Topography shapes the diversity, structure and carbon content of tropical forest landscapes

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GFBI – FECS joint symposium
Beijing, 6th September 2017
Meet the team

David Coomes

Michele Dalponte

David Burslem
What controls the structure, composition & function of tropical forests?
Macro-scale drivers of structure, composition & function

Boisvenue & Running (2006) GCB
What about fine-scale heterogeneity in forest structure & function?
Topography, forest structure & function

- Topography
- Species diversity & functional trait composition
- Forest structure
- Carbon stocks
A bird’s eye view of forest ecosystems
Airborne laser scanning (a.k.a. LiDAR)

Top-of-canopy height
A bird’s eye view of forest ecosystems

- Topography
- Forest structure
- Carbon stocks
- Species diversity & functional trait composition

Data sources:
- Airborne laser scanning data
- Hyperspectral imagery & permanent plot data
Hyperspectral imagery

- Hyperspectral imagery
- Water absorption
- Chlorophyll absorption
- Reflectance
- Visible
- Near infrared
- Shortwave infrared (SWIR)
- Wavelength (nm)
Sabah, Malaysian Borneo
Sepilok Forest Reserve

Sandstone       Alluvial       Heath
Variation in forest structure
Variation in forest structure

Alluvial

Sandstone

Heath

Height above-ground (m)

Proportion of LiDAR returns (%)
Variation in species composition, diversity & functional make-up
Variation in species composition, diversity & functional makeup
Testing the model

Species diversity & functional trait composition

Topography

Forest structure

Carbon stocks
Testing the model

i. Develop plot-level models relating field estimates of *species richness*, *wood density* and *aboveground carbon stocks* to remotely-sensed attributes

ii. Use local models to up-scale forest attributes from plot to *landscape level*

iii. Fit structural equation models to identify direct and indirect *effects of topography* on forest structure, functional composition, diversity and carbon stocks
Up-scaling species diversity & wood density using hyperspectral imagery

Species diversity $\approx$ within-plot variation
Wood density $\approx$ within-plot mean
Estimating tree species richness & wood density
Estimating aboveground carbon density

Field estimated ACD (Mg C ha\(^{-1}\)) vs. Modelled ACD (Mg C ha\(^{-1}\))

RMSE = 39.3 Mg C ha\(^{-1}\)

Jucker et al. (in review)
Testing the model

- Topography
- Forest structure
- Carbon stocks
- Species diversity & functional trait composition
Testing the model

Effect size
- 0.8
- 0.4
- 0
- 0.4
- 0.8

Model fit statistics
- $\chi^2 = 5.0$, d.f. = 4, $P = 0.29$

- Slope
- Elevation
- TPI

- No species
  - $R^2 = 0.36$

- Wood density
  - $R^2 = 0.16$

- TCH
  - $R^2 = 0.32$

- Gap fraction
  - $R^2 = 0.30$

- ACD
Topography & forest structure

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ACD
Topography & forest structure

Relative elevation within the landscape (m.a.s.l.)

- Top-of-canopy height (m)
- Gap fraction at 20 m
Topography, species diversity & traits

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- 0.4
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Topography, species diversity & traits

Species richness vs. Relative elevation within the landscape (m.a.s.l.)

Wood density (g cm$^{-3}$) vs. Relative elevation within the landscape (m.a.s.l.)
Forest structure & composition

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Topography & carbon stocks

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Topography & carbon stocks
1. Elevation as a key driver of forest structure, composition & diversity

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2. Complex relationship between carbon stocks and topography
3. Better estimates of wood density from hyperspectral imagery
4. Carbon – biodiversity co-benefits in human modified tropical forests