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UAS-based high-resolution CIR image analysis to detect pest infestation in forestry

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The detection and monitoring of pest infestation is an important task in forest management for ecological as well as economic reasons. Traditionally the level of pest infestation is examined by ground-based inspection of individual trees regarding indicative symptoms. This method is very time consuming and often hindered by external factors like limited access to the study area or poor visibility of individual tree crowns in dense forest stands. In the case of oak splendor beetle (Agrilus biguttatus) infestation the affected oaks show high levels of defoliation and altered canopy reflection signature. These critical features can be identified in high-resolution color infrared (CIR) images of the tree crown level captured by unmanned aerial systems (UAS). Such sensor platforms have already proven to be an highly flexible and cost-effective means for data acquisition in many other environmental and geoscientific application fields. In forestry the topographic situation of affected areas often hampers the application of fixed-wing UAS (planes) due to limited space for take-off and landing. Consequently the use of multicopters with their vertical take-off and landing (VTOL) capabilities provides a promising alternative. In this study we used a professional, small quadrotor UAS equipped with a compact digital camera (Canon Ixus 100) which has been calibrated and modified to record not only the visual but also the near infrared reflection (∼400 to 1100 nm) of possibly infected oaks. The flight campaigns were carried out in August 2013 covering two test sites which are located in a rural area near the town of Soest in Germany. They represent small-scale, privately owned and managed commercial timberlands in which oaks are the economically most valuable species. The proposed workflow includes the CIR image acquisition, mosaicking, rectification and enhancement followed by pixel based and object-based image classification techniques for the detection of infected oaks. Hereby different camera specific vegetation indices like a modified NDVI and SAVI as well as object-related features (e.g. texture, shape, size) proved useful for the distinction of four classes: healthy, less infected, highly infected, dead trees and canopy gaps.

The resulting infestation maps will be disseminated via a web service according to open geospatial consortium (OGC) standards. Consequently potential users can easily combine these maps with their own existing, conventional forestry geodata within a GIS to provide a multitemporal perspective on the study area. This UAS-based procedure facilitates fundamental forest management tasks like clearing forest stands by detecting and removing infected trees before the sprawl of the fully developed beetles and as long as the timber represents a substantial value. Furthermore it enables a cost-effective long-term monitoring not only for large scale state-owned woodland but also for private forest owners pursuing an economically and ecologically sustainable management strategy of their property. Our research therefore indicates multirotor UAS to be promising remote sensing platforms in forest applications. They enable an effective and non-invasive analysis of pest induced spectral anomalies of tree canopy in order to detect and possibly monitor the level of oak splendor beetle infestation.