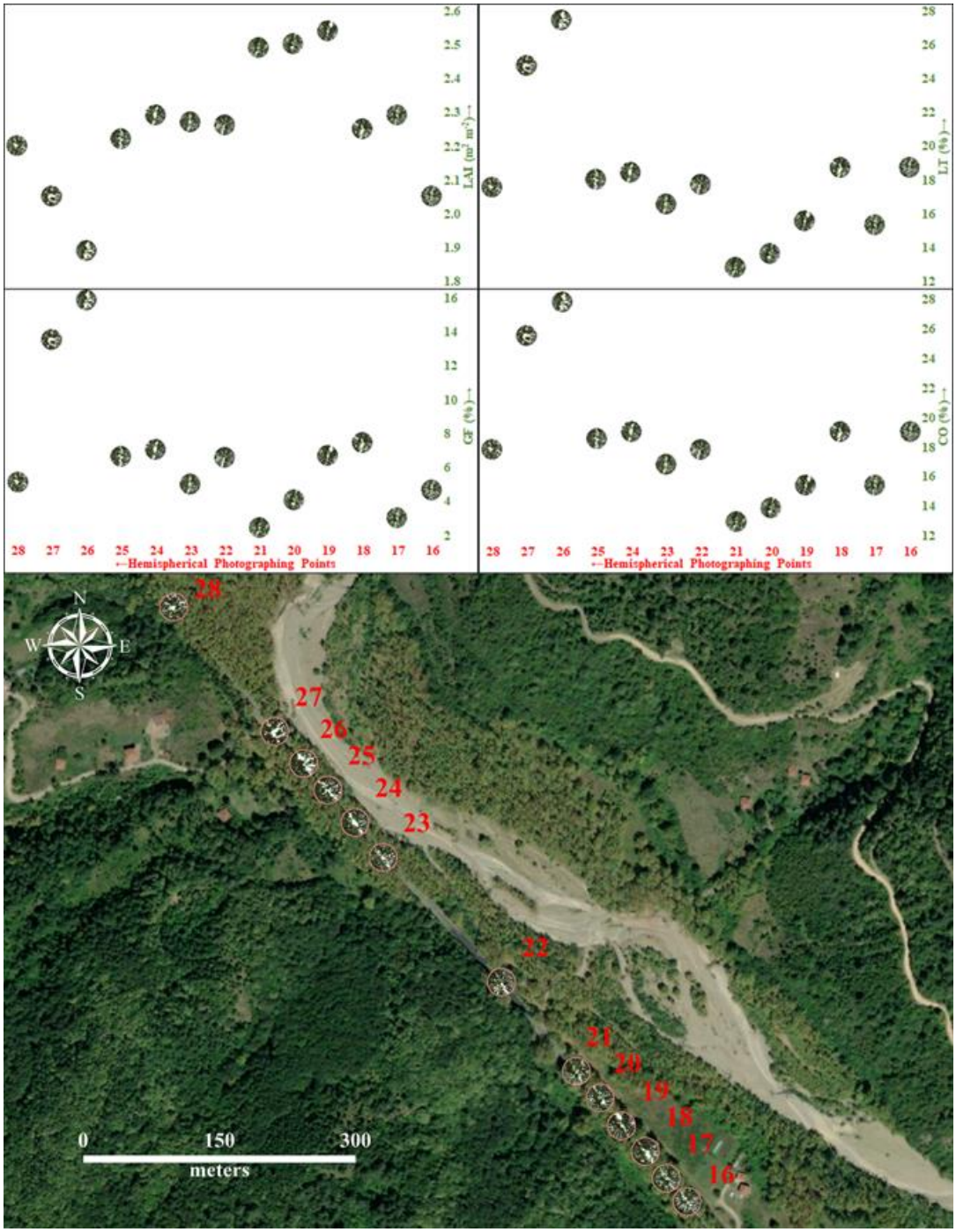

Fig. 3. Location of the second 13 hemispherical photographing points together with their LAI values, and LT, GF, CO percentages in the Section 2

3.2. Section 2

Regarding to the study results, the LAI ranged between 1.89 m^2 m^{-2} and 2.54 m^2 m^{-2} for the next 13 hemispherical photographing points where the mean LAI was 2.25 m^2 m^{-2} within the Section 2 of the greenway research field (Fig. 3). On the other side, the mean LT was 18.1% ranging between 12.8% and 27.4% whereas the mean GF was 6.7% ranging between 2.4% and 15.8%. Confirming these values, the mean CO was 18.4% varying between 12.9% and 27.8% (Fig. 3). The values of the canopy parameters pointed the relative sparsity of the roadside tree canopies and therefore relatively lower shading supply in this Section 2. In fact, based on a driver simulator study, the increment in the vegetation density did not lead to any speed reduction for the drivers (Fitzpatrick et al., 2016).

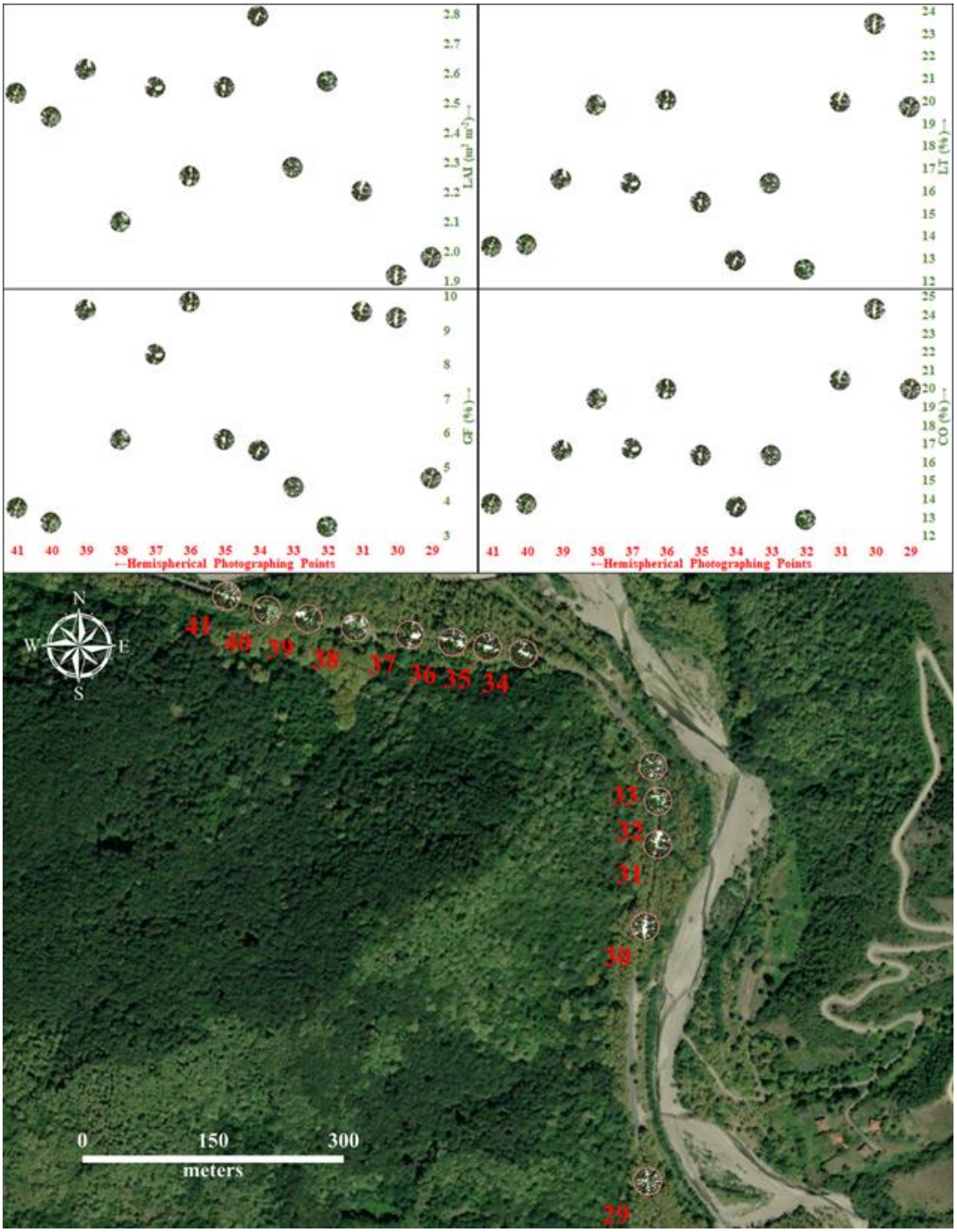

Fig. 4. Location of the third 13 hemispherical photographing points together with their LAI values, and LT, GF, CO percentages in the Section 3

3.3. Section 3

Regarding to the study results, the LAI ranged between 1.92 m^2 m^{-2} and 2.79 m^2 m^{-2} for the following 13 hemispherical photographing points where the mean LAI was 2.37 m^2 m^{-2} within the Section 3 of the greenway research field (Fig. 4). On the other hand, the mean LT was 16.9% ranging between 12.5% and 23.4% whereas the mean GF was 6.4% ranging between 3.2% and 9.8%. Confirming these values, the mean CO was 17.2% varying between 12.8% and 24.3% (Fig. 4). The highest values of the canopy parameters showed the dense canopy closure and associated high shading supply in this Section 3. Thus, as the closure of the canopy gets intensive, the amount of light penetrating through that canopy diminishes (Kucharik et al. 1999). Therefore, this lower light intrusion would lead to less distractibility for the drivers.

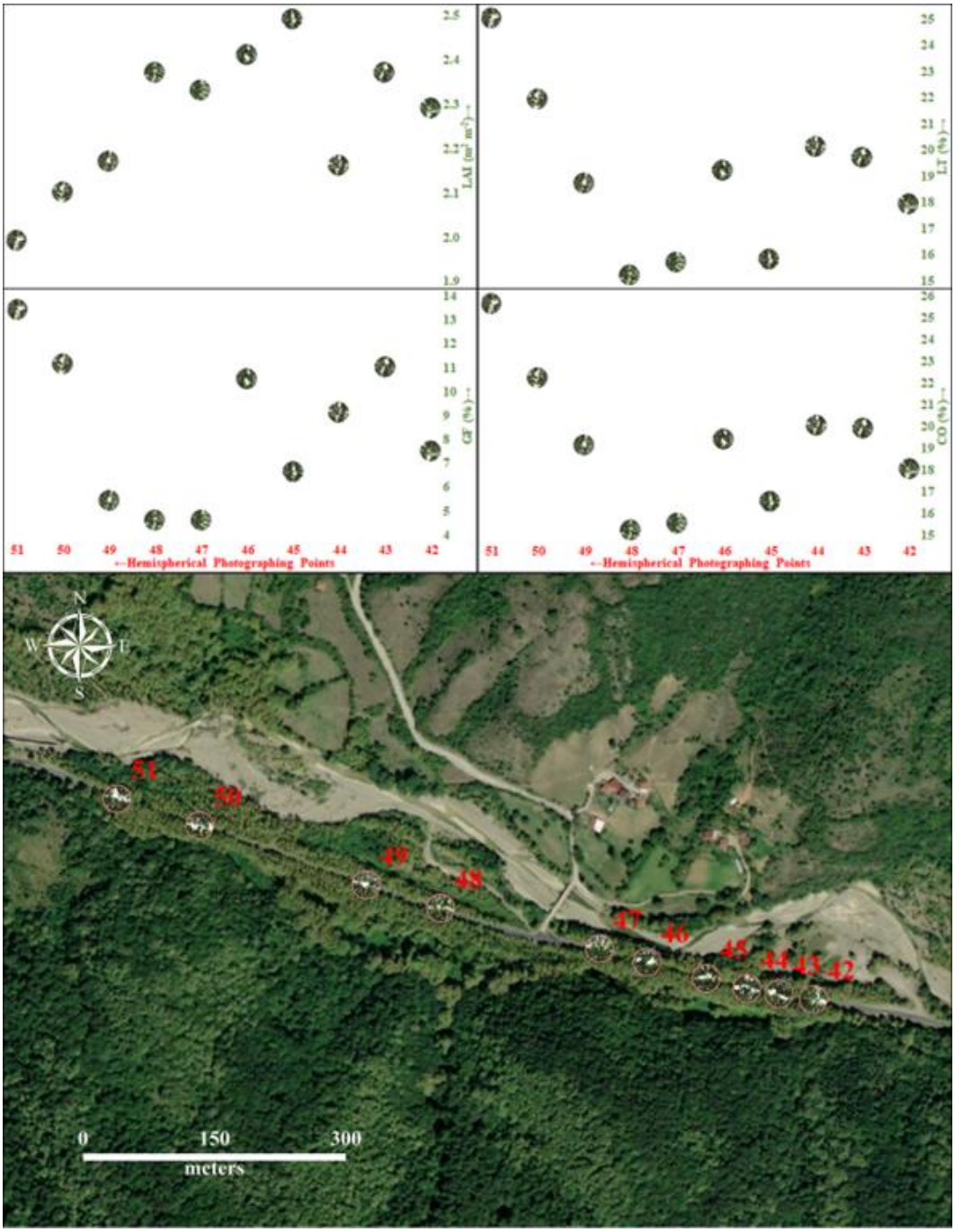

Fig. 5. Location of the fourth 10 hemispherical photographing points together with their LAI values, and LT, GF, CO percentages in the Section 4

3.4. Section 4

Regarding to the study results, the LAI ranged between 1.99 m^2 m^{-2} and 2.49 m^2 m^{-2} for another following 10 hemispherical photographing points where the mean LAI was 2.27 m^2 m^{-2} within the Section 4 of the greenway research field (Fig. 5). On the other hand, the mean LT was 18.8% ranging between 15.1% and 24.9% whereas the mean GF was 8.4% ranging between 4.6% and 13.4%. Confirming these values, the mean CO was 19.1% varying between 15.2% and 25.6% (Fig. 5). The relatively lower values of the tree canopy parameters emphasized the relatively more light intrusion beneath those canopies and consequently less shading supply in this Section 4. However, landscapes with alternating between the forested and open spaces rose the stress level of the drivers compared to the uniform forested or open areas, as indicated in another driver simulation study by Antonson et al. (2009).

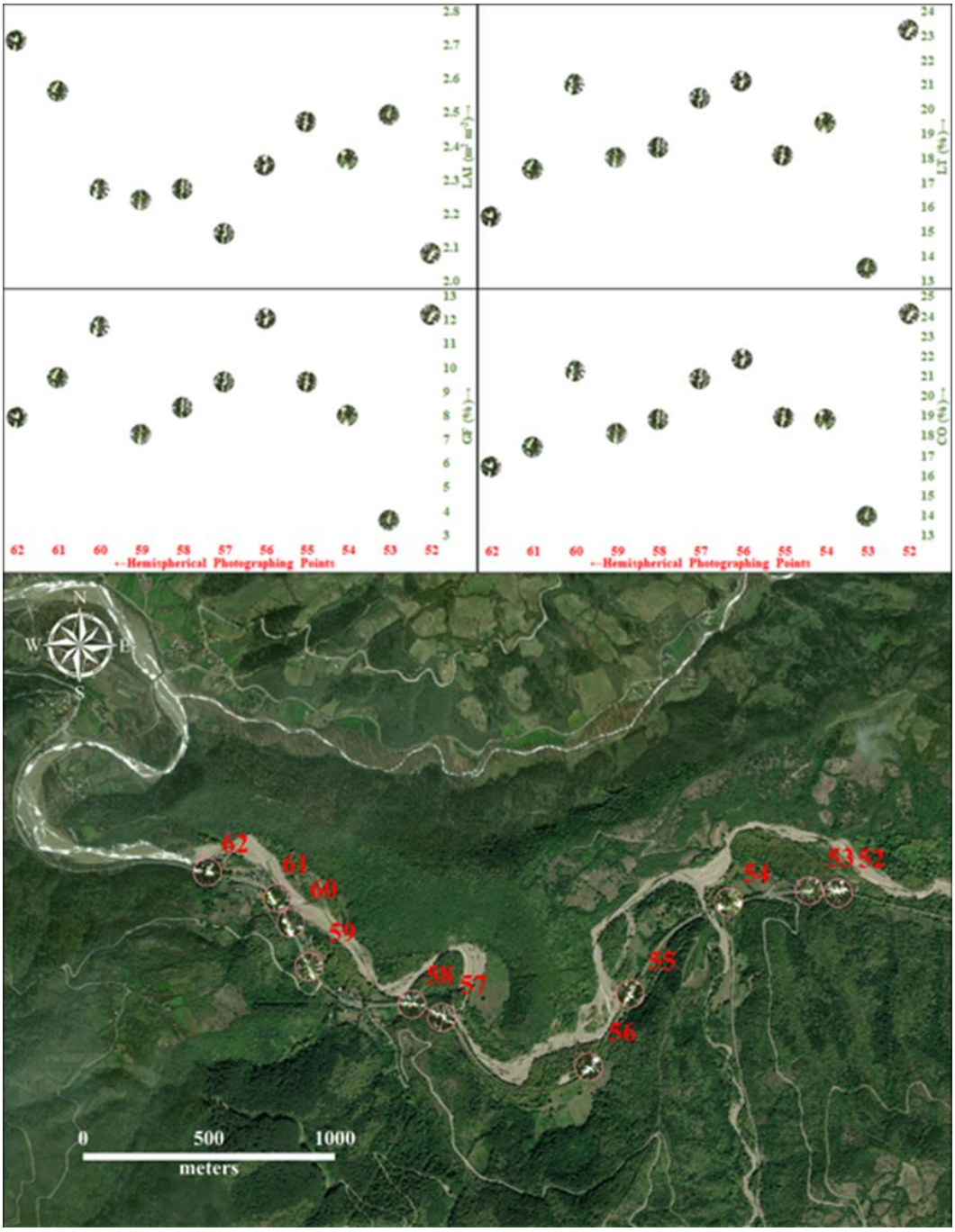

Fig. 6. Location of the fifth 11 hemispherical photographing points together with their LAI values, and LT, GF, CO percentages in the Section 5

3.5. Section 5

Regarding to the study results, the LAI ranged between 2.08 m^2 m^{-2} and 2.71 m^2 m^{-2} for another next 11 hemispherical photographing points where the mean LAI was 2.36 m^2 m^{-2} within the Section 5 of the greenway research field (Fig. 6). On the other hand, the mean LT was 18.7% ranging between 13.5% and 23.2% whereas the mean GF was 9.0% ranging between 3.6% and 12.2%. Confirming these values, the mean CO was 19.1% varying between 13.9% and 24.1% (Fig. 6). These tree canopy parameter values remarked that the canopies of the roadside trees were also relatively dense and therefore they had high shading supply in this Section 5. Contrary to the previous mentioned study by Antonson et al. (2009), dependent upon the comparisons between the prior and after crashes, Mok et al. (2006) reported that the alternating landscapes had positive impacts on the visual perception of the drivers.

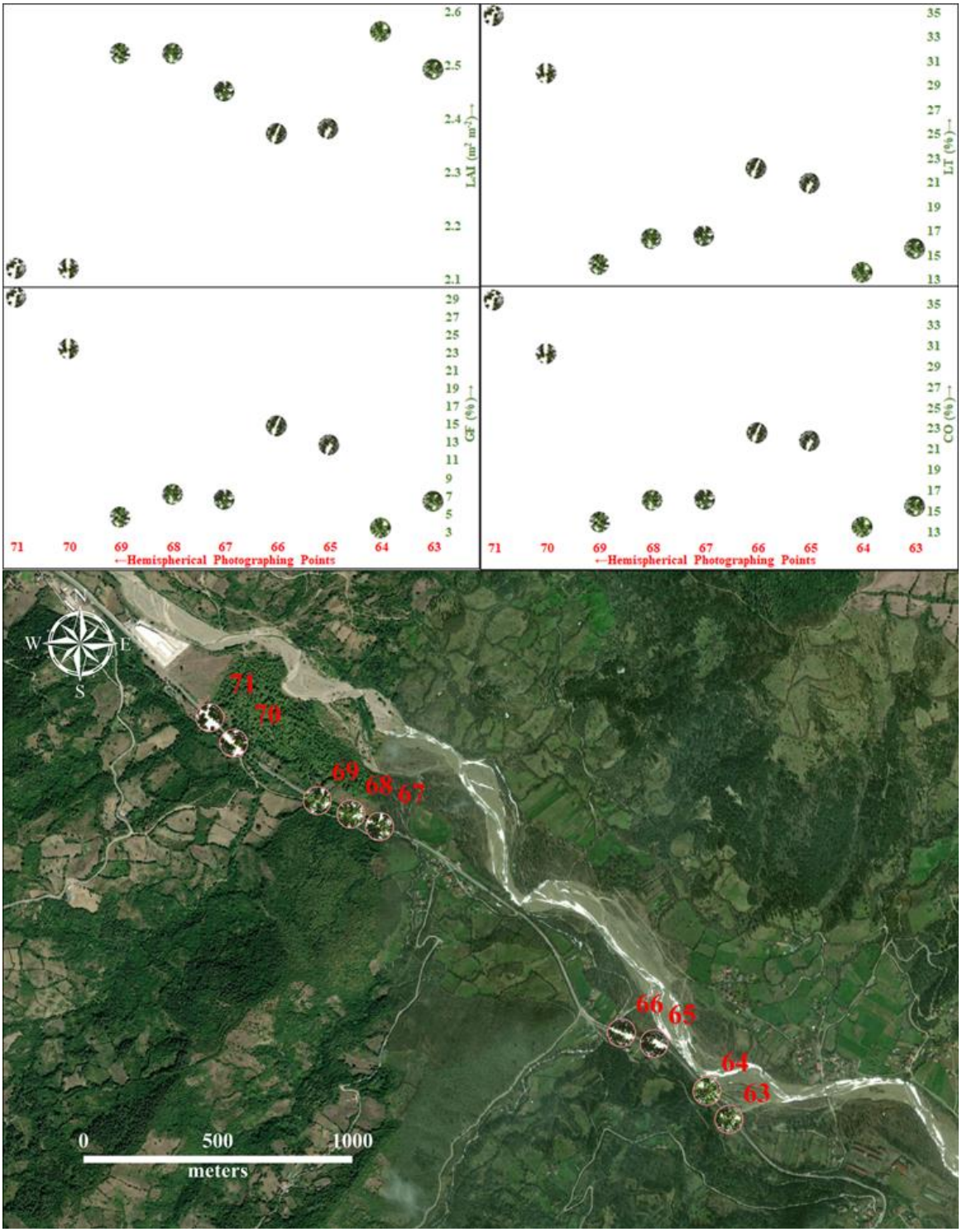

Fig. 7. Location of the sixth 9 hemispherical photographing points together with their LAI values, and LT, GF, CO percentages in the Section 6

3.6. Section 6

Regarding to the study results, the LAI ranged between 2.12 m^2 m^{-2} and 2.56 m^2 m^{-2} for the following last 9 hemispherical photographing points where the mean LAI was 2.39 m^2 m^{-2} within the Section 6 of the greenway research field (Fig. 7). On the other hand, the mean LT was 20.4% ranging between 13.5% and 34.7% whereas the mean GF was 11.9% ranging between 3.4% and 29.1%. Confirming these values, the mean CO was 20.5% varying between 13.4% and 35.3% (Fig. 7).

4. Conclusions

From the point of global protection, maintenance, sustainability and management of the study region, ultimate outcomes of this study provide significant data. Thus, the study region which hosts to the valuable greenway systems, possesses broad dimensions; basically ecological, aesthetic, and recreational. Eventually, by referring to this study outcomes, and also by integrating them with the possible further shading supply, associated recreation potential and safety degree researches should be conducted. Hence, by constructing more comfortable, recreational, and also by securing safer travel for both the drivers and passengers throughout the greenways within the region, significant and valuable bases can be achieved for their long-term sustainability.

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References

1. **Ahern J. (1995).** Greenway as a planning strategy. *Landscape and Urban Planning*, 33: 131-155. https://doi.org/10.1016/0169-2046(95)02039-V
2. **Antonson H., Mårdh S., Wiklund M. & Blomqvist G. (2009).** Effect of surrounding landscape on driving behavior: A driving simulator study. *Journal of Environmental Psychology*, 29: 493-502. https://doi.org/10.1016/j.jenvp.2009.03.005
3. **Atalay İ. (2011).** Climate Atlas of Turkey (in Turkish). İnkılâp Bookstore Press, İstanbul, Turkey.
4. **Cackowski J.M. & Nasar J.L. (2003).** The restorative effects of roadside vegetation: Implications for automobile driver anger and frustration. *Environment and Behavior*, 35(6): 736-751. https://doi.org/10.1177/0013916503256267
5. **Chen J.M. & Cihlar J. 1995.** Quantifying the effect of canopy architecture on optical measurements of leaf area index using two gap size analysis methods. *IEEE Transactions on Geoscience and Remote Sensing*, 33: 777-787. https://doi.org/10.1109/36.387593
6. **Fitzpatrick C.D., Samuel S. & Knodler Jr. M.A. (2016).** Evaluating the effect of vegetation and clear zone width on driver behavior using a driving simulator. *Transportation Research Part F*, 42: 80-89. http://dx.doi.org/10.1016/j.trf.2016.07.002
7. **Forman R.T.T. & Godron M. (1986).** Landscape Ecology. John Wiley & Sons. Inc., USA.
8. **Forman R.T.T. &Alexander L.E. (1998).** Roads and their major ecological effects. *Annual Review of Ecology and Systematics*, 29: 207-231+C2. https://doi.org/10.1146/annurev.ecolsys.29.1.207
9. **Kucharik C.J., Norman J.M. & Gower S.T. (1999).** Characterization of radiation regimes in nonrandom forest canopies: theory, measurements, and a simplified modeling approach. *Tree Physiology*, 19: 695-706. https://doi.org/10.1093/treephys/19.11.695
10. **Marsh, W.M. (2010).** Landscape Planning; Environmental Applications. Fifth Edition. John Wiley & Sons, Inc., New Jersey, USA.
11. **Mok J.H., Landphair H.C. & Naderi J.R. (2006).** Landscape improvement impacts on roadside safety in Texas. *Landscape and Urban Planning*, 78: 263-274. https://doi.org/10.1016/j.landurbplan.2005.09.002
12. **Nobis M. & Hunziker U. (2005).** Automatic thresholding for hemispherical canopy-photographs based on edge detection. *Agricultural and Forest Meteorology*, 128: 243-250. https://doi.org/10.1016/j.agrformet.2004.10.002
13. **Öztürk M. & Gökyer E. (2015).** Seasonal variation in light transmission and canopy gaps of deciduous roadside vegetation: Assessment within forest landscape. *Eurasian Journal of Forest Science*, 3(2): 1-11.
14. **Öztürk M. & Gökyer E. (2016).** Spatio-temporal characteristics of roadside landscape components along the coastal zone between Amasra and Kurucaşile Cities of Bartın Province, Turkey. pp. 293-302. 5th Fábos Conference on Landscape and Greenway Planning. Volume: Landscapes and Greenways of Resilience. 30 June-3 July, 2016. Budapest, Hungary.
15. **Öztürk M. (2017).** Driver and passenger perception along the roadside landscapes: Safety and recreation. In: Sustainable Landscape Planning and Design (Ed. Murat Özyavuz). Peter Lang Publications. Frankfurt, Germany. https://doi.org/10.3726/b11768
16. **Öztürk M., Gökyer E. & Palta Ş. (2019).** Role of roadside vegetation canopy on trekking comfort along Karakışla-Uluyayla route of highland forest landscape in Western Black Sea Region of Turkey. pp. 103-108. III. International Mediterranean Forest and Environment Symposium. 03-05 October, 2019. Kahramanmaraş, Turkey.

17. **Schleppi P., Conedera M., Sedivy I. & Thimonier A. 2007.** Correcting non-linearity and slope effects in the estimation of the leaf area index of forests from hemispherical photographs. *Agricultural and Forest Meteorology*, 144: 236-242. https://doi.org/10.1016/j.agrformet.2007.02.004
18. **TGDF (Turkish General Directorate of Forestry). (2011).** Forest Management Plans of Bartın, Amasra, Kurucaşile and Ulus Forest Administrations. Ankara, Turkey.
19. **TSMS (Turkish State Meteorological Service). (2013).** Daily meteorological data. Ankara.
20. **Turner M.G. & Gardner R.H. (2015).** Landscape Ecology in Theory and Practice; Pattern and Process. Second Edition. Springer Science + Business Media LLC, New York, USA.