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Abstract
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Fractional Mapping of Savannah Vegetation Species using Drone and EnMap Hyperspectral Data

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Challenge

In order to meet the UN Sustainable Development Goal for Land Degradation Neutrality (LDN) by 2030 it is imperative to accomplish an assessment of the state of savannahs as early and as accurately as possible. Monitoring the species composition of vegetation is also essential for land degradation assessments, while respective spatially distributed species composition maps are still unavailable. UAV technologies employing hyperspectral (HS) cameras are increasingly employed for mapping different woody species, but their high cost has so far impeded their use for continuous monitoring. The recent launch of the EnMap HS satellite sensor could significantly improve our ability to distinguish between different savannah woody species at larger scales. This works targets the accurate mapping of the fractional cover of savannah vegetation components, further analysing the woody component into different woody species. Experiments are performed over a South African (SA) savannah, in Kalahari region using EnMap HS data in combination with very high resolution multispectral drone data.

Methodology

Field data of vegetation types, with a focus on encroaching woody species of concern were acquired during in-situ campaigns over a savannah region in Kalahari, SA during the dry season of 2023. In particular, field campaigns included the annotation of savannah vegetation types using GPS measurements and geo-tagged images, as well as the acquisition of drone data at 2cm spatial resolution, with a DJI Mavic 3M multispectral camera. The field annotations were combined with the drone data applying a U-NET semantic segmentation architecture for producing labeled maps, including three woody vegetation classes (*Grewia flava*, *Senegalia Mellifera*, and plants from the *Vachellia* genus) and two non-woody species categories (grasses and soil). The choice for the specific woody species was based on local stakeholder input, regarding their perception of where they sit with regards to their land degradation potential. *Senegalia Mellifera*, for example, was considered by all stakeholders that were interviewed to be one of the most rapidly encroaching and most undesirable species, as it can form rapidly impenetrable thickets, impeding access to palatable grasses or bushes. The classified maps from the drone mosaics were then used for generating fractional woody cover (FWC) samples per woody species class at the EnMap spatial resolution, i.e., 30m. EnMap images captured during the same period were requested and acquired via the EnMap IPS portal. EnMAP-Box with python was used in order to

perform several regression experiments towards producing species-level FWC maps from the EnMap data, while also assessing the performance of various regression algorithms.

Expected results

The proposed methodology was designed and implemented to produce fractional cover maps for five savannah cover classes, including three representative woody species families, in Kalahari savannah of SA. Important remarks were drawn by benchmarking various regression algorithms, available for use via the EnMap-box. The contribution of multi-temporal information on an intermediate, between the two main datasets, spatial resolution was also assessed, by employing as regression features, Sentinel-2 10-m data of multiple dates. Model cross validation and thorough visual assessments of the FWC maps beyond the training areas, demonstrated the suitability of our approach and EnMap data for accurately mapping FWC at the species level. Figure 1 presents some preliminary results of the proposed methodology using EnMap data and the Radial Basis Function Support Vector Machine (RBF SVM) regression algorithm.

Outlook for the future

Savannahs in Africa contain millions of pastoralists whose livelihoods are threatened by woody encroachment. The present work aims towards the direction of providing much needed information on the accurate mapping and evolution of the spatial distribution of specific woody species to intergovernmental and governmental policy makers and local stakeholders that will use it as baseline data for the development of sustainable management strategies and for assessing the effects of management decisions. The developed pipeline assesses the capabilities of the new-generation imaging spectrometer EnMAP in monitoring and mapping of savannah woody vegetation at the species level. Results and validation raise significant expectations for the expansion of such methodologies towards operational monitoring and mapping over extended areas for supporting decision making and planning.

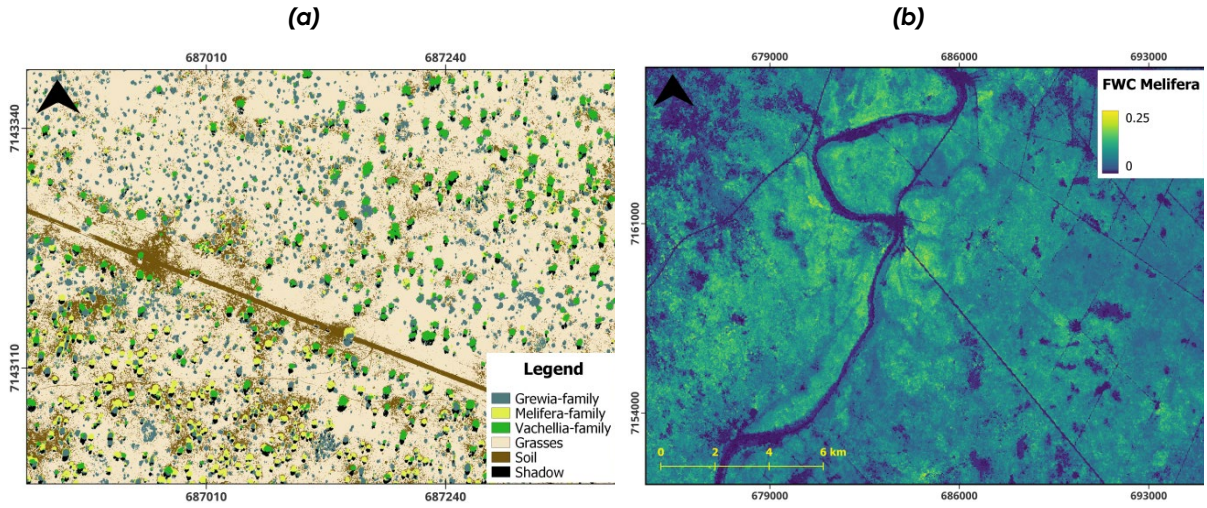

Figure 1: (a) Subset of the 5-class land cover map produced from the drone data and U-Net; (b) subset of the EnMAP-based fractional woody cover map for *Senegalia Mellifera*.