Habitat-related tree species distributions and diversity in a Peninsular Malaysian rainforest

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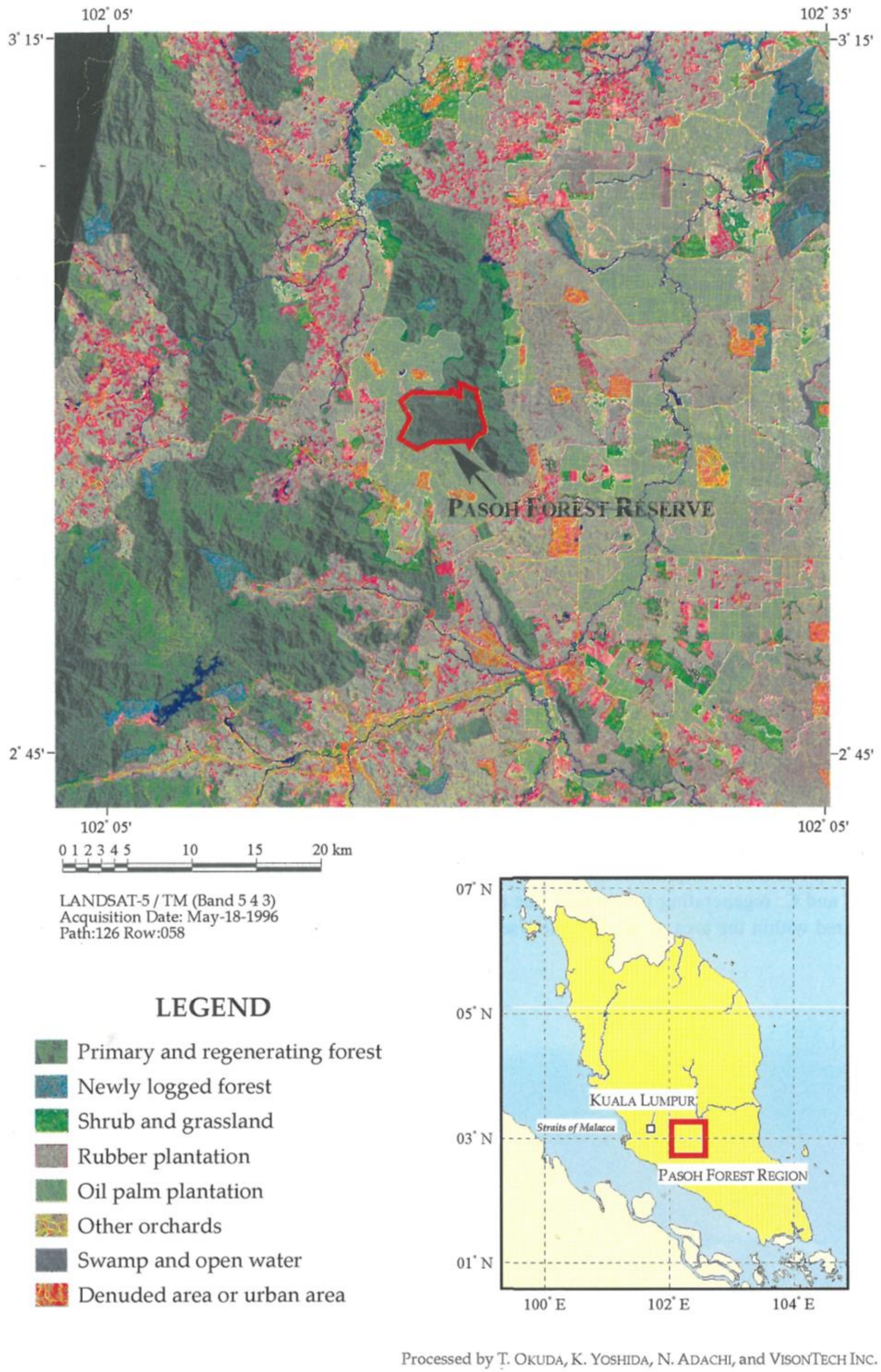
INTRODUCTION

Pasoh FR

- West coast of Peninsular Malaysia, eastern part of Negeri Sembilan, 140 km from KL
- A rain-shadow area situated in an inter-montane valley, annual rainfall < 2000 mm
- Entire FR: 13,900 ha; the SW corner is the site of Pasoh Research Forest (Hutan Penyelidikan Pasoh) 1,840 ha
- Lowland dipterocarp forest, Red Meranti-Keruing dominated (Wyatt-Smith, 1987, ed.2 1995)



INTRODUCTION

Early studies

- Records of silvicultural practices conducted in Pasoh FR dated back to 1930's (Wyatt-Smith, 1987, ed.2 1995)
- Earliest scientific study started in 1961 (Wong & Whitmore 1970) on influence of soil properties on species distribution
- A series of researches under International collaboration/initiative, started as International Biological Programme
- The best studied forest in Tropical Asia

INTRODUCTION

Pasoh 50-ha plot

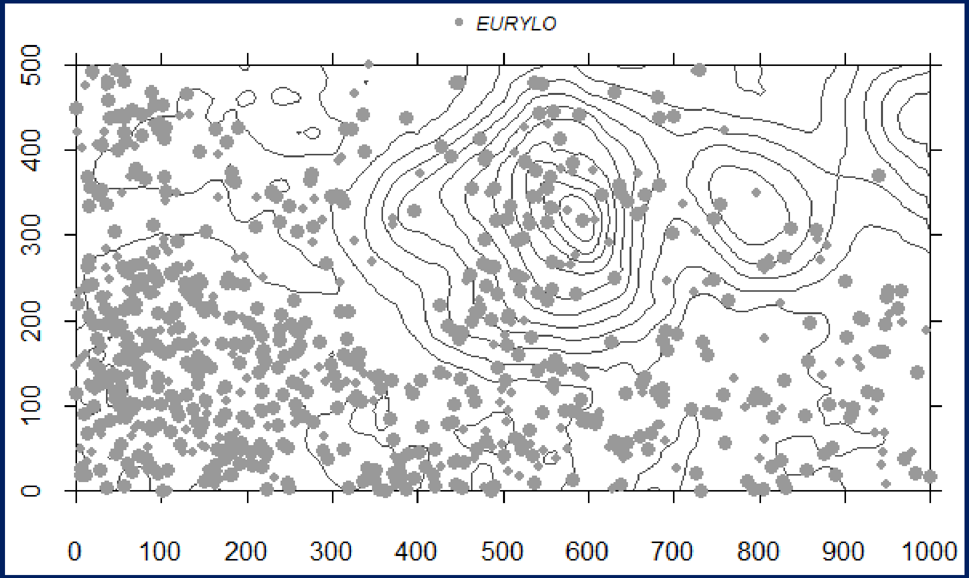
Origin

- In BCI, Panama most species are effectively equivalent competitors whose abundances fluctuate stochastically (Hubbell & Foster, 1986; Welden *et al*. 1991), a.k.a drift model
- Ashton argued that drift model would not apply to SE Asian forests, where tree, diversity is very high and many congeneric species coexist (Condit, 1995)
- To settle the matter, FRIM in collaboration with Smithsonian Tropical Research Institute (STRI) established the second 50-ha plot at Pasoh, following the BCI protocol strictly
- Established in 1985(-1987)

- The network of big plots expands

INTRODUCTION

Plot dimensions and details



- 1000 m * 500 m = 50 ha
- Topography determined, measured at 10 * 10 m scale, sub-quadrats marked
- Difference of highest and lowest points = 20 m, contour line at 2m intervals
- Stems >= 1 cm dbh are tagged, measured, mapped and identified to species level; stems are re-measured every 5-years
- Total trees 338,924; comprising 81 families, 295 genera and 818 species; 20 % >= 5 cm dbh (Davies *et al*. 2003; concluded from Census-3 results)
- Fieldwork of the Census-7 concluded in March 2017, new recruits *c*. 38,000

RESEARCH BACKGROUND

- Many studies have shown that paleo-tropical tree species show strong patterns of habitat specialisation for topographically and edaphically defined habitats (Korup – Chuyong *et al*. 2001, Lambir – Russo *et al*. 2005, Korup – Kenfack *et al*. 2014).

Journal of Ecology 2005
93, 879–889

Soil-related performance variation and distributions of tree species in a Bornean rain forest

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Distributions of five species of *Shorea* (Dipterocarpaceae) aggregated on

(a) Sandy loam

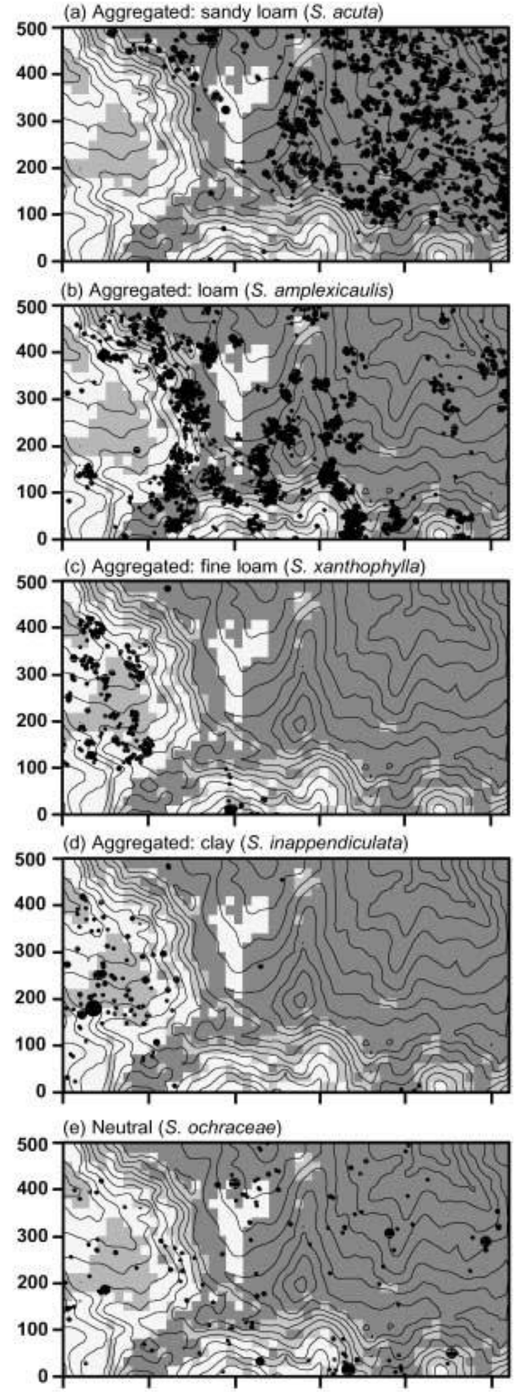
(b) Loam

(c) Fine loam

(d) Clay

(e) with a Neutral distribution; in the Lambir plot.

Shading indicates soil types: dark grey, sandy loam; light grey, loam; white, fine loam; medium grey, clay.



Kenfack *et al. Forest Ecosystems* 2014, **1**:22
http://www.forestecosyst.com/content/1/1/22

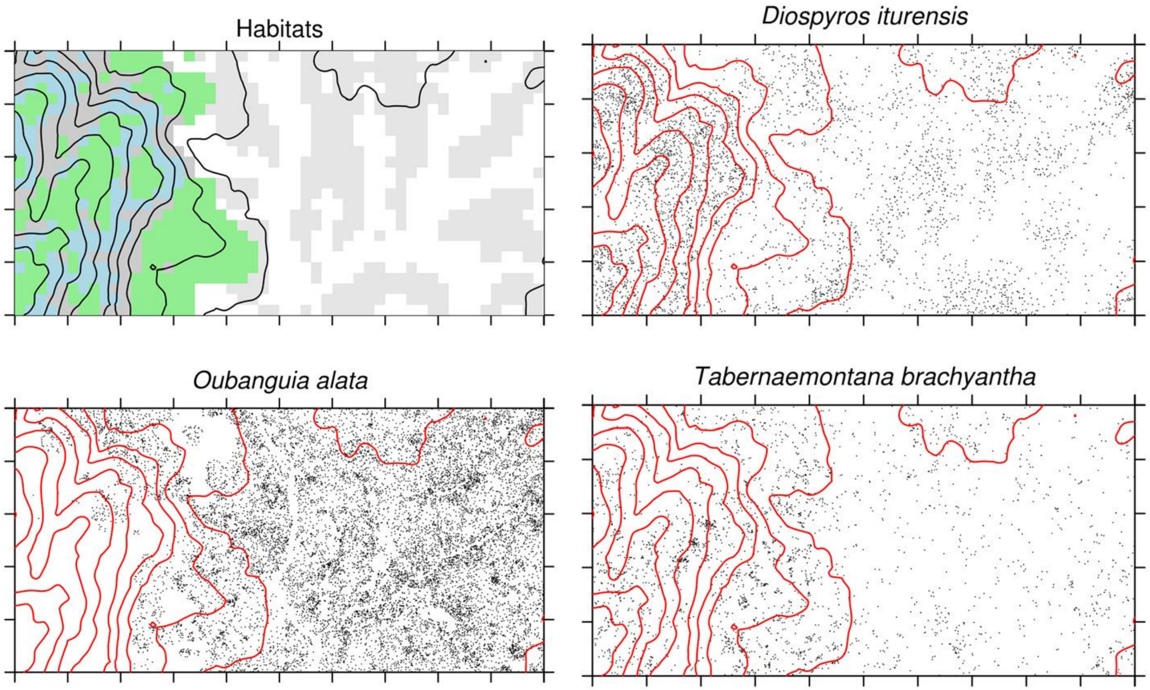
Forest Ecosystems
a SpringerOpen Journal

RESEARCH ARTICLE Open Access

Demographic variation and habitat specialization of tree species in a diverse tropical forest of Cameroon

David Kenfack[1*], George B Chuyong[2], Richard Condit[3], Sabrina E Russo[4] and Duncan W Thomas[5]

- A map of topographic habitats of the Korup 50-ha plot, Cameroon, The habitats, shown in the top, left panel, are: depression (white), flat (light gray), slope (blue), gully (dark gray), ridge (green), as defined in Chuyong *et al*. (2011).
- *Oubanguia alata* (Lecythidaceae) is a specialist of the depressions, *Diospyros iturensis* (Ebenaceae) of gullies, and *Tabernaemontana brachyantha* (Apocynaceae) of the ridge.



RESEARCH BACKGROUND

- Habitat specialisation patterns for Pasoh were not quantified using modern statistical methodology

- Since edaphic and topographic habitats in part define resource availability to trees, we then expect future environmental change to manifest differently in different habitats for predicting responses to climate change, knowing habitat preferences of individual species is important

Habitat-related tree species distributions and diversity

OBJECTIVES

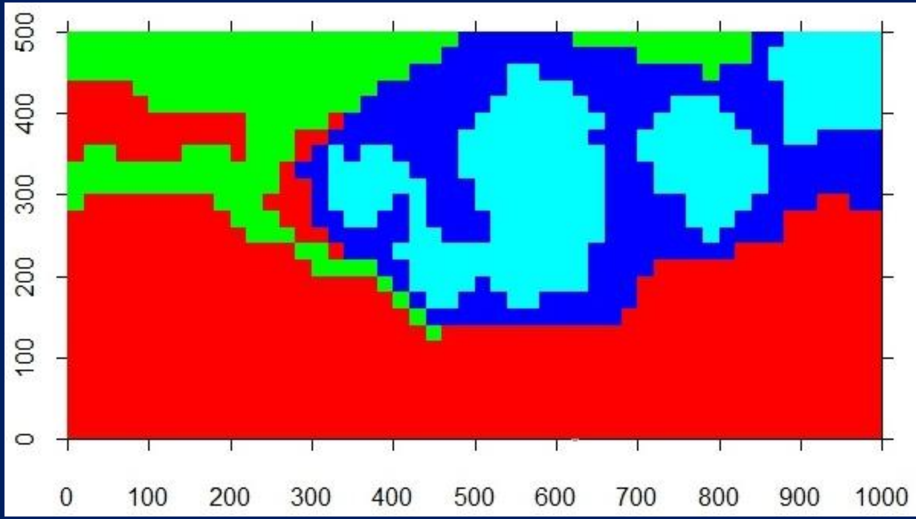
I. To determine the patterns of tree species specialisation on different habitats

II. To examine whether different habitats vary in α and β diversities

III. To prioritise species group for further study on drought tolerance against climate change

METHODOLOGY

Habitat Types



7.08 ha (14 %)	Swamp	9.96 ha (20 %)	Slope
24.08 ha (48 %)	Alluvial	8.88 ha (18 %)	Ridge

- Predefined, discreet
- Based on Yamashita *et al*. (2003)
- 11 soil types defined using Malaysian soil series classification method; categorised into four major groups; highly in congruence with the topography
- Edaphic and topographic habitat types

- Group 1 > **Slope**: derived from shale (C)
- Group 2 > **Ridge**: lateritic (C)
- Group 3 > **Alluvial**: sandy, well-drained (A)
- Group 4 > **Swamp**: developed in riverine (A), only seasonally inundated

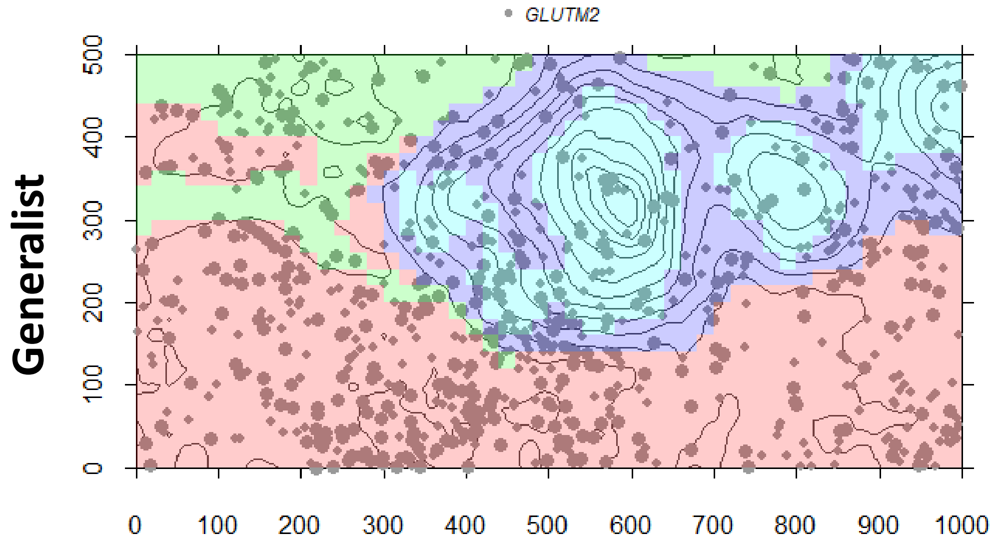
METHODOLOGY

Torus Translation Test (TTT)

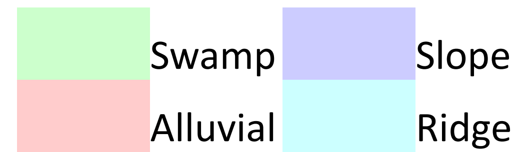
- Habitat preference was determined using TTT (Harms *et al*., 2001)
- Incorporate critical properties of the spatial structure observed in both the plant and habitat data sets
- Moving the true habitat map about flat, torus by 20-m increments (Harms, 1997); a map of the habitats of lying beneath a distribution map of the trees and being translated, by 20-m increments
- Produced toroidal randomizations and restricted permutations

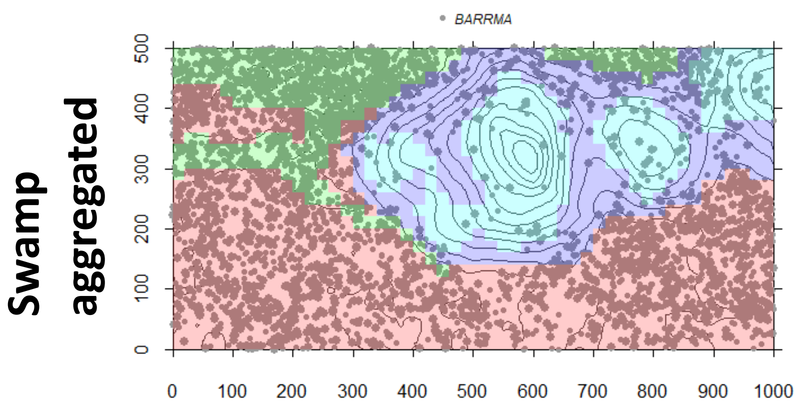
- a species is **positively associated** with a particular habitat if and only if: **Proportion {observed map relative density > simulated map relative density} ≥ 0.975: aggregated**
- a species is **negatively associated** with a particular habitat if and only if: **Proportion {observed map relative density < simulated map relative density} ≥ 0.975: repelled**

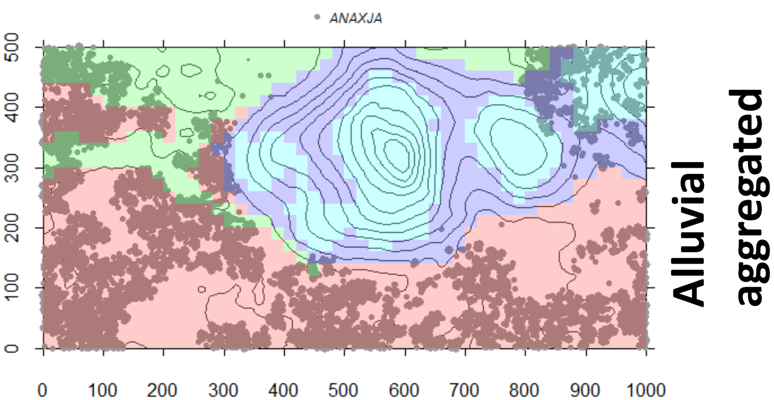
- Result for each species: **aggregated, neutral, repelled**

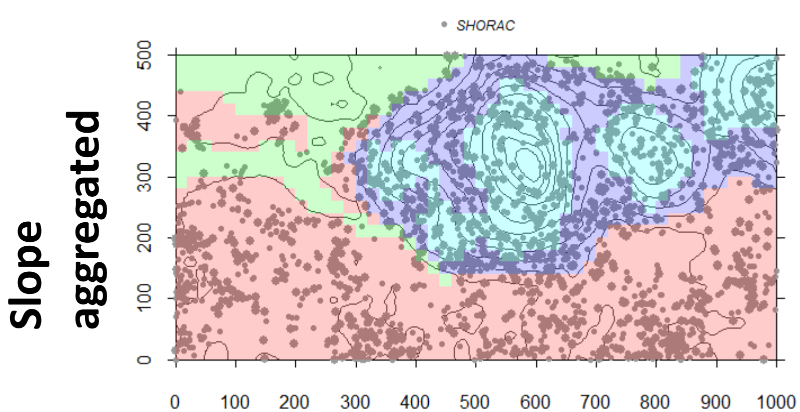


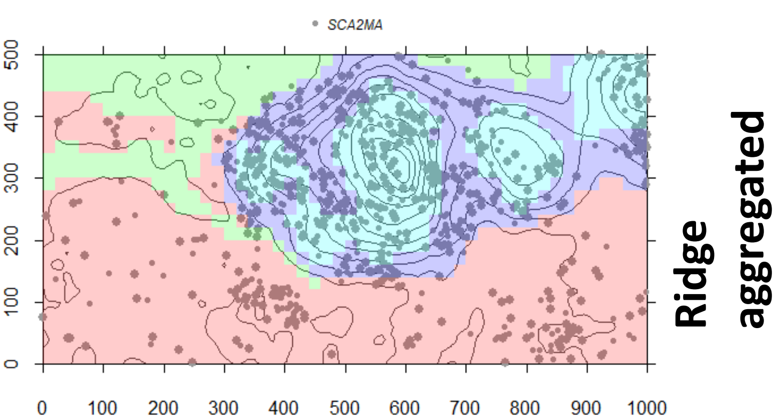
- Tree data: Pasoh Census 1
- 535 species with >= 50 individuals were subjected to the test





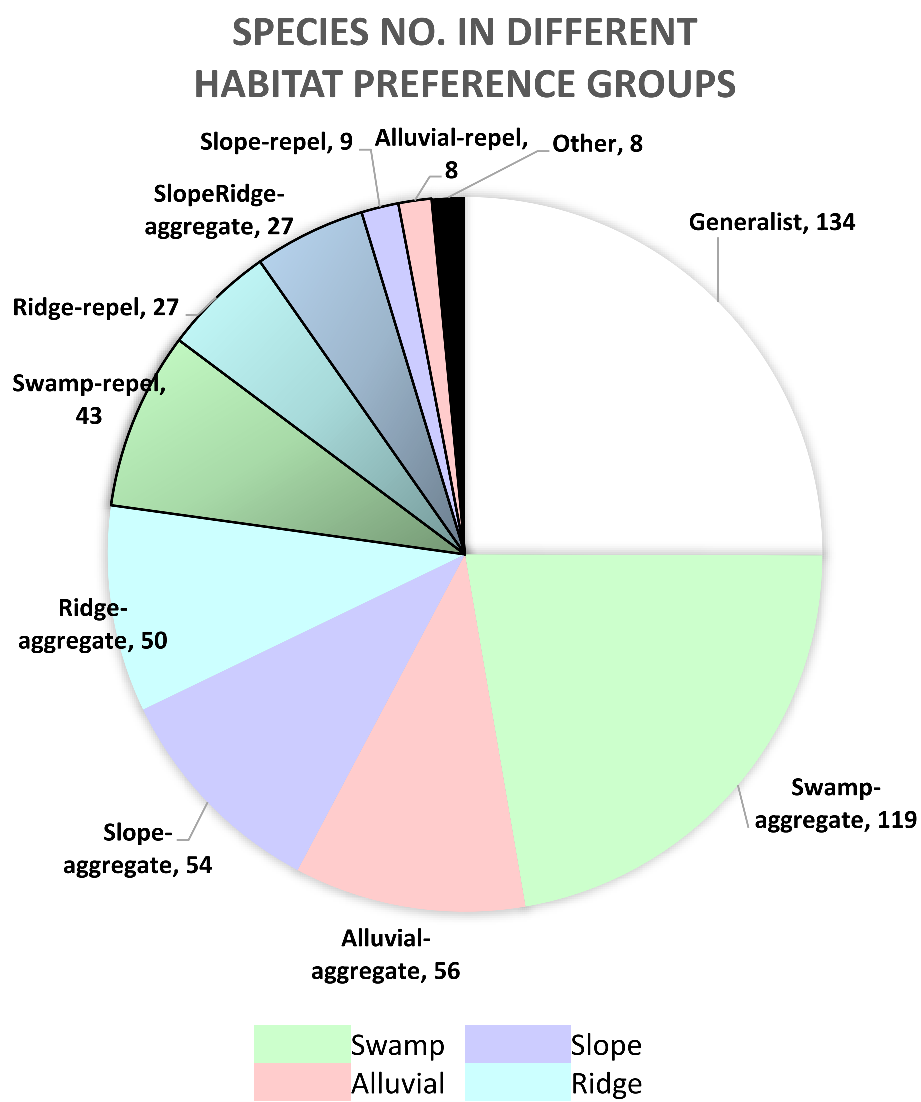






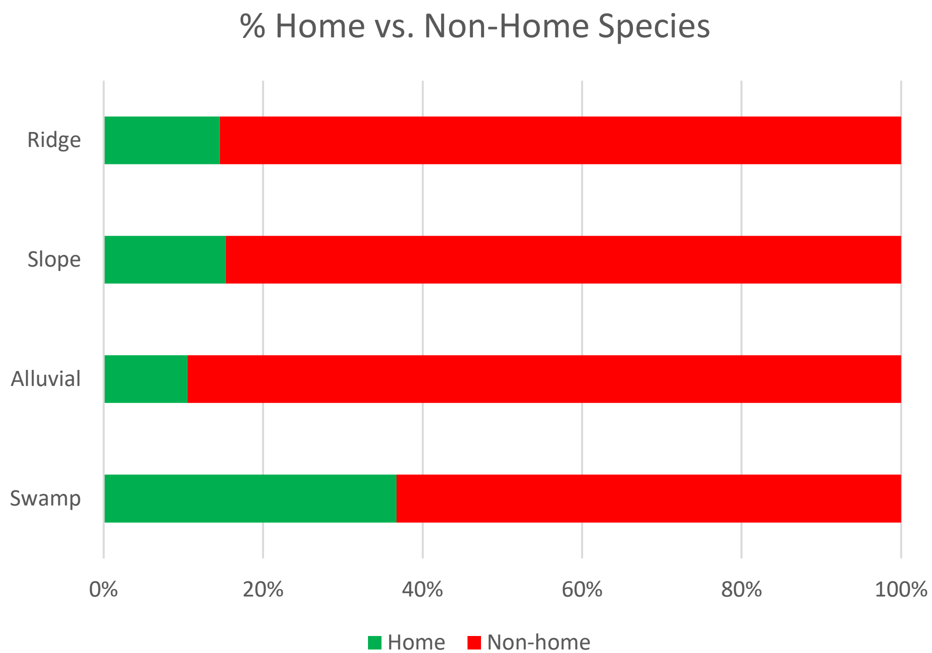
Results and Discussion

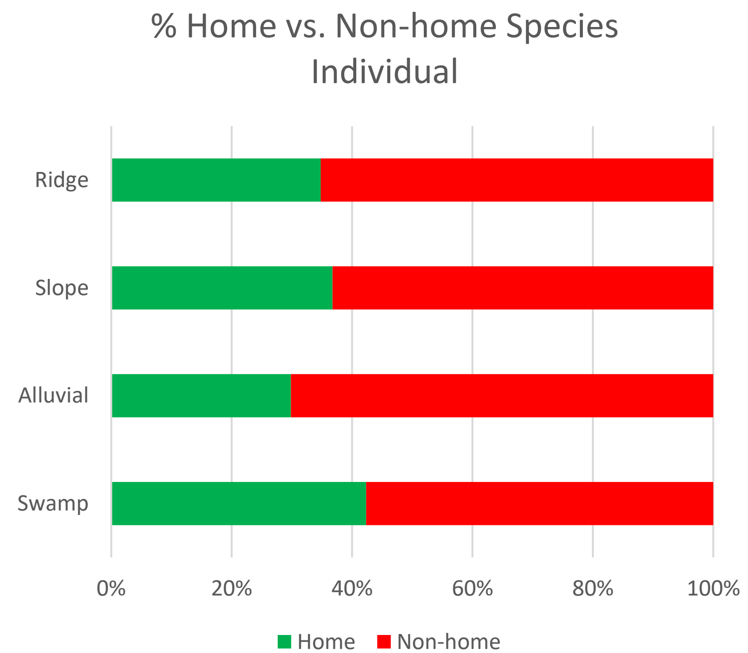
TTT on species specialisation



- Almost three quarters of species subjected to the test are either positively/negatively associated in certain habitat(s)
- 24% of the species are swamp aggregated. The high ratio of aggregation in the swamp habitat may be due to greater water availability during drier months
- Indication of species diversity being driven by differences in habitats

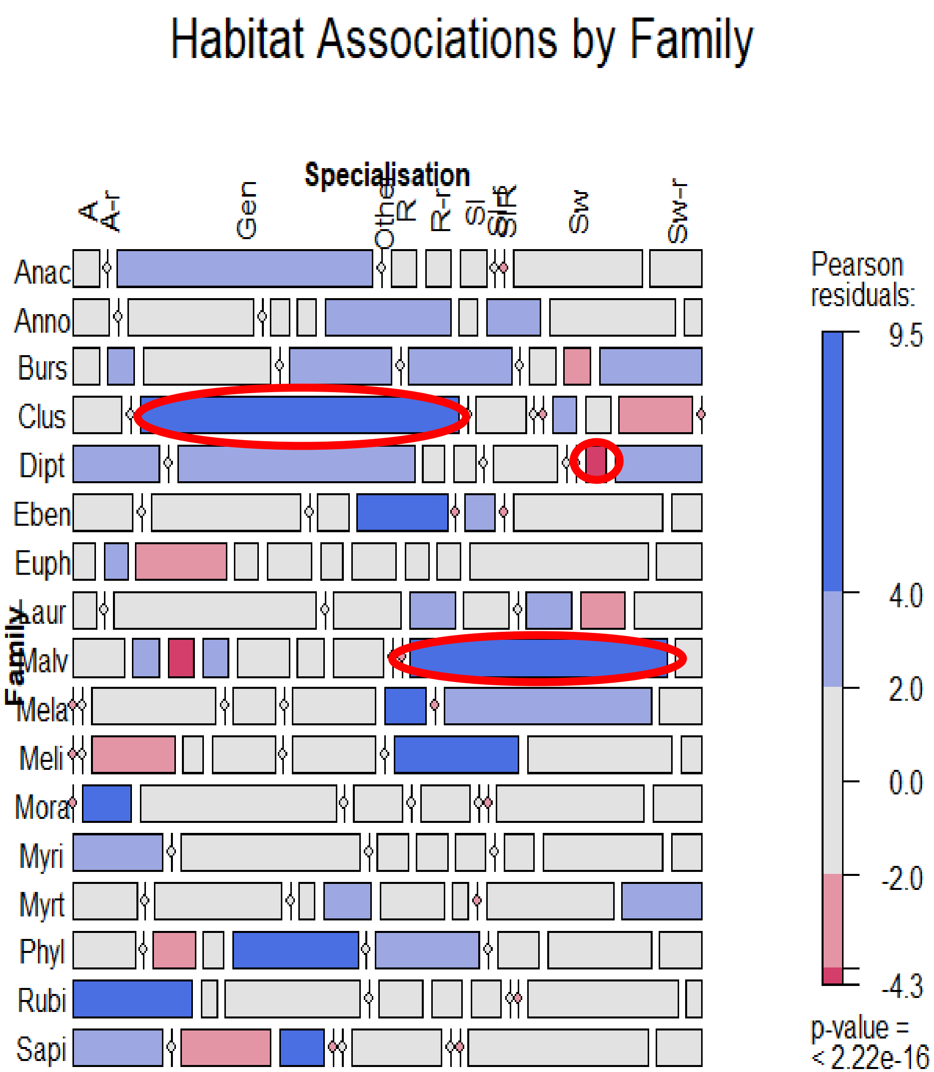
Results and Discussion





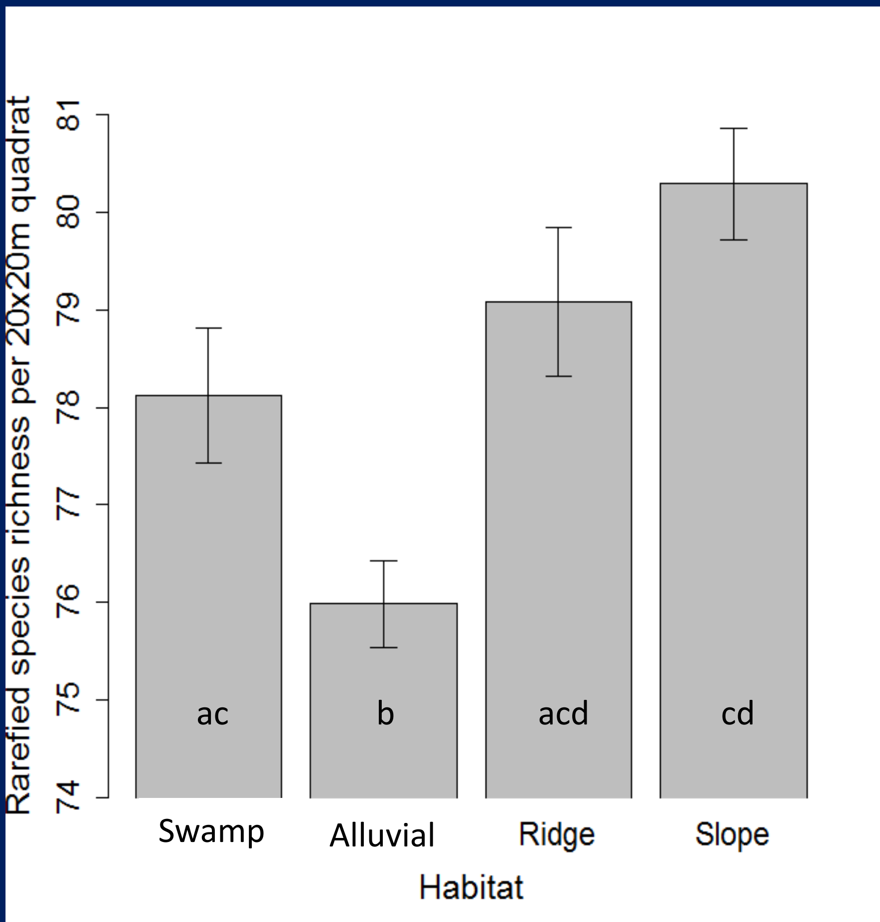
- Ratio of home and non-home species in their corresponding habitats
- Home VS non-home: i.e., slope-aggregated species occurring in slope is define as home species, non-home species includes other habitat preference groups or generalist
- High ratio of home species and individual occurrence in swamp. This habitat is inundated during the wettest months. Soil anoxic condition plays greater habitat filtering role in limiting the occurrence of non-home species

Results and Discussion



- Test the species-habitat association at family level
- Fit Log-Linear Models by Iterative Proportional Scaling
- The mosaic diagram illustrates tree species association to habitats at family level (species no. >= 15)
- The mosaic length indicate the ratio of species in the corresponding habitat preference
- Deeper blue tones denotes stronger association, i.e. Clusiaceae is generally generalist; Malvaceae is strongly represented in swamp habitat;
- Deeper red tones denotes weaker association, i.e. Dipterocarpaceae is strongly under-represented in swamp habitat

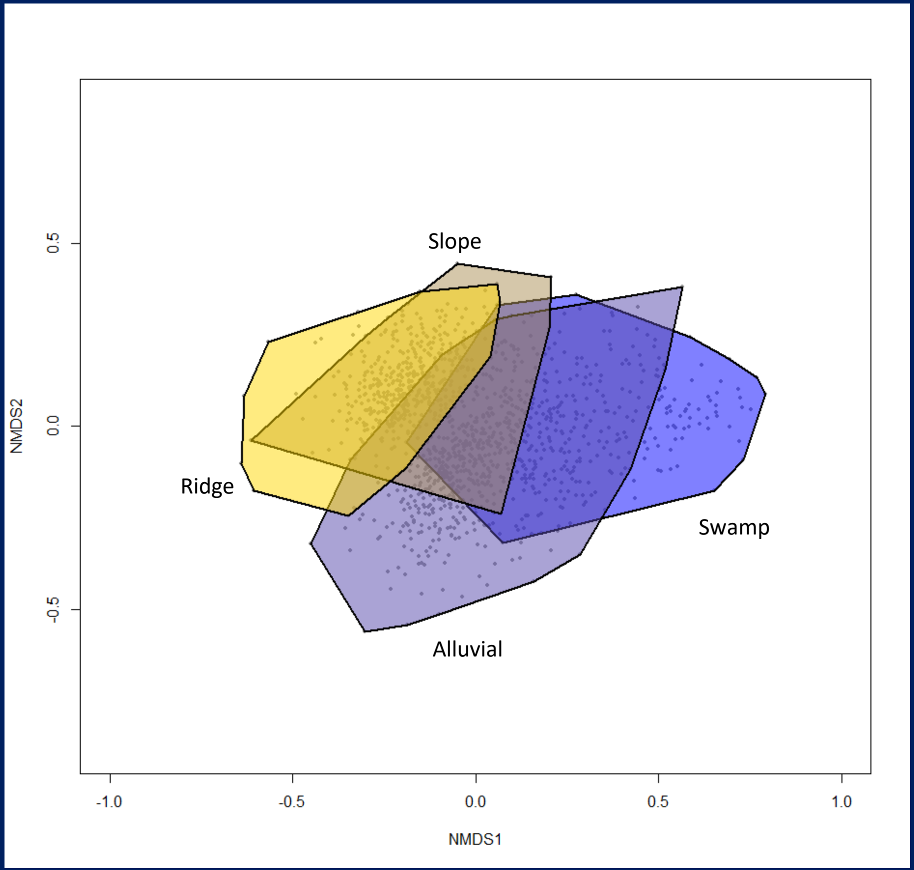
Results and Discussion



α-diversity

- Rarefied richness
- compare diversity richness between habitats
- Subject the analysis of variance to Tukey multiple comparisons of means
- Alpha diversity is significantly poor in alluvial.
- Alpha diversity variation between swamp and ridge, as well as ridge and slope are not significant.
- Slope is the richest in species diversity

Results and Discussion



β-diversity

- Species compositions in different habitats were subjected to Permutational Multivariate Analysis of Variance using Distance Matrices
- Plotted using non-metric multidimensional scaling
- The different polygons in the chart set boundary of species composition in different habitats

- Overlapping between species composition in two extreme habitats, ridge VS swamp is rather minimal
- As expected, slope habitat with the richest species diversity has the largest proportion overlapping with other habitats
- Habitat difference does contribute to beta-diversity in Pasoh
- Suggested the role of habitat heterogeneity in maintaining tree species diversity

Results and Discussion

Comparisons with previous studies

- Wong & Whitmore (1970) concluded no evidence for correlation between species distribution and soil types
- Ashton (1976) demonstrated species composition is influence by soil type, and pointed out a number of common understorey trees, i.e. *Aporosa globifera* as best indicator of soil type
- Thomas (2003) categorised habitat preferences of tree species based on subjective evaluation of mapped data (Manokaran, 1992) aided by personal knowledge of distribution elsewhere in nearby forests

Thomas (2003)	Count (%)	Present study	Count (%)
Generalists	354 (61)	Generalists	134 (25)
Upland/Granitic Ultisols	105 (18)	Slope/Ridge	131 (24)
Riparian/Swamp	97 (17)	Swamp	119 (22)
Alluvial soils	22 (4)	Alluvial	56 (11)
		Other	95 (19)
Total	578		535

Conclusions and suggestions

Patterns of tree species specialisation on different habitats:

- **75 % of the total species tested are either positively or negatively associated to certain habitat(s)**

Variation in α and β diversities in different habitats:

- **α and β diversities varies considerably in different habitats**
- **Indication of species diversity being driven by niche differentiation**

Priority species group for further study on drought tolerance

- **Swamp aggregated species with restricted distribution / uncommon elsewhere**

ACKNOWLEDGEMENTS

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Pasoh Forest as dawn breaks after a night of heavy downpour
Thank you