SPECIES DISCRIMINATION OF AFRICAN SAVANNAH TREES AT LEAF LEVEL USING HYPERSPECTRAL REMOTE SENSING

Majeke B[1]. Cho M[1]. Debba P[2]. Mathieu R[1]. Ramoelo A[1].

Council for Scientific and Industrial Research (CSIR), Natural Resource and Environment (NRE)[1], Built Environment[2], P.O.Box 395, Pretoria, 0001, South Africa

Introduction

The management of the Kruger National Park, South Africa has expressed the need to find cost-effective and rapid means to assess tree species diversity in the park. To do this, remote sensing is viewed as a cost-effective alternative to intensive field sampling. Therefore, there is a need to spectrally discriminate various tree species to understand their composition and distribution.

The assessment of species diversity using remote sensing necessitates to build a spectral library of tree species occurring in savannah ecosystems. Along with the development of the spectral library, there is a need to investigate how similar or dissimilar are savannah tree species. Leaf optical properties are determined by the species-specific leaf structure, concentration of chlorophyll and other biochemical constituents e.g. water content (Asner, 1998, Jacquemoud and Baret, 1990). Several studies have shown the capability of using leaf optical properties to separate grasses, shrubs and trees in various ecosystems, including the Mediterranean environment (Shobhan *et al.,* 2007, Schmidt, 2001, 2004). Limited tree species libraries exist in the savannah ecosystem, particularly in the Kruger National Park.

This study was carried out to (1) develop a spectral library of dominant tree species in the Kruger National Park and (2) assess the utility of hyperspectral remote sensing in discriminating the dominant species in central part of the Park.

Material and Method

The study was conducted in the Kruger National Park, South Africa (Figure 1a). The park is located in the north eastern part of the country, in the savannah ecosystem characterised by rich biodiversity (both wild vegetation and animals).

The spectral reflectances of seven common tree species (*Combretum apiculatum*, *Combretum hereroense*, *Combretum zeyheri*, *Gymnosporia buxifolia*, *Gymnosporia senegalenses*, *Lonchocarpus capassa*, *Terminalia sericea*) were measured using the ASD spectrometer (Analytical Spectral Radiometer (ASD) (350-2500 nm)). Ten (10) leaf reflectances were collected and averaged for each tree species. In addition, a variance of a mean spectra for each species was computed.

Four similarity measures, namely, spectral correlation measure (SCM) (van der Meer and Bakker, 1997), spectral angle mapper (SAM) (Yuhas *et al.*,1992, Kruse *et al.,* 1993), spectral information divergence (SID) (Chang 2003 and van der Meer, 2006) and a combination of SAM and SID (with either sin (SSS) or tan (SST)) (Du *et al*., 2003, 2004) were used to measure the similarities amongst species. A statistical approach was used to determine the performance of the various similarity measures, namely, relative spectral discriminatory probability (RSDPB) (Chang 2003, van der Meer, 2006). The higher the RSDPB, the better the discrimination capability of a particular spectral similarity measure. These similarity and discriminability measures were applied to the whole spectrum, visible range, near infrared (NIR) range and short wave infra red (SWIR) range.

Result

The mean and variance of collected spectra for tree species are shown in Figure 1b & c, respectively. *C. apiculatum* shows a high variance as compared to the other tree species.

The results shows that according to RSDPB, SAM can spectrally discriminate at least 4 to 5 species using all (whole spectrum), visible, NIR and SWIR out of seven species as compared to other methods (Figure 2). On the other hand, *C. apiculatum* and *G. senegalenses* can be well discriminated by SSS, SST, and then SAM using all, NIR and SWIR.

Whole spectrum outperformed other wavelength regions in discriminating several tree species using SAM specifically. Second best wavelength region to discriminate considered tree species is SWIR.

In *Combretum* species, *C. apiculatum* is completely different from the reflectance of both *C. hereroense* and *C. zaheri* using all, NIR and SWIR bands. This shows a high intra-species variability (at genus level). While *Gymnosporia species* are similar in visible and dissimilar in whole spectrum, NIR and SWIR bands. *L. capassa* and *T. sericea* were generally separated from *C. apiculatum* and *G. senegalensis* (Figure 2).

Conclusion

SAM outperformed other similarity measures in discriminating several species. This results differ with what Sobhan et al., (2007) and Du *et al* (2004) found. Though they were using completely different species, they concluded that SST and SID outperformed SAM. The difference might be attributed to the geographical location of the species, Mediterranean vs Savannah species.

Whole spectrum surpassed specific regions of the spectrum (visible, NIR and SWIR) in discriminating the species because it uses the advantage of the entire spectrum.

Leaf reflectance of *C. Zeyheri*, *C. hereroense* are similar but dissimilar to *C. apiculatum*. The difference (intra-species variability) is due to high spectral variability of *C. apiculatum* leaf reflectance (both dry and fresh leaves were sampled).

Hyperspectral remote sensing can be used to discriminate tree species in the savannah ecosystems. It is of utmost importance to consider phenological issues when relying on remote sensing for species seperability exercises. Methods performs differently on various species. Nevertheless, SAM has shown a capability to discriminate among tree species as compared to the other species. Due to intra-species spectral variability, a spectral library will consist of individual species.

Further study is warranted to test these techniques at tree canopy level. A statistical test such as relative spectral discriminatory power (RSDPW) should be undertaken to ascertain the discriminatory performance of each method both at leaf and canopy level.

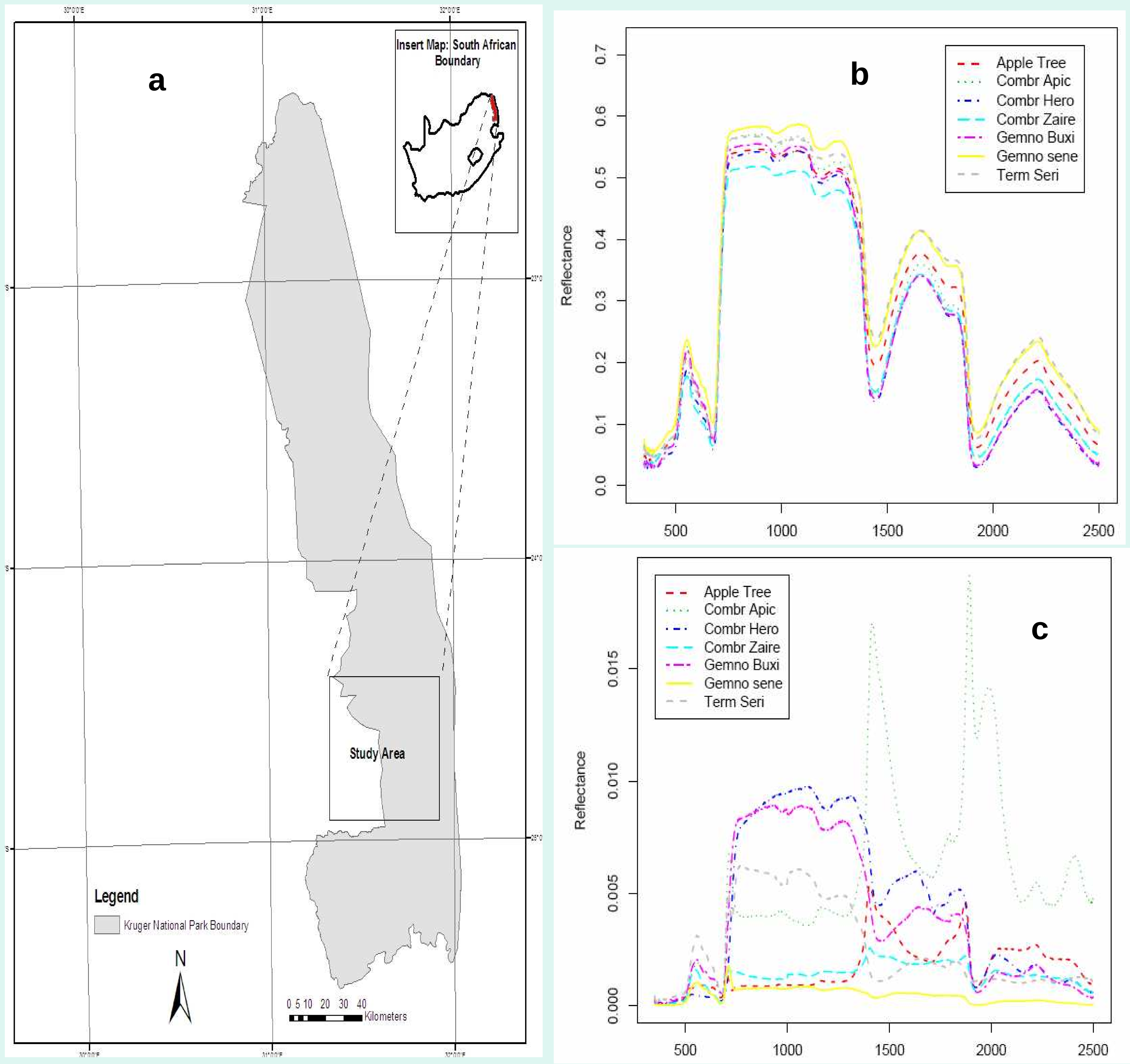

Figure 1:(a) Study area map, (b) mean spectral reflectance all the species and (c) variance of spectral reflectance of species.

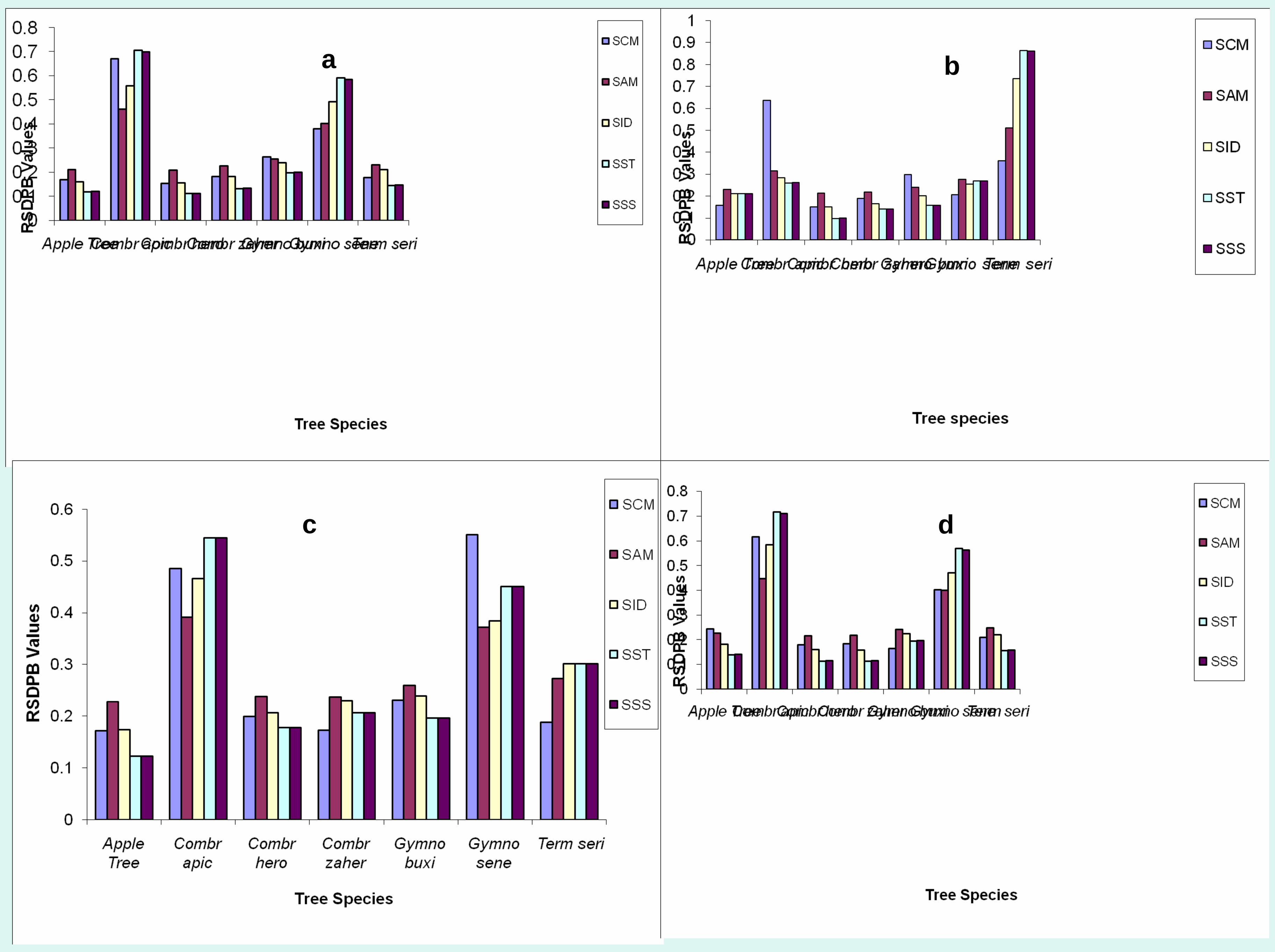

Figure 2: Relative spectral discriminatory probability (RSDPB) of the similarity methods used for (a) all the bands (whole spectrum (b) visible spectrum (c) NIR and (d) SWIR. The higher the RSDPB, the better the discrimination capability of a spectral similarity measure.

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For further details contact: Dr. M.Cho, Email: mcho@csir.co.za, Tel: +27 12 841 3669, Fax: +27 12 841 2689

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