# SPECTRAL DISCRIMINATION OF BUSH ENCROACHING SPECIES AT CANOPY LEVEL USING CAO HYPERSPECTRAL DATA

## Preliminary Results & Observations

L. Naidoo [1], Cho M [1], Mathieu R [1] & Asner GP [2]

[1] Council for Scientific & Industrial Research (CSIR), Natural Resources and the Environment

lnaidoo@csir.co.za; mcho@csir.co.za; rmathieu@csir.co.za

[2] Carnegie Institution for Science, Stanford, CA, USA

gpa@stanford.edu

# THE ULTIMATE BUSH ENCROACHMENT QUESTION

- Is it possible to spectrally decompose & map the bush encroachment phenomenon at a species level for the Kruger National Park, Sabie Sands & Bushbuckridge region?

⇒ Only possible if these bush encroaching species can be spectrally discriminated

⇒ Hence the use of spectral similarity measures

# Aims & Questions

- Aim: To explore the spectral discriminability of bush encroaching species as seen by the CAO hyperspectral imagery for the Bushbuckridge, Sabi Sands & KNP region

- Questions:
  - Which spectral region or band combinations are best for species discrimination?
  - Does secondary plant chemical spectral absorption wavelengths aid in this discrimination?
  - Can the continuum removal transform function be used enhance the absorption features necessary for species discrimination?
  - Which spectral similarity measure yields the best results?

- 6 Main bush encroaching species were investigated:

Combretum apiculatum; Dichrostachys cinerea; Terminalia sericea; Dalbergia melanoxylon; Maytenus acuminata; Strychnos madagascariensis

# Bush Encroachment

- **Definition:** The suppression of palatable grasses and herbs by encroaching woody species (trees & shrubs) which are unpalatable to domestic livestock
- Prevalent in Savanna ecoregions

- **Impacts:**

- Reduces arable land & threatens livestock production
- Threatens sustainability of pastoral systems & threatens livelihoods
- Reduces biodiversity & causes food insecurity

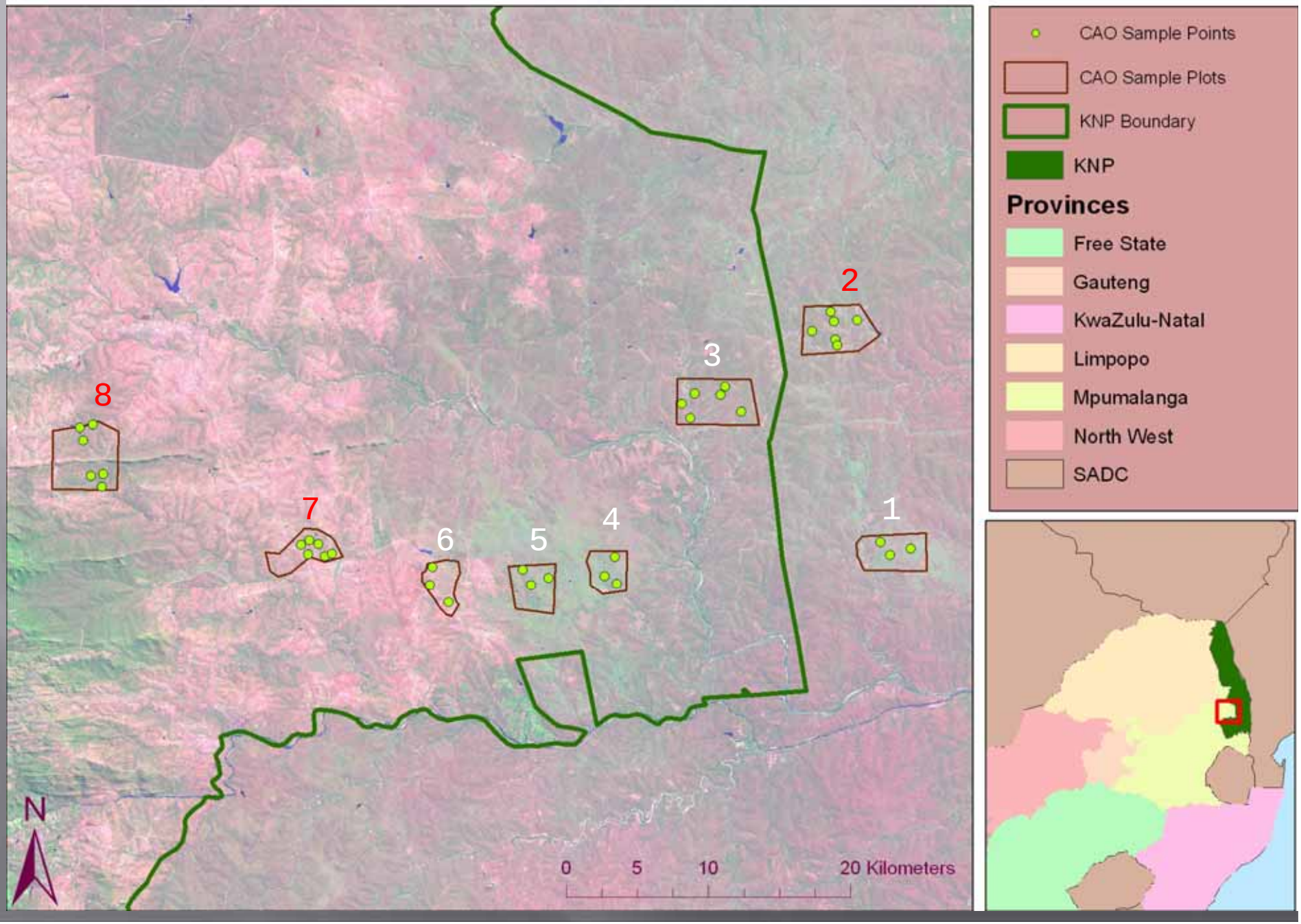
# Bush Encroachment

# Spectral Similarity Measure

- SAM: calculates the spectral similarity by measuring the angle between the spectral signature of two samples / species
- SID: calculates the probabilistic behaviours between spectral signatures
- SID-SAM: enhances discriminability by making similar spectra more similar & makes dissimilar spectra more distinct

- PSD: calculates the relative capability of all spectra to be discriminated from others - used to establish a comparable statistic to see which measure yielded the best results

# CAO Study Area Map of the Greater Kruger National Park Region



# Methodology

The following main analytical tasks were conducted:

- SAM, SID & SID-SAM matrices for:

i. the entire spectral range (394.3nm to 1044.9nm)

ii. Red, Green, Blue, **Visible** & *Near-Infrared*

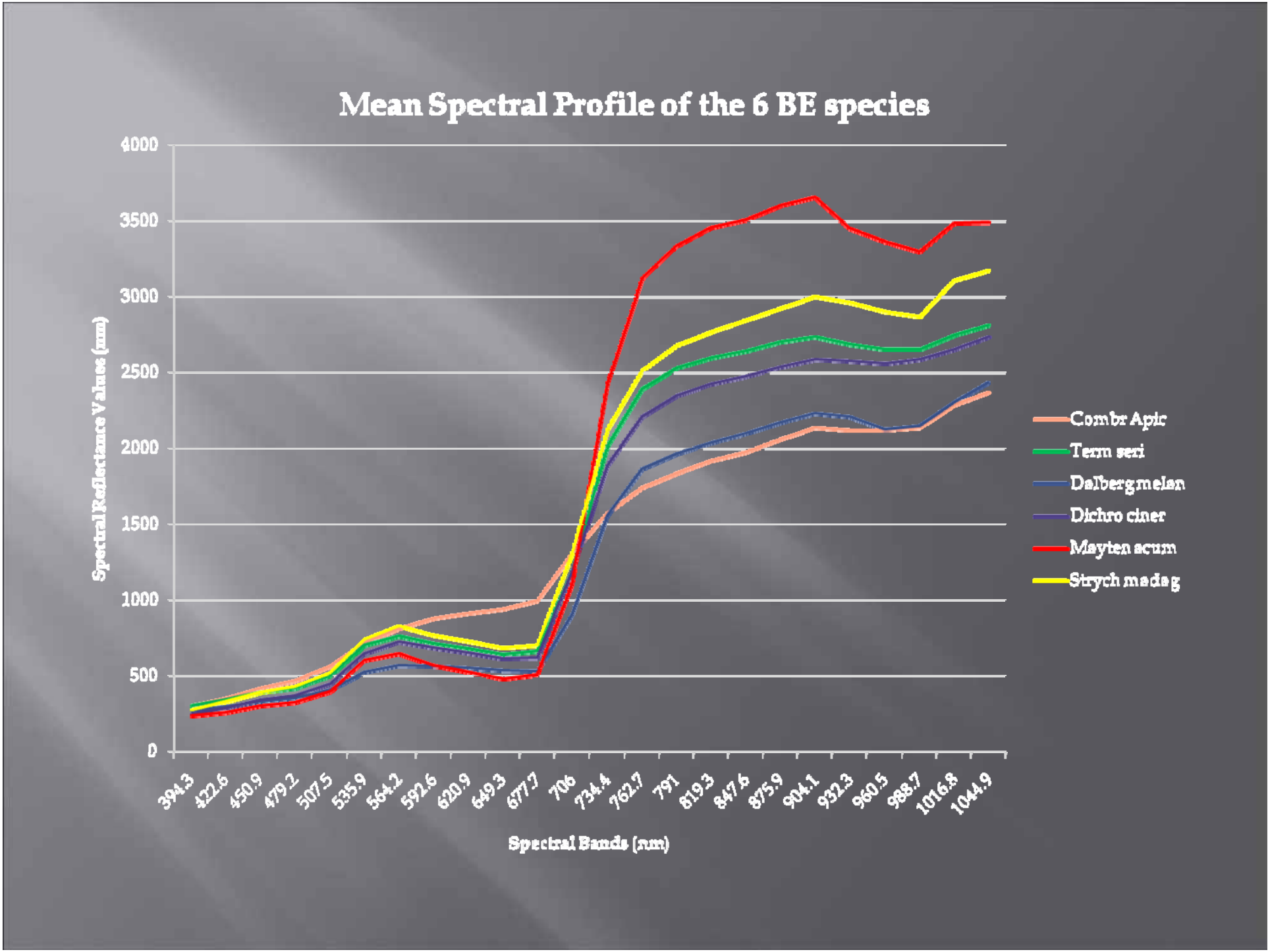
iii. Wavelengths where carotenoids & xanthophyll were most expressive (422.6nm, 450.9nm, 479.2nm, 649.3nm)

iv. Transformed (Continuum removal) red, blue & visible absorption features

- Probability of spectral discrimination (PSD) to determine which index yields the best results

## Methodology (continued…)

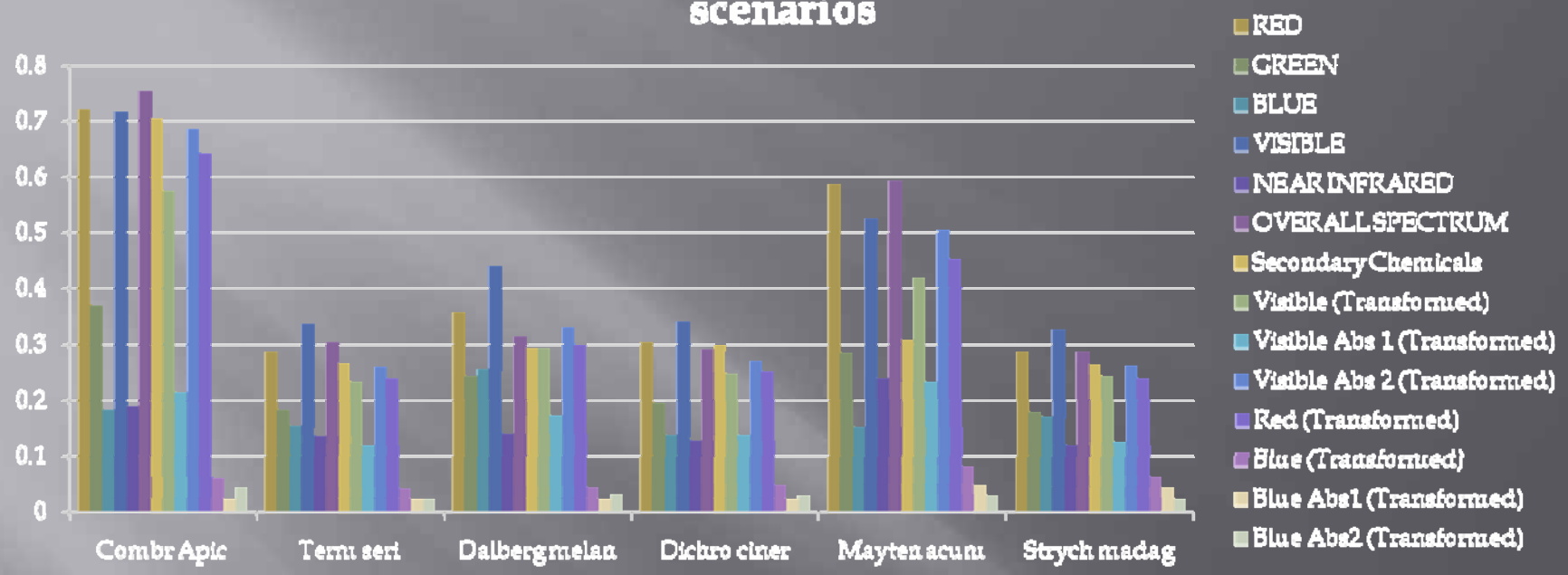
- Pure pixels (reference spectra) of the 6 bush encroaching species were extracted at canopy level over the available spectral range
- Done by overlaying GPS point shapefiles of the trees over the high res hyperspectral imagery and using the spectra profile tool in ENVI 4.5 to collect only the pure pixels of each species' canopies
- The spectral reflectance values of the pure pixels for each species were compiled in Microsoft EXCEL
- Three spectra similarity measures ~ Spectral Angle Mapper (SAM), Spectral Information Divergence (SID) & a SID-SAM combination ~ were applied to the average species spectra on a pair-wise basis to create matrices

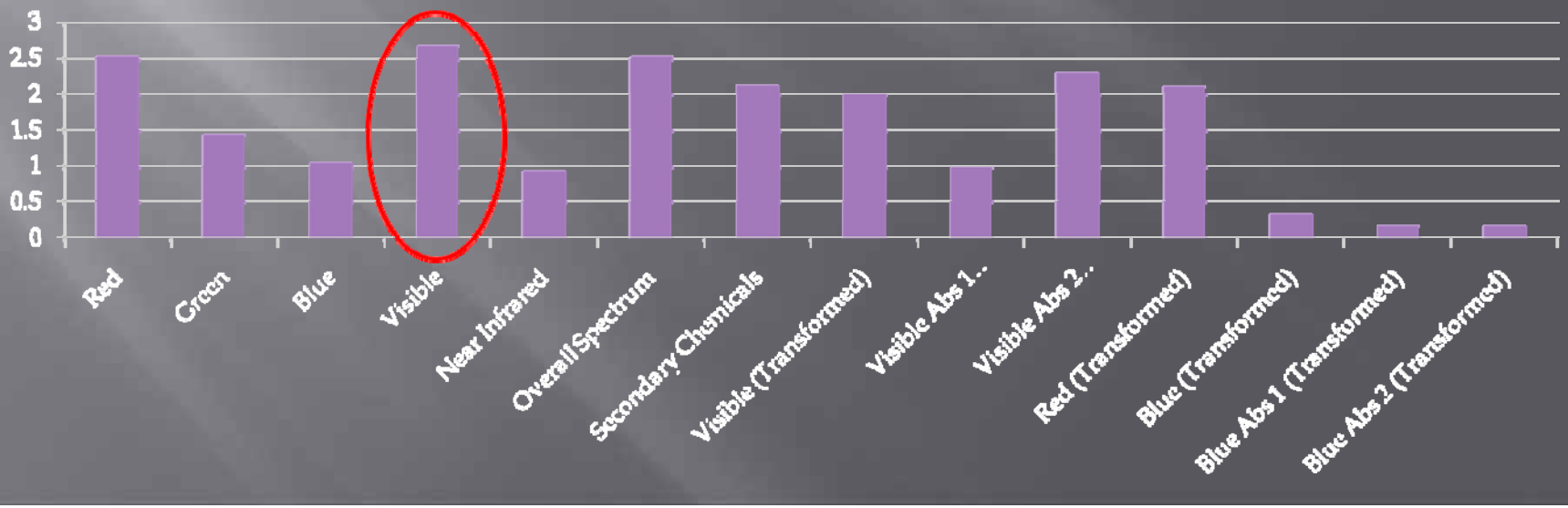

Mean Spectral Profile of the 6 BE species
Spectral Reflectance Values (nm)
4000
3500
3000
2500
2000
1500
1000
500
0
394.3
422.6
450.9
479.2
507.5
535.9
564.2
592.6
620.9
649.3
677.7
706
734.4
762.7
791
819.3
847.6
875.9
904.1
932.3
960.5
988.7
1016.8
1044.9
Spectral Bands (nm)
Combr Apic
Term seri
Dalbergmelan
Dichro ciner
Mayten acum
Strych madag

# Example of matrix output

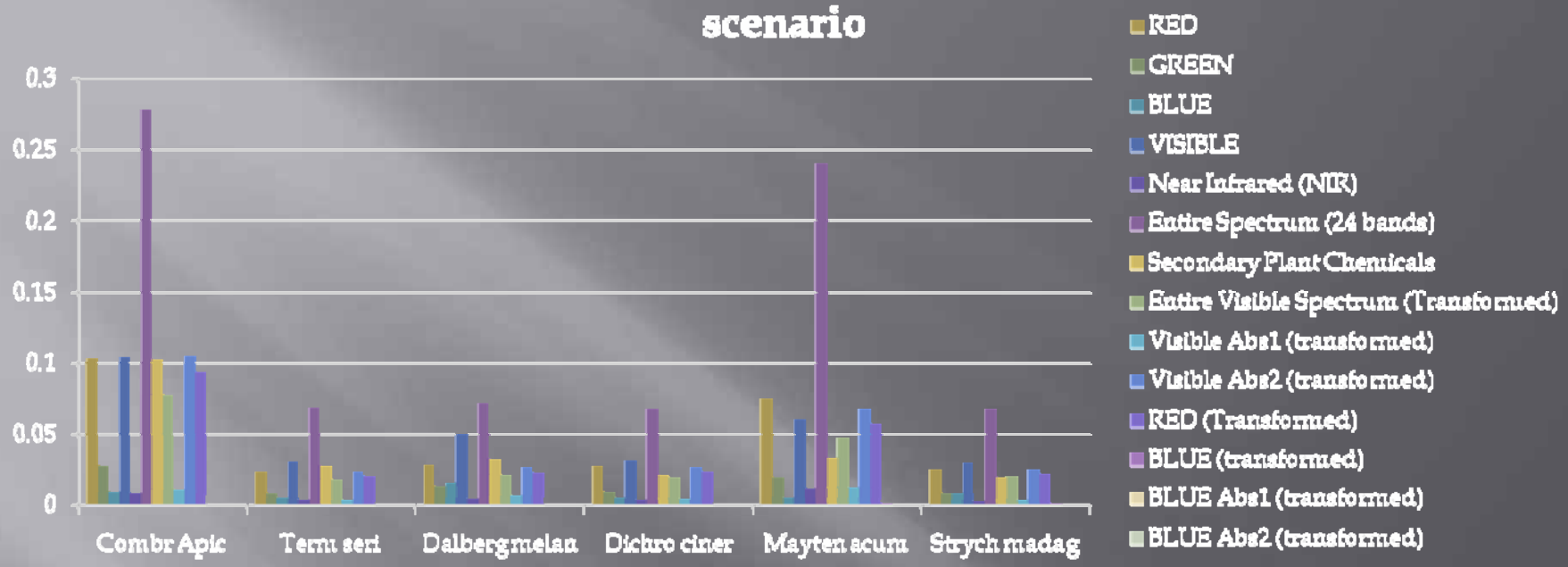
| SAM Matrix | Combr Apic | Term seri | Dalberg melan | Dichro ciner | Mayten acum | Strych madag |
|---|---|---|---|---|---|---|
| Combr Apic | | 0.135275258 | 0.133487573 | 0.130417939 | 0.221305435 | 0.134390105 |
| Term seri | 0.135275258 | | 0.033700207 | 0.02061871 | 0.090247003 | 0.024102399 |
| Dalberg melan | 0.133487573 | 0.033700207 | | 0.02908885 | 0.096442996 | 0.02172208 |
| Dichro ciner | 0.130417939 | 0.02061871 | 0.02908885 | | 0.0959026 | 0.015390619 |
| Mayten acum | 0.221305435 | 0.090247003 | 0.096442996 | 0.0959026 | | 0.091238772 |
| Strych madag | 0.134390105 | 0.024102399 | 0.02172208 | 0.015390619 | 0.091238772 | |

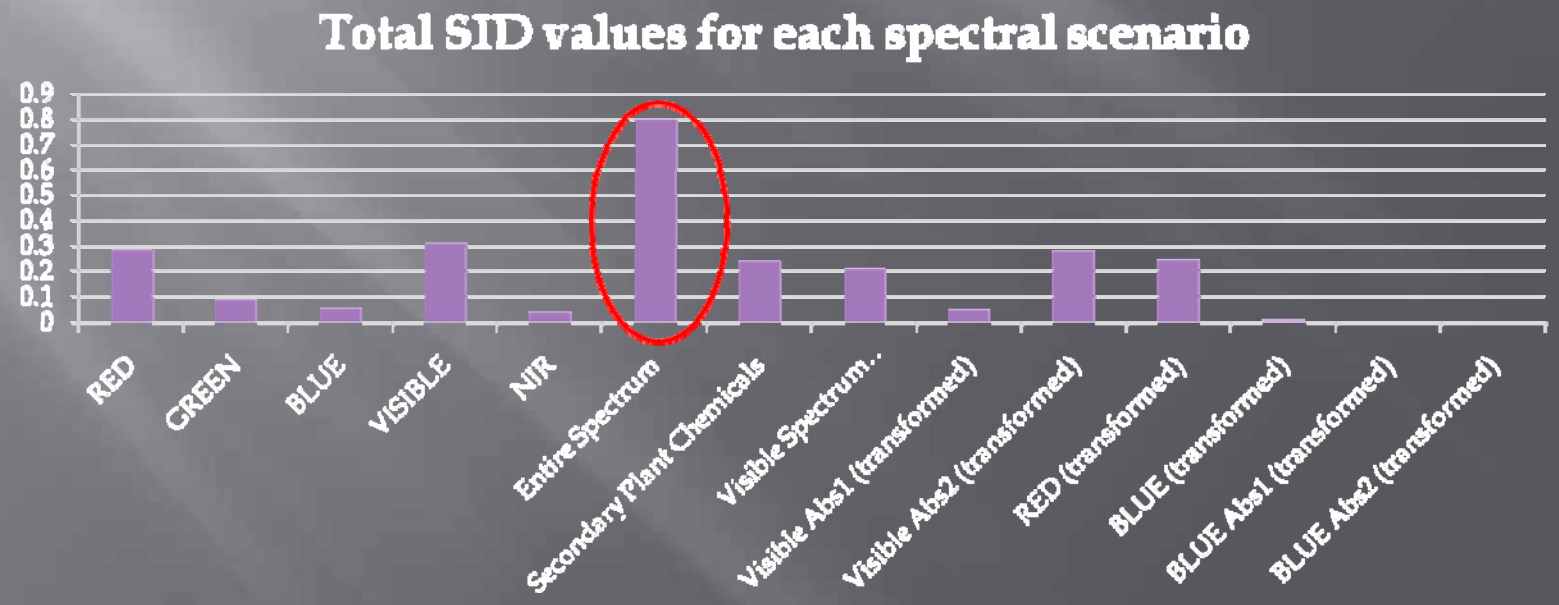
# Overall SAM results across the spectra



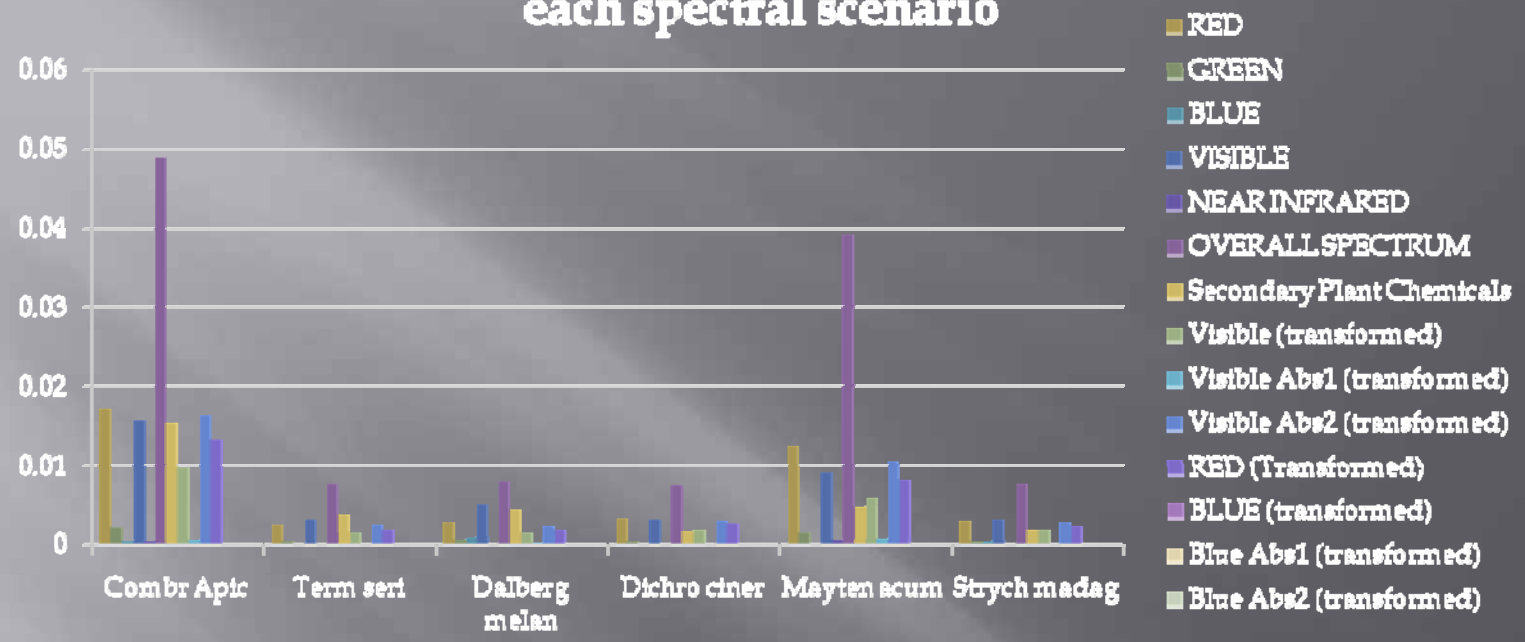



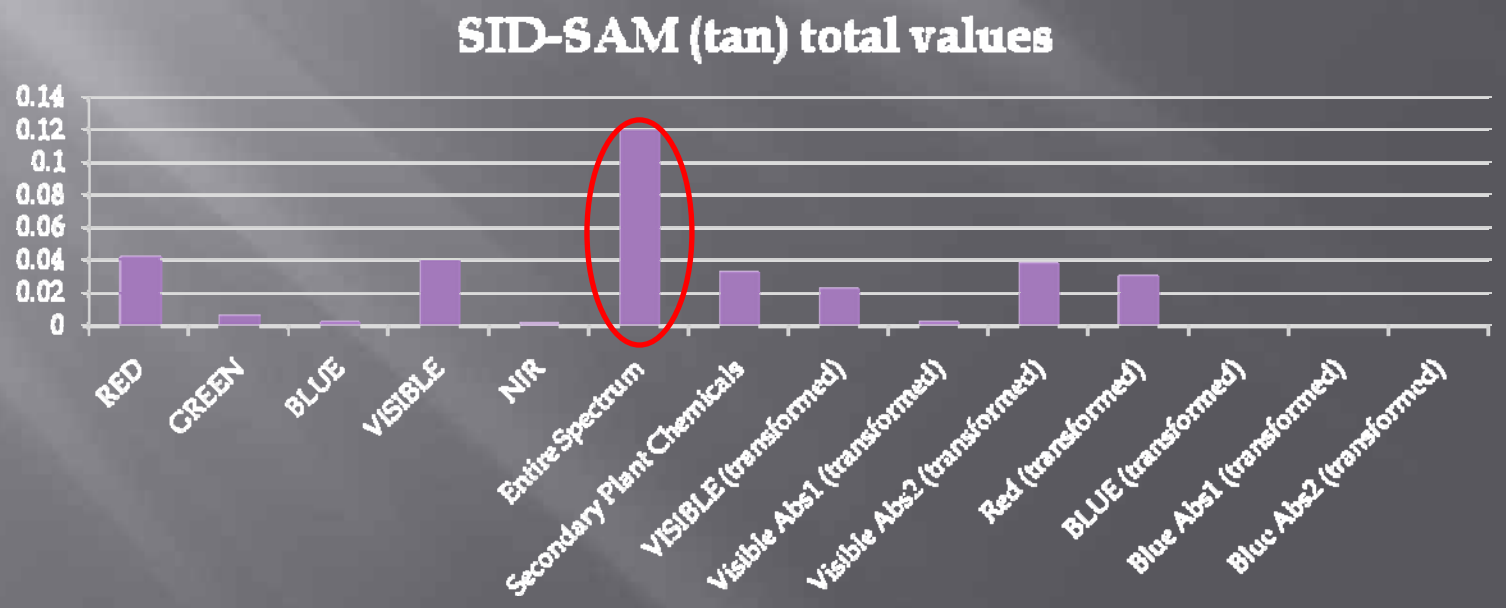
# Preliminary Results for SID



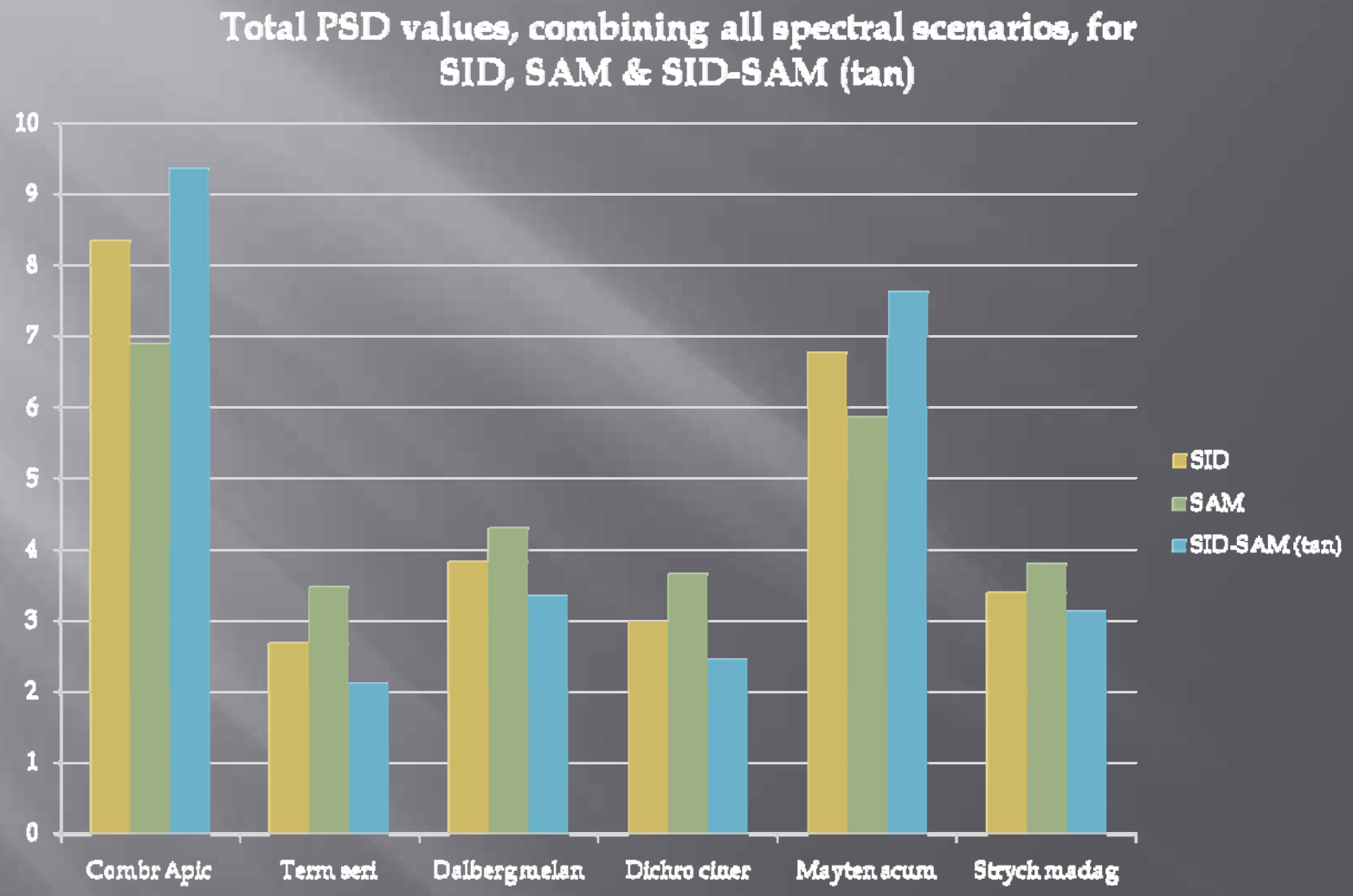



# Preliminary Results for SID-SAM (tan)



# Overall PSD Results



# Preliminary Conclusions

- The SAM results proved to be most reliable, with lower variability, especially for the spectrally similar species (*Terminalia sericea*, *Dichrostachys cinerea & Stychnos madagascariensis*)
- Also within the SAM results, the two species *Combretum apiculatum & Maytenus acuminata* still remain spectrally distinct
- *Combretum apiculatum* is the most spectrally distinct species
- *Terminalia sericea* is the least spectrally distinct species

- The research question can now be answered
  - Best spectral band / region was concluded to be the visible region according to the SAM results
  - The secondary plant chemical spectral absorption wavelengths do aid in discrimination mainly with the *Combretum apiculatum* species. This was not very effective for the other species
  - The continuum removal transform results did not produce higher SAM values than visible or the entire spectrum results
  - The transformed visible spectrum of 564.2nm-706nm results, however, showed a positive SAM result of 2.32 which illustrated the particular influencing region within the visible spectrum

# Acknowledgements


- The CSIR team in Pretoria (Moses, Renaud, Abel & Russell) for MSc funding
- The Andrew Mellon Foundation
- The CAO team for the imagery data acquisition & pre-processing