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Potential to monitor plant stress using remote sensing tools

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A B S T R A C T

The growing energy crisis has necessitated the expansion of thermal power stations to meet South Africa's electricity needs. Possessing vast amounts of coal deposits, the Waterberg region of the Limpopo Province is set to undergo rapid transformation as new power stations and coal mines are built, expected to exacerbate water shortages. Detailed baseline information to assess future impacts on key plant species is lacking compromising biodiversity conservation efforts in a region where eco – tourism is a major source of livelihood. In this study we evaluated the spatio – temporal distribution plant status during wet and dry seasons using two measures of plant stress namely the midday leaf water potential (LWP), and leaf nitrogen (N) concentrations. At leaf level, spectral indices such as the moisture stress index (MSI), normalized difference water index (NDWI), and the water index (WI) predicted more than 70% of LWP variation using leaf reflectance data. At landscape level, red edge based simple ratio indices were selected for mapping leaf water potential and leaf N for wet and dry season using RapidEye data. We conclude that remote sensing images can be applied for the long term vegetation monitoring for future biodiversity conservation efforts.

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1. Introduction

Global change including land cover or use and climate changes due to increasing economic activities and growing populations as well as alterations in temperature and precipitation regimes pose major threats to freshwater ecosystems and biodiversity in many catchments (Dye et al., 2008; Everson et al., 2011; Staden and Bredenkamp, 2005; Zhu and Ringler, 2012). These influence water availability to vulnerable ecosystems such as plant communities which are vital sources of food and shelter for animal, bird, and aquatic species. For example, Waterberg region which is relatively pristine in South Africa is set to experience drastic transformation. New thermal power stations and coal mines are being developed to stem a growing energy crisis in South Africa (Corbett et al., 2008; Orbeholster et al., 2010). Waterberg region constitutes close to 50% of the remaining coal reserves in South Africa, and has a huge economic development potential to allay some of the highest unemployment levels (Mgojo, 2012). Besides the coal deposits, the region is also rich in biodiversity inhabiting rare freshwater fish species such as the *Ophrydium versatile*, which are not known to occur anywhere else on the African continent (Orberholster et al., 2010) and rare wetland plant species such as the *Oryza longistaminata* (DWA, 2008), among others.

The planned large scale land use changes in the Waterberg will inevitably have adverse impacts on the environment given that the region is already severely water stressed (Staden and Bredenkamp, 2005). The goal of our study is to provide detailed quantitative information on typical water stress levels of dominant indigenous plant species in the region under the current land and water allocation practisesthereby filling an important information gap. We use this information to identify potential remote sensing tools that can be used for future monitoring of plant stress which is expected to worsen as pressure on the limited water resources intensifies. Remote sensing techniques have been used to estimate biophysical parameters (e.g. leaf area index – LAI, biomass) and biochemical parameters (e.g. leaf water content, leaf N and leaf pigments) at scales ranging from local (Dzikiti et al., 2011; Stuckens et al., 2011; Ramoelo et al., 2011) using portable spectrometers to regional scales using air or space-borne sensors (Ramoelo et al., 2011, 2012a,b; 2013). Commonly used approaches employ empirical

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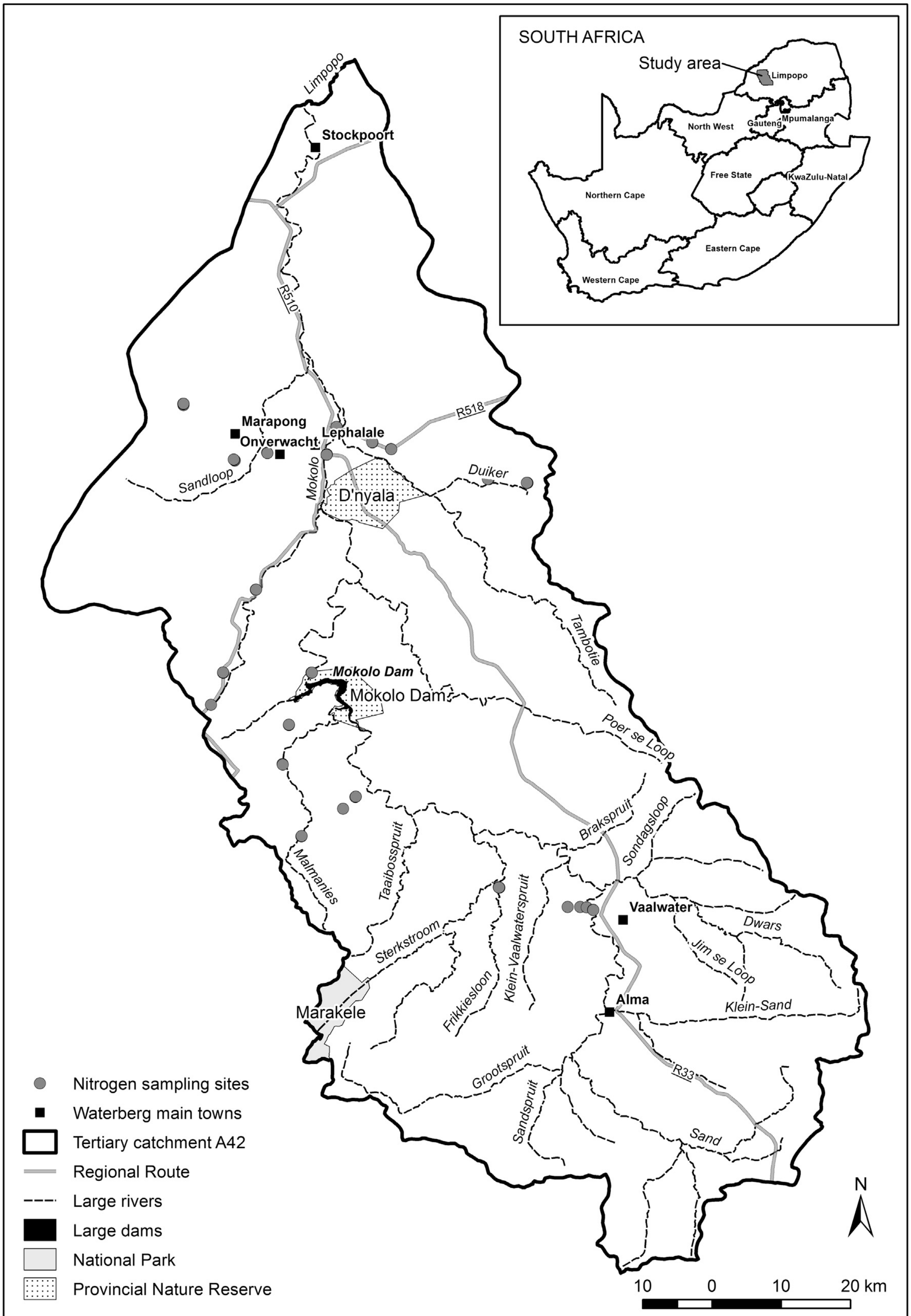

Fig. 1. Map of the study area and the location of sampling sites at the Waterberg region, Limpopo.

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