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Monitoring post-fire vegetation recovery using AUV: A successional analysis from the Ankarafantsika national park Madagascar

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Abstract

Ankarafantsika National Park contains one of the largest remaining blocks of semi-deciduous dry dense forest in western Madagascar. Like most vegetation formations in the region, it is regularly exposed to wildfires. Yet, information on post-fire vegetation structure remains scarce and is almost entirely absent for this site. To address this gap, we used UAV technology as a modern tool to analyse post-fire vegetation succession.

Burned areas within the park from 2000 to 2022 were mapped by reconstructing fire history using three satellite data sources: MODIS, LANDSAT-8, and SENTINEL-2. Nineteen transects representing vegetation of different post-fire ages (1 to 21 years), along with one unburned reference transect, were established. Each vegetation formation was represented by a 6-hectare transect (300 m × 200 m) surveyed using a UAV. Data processing included generating Digital Terrain Models (DTMs) and Digital Canopy Models (DCMs), followed by Individual Tree Detection (ITD) and extraction of structural profiles from dense point clouds. Tree detection accuracy, assessed using the F score, reached 0.8, indicating robust and reliable performance.

Vegetation was classified into five successional age groups (G) based on dominant tree height. G1 (1–5 years) is characterised by regenerating individuals less than 2 m tall. G2 (6–7 years) includes vegetation between 2 and 5 m. G3 (8–9 years) corresponds to stands reaching 5–7 m. In G4 (10–18 years), vegetation shows full colonisation and increasingly taller structures. G5 (20–21 years) resembles G4 but is distinguished by trees approaching 10 m in height.

Statistical analyses using Spearman's rank correlation revealed strong relationships between stand age and both average tree height ($R^2 = 0.92$) and dominant tree height ($R^2 = 0.87$), enabling the development of successional models. According to Lebot's evaluation scale, these models are considered reliable and indicate that, following a single fire event and in the absence of subsequent disturbances, forest structure in Ankarafantsika may return to reference conditions within approximately 30 years. These findings emphasise that effective fire-landscape management must be tailored to local ecological realities, beginning with a deeper understanding of forest patch heterogeneity and species composition.

Keywords: Dry forest ecosystems, Madagascar, post-fire recovery, unmanned aerial vehicles (UAVs), vegetation succession

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