Visualizing the impact of fire on forest biomass using UAV laser scanning

by **Ching-Ting Chia**

This study utilizes point clouds from UAV laser scanning to estimate forest biomass before and after the forest fire in Saxon Switzerland National Park in July 2022, with an emphasis on visualizing the changes. By implementing biomass estimation and visualization techniques, the research aims to visualize the impact of the fire on vegetation and quantify the effects of the disaster on forest ecosystems. The study demonstrates how this technology can be applied to estimate the damage to vegetation and provides a method for quantifying the ecological impact of such disasters. The research is divided into three main components: individual tree segmentation from UAV LiDAR point clouds, biomass estimation, and the development of a high-usability visualization tool.

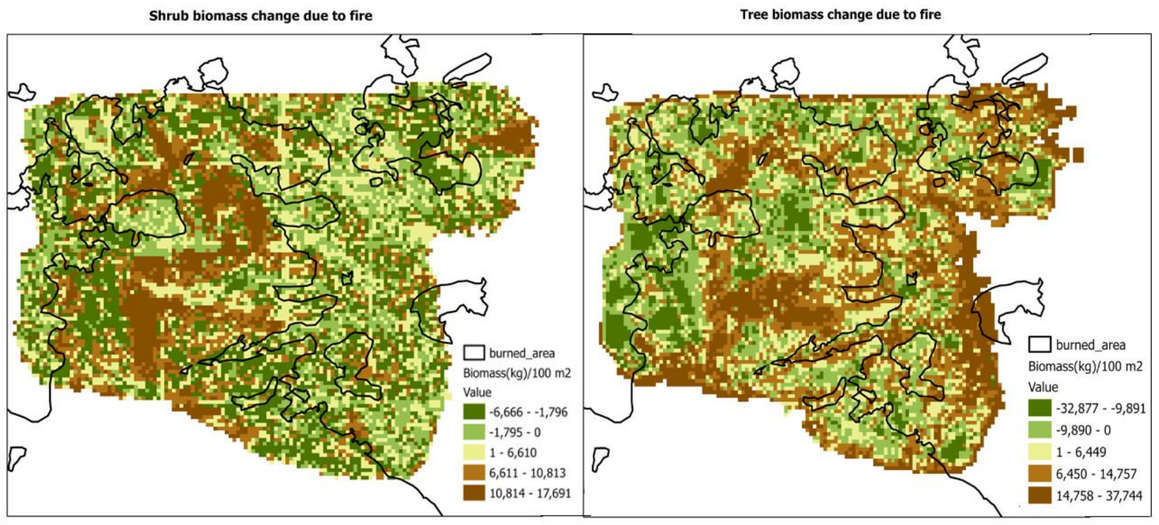

Fig.2. The shrub biomass change map and the tree biomass change map due to fire (left: shrub biomass change map, right: tree biomass change map)

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INTRODUCTION

Forest biomass refers to the total mass of all living organisms within a forest ecosystem[1][2] and serves as an indicator of forest vegetation quantity. The impact of wildfires on forest ecosystems can be assessed by monitoring changes in forest biomass. Furthermore, with advancements in LiDAR technology, UAV laser scanning offers high-resolution data, accessibility, and low time and labor costs, making it possible to visualize changes in forest biomass before and after wildfires. Additionally, the study conducts user testing on color schemes to enhance the usability of forest biomass change maps.

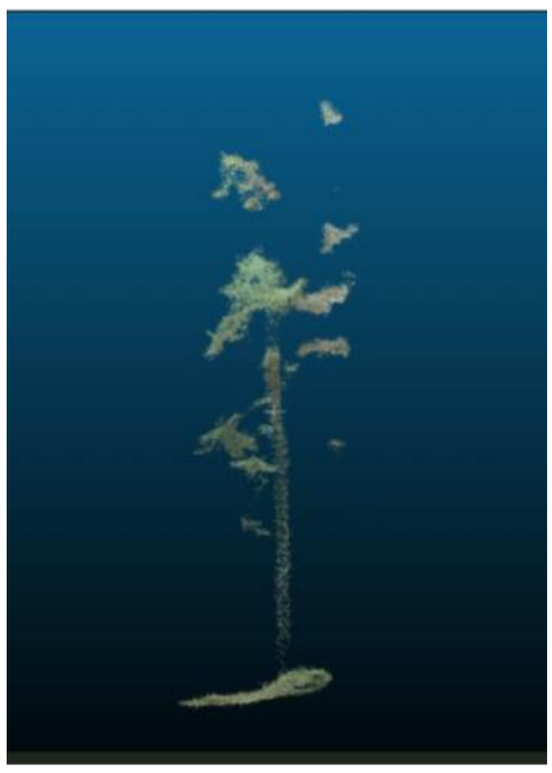

Fig 1. One of the individual tree segment

DATA

The study mainly uses UAV laser scanning data collected in the Saxon Switzerland National Park on 13 September 2022. The data was collected two months after the forest fire. The forest fire occurred on 24 July 2022, burning 2287 hectares and affecting 105 people inside[3].

METHODOLOGY

This study focused on quantifying fire impacts using pre- and post-fire biomass estimates. Biomass is limited to tree and shrub biomass estimates due to limitations in point cloud collection. The methodology includes point cloud segmentation, biomass estimation before and after fire, and visualization with usability user testing.

Point Cloud Segment

The point cloud data was segmented into individual trees and shrubs. The point cloud of individual trees was removed, and the remaining point cloud was regarded as the shrub point cloud. Due to canopy occlusion, the shrub point cloud could not be segmented into individual shrubs. Using the digital terrain model, digital surface model, and canopy height model as input, the PyCrown library [4] was used to segment trees through the canopy rendering algorithm, as shown in Fig 1.

Pre- and Post-Fire Biomass Estimate

Post-fire tree biomass was estimated based on tree volume, wood density, and biomass expansion factors, with wood density and tree radius detection varying according to forest type. Post-fire shrub biomass was calculated using the proportion of point cloud data at different heights and the statistical distribution of point cloud heights. The pre-fire tree biomass was estimated by analyzing the relationship between tree density and canopy cover in unburned areas after the fire, utilizing UAV laser scanning data from 2017. The pre-fire biomass in burned areas was estimated using Kriging interpolation based on the spatial continuity of unburned regions after the fire.

Visualizing and User Testing

This study used user testing to explore how different visualization types, color-stretched versus color-classified, represented higher map usability for maps showing changes in forest biomass due to fire. The usability study focused on the accuracy of regional discrimination when time and biomass changed significantly. It also considered whether the user was color blind, the user's age, and the user's understanding of biomass, all of which affected the user's choice.

RESULT AND CONCLUSION

The study showed that the impact of fire on biomass was primarily observed in shrubs, while trees didn't show significant changes in biomass (Fig 2). User testing indicated that there were no significant differences between color-stretched and color-classified visualizations, suggesting both visualization methods were equally viable. Furthermore, this research demonstrated that UAV laser scanning can effectively estimate changes in biomass within forested areas, providing a valuable contribution to monitoring forest ecosystems..

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