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Stem-mapping live and dead trees in a mixed fir-pine forest

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Abstract

Dead trees are vital to the conservation and sustainability of biodiversity. The number of large-diameter live trees and dead trees in a stand are some of the most common stand characteristics used to determine the structural complexity of the stand. In this study, spatial patterns of trees in a mixed Kazdağı fir (*Abies nordmanniana* subsp. *equi-trojani*)-Scots pine (*Pinus sylvestris* L.) stand was examined, and mapped. Moreover, distribution pattern of the standing deadwoods was also monitored. Distribution of all trees was dispersed, while the deadwoods were clustered within the stand.

Introduction

Biodiversity affects the quality of life on Earth, so maintaining biodiversity is one of the most critical tasks of forest management [1]. Features of stand structure can affect biodiversity. The number of large-diameter live trees and dead trees in a stand are some of the most common stand characteristics used to determine the structural complexity of the stand [2]. Dead trees are vital to the conservation and sustainability of biodiversity [5], and they play a key role in the carbon (C) cycle [3]. Thus, it is very important to determine the distribution of dead trees in the stands and to determine the factors affecting this distribution.

Detection of the spatial distribution of trees in stands has been useful in estimating stand dynamics, analyzing canopy spacing, conserving biodiversity, examining regeneration, and making inferences about ecological mechanisms [4]). The "horizontal pattern" of trees is widely used to determine the stand structure, and they are usually determined by "point pattern analyzes" [5]. Tree species can show a random distribution, cluster in the stand or show a regular distribution within the stand. Spatial distribution of trees can be shaped by competition conditions among forest trees, tree death due to density in the stand, and disturbance of the canopy.

Various studies have been conducted on the spatial distribution of trees in the stands in forests consisting of different tree species [6]. However, studies on the spatial distribution of dead trees in the stand are very limited. Kazdağı fir (*Abies nordmanniana* subsp. *equi-trojani*) and Scots pine (*Pinus sylvestris* L.) are two of the most economically and ecologically important tree species in Turkey. These forests also exhibit a rich biodiversity in their distribution in northern Turkey. Although there have been various studies on the number of dead trees in Kazdağı fir forests, there is no study on the spatial distribution of the dead trees in forests dominated by Kazdağı fir. Therefore, the main purpose of this study was to determine the spatial distribution of dead trees in a mixed Kazdağı fir-Scots pine stand. It was also aimed to map all tree species using standard procedures for stem mapping of trees within the study area.

Material and Method

This study was carried out within the borders of Ilgaz Mountain National Park in Kastamonu province. The study area is in the transition zone between the Black Sea climate and the continental climate of Turkey. The average temperature of the region is 5.2 °C and the annual average precipitation is 612 mm. The dominant soil group is brown calcareous. The altitude in the study area varies between 1000 and 1900 m. In addition to Kazdağı fir and Scotch pine, other tree species that can be seen in the Kastamonu region are black pine (*Pinus nigra* Arnold.), eastern beech (*Fagus orientalis* L.) and oak (*Quercus* spp.).

In order to determine the distribution of dead trees, the Ilgaz Mountain National Park was chosen as the study area for this study, since protection forests with natural stand dynamics were preferred. First of all, a working plot of approximately 3-4 hectares was selected in the study area. In order to determine whether the distribution of dead trees differs according to tree species, attention was paid to the fact that the study plot is a mixed field consisting of Kazdağı fir and Scots pine. Stem mapping of all trees in the study area was made with the help of ArcMap program using standard procedures.

First of all, a reference point was determined within the work plot and its coordinates were recorded with the help of handheld GPS. Then, the distances between the reference point of all trees that can be seen from the reference point was measured with a TruPulse 360 laser device. In addition, the degrees of deviation of trees from the reference point (i.e., deviation from north; azimuth) was also recorded using a compass. After all trees visible from the first reference point were recorded, a second reference point was established and the same procedure was followed until all trees in the selected study plot were registered. To determine the individual coordinates of each tree, the coordinates of the reference points and the distances and azimuth values of the trees from the respective reference points were be used. For each tree with a diameter (d1.3) at chest height greater than 5 cm in the study plot, the diameter d1.3 (cm) were measured with the help of a caliper and the types of trees were recorded. Whether the tree measured in the study plot was alive or dead was also recorded.

After determining the individual coordinates of all trees in the study plot, these data were added to the ArcMap program and stem maps of the trees were created. The "Average Nearest Neighbor Analysis" in ArcMap was used to calculate the average nearest neighbor distance of both all trees and dead trees in the study plot. Also, Ripley's k-function analysis was used in ArcMap to see if the point distribution was clustered, random, or scattered. Visual evaluation of the spatial distribution model of all trees and dead trees was also performed and interpreted using both the R-statistics software and ArcMap. Stem map was used to determine the factors affecting the distribution of dead trees (such as thick live trees, presence of other species, stand density).

Results and Discussion

The observed mean distance, which means how far each tree is from the next on average, was 1.97 m. The expected mean distance based on a random distribution throughout the sampling area was 0.33 m between each tree. Based on the Average Nearest Neighbor Analysis, the distribution of all trees across the study stand was dispersed, while the deadwoods were clustered (Table 1). Map of point patterns attained following stem mapping indicated that there were clustering of trees within the study plot (Figure 1). Moreover, canopy openings were also apparent in stem-map.

Table 1. Average Nearest Neighbor Analysis Summary

	All Trees	Dead Trees
Parameters	Values	
Observed Mean Distance (m)	1.917	4.785
Expected Mean Distance(m)	0.033	6.310
Nearest Neighbor Ratio	56.52	0.758
z-score	2712.4	-4.185
p-value	0.0000	0.0001

Figure 1 shows the spatial distribution of trees by species, and diameter size. The stand is mostly dominated by firs. Firs were mostly present in all diameter classes; this can be attributed to its shade tolerance since firs can survive and grow under high stand densities for prolonged times. Pines were mostly present in relatively larges diameters (Figure 1). This is mostly because Scots pine is a shade-intolerant species and it did not have enough chance to recruit under shady conditions. Deadwoods were available in most diameter classes ranging from 5 to 83 cm. About 95% of the dead trees was fir (Figure 1).

The presence of mostly small forest gaps is revealed by the close spacing between trees. When it was looked at the spatial patterns of Norway spruce (*Picea abies* L.) [7], they found that smaller canopy gaps can be caused by reduced mean distances between trees. Canopy gaps can further create clustered spatial patterns of trees [8]. The presence of relatively larger trees that are close to and around the canopy gaps raises the possibility that these gaps were caused by the demise of specific, massive trees. These sort of canopy gaps are typically caused by wind-throws, insect damage, diseases, lightning, etc. since these tree species typically grows in an area where these disturbances occur frequently [9]. Trees may develop in the gap left over when one or more old trees are destroyed by storms, insects, illnesses, or lightning. Little canopy gaps may also result from competition for underground resources between large trees.

Fir is known to be a shade tolerant species; thus, fir seedlings are usually present under canopy waiting for overstory disturbances to star height growth. A new opened space is usually colonized by juveniles because competition for light and other nutrients with overstory trees is usually decreased when a canopy opening is formed [10].

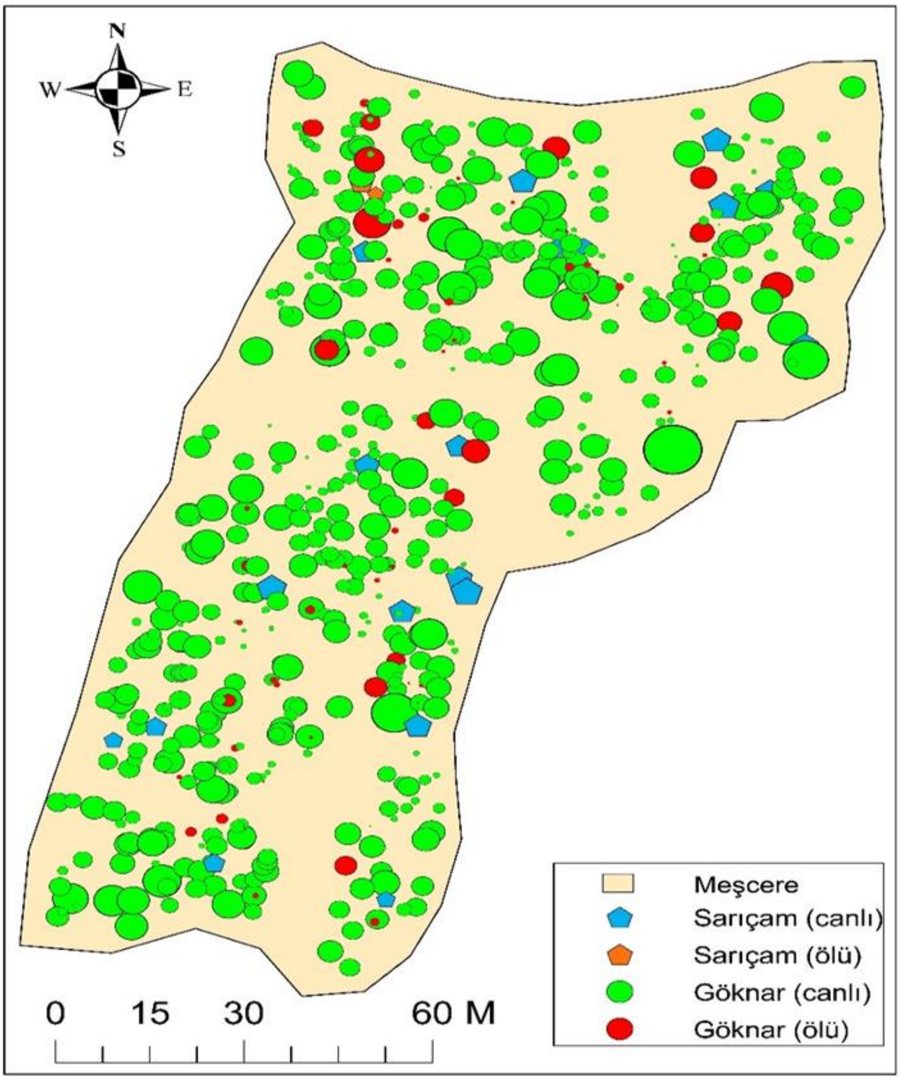

Figure 1. Stem-map in a mixed fir-pine stand

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