Analysis of Spatial Pattern of Oak Wilt Outbreak Using UAV Images

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KEY WORDS: oak wilt disease, UAV image, spatial pattern analysis

ABSTRACT: UAV image has been effective tool to detect and monitor tree-level crown damages caused by forest diseases. In this study, we tried to analyze the spatial pattern of oak wilt outbreak using UAV images. High-resolution UAV images were obtained in June and August 2018 over suburban forest within the in Incheon, Korea. Initially, the oak wilt damaged trees were selected by the visual interpretation of two UAV images. Further, two thematic maps (crown map of oak trees and hiking trail map) that were presumed to have an influence on the spread of the disease were produced from the UAV images. Among the several factors considered, the proximity to the hiking trail and the density of oak trees were the major factors to describe the spatial pattern of oak wilt outbreak and its spread.

1. INTRODUCTION

Since the first encounter in 2004, oak wilt disease has become one of the most common forest diseases in Korea. Despite the continuous control efforts, oak wilt damages have not been reduced (Cha et al., 2017) and are being found near the Seoul metropolitan area. Although there were a few studies on the oak wilt damage, they have certain limitations to fully explain the spatial characteristics of oak wilt outbreak and to be used for the practical control work to prevent further spread. First of all, it was very difficult to correctly detect oak wilt damaged trees using satellite and aerial imagery. The recent development of UAV-based image acquisition system helps to acquire very high-resolution images to detect individual tree crowns as well as other spatial features that have not been able to detect by airborne and spaceborne remote sensor system. Further, UAV system can provide timely images with relatively low cost, which would be big advantages for the continuous monitoring of forest disease. There were also a few studies on the topographic characteristics of oak wilt outbreak (Kang et al., 2017). Because of the relatively small size of the study area and the lack of accurate location of all oak wilt damaged trees, there has been no consistent spatial pattern to describe the outbreak of oak wilt disease. The objectives of this study were to assess the potential of UAV images to analyze the spatial patterns of oat wilt outbreak and to suggest effective control works to prevent further spread.

2. MATERIALS AND METHODS

The study area covers relatively small isolated forests (about 160 ha) within the Incheon Grand Park located in suburban area of the Seoul metropolitan area. This area has been suffered oak wilt disease for the last several years. The UAV images were acquired on June 4, 2018, and August 13, 2018, at the flight altitude of 300 meters, which provides a spatial resolution ranging from 6 to 9 cm because of the elevation difference within the study area having two small mountains of about 160m height. Two images were ortho-rectified and mosaicked into the UTM coordinate system. In this area, the onset of oak leaves begins in May and the new oak wilt damages appear in July and August. Therefore, the discolored and defoliated oak crown observed in the June image can be regarded as oak wilt damage occurred in 2017. The UAV image obtained in August showed a very different distribution of oak wilt damages. Comparing with the 2017 damaged trees detected from the June image, there were many newly developed browning oak crowns. Oak wilt damaged crown detected in August image were classified into the new outbreak of oak wilt in 2018. Based on the photo-interpretations and field survey, the total number of oak wilt damaged trees were 355 in 2017 and 294 in 2018.

Oak wilt in Korea has been caused by bacteria (*Raffaelea quercus-mongolicae*) that has a partnership with tiny insect vector (*Platypus koryoensis*). Therefore, the bacteria mainly spread to healthy trees by the insect vector. To analyze the spatial pattern of oak wilt outbreak and its spread, we produced two map layers that might be related to the oak wilt outbreak. Since the insect vector prefers to move through relatively open air, we produced the hiking trail map from the UAV image. The second map was related to the distribution of host tree species. The study area has several types of forest stands ranging from the plantation coniferous to the natural stands of mixed deciduous and pine. With the help of a very high-resolution of the UAV image, we were able to identify the crown of oak trees. Although there were a few oak species, their crown size and shape were not much different from the major oak species (*Quercus mongolica*).

3. RESULTS AND DISCUSSIONS

The spatial pattern of oak wilt outbreak can be analyzed by several factors including topography, climate, and other forest conditions. In this preliminary analysis, we only considered two factors on forest condition. As expected, the higher crown ratio of oak trees, the higher frequency of the outbreak. More than 20% of the outbreak were found within the pure oak forest. Although the outbreak was also found at the forest surrounded by other than oak species, 60% of the outbreak occurred at the point where oak crown ration was larger than 50%. The damaged trees also showed a clear relationship with the proximity to the hiking trail. The closer to the trail, the more occurrence of oak wilt outbreak. About 66% of the total damaged trees were found within 60 m from the hiking trail. The infection of the disease is closely related to the relative openness of tree canopy, which may be a desirable condition for the insect vector of oak wilt.

In Figure 1, the dotted line shows the distribution ratio of the newly infected trees within a radius of 25 m of past damaged trees. At this time, the radius was selected to be 25 m in consideration of the mean spread distance of *Platypus koryoensis* (Lee et al., 2018). The newly damaged trees show a similar distribution with the total outbreak pattern. The spread condition of the disease looks very similar to the outbreak in which it prefers dense oak canopy and relatively open air. Furthermore, 78% of the newly damaged trees were found within 40m from the previously damaged trees (2017). There are many other factors that have an effect on the spread of the disease. The oak crown map and the hiking trail map, which were derived directly from the high-resolution UAV images, showed the close relationship with the outbreak and spread of the disease.

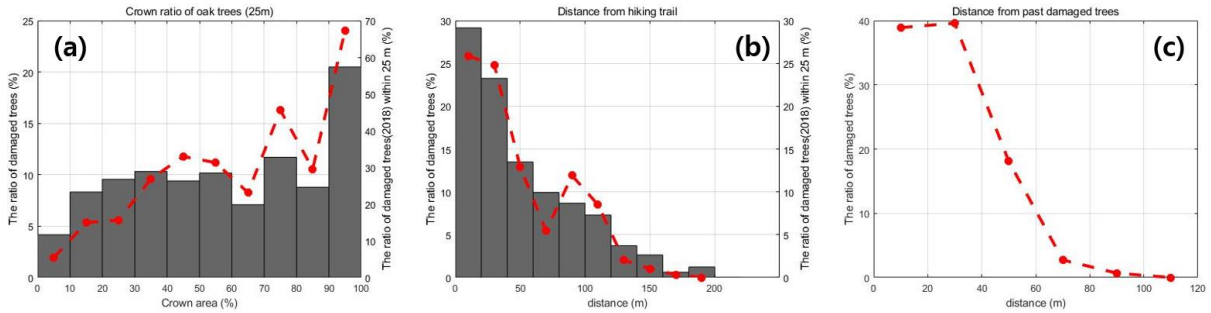

Figure 1. Distribution ratio of the oak wilt damaged trees (bar) and the newly infected trees (dot line) by the ratio of oak crown (a), the proximity to hiking trail (b), and the distance from 2017 damaged trees(c)

4. CONCLUSIONS

Characterization of the spatial pattern of the forest disease outbreak and spread is the most important issue to control the damage. In this study, we have shown that UAV images can be effectively used to analyze the spatial distribution of damaged trees. Based on the results obtained from the study, the control of oak wilt damage should be focused on the area near the trail and other gaps and within the high oak density stands to reduce the spread. Easy and continuous acquisition of UAV image enables us to monitor the spread pattern. Besides the two factors analyzed in this study, other environmental and topographic factors will be included in the near future.

ACKNOWLEDGEMENTS

This work was carried out with the support of "Research Program for Forest Science & Technology Development (Project No. FE0700-2017-03-2019)" funded by National Institute of Forest Science, Republic of Korea.

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