Estimating fractional land cover in the central Kalahari: The impact of vegetation morphology and sensors across three spatial scales

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INTRODUCTION

Understanding, monitoring and managing savanna ecosystems requires characterizing both functional and structural properties of vegetation. From a functional perspective, in savannas, quantitative estimation of fractional cover of **photosynthetic vegetation (f_{PV}), non-photosynthetic vegetation (f_{NPV}) and bare soil (f_{BS})** is important as it relates to carbon dynamics and ecosystem function. On the other hand, vegetation morphology classes describe the structural properties of the ecosystem. Due to high functional diversity and structural heterogeneity in savannas, accurately characterizing both these properties using remote sensing is methodologically challenging. While mapping both fractional cover and vegetation morphology classes are important research themes within savanna remote sensing, very few studies have considered systematic investigation of their spatial association across different spatial resolutions.

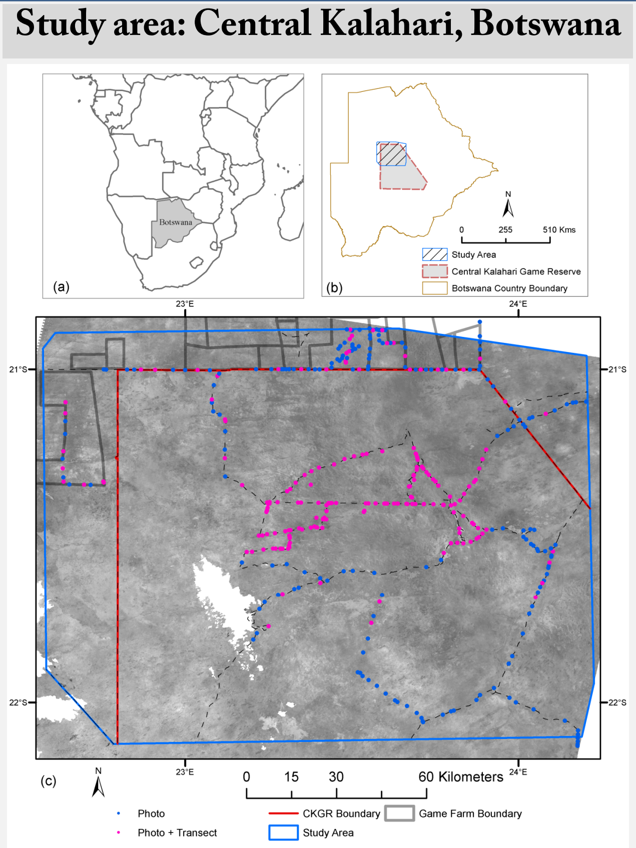
RESEARCH QUESTIONS

Focusing on the savanna ecosystem in the central Kalahari, this study utilized f_{PV}, f_{NPV} and f_{BS} derived *in situ* and estimated from **spectral unmixing of high (GeoEye-1), medium (Landsat TM) and coarse (MODIS)** spatial resolution imagery to examine:

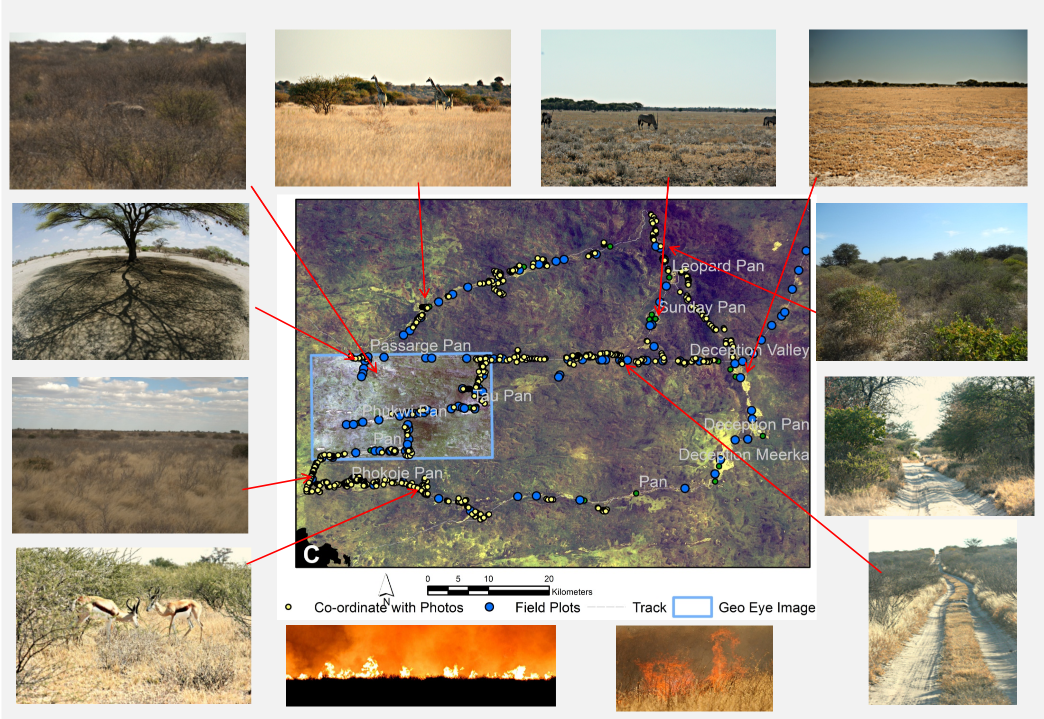
- **what is the impact of reducing spatial resolution on both magnitude and accuracy of fractional cover?**
- **How are the fractional cover magnitude and accuracy spatially associated with savanna vegetation morphology classes?**

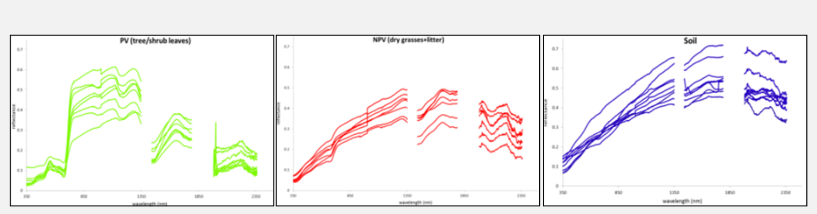
STUDY AREA/ FIELD DATA

Study area: Central Kalahari, Botswana

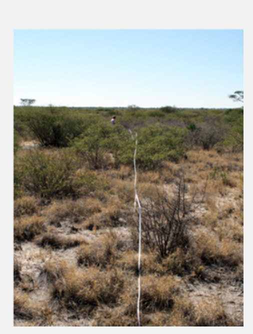


Structural heterogeneity and functional diversity of vegetation





Field Spectral Libraries



148 Fractional cover transects

Vertical plot photography

METHODOLOGY

Deriving endmembers for spectral unmixing

GeoEye and Landsat TM: Established purity measures

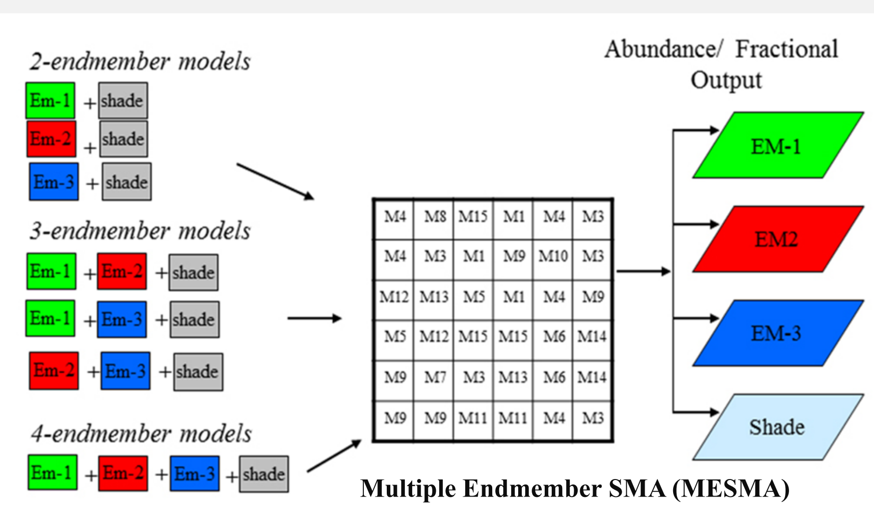
- Pixel Purity Index (**PPI**)
- Endmember Average RMSE (**EAR**)
- Minimum Average Spectral Angle (**MASA**)
- Count Based Endmember selection (**CoB**)
- Feature space plots
- Spectral Indices
- Visual interpretation

GeoEye Endmembers	Landsat Endmembers	MODIS Endmembers
PV+Shade (7)	PV+Shade (13)	
NPV+Sahde (8)	NPV+Sahde (9)	
Soil+Shade (10)	Soil+Shade (9)	
PV+NPV+Shade (56)	PV+NPV+Shade (117)	
PV+Soil+Shade (70)	PV+Soil+Shade (117)	
NPV+Soil+Shade (80)	NPV+Soil+Shade (81)	
PV+NPV+Soil+Shade (560)	PV+NPV+Soil+Shade (1053)	PV+NPV+Soil+Shade (12)
Total models:791	Total models: 1399	Total models: 12

Table 2: Different Type and varying complexity of MESMA models used in this study

MODIS: Multi-scale hierarchical approach

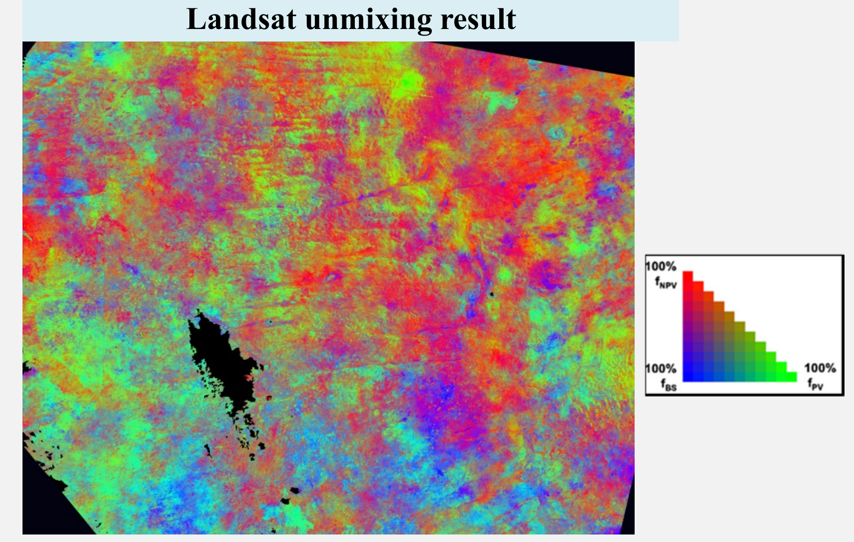
PPI thresholding of MODIS imagery → Endmember candidate pixels (n=112) → Overlay on landsat unmixing output (minimum mean fraction 80%) → Candidate endmembers: PV=5, NPV=6, Soil=6 → Overlay on high resolution GeoEye/SPOT → **Final Endmembers: PV=2, NPV=3, Soil=2**



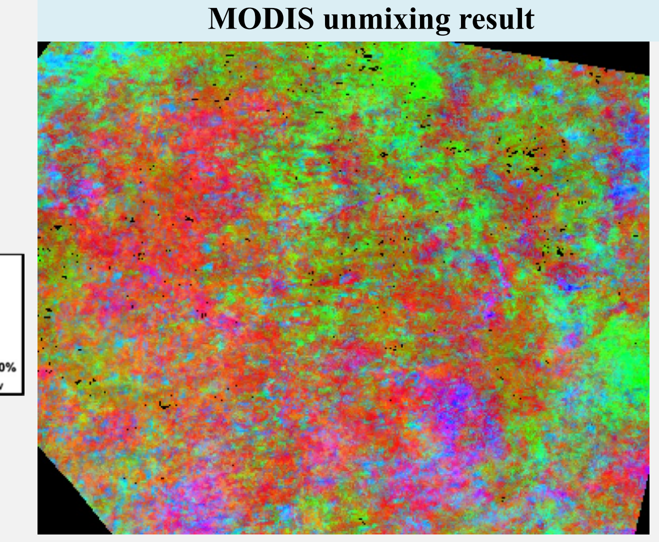
- MESMA allows the number and type of endmembers to vary on a per pixel basis and addresses: pixel scale variability in spectral dimensionality, natural variability in the spectra of most material
- This study utilized image derived endmembers which offered better scaling relation as compared to the field derived endmember spectra

RESULTS

Landsat unmixing result

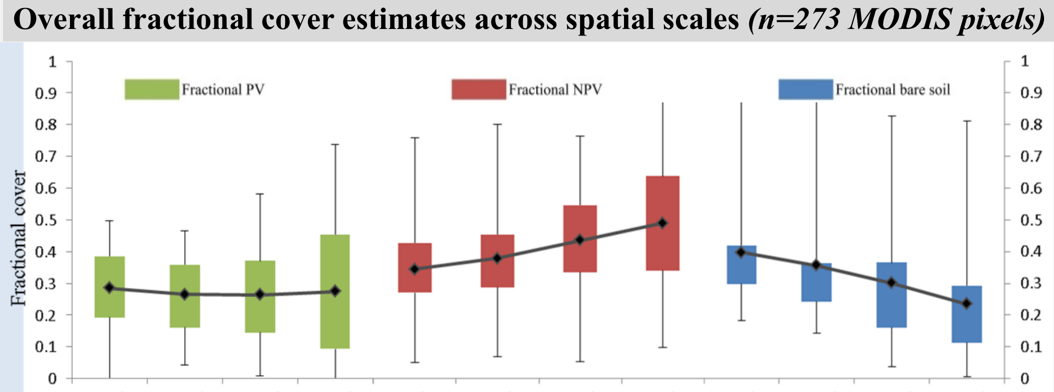


MODIS unmixing result



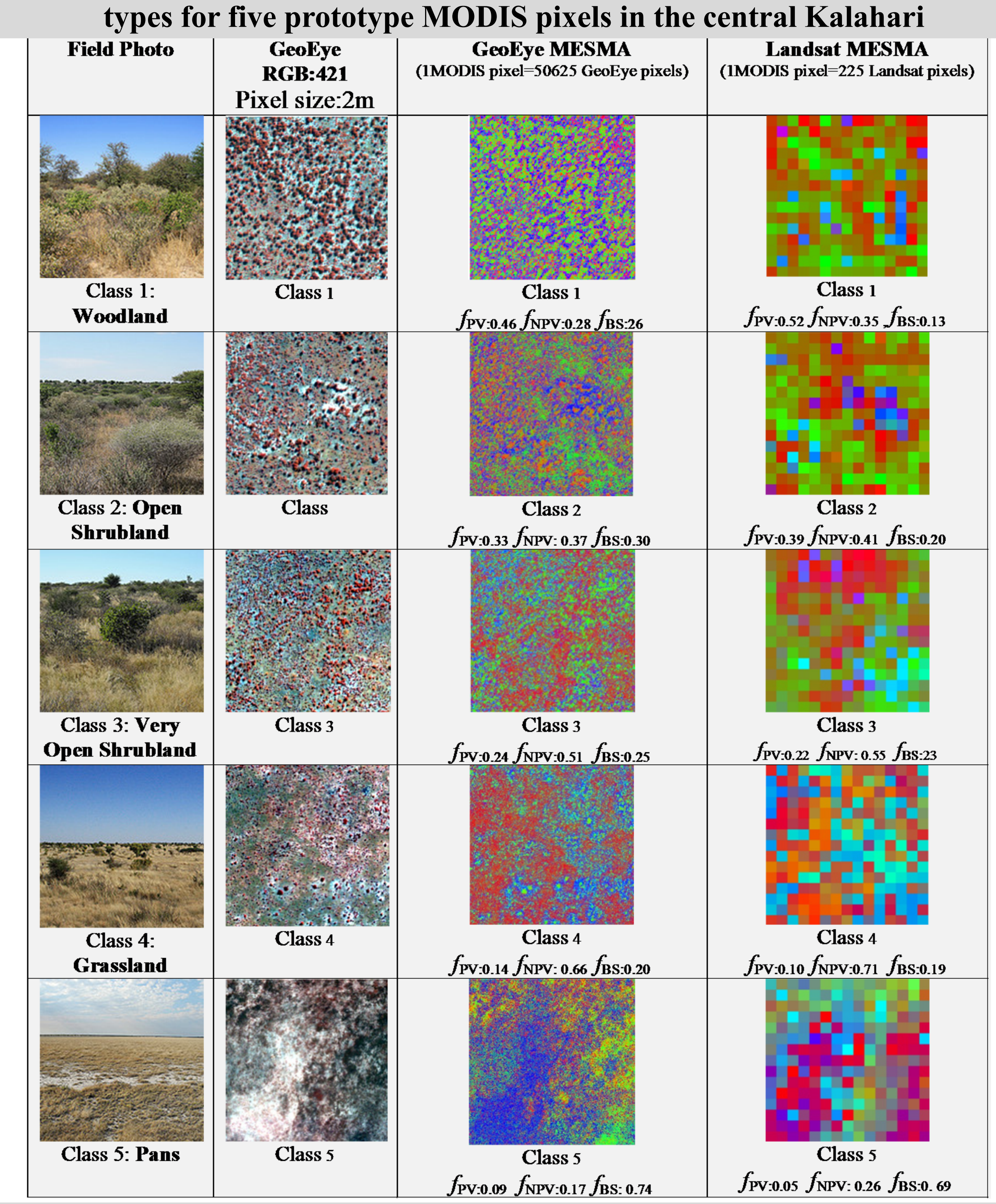
- **Comparison of field (total 148 transects) derived fractions with GeoEye derived fractions (15x15=225 pixels): correlation for f_{PV} (r^2= 0.76), f_{NPV} (r^2= 0.70), f_{BS} (r^2= 0.67)**
- **MODIS and Landsat validated using GeoEye (273 pixels each covering area equivalent to 1 MODIS pixel)**

Overall fractional cover estimates across spatial scales *(n=273 MODIS pixels)*

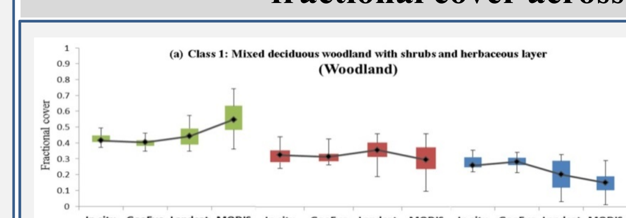


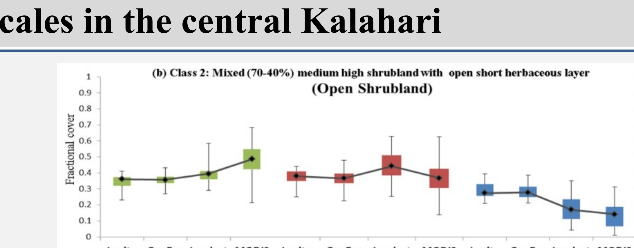
- Decreasing spatial resolution causes consistent increase in variance of fractional cover
- Increasingly biased fractional cover estimates with Landsat and MODIS
- Important to notice the cover specific difference : f_{PV} estimates less biased than f_{NPV} and f_{BS} at MODIS

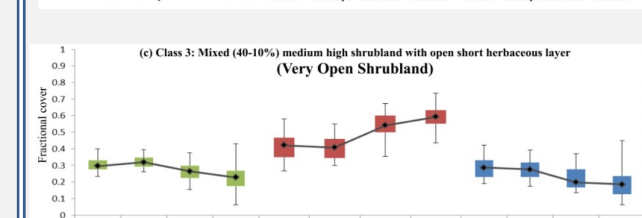
Spatial association of multi-scale fractional cover with vegetation morphology types for five prototype MODIS pixels in the central Kalahari

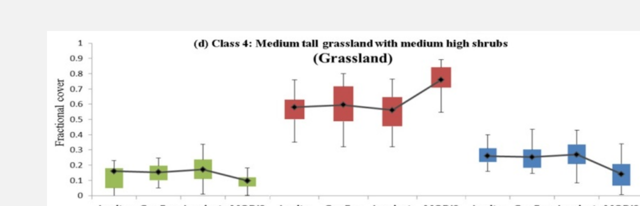


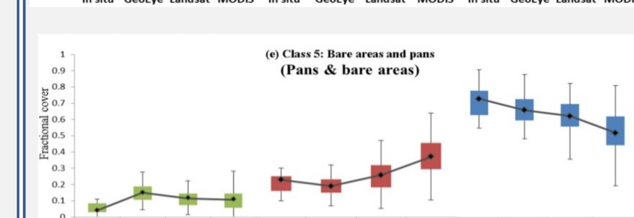
Vegetation morphology specific variability in fractional cover magnitude and accuracy of fractional cover across spatial scales in the central Kalahari











- **Vegetation morphology impacts fractional cover accuracy across all spatial resolutions tested. Important to sample of all vegetation morphology types for both model calibration and validation.**

Acknowledgements

Funding: NSF DDRI: NSF/BCS# 1203580 , Veselka Field Research Grant from the University of Texas, Multiple GeoEye imagery grants from GeoEye Foundation, Virginia, SPOT imagery grant from Planet Action Austrim, France. Thanks to Dr. Glyn Maude (CKGR Predator Research) and Dr. Thoralf Meyer (SGI Botswana).

References

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