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Woody vegetation cover monitoring with multi-temporal Landsat data and Random Forests: the case of the Northwest Province (South Africa)

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Land degradation and desertification (LDD) are serious global threats to humans and the environment. Globally, 10-20% of drylands and 24% of the world's productive lands are potentially degraded, which affects 1.5 billion people and reduces GDP by €.4 billion. In Africa, LDD processes affect up to a third of savannahs, leading to a decline in the ecosystem services provided to some of the continent's poorest and most vulnerable communities. Indirectly, LDD can be monitored using relevant indicators. The encroachment of woody plants into grasslands, and the subsequent conversion of savannahs and open woodlands into shrublands, has attracted a lot of attention over the last decades and has been identified as an indicator of LDD. According to some assessments, bush encroachment has rendered 1.1 million ha of South African savanna unusable, threatens another 27 million ha (∼17% of the country), and has reduced the grazing capacity throughout the region by up to 50%.

Mapping woody cover encroachment over large areas can only be effectively achieved using remote sensing data and techniques. The longest continuously operating Earth-observation program, the Landsat series, is now freely-available as an atmospherically corrected, cloud masked surface reflectance product. The availability and length of the Landsat archive is thus an unparalleled Earth-observation resource, particularly for long-term change detection and monitoring. Here, we map and monitor woody vegetation cover in the Northwest Province of South Africa, a mosaic of 12 Landsat scenes that expands over more than 100,000km2. We employ a multi-temporal approach with dry-season TM, ETM+ and OLI data from 15 epochs between 1989 to 2015. We use 0.5m-pixel colour aerial photography to collect >15,000 samples for training and validating a Random Forest model to map woody cover, grasses, crops, urban and bare areas. High classification accuracies are achieved, especially so for the two cover types indirectly linked with bush encroachment, i.e. woody cover and grasses. Results show that there is a steady increase in woody vegetation cover over the 26-year-long period of study in the expense of graminoids. We identify woody vegetation encroachment 'hot-spots' where mitigation measures are required and thus provide a management tool for the prioritisation of such measures in degraded and food-insecure areas. Our approach can be instrumental in informing international land degradation mitigation and adaptation policy interventions that can advance sustainable development and protect livelihoods and lives in South Africa and other African savannahs.