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Remote sensing of species diversity using Landsat 8 spectral variables

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Abstract:
The application of remote sensing in biodiversity estimation has largely relied on the Normalized Difference Vegetation Index (NDVI). The NDVI exploits spectral information from red and near infrared bands of Landsat images and it does not consider canopy background conditions hence it is affected by soil brightness which lowers its sensitivity to vegetation. As such NDVI may be insufficient in explaining tree species diversity. Meanwhile, the Landsat program also collects essential spectral information in the shortwave infrared (SWIR) region which is related to plant properties. The study was intended to: (i) explore the utility of spectral information across Landsat-8 spectrum using the Principal Component Analysis (PCA) and estimate alpha diversity (a-diversity) in the savannah woodland in southern Africa, and (ii) define the species diversity index (Shannon (H0), Simpson (D2) and species richness (S) – defined as number of species in a community) that best relates to spectral variability on the Landsat-8 Operational Land Imager dataset. We designed 90 m 90 m field plots (n = 71) and identified all trees with a diameter at breast height (DbH) above 10 cm. H0 , D2 and S were used to quantify tree species diversity within each plot and the corresponding spectral information on all Landsat-8 bands were extracted from each field plot. A stepwise linear regression was applied to determine the relationship between species diversity indices (H0 , D2 and S) and Principal Components (PCs), vegetation indices and Gray Level Cooccurrence Matrix (GLCM) texture layers with calibration (n = 46) and test (n = 23) datasets. The results of regression analysis showed that the Simple Ratio Index derivative had a higher relationship with H0 , D2 and S (r2 = 0.36; r2 = 0.41; r2 = 0.24 respectively) compared to NDVI, EVI, SAVI or their derivatives. Moreover the Landsat-8 derived PCs also had a higher relationship with H0 and D2 (r2 of 0.36 and 0.35 respectively) than the frequently used NDVI, and this was attributed to the utilization of the entire spectral content of Landsat-8 data. Our results indicate that: (i) the measurement scales of vegetation indices impact their sensitivity to vegetation characteristics and their ability to explain tree species diversity; (ii) principal components enhance the utility of Landsat-8 spectral data for estimating tree species diversity and (iii) species diversity indices that consider both species richness and abundance (H0 and D2) relates better with Landsat-8 spectral variables.