

Mapping the Biomass and Forest Structure in the SAFE Area using Fourier Analysis of Satellite Imagery

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Abstract

The research focusses on differentiating between the AGB and forest stand parameters of riparian and non-riparian zones of a mixed land use type in Malaysian Borneo comprising of lowland forests, logged forests and oil palm plantations. Fourier analysis and grey level co-occurrence based texture analysis techniques were applied on SPOT 5 data for both differentiating and predicting the AGB values for different forest types. It was found Fourier based method (FOTO) could both differentiate and predict the biomass of different land use types without undergoing saturation. Fourier Transform Textural Ordination (FOTO) combination of two different techniques- 2D Fast Fourier Transform (FFT) and ordination through Principal Component Analysis (PCA) for characterizing the structural and textural properties of vegetation. The research establishes thresholds for disturbances these forests zones can undergo before their AGB values decline. The research also determined that AGB value is much higher for riparian margins than for surrounding oil palm plantations.

Aims

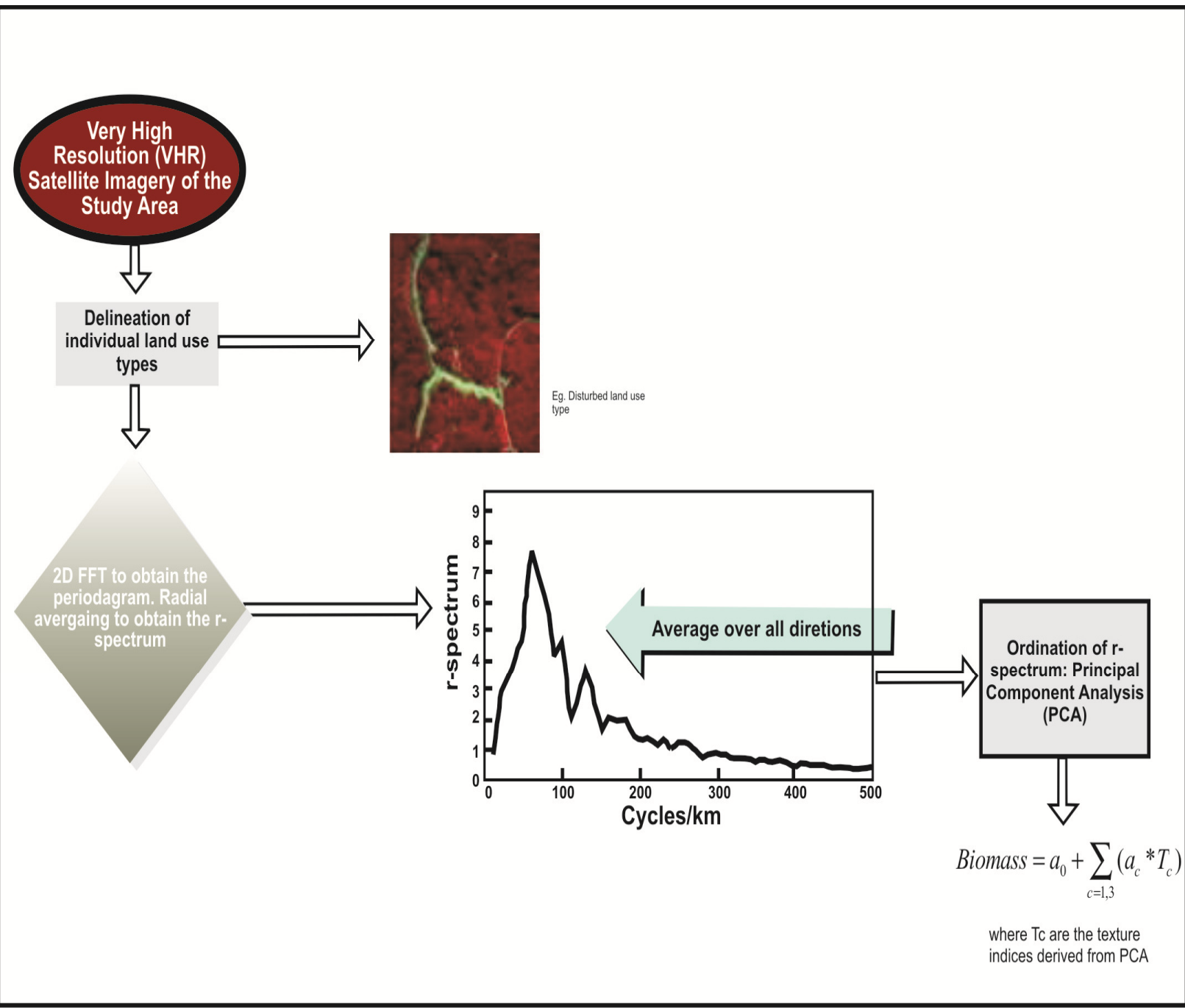
Methods

Results

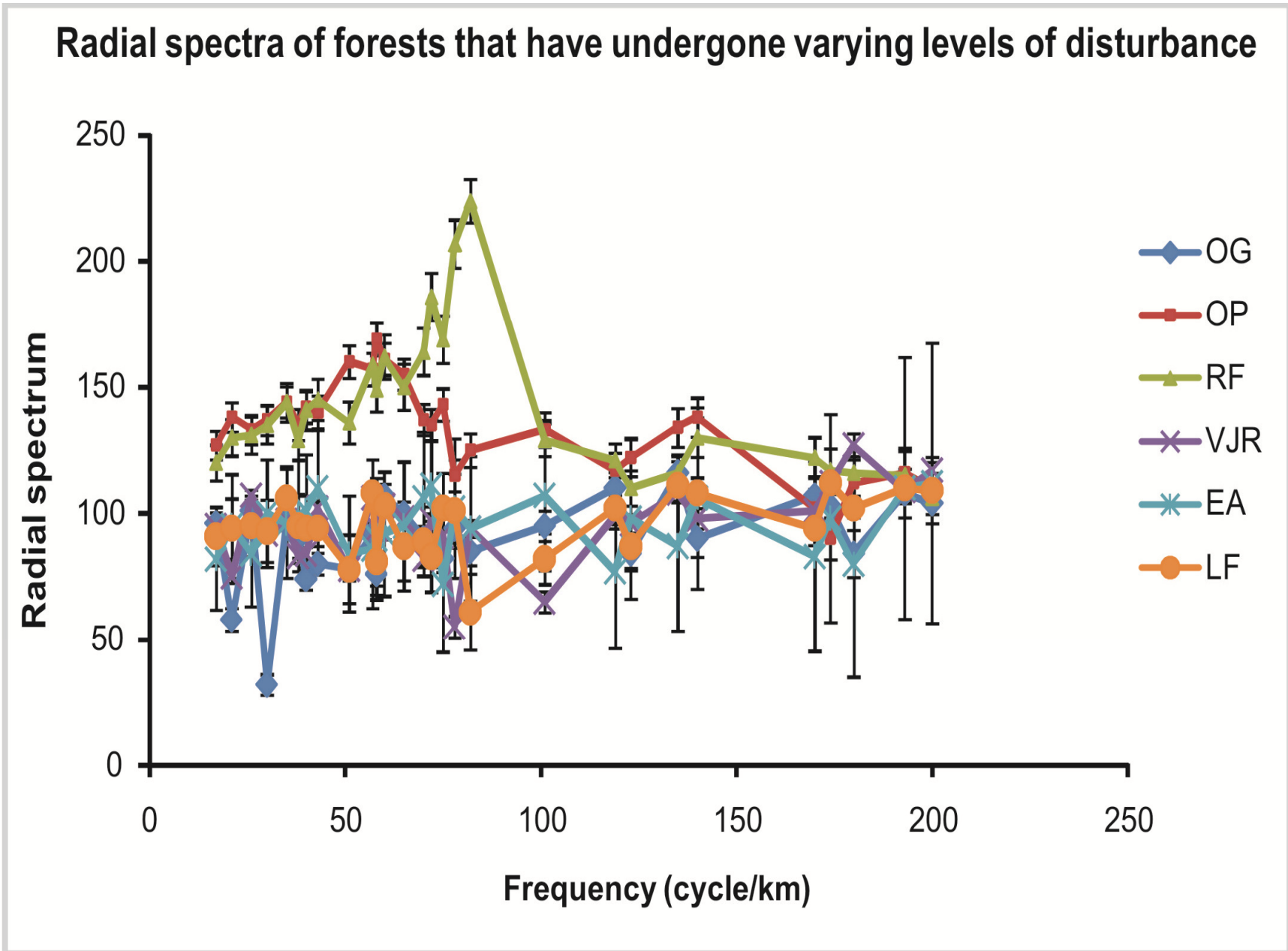
Specifically the research seeks to:

- 1) To distinguish between different land-cover types, including forests of different logging intensities, oil palm plantations and pristine forests from one another using FOTO method
- 2) To develop texture based biomass estimate models for different land use types
- 3) To examine the possibility of distinguishing a remnant/isolated forest ecosystem (in this case riparian forests) from surrounding contiguous forest types

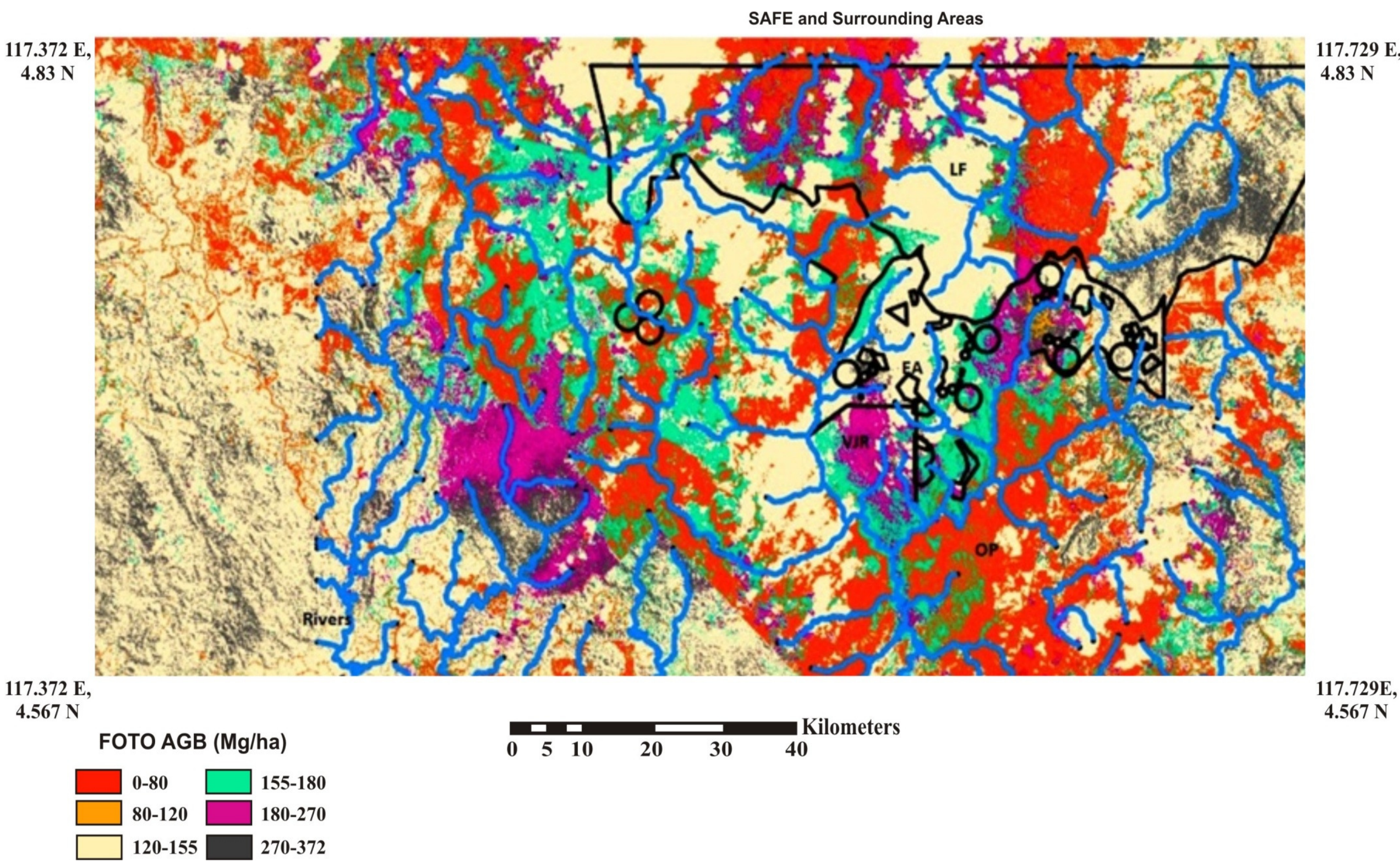
Fourier Transform Textural Ordination (FOTO):



1) Different land use types such as logged forests, oil palm plantation and riparian forests have different frequency signals expressed in cycle/km

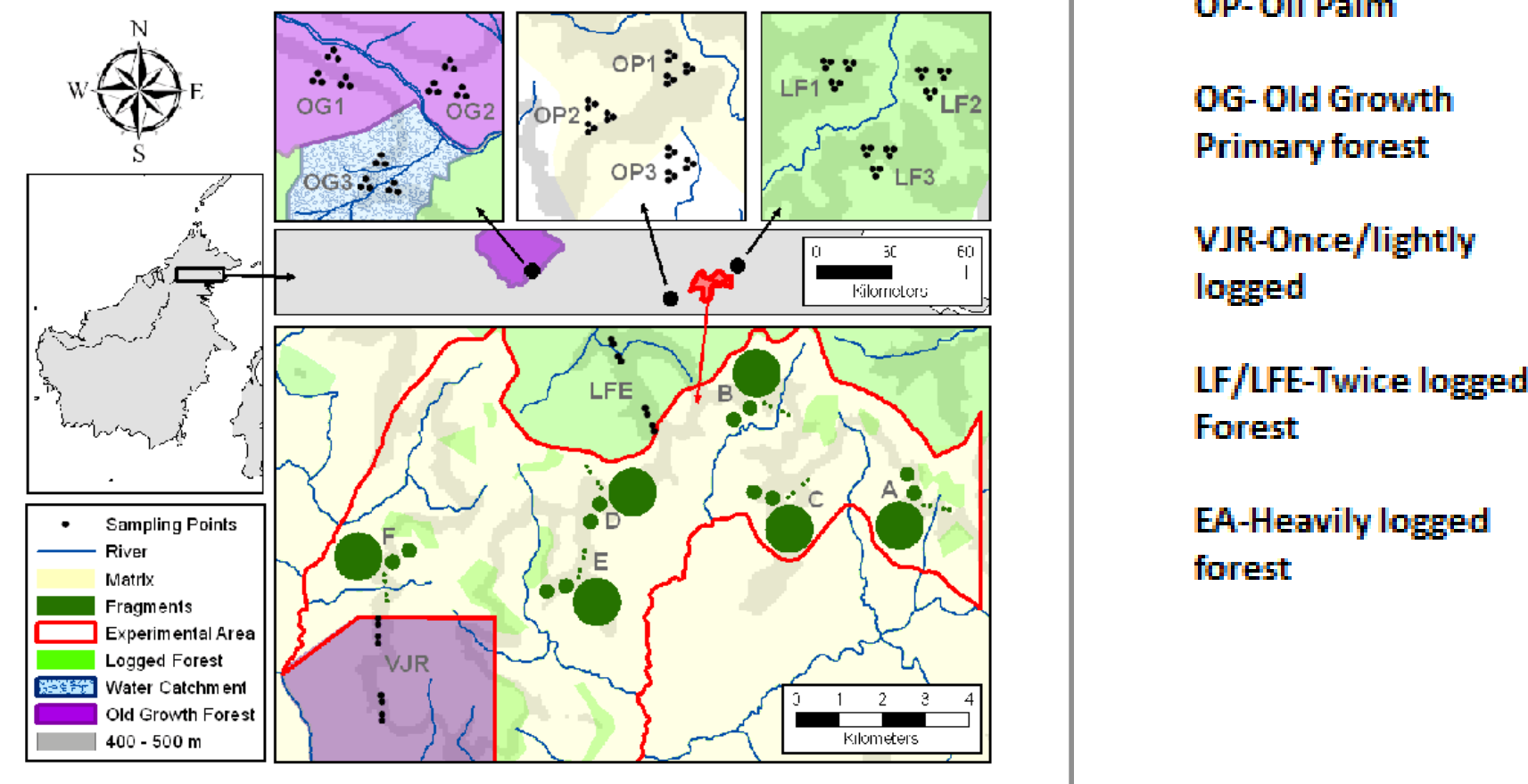


3) Biomass Map derived from FOTO texture indices



Study Area

The research was carried out at the Stability of Altered Forest Ecosystems [SAFE] Project (SAFE Project, 2011) in Sabah, Malaysia. The area comprises of a mixed landscape that includes areas of a twice logged forest (LF/LFE), virgin jungle reserve/ VJR, oil palm plantation (OP) and a 7200 hectare heavily logged area known as the experimental area (EA) which has been earmarked for conversion to oil palm beginning in December, 2011. The study area of the research extends to the Maliau Conservation Basin (116.87 E, 4.82 N) and the surrounding areas. At the mouth of the this area, near the Maliau river is the undisturbed old growth lowland primary forest.



Experimental Design of SAFE Area. Currently the area inside the red outline (which is a heavily logged forest) is being converted to oil palm. Fragments A-F (of sizes 1ha, 10ha and 100ha) and riparian margins will be spared from conversion.

1) 2D Fast Fourier Transform (2D FFT) is applied to the satellite image to convert the spatial information to the frequency domain

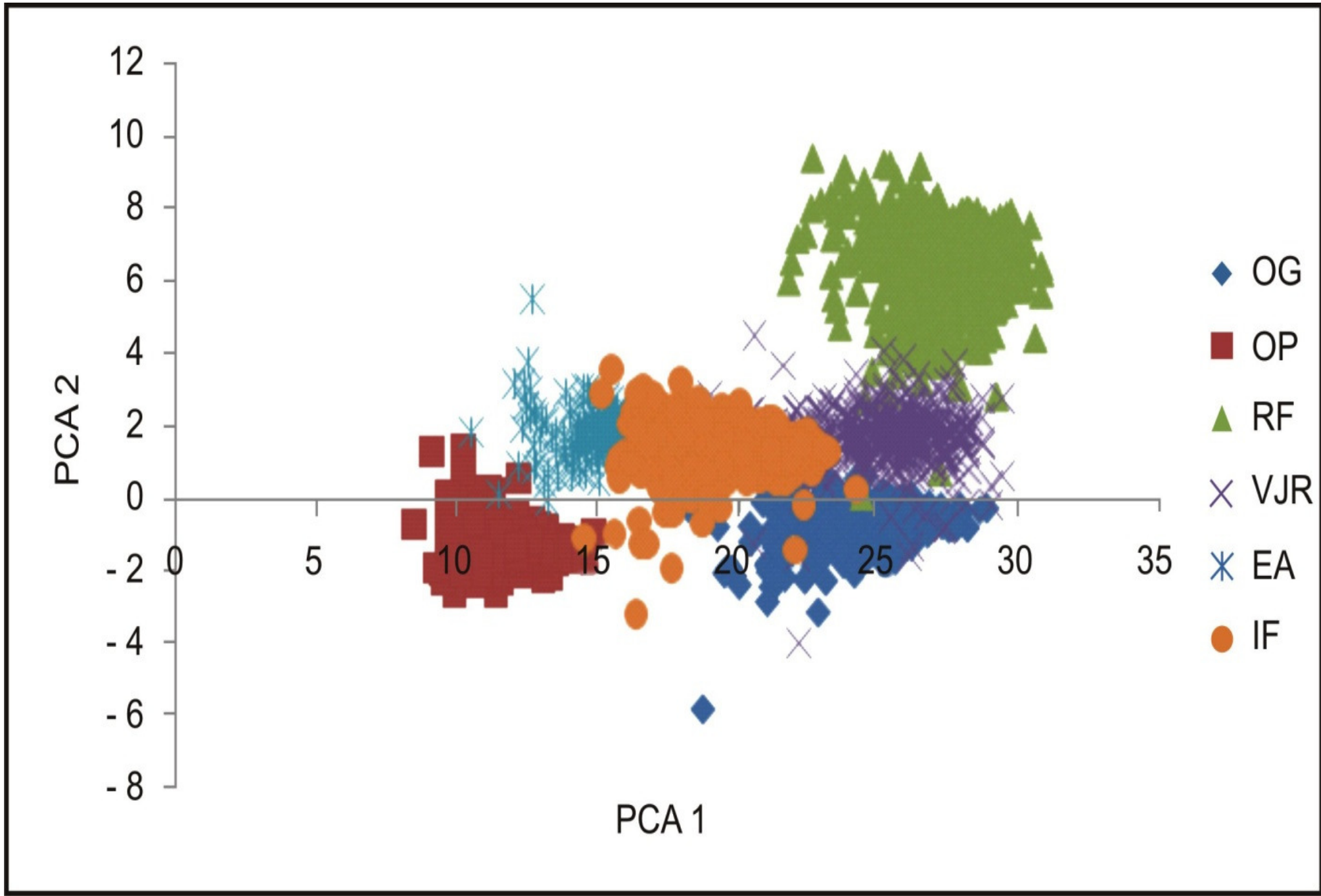
2) The power spectrum is obtained by squaring the amplitude of the Fourier transform obtained previously

3) As a way of expressing the repetitive canopy structure, the radial spectrum or r-spectra (which is the average of frequency information for across the azimuthal directions for space) is plotted with respect to frequencies which are expressed in cycles/km

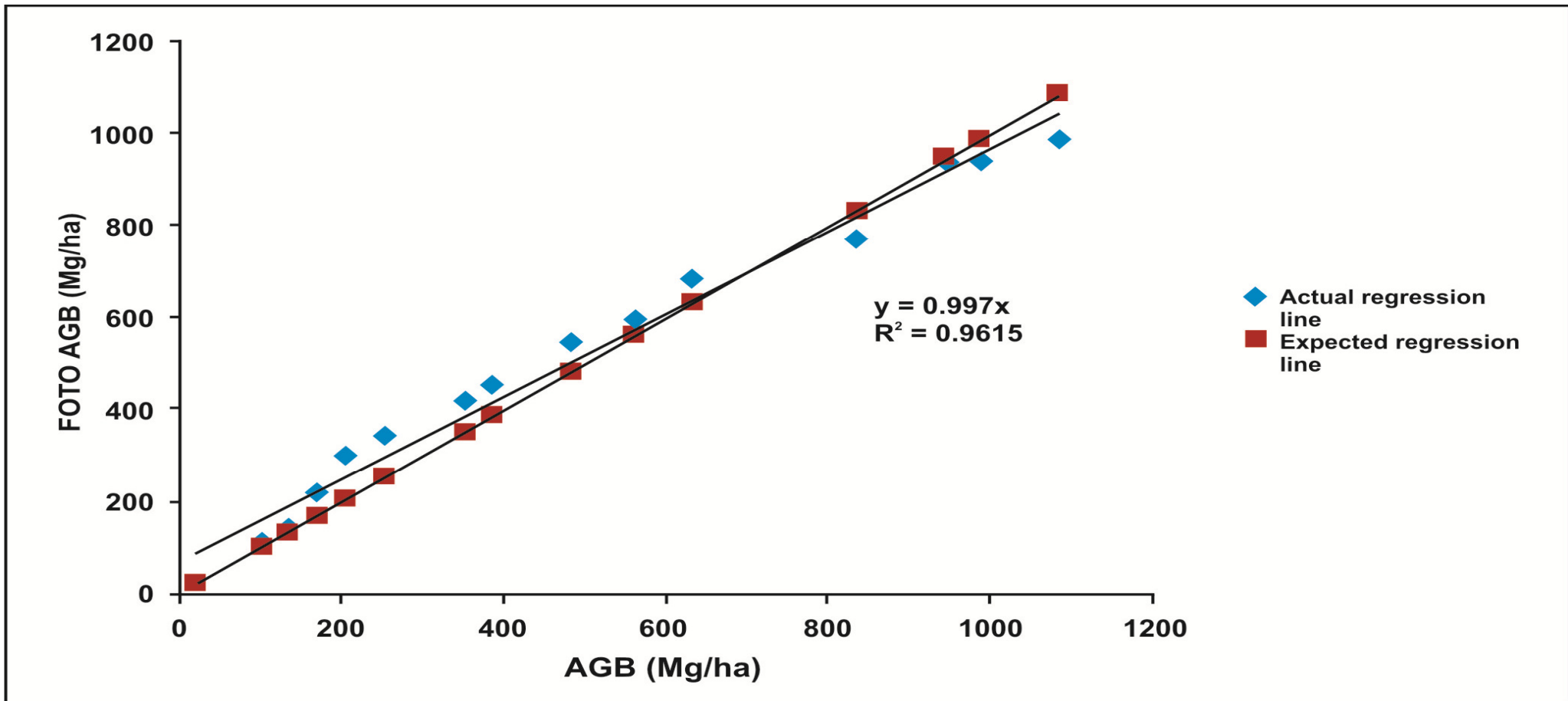
4) The r-spectrum values are submitted to multivariate analysis techniques (ordinations/classifications), in this case Principal Component Analysis (PCA)

5) For this research, first three PC axes have been used as texture indices, which are also known as the FOTO indices.

2) The first two axes obtained from the PCA evaluation (PC1 and PC2) allowed for distinguishing the different forest types across both a disturbance and fragmentation gradient respectively.



4) No saturation at high biomass values



Conclusion

1) Texture based methods such as FOTO allow for distinguishing between the different land use types such as lowland forests, oil palm plantations, riparian forests

2) FOTO derived AGB values showed no signs of saturation at high biomass values. Therefore this method can be applied for tropical ecosystems such as those found in Borneo.

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