Understanding lepidopteran biodiversity in the landscape

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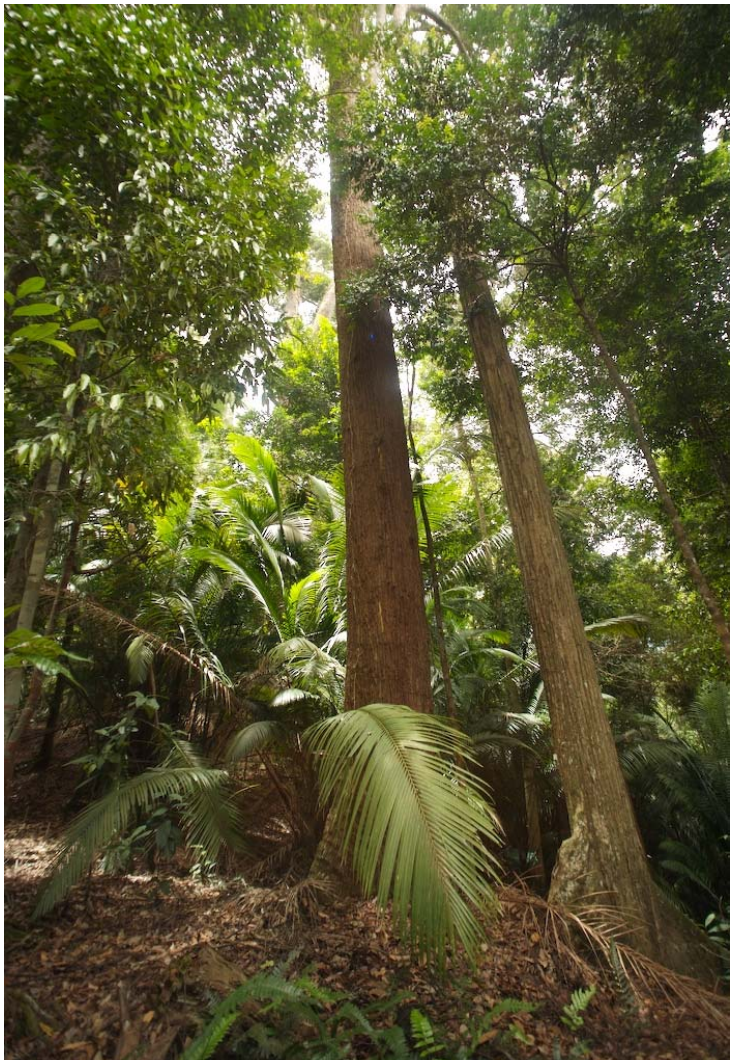
What is biodiversity?

Sum of all gene sequences in a given area…?.!

Species diversity is currently the most commonly used proxy

Phylogenetic diversity also gainingpopularity

Biodiversity is only meaningful in a comparative context



How many species are found at Site A compared to Site B?

What is the difference in species composition between sites A and B?

A knowledge of the distribution of biodiversity is essential to conservation

‘Greatest good for the greatest number’

What is biodiversity assessment?

Cost effective method for estimating biodiversity

Used in EIAs, forest certification, state planning, assessments for conservation, etc.

Are lepidoptera good for biodiversity assessment / conservation planning?

Taxonomy is tractable (if still a problem in some places)

Standard survey methods are available

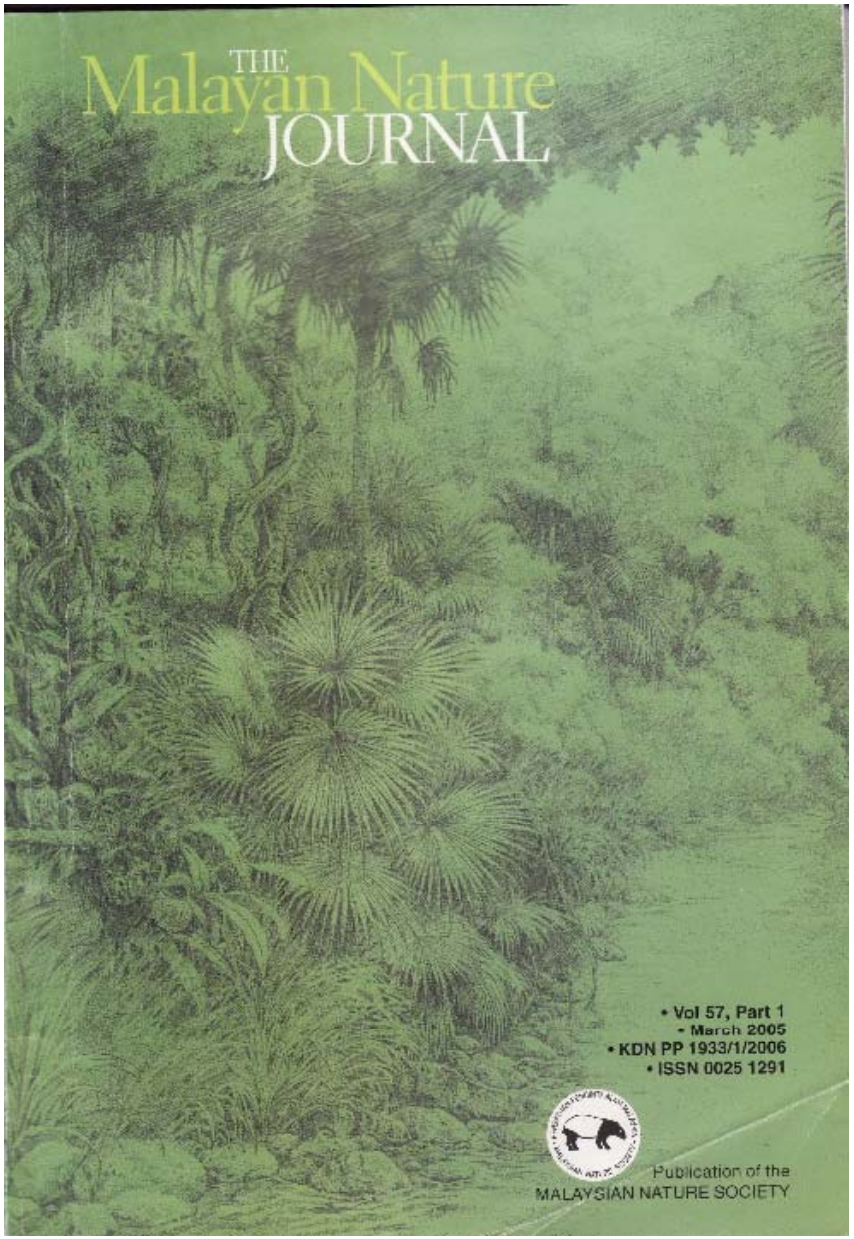
Responses to disturbance better understood than most groups

But…How is lepidopteran diversity distributed across the landscape?

Are they dispersal limited?
At what scale?

What are the habitat factors driving variation in alpha- and beta-diversity? At what scale?

How do they respond to disturbance? At what scale?



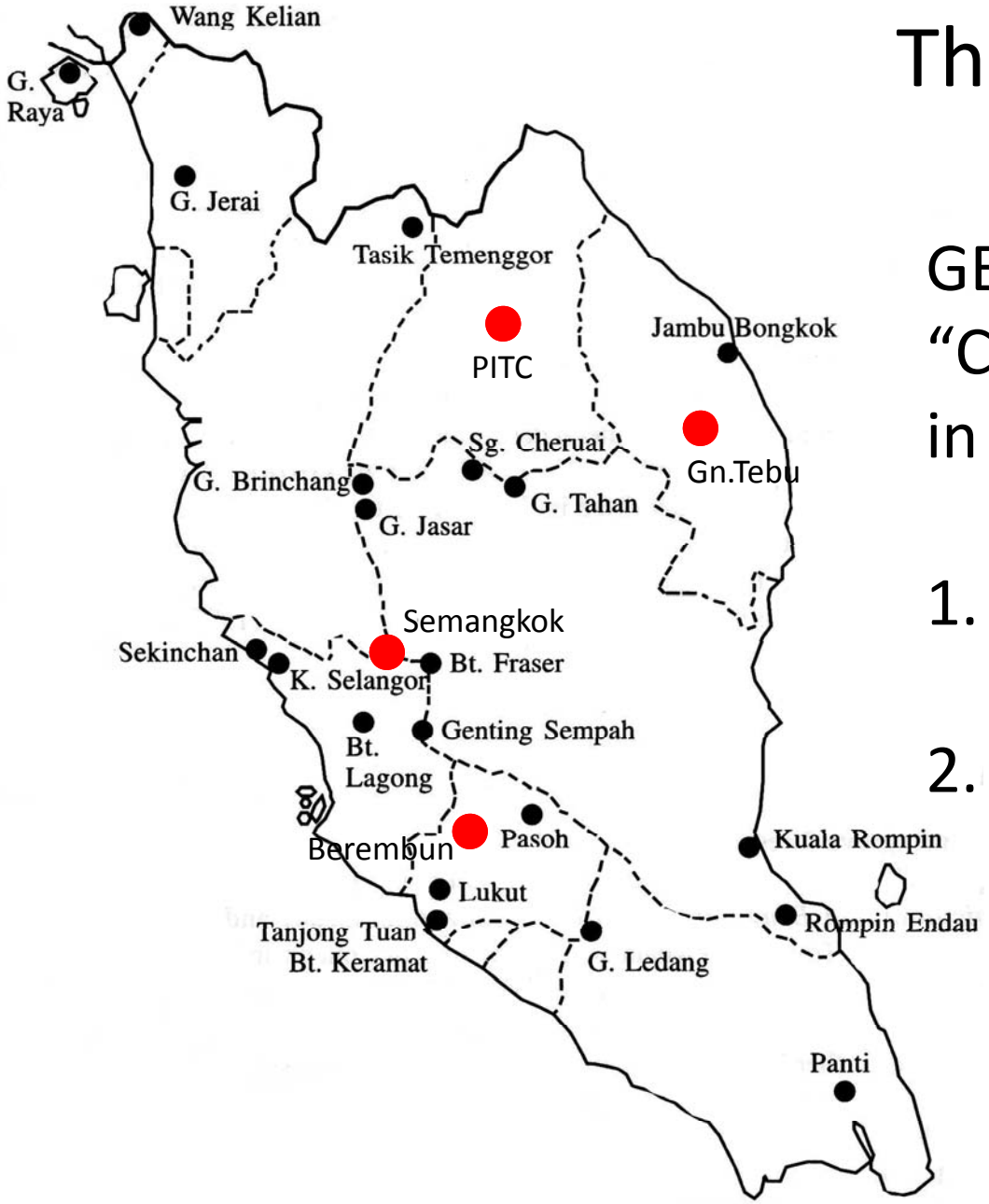
The datasets…

Intachat et al (2006)Malayan Nature Journal 57:1-28

Peninsula-wide study of Geometridae

One sample point per site
Only spp with >10 individuals

Included comparison of forest type and primary vs logged in lowland dipterocarp forests



The datasets…

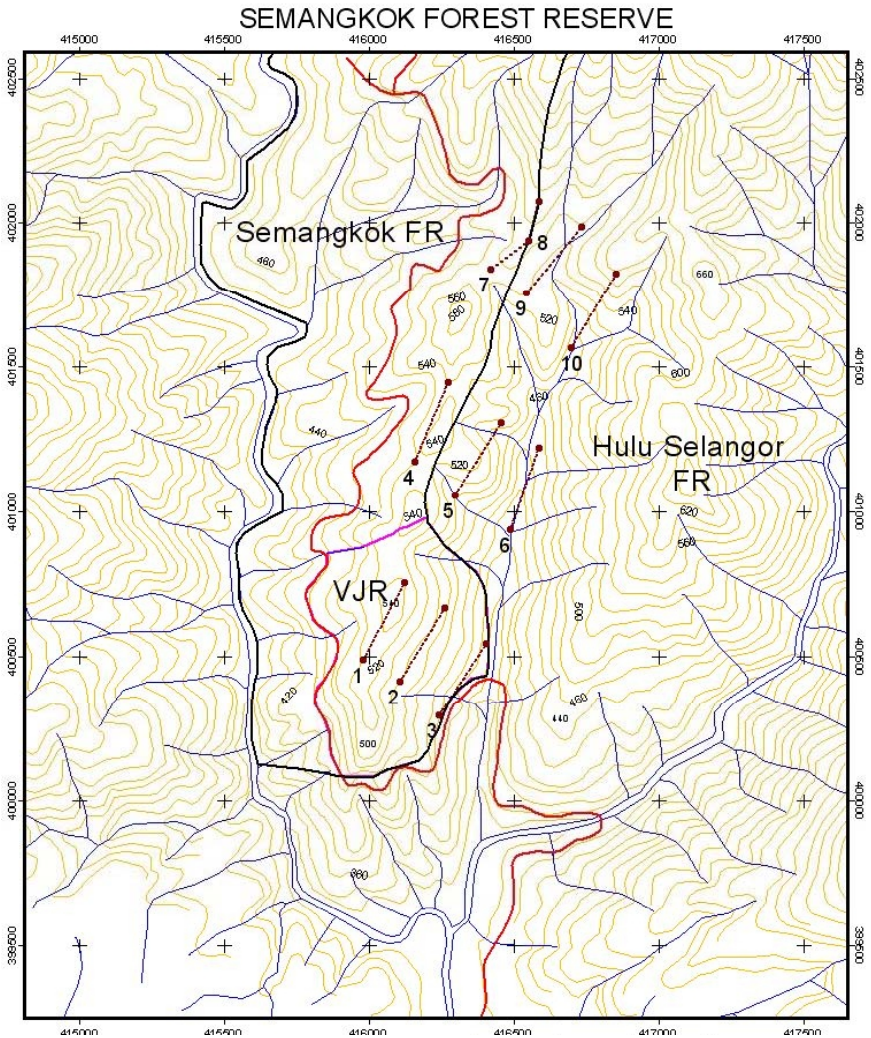
GEF/ITTO funded project on "Conservation of biodiversity in production forests" at FRIM

1. VJR study – value of small protected areas
2. Logging experiment – maintenance of canopy structure

Nine taxa groups surveyed at each site

1. Trees
2. Moths
3. Ants
4. Dung beetles
5. Stingless bees
6. Birds
7. Bats
8. Stream macro-invertebrates
9. Frugivores

The datasets…

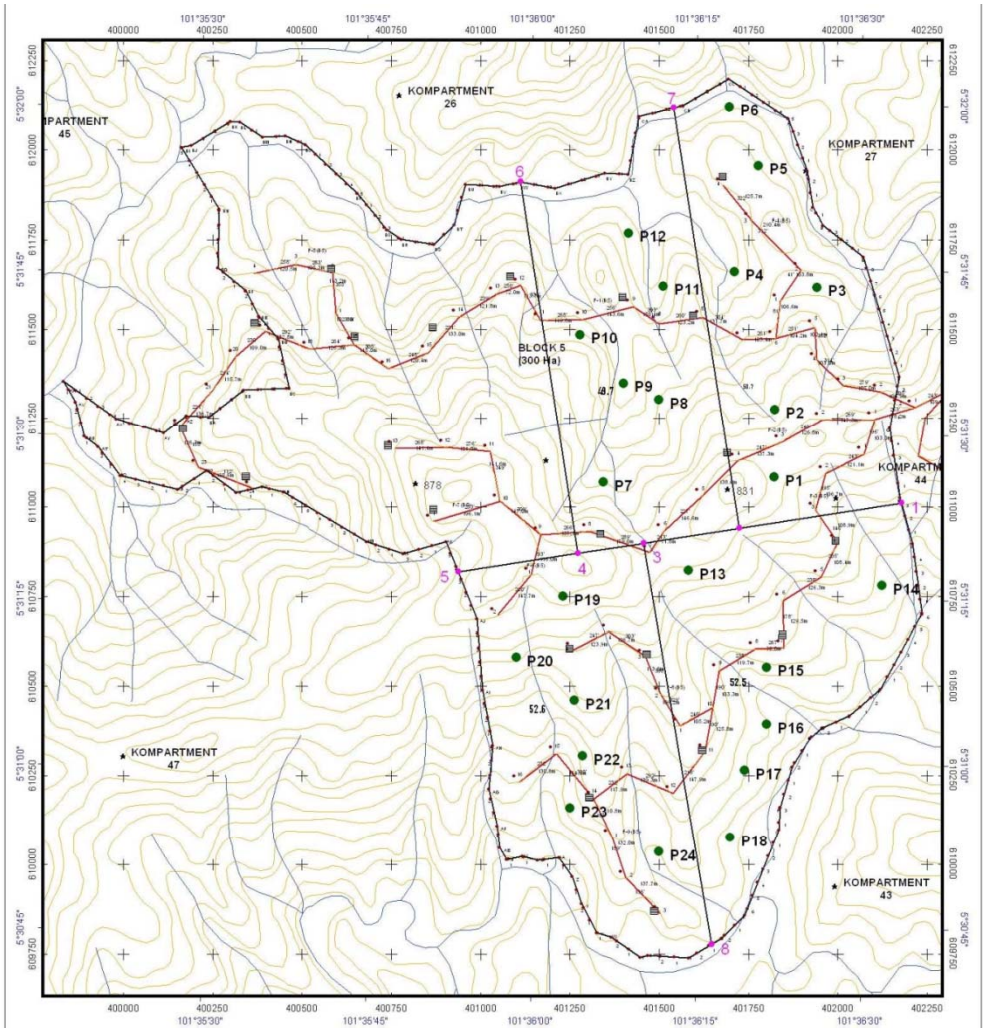


Currently 3 VJR sites in northern P. Malaysia

- Berembun FR (NS)
- Semangkok FR (Selangor)
- Gn. Tebu (Trengganu)
- three more planned

Nine sample sites per VJR

The datasets…



Perak Integrated Timber Complex (PITC)

- Block 5
  (sub-blocks 1 & 2)
- 200 ha
- Hill dipterocarpfores
  (550 – 800 m)

24 sample sites

Analysis

Alpha diversity measured with Simpson's Diversity index 1/D

$$D = \frac{n(n-1)}{N(N-1)}$$

and linear models

Analysis

Beta diversity measured using community distances

		Species in community I	
		1	0
Species in community II	1	*a*	*b*
	0	*c*	*d*

$$\frac{a}{a+b+c} = \frac{S12}{S1+S2-S12}$$

Analysis

Beta diversity measured using community distances

		Individual in community I	
		Shared	Not shared
Individual in community II	Shared	*A = UV*	*B = U(1-V)*
	No shared	*C = (1-U)V*	*D = (1-U)(1-V)*

U = total relative abundance of shared species in community I
V = total relative abundance of shared species in community II

$$\frac{UV}{U+V-UV}$$

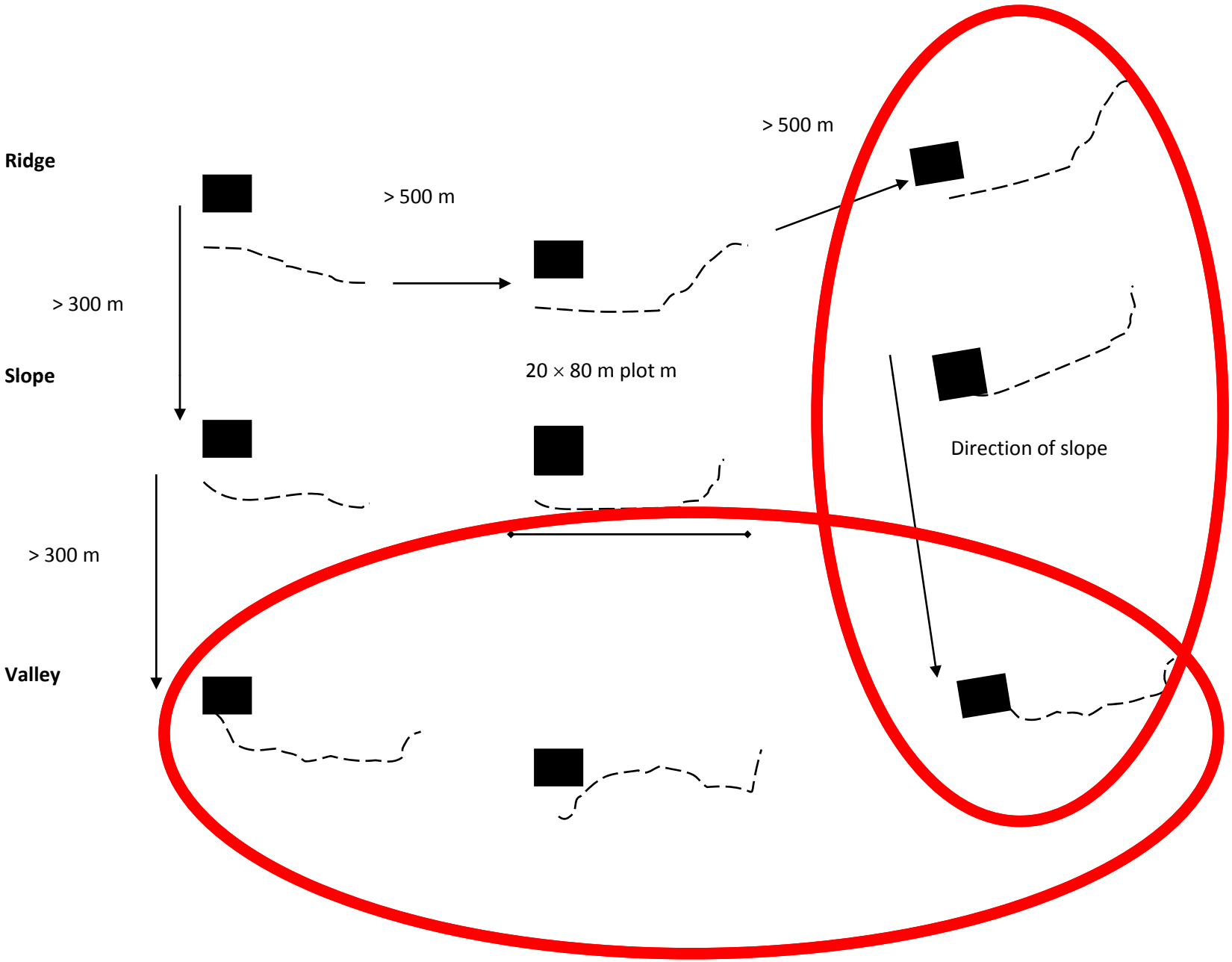
Chao et al *Ecology Letters* (2005)

Analysis - Randomisation

	Site A	Site B	Site C	Site D
Site A				
Site B	0.34			
Site C	0.66	0.25		
Site D	0.50	0.55	0.15	
Site E	0.94	0.34	0.44	0.25

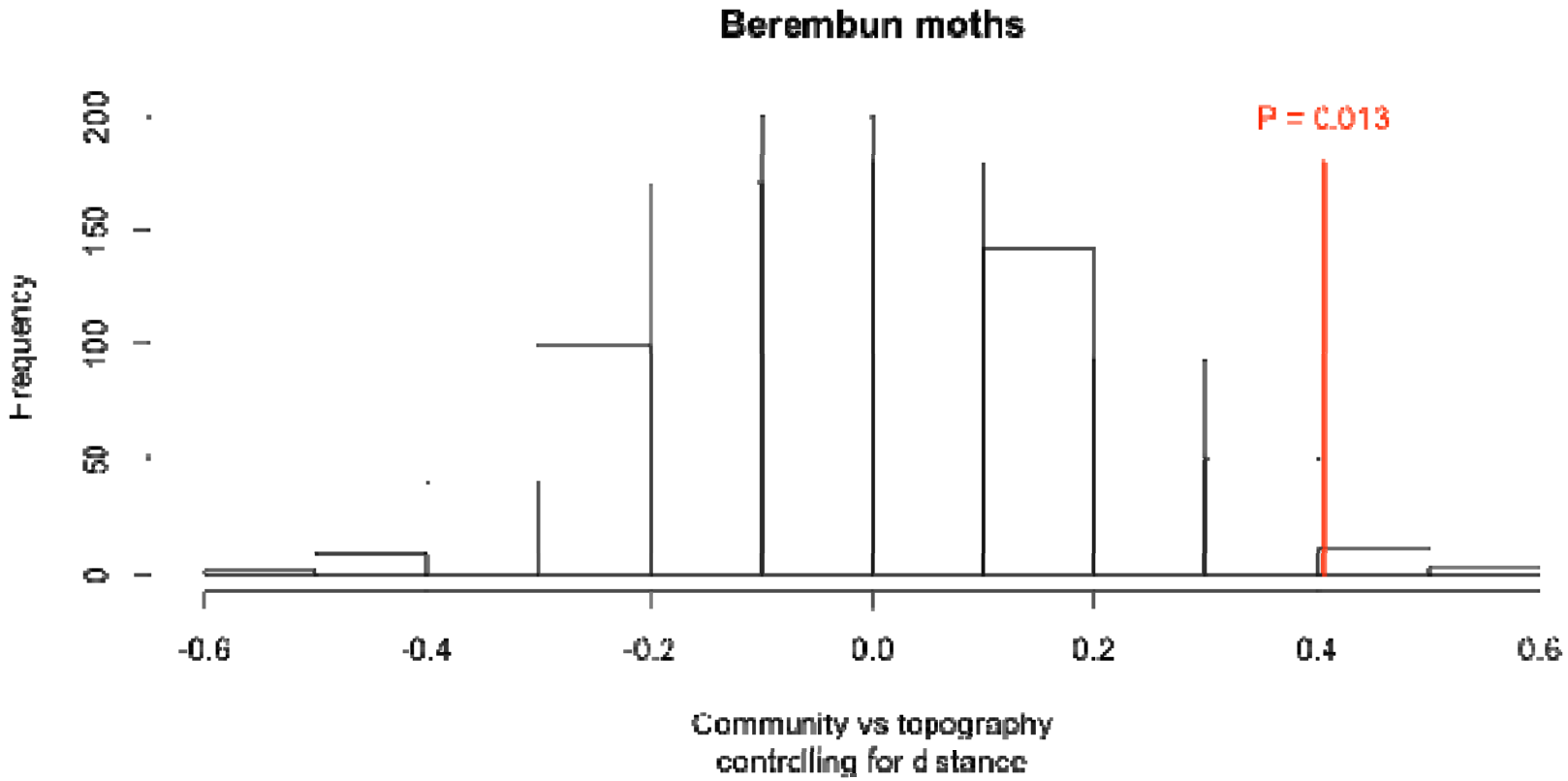
Possible analytical options

1) Community distances not independent ➔ cannot use standard statistics
2) Mantel test – randomises the community matrix, but does not control for sampling error
3) Random sampling – re-samples the community. Difficulty arises in defining the correct Null model. We controlled for sample size and structured the community by distance / topography where appropriate.


Ridge
> 500 m
> 500 m
> 300 m
Slope
20 × 80 m plot m
Direction of slope
> 300 m
Valley

Analysis - Randomisation

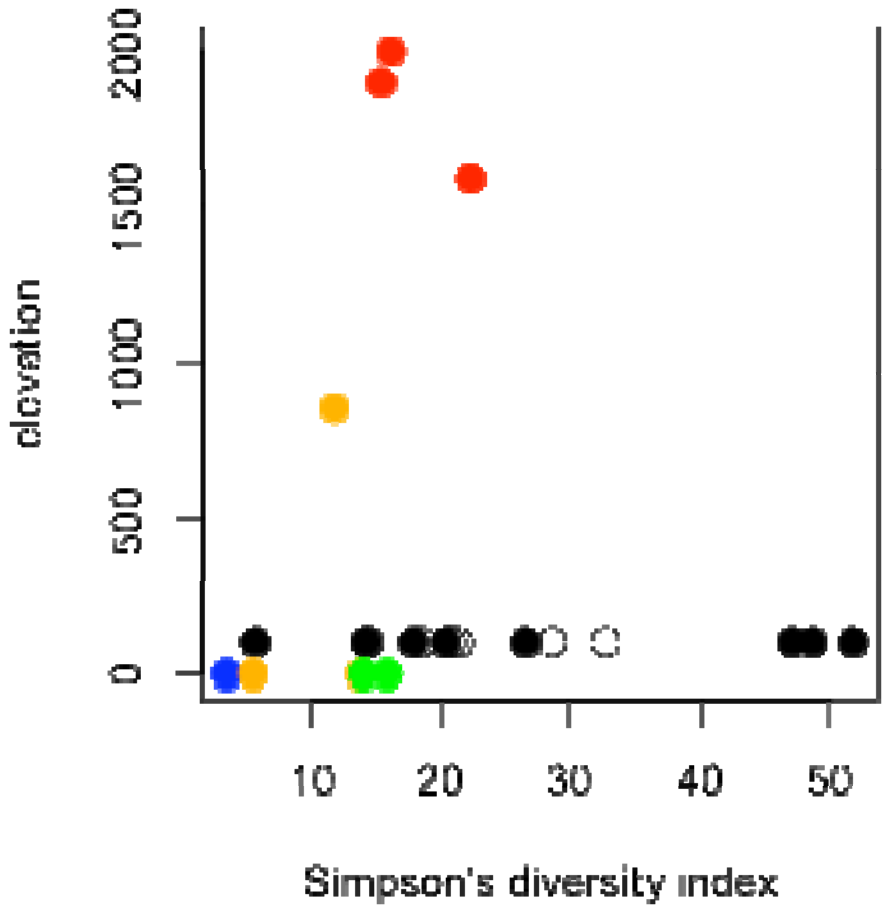
Typical results from a randomisation test



Results…

Intachat et al 2006

- Mangrove
- Heath
- Swamp
- Dipterocarp
- Oak
- Montane
- Logged dipterocarp



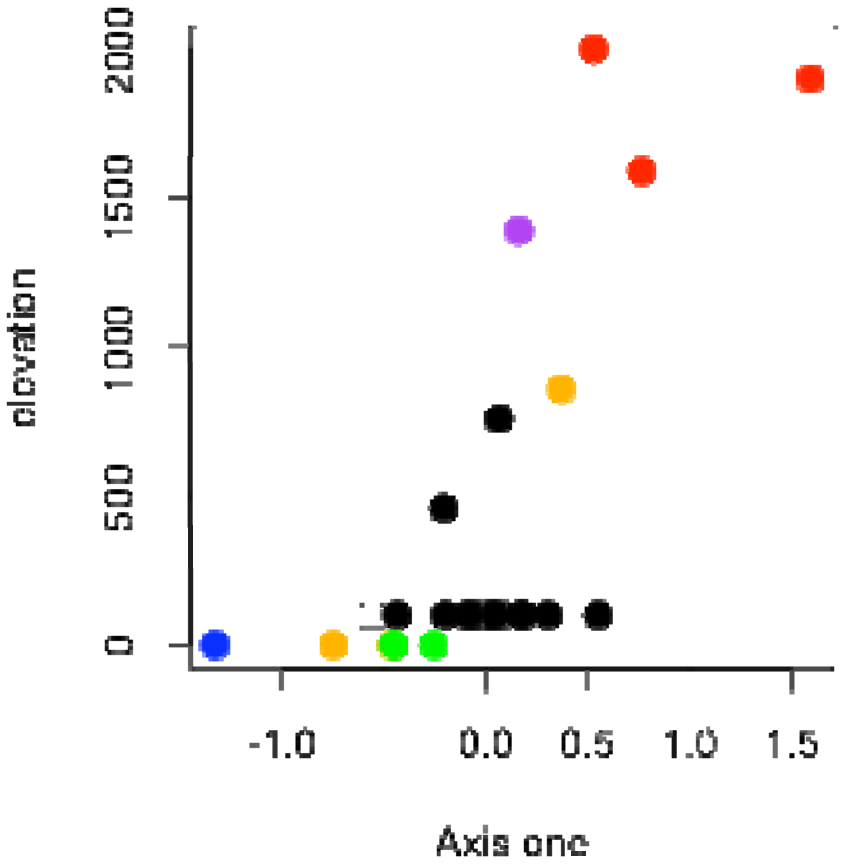
$F_{5,20}$=2.207, *P*=0.094

Results…

Intachat et al 2006

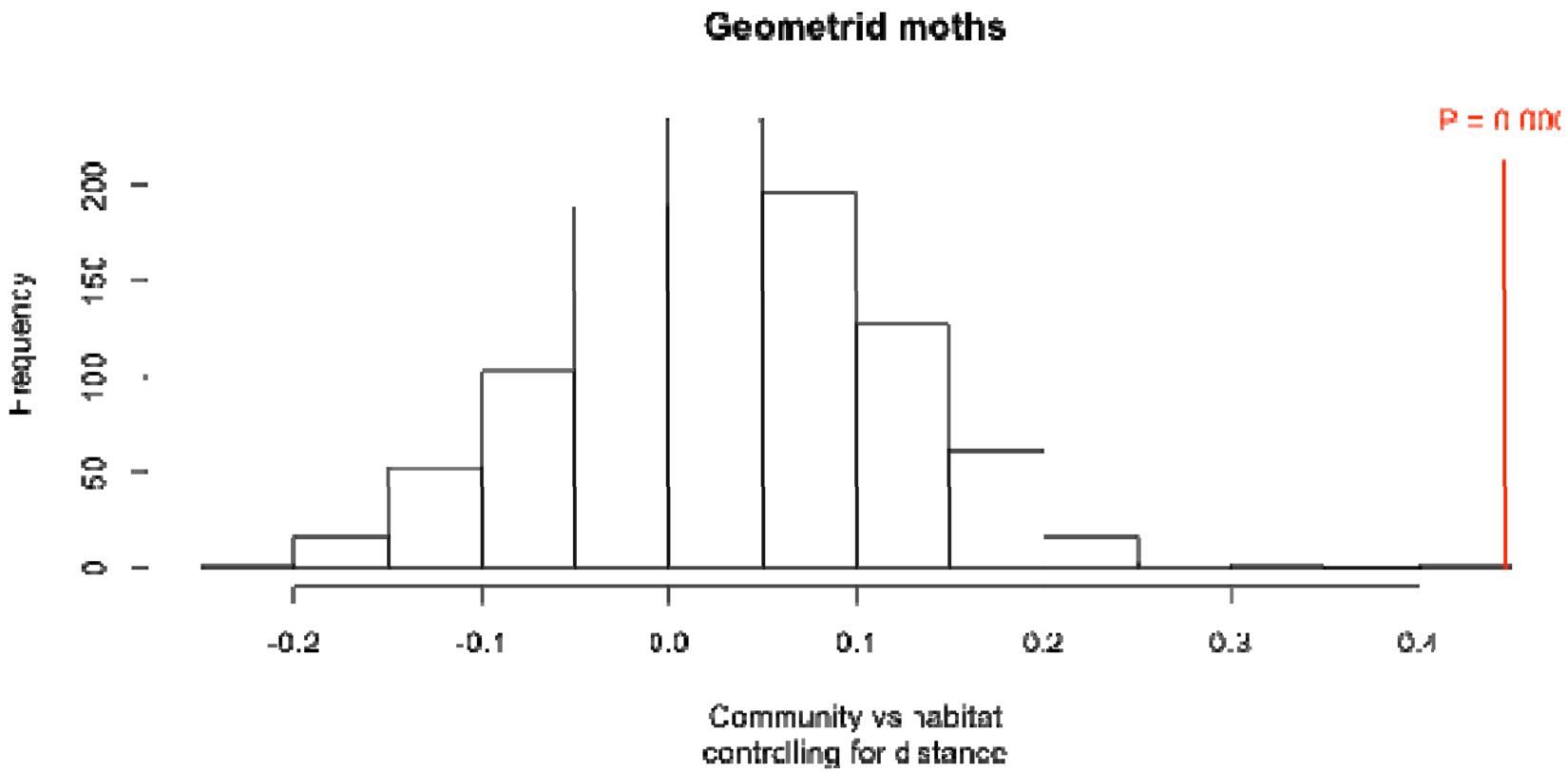
- Mangrove
- Heath
- Swamp
- Dipterocarp
- Oak
- Montane
- Logged dipterocarp

Community composition against elevation



Results…

Intachat et al 2006



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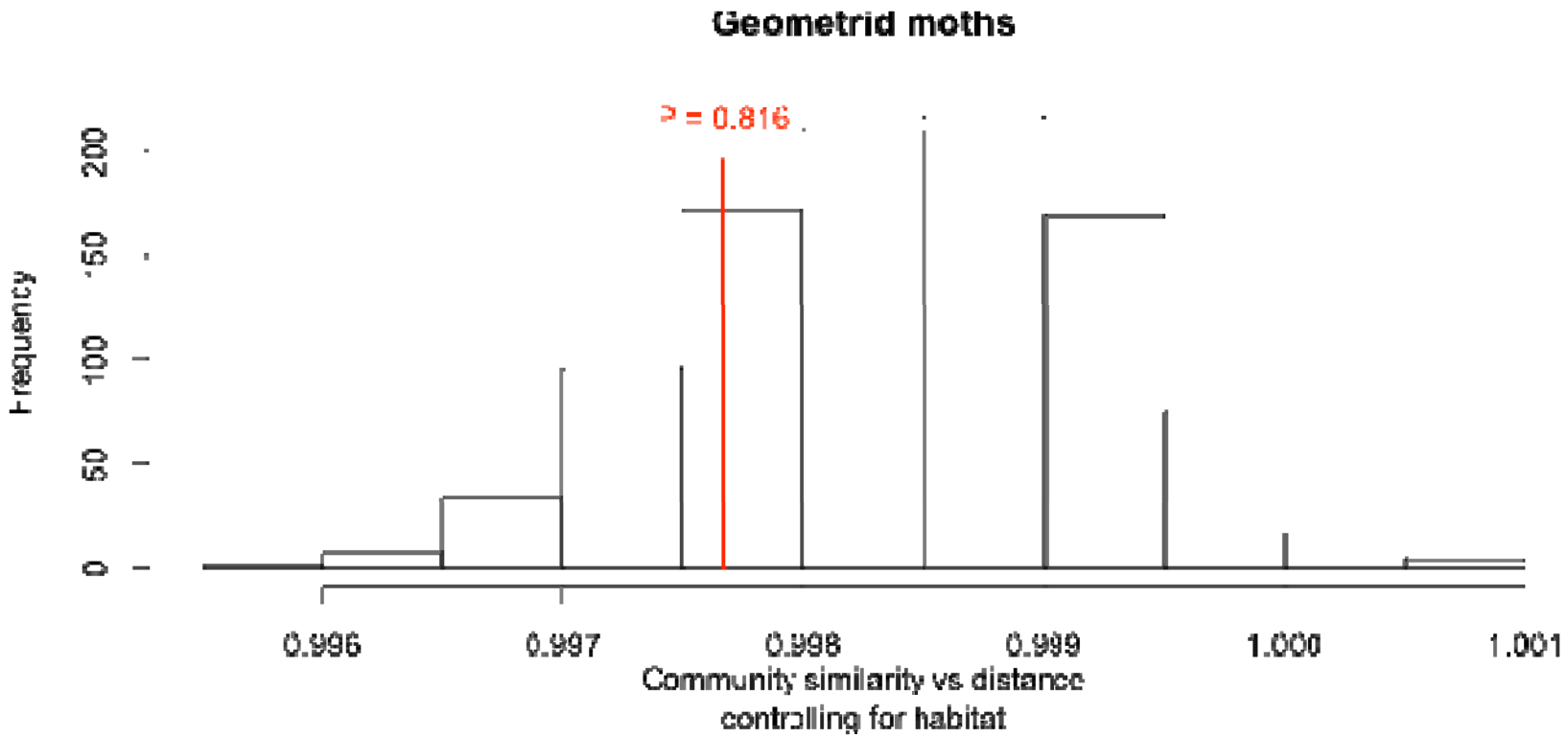

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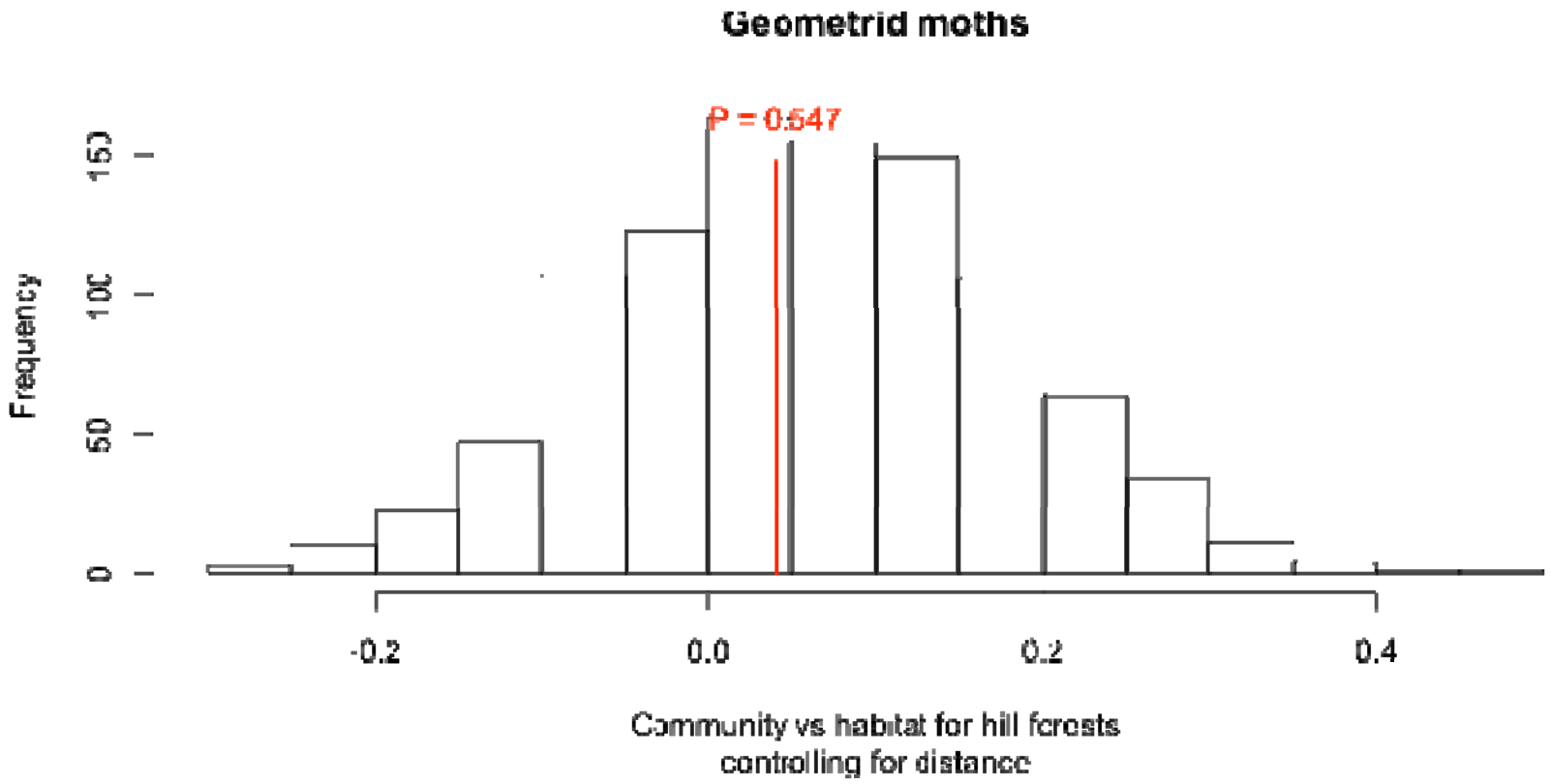

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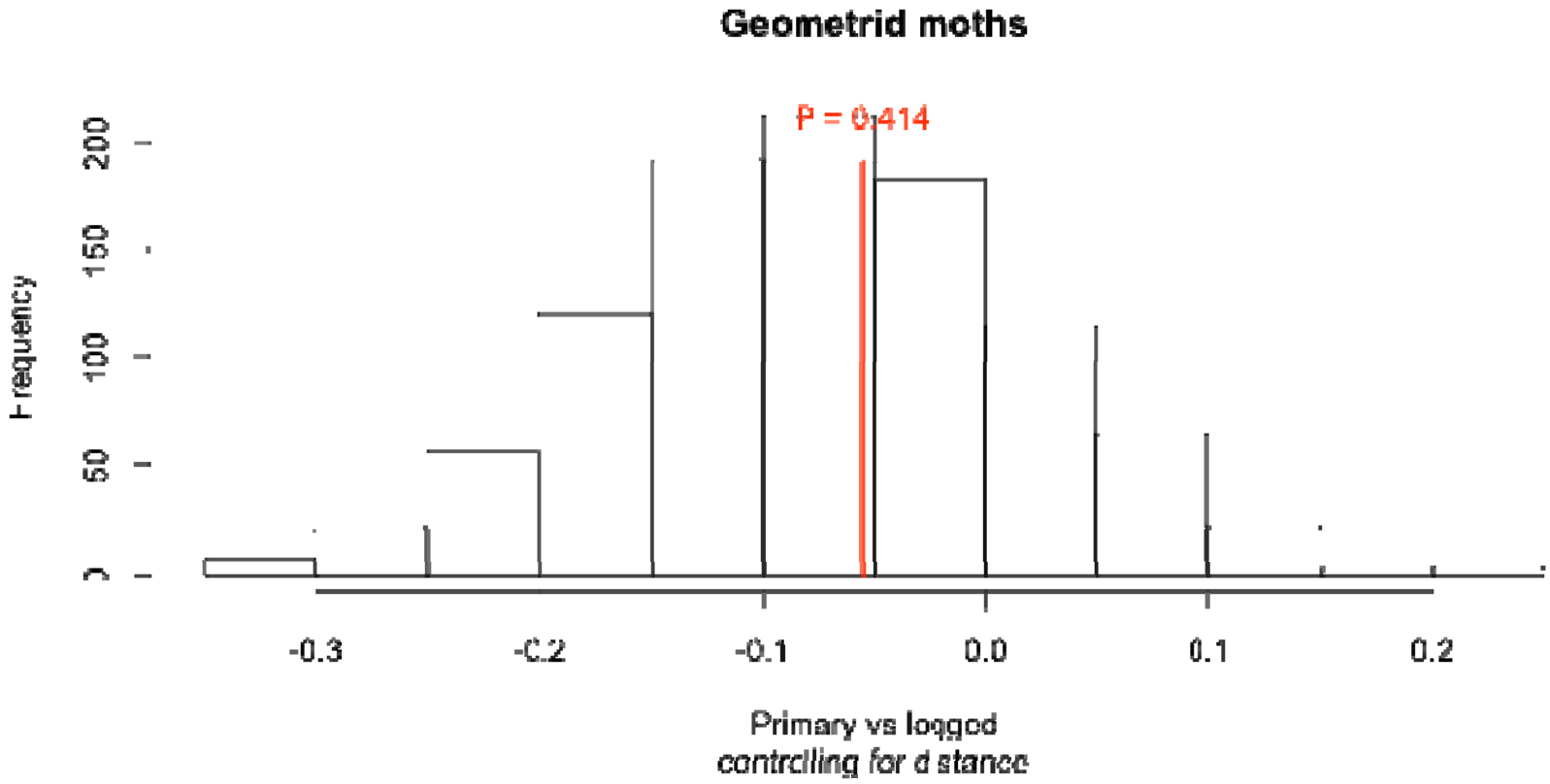
Intachat et al 2006



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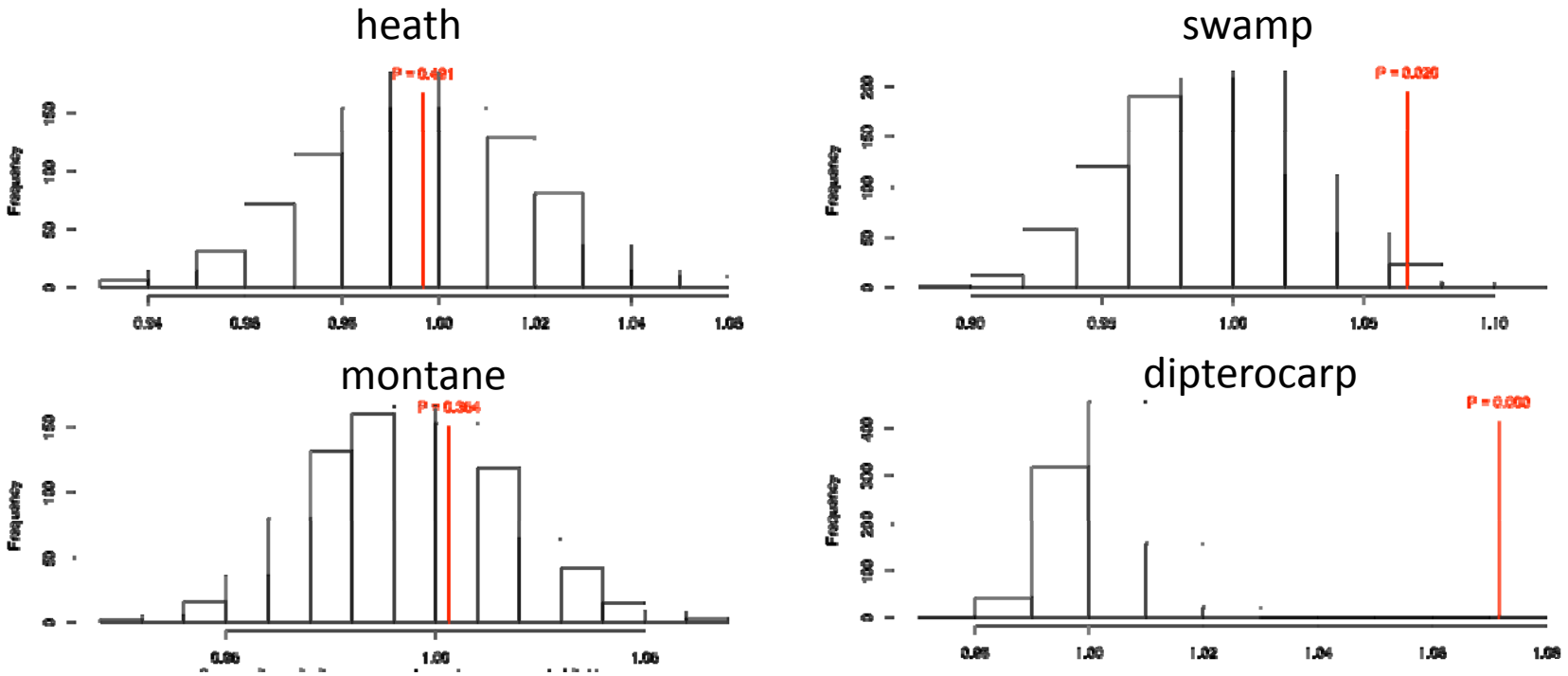


Community similarity within vs among habitat types

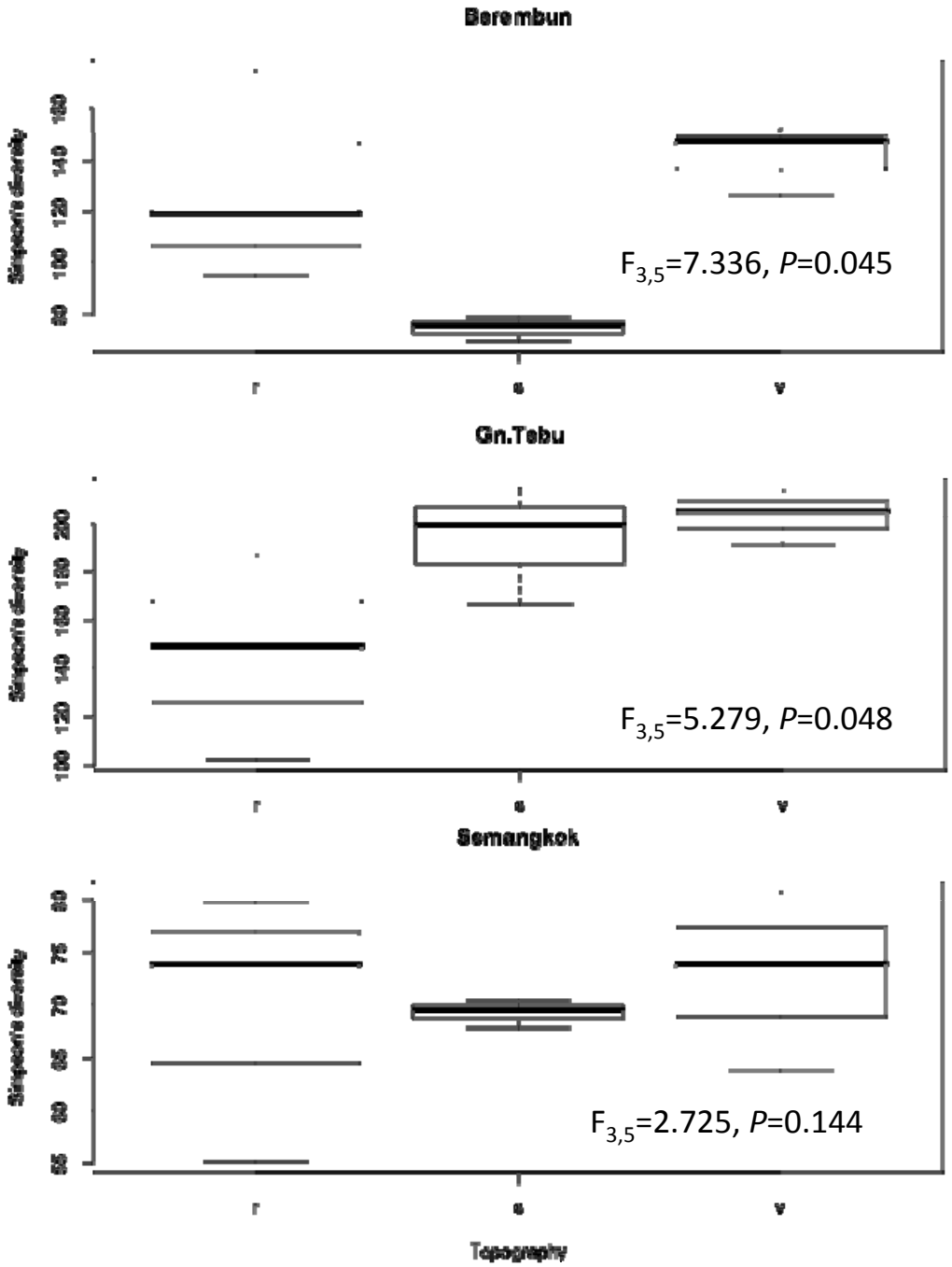
Conclusions…

Intachat et al 2006

1) No clear pattern of alpha-diversity among forest types – highest diversity recorded in the lowland forests
2) Geometrid communities are coarsely segregated by habitat type
3) No significant community structure among forest types for ~100 m to ~1200 m
4) No significant community structure among primary and logged over forest
5) No effect of distance even at Peninsula-wide scale

Qualifiers…

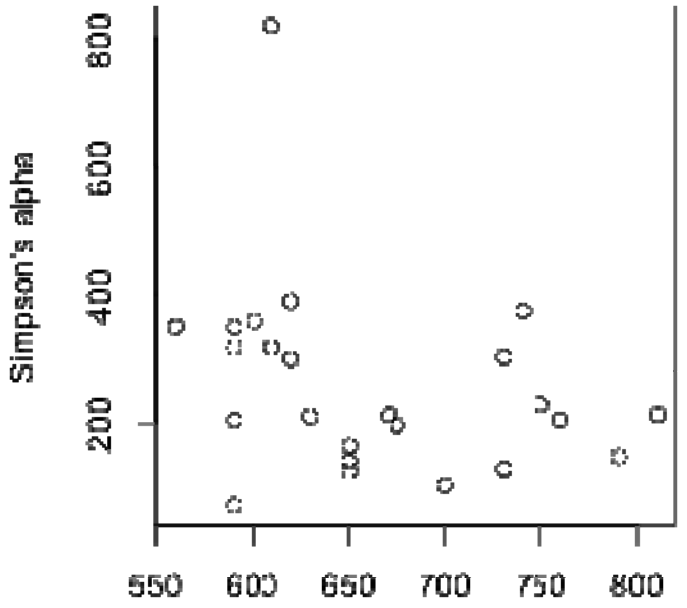
1) Only one sample point per site
2) Rare species (<10 individuals in total community) discounted
3) Primary forests sampled were often disturbed

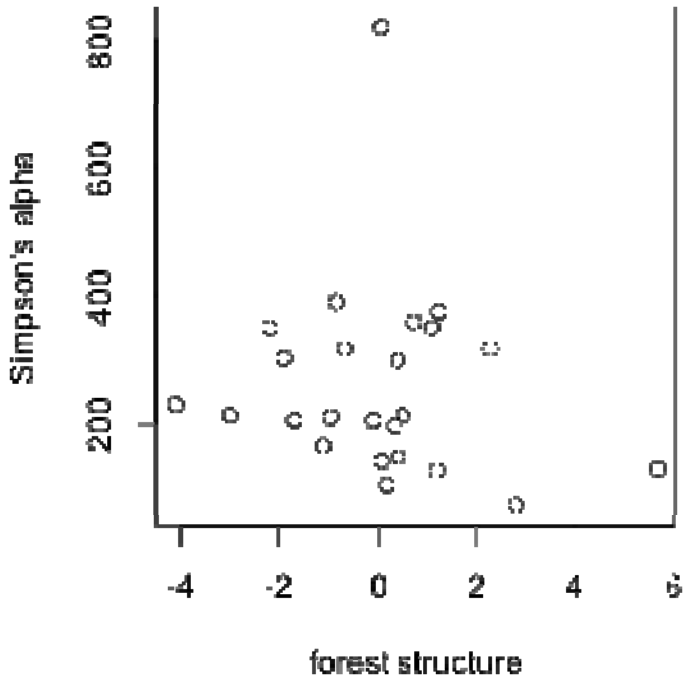


Results…

GEF/ITTO project

Alpha-diversity - VJRs



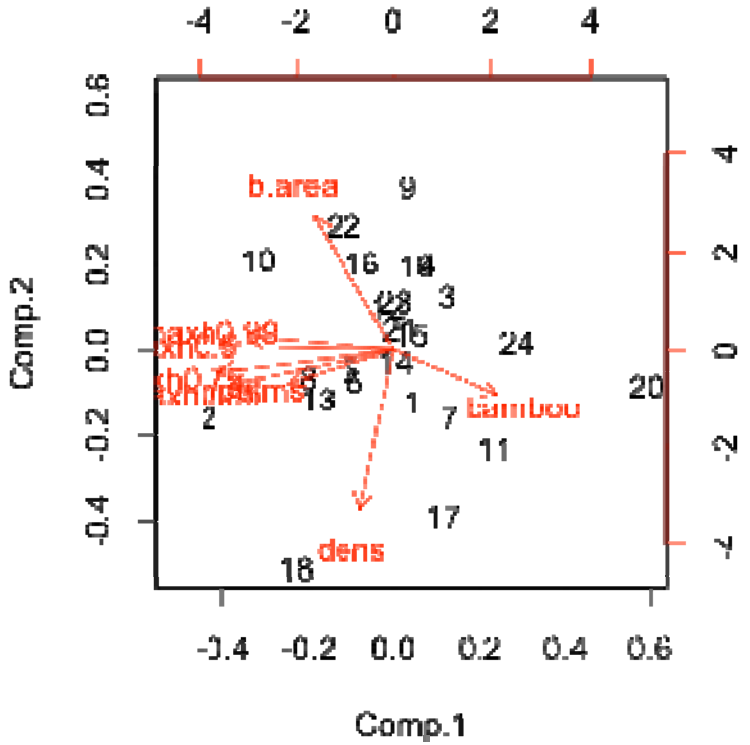


Results…

GEF/ITTO project

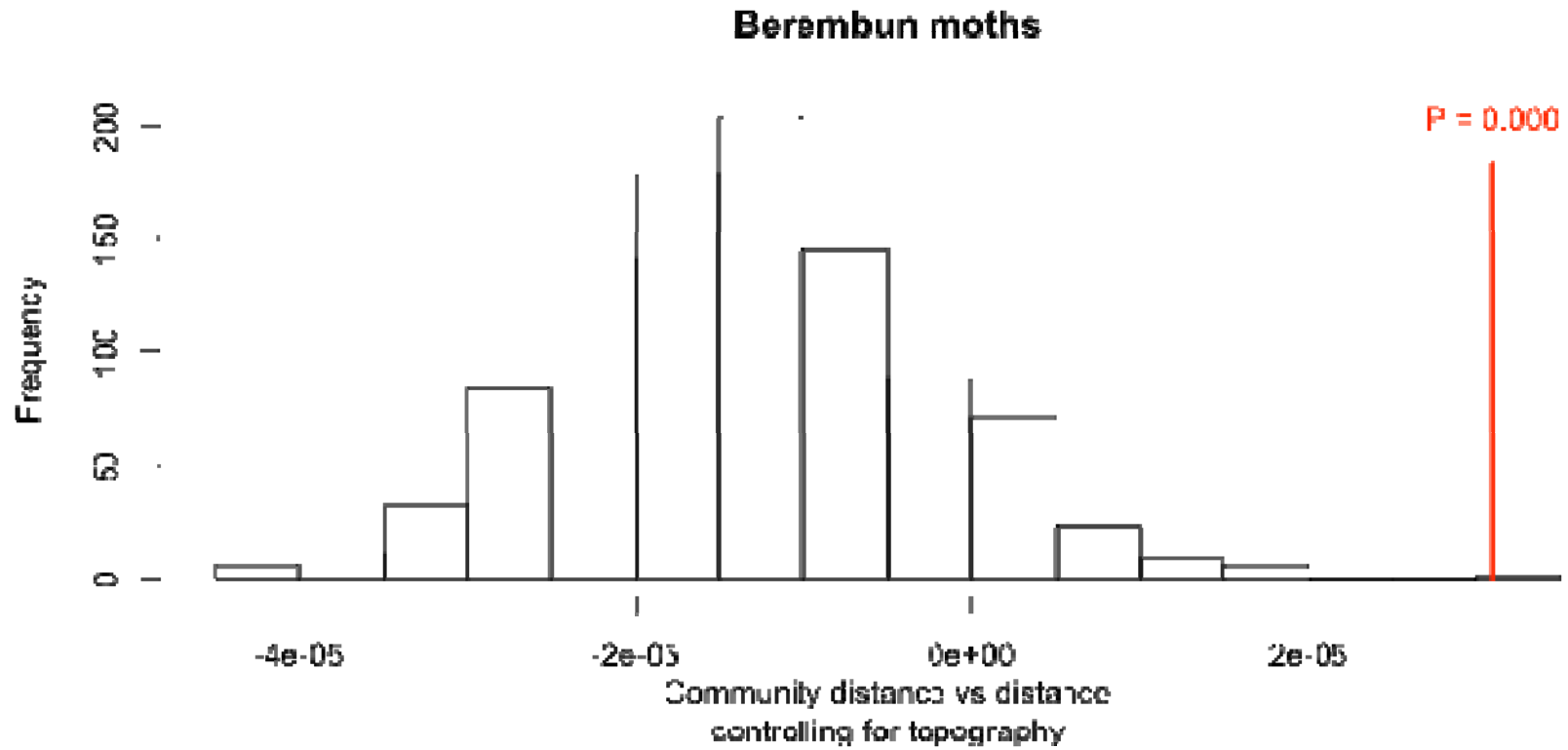
Alpha-diversity - PITC

$F_{2,21}$=1.366, *P*=0.2768



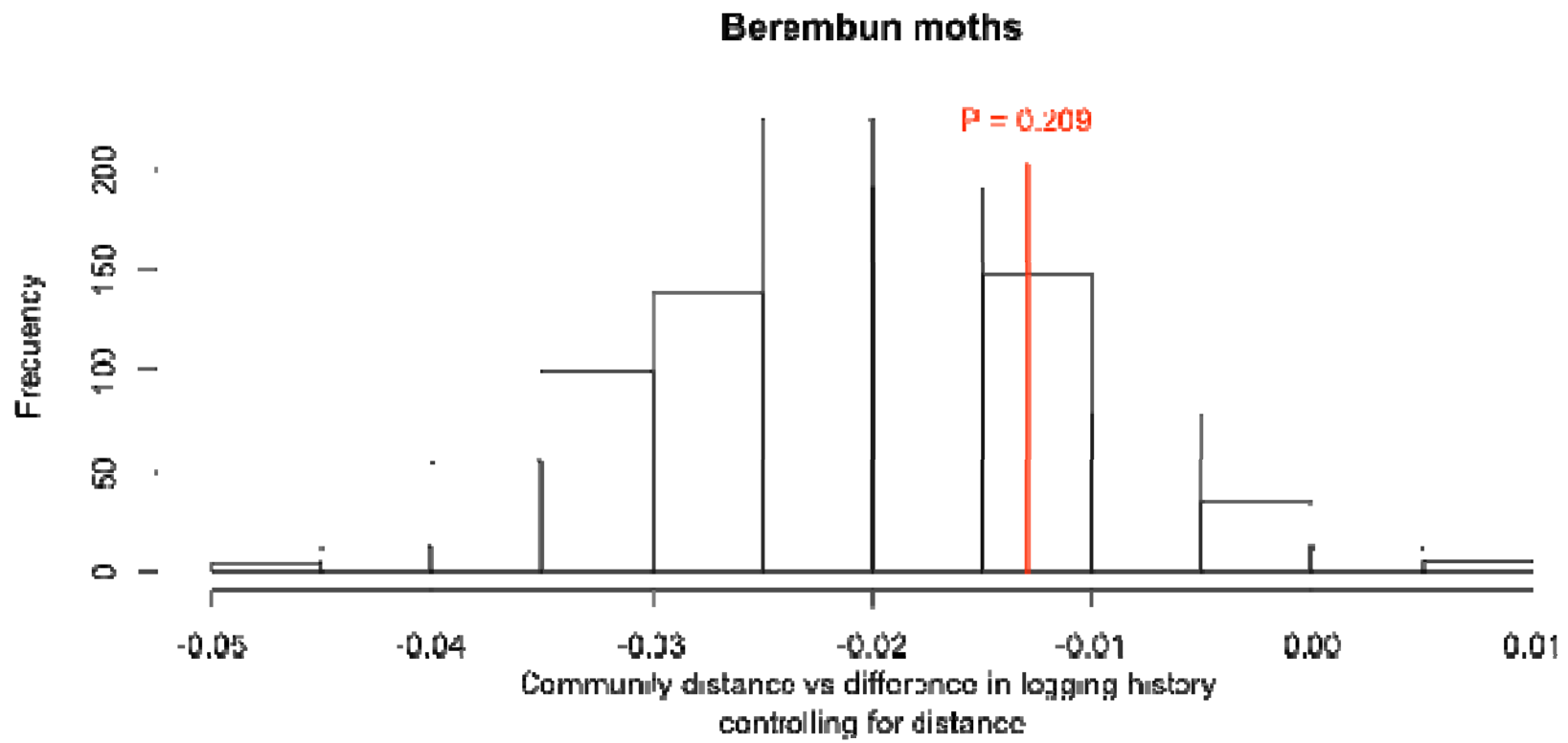
Results…

GEF/ITTO project



Results…

GEF/ITTO project

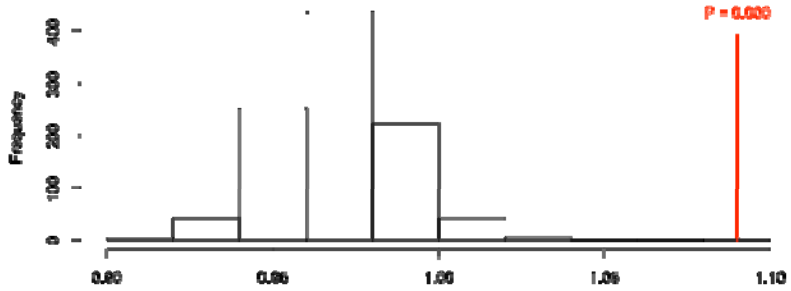


Results…

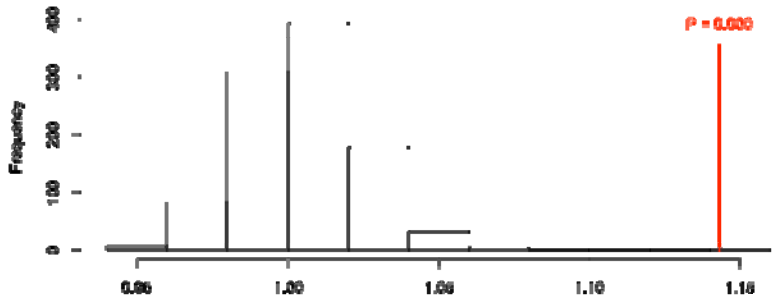
GEF/ITTO project

Berembun VJR

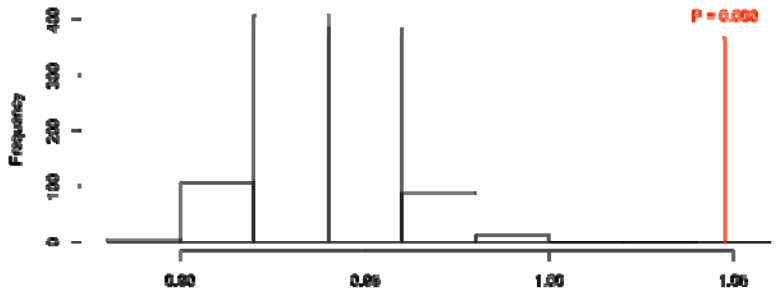
Ridge



Slope



Valley



Difference in mean community similarity within a habitat vs among habitats

Results…

GEF/ITTO project

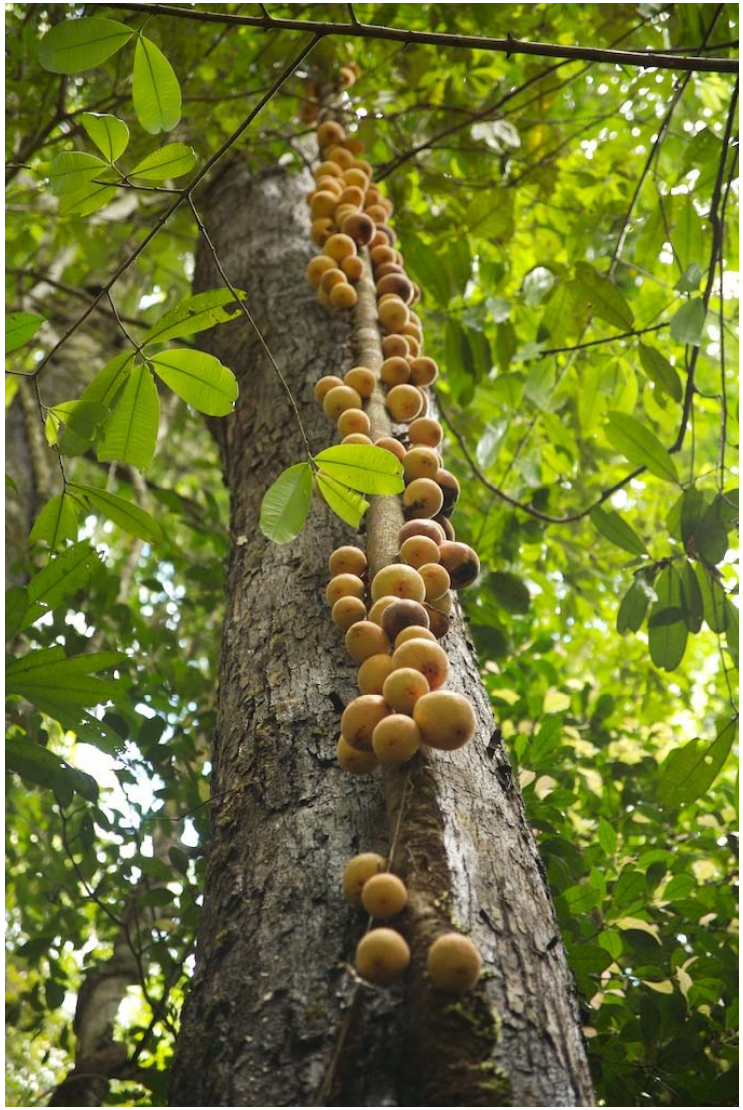
Site	Distance	Logging	Ridge	Slope	Valley
Berembun	<0.001	<0.209	<0.001	<0.001	<0.001
Semangkok	=0.874	=0.365	<0.001	<0.001	<0.001
Gn. Tebu	=0.716	=0.448	<0.001	=0.042	<0.001

Site	Distance	Elevation	Habitat structure
PITC	=0.998	=0.984	=0.086

Conclusions…

GEF/ITTO project

1) No consistent pattern of variation in alpha diversity
2) Evidence of strong topographical effect at three sites
3) Marginally significant effect of habitat structure at forth site
4) No evidence of effect of logging history at all three VJR sites
5) Significant distance effect only recorded at one site



Discussion…

GEF/ITTO project

1) Lack of logging effect may reflect recovery of forest or the degradation of the VJR
2) Moth communities are not apparently dispersal limited
3) Differences between VJRs and PITC may reflect different / reduced response to habitat in higher elevation forest

General comments

1) Rare species are informative
2) Need to sample at multiple scales
3) Effect of disturbance is often scale dependent
4) If lepidoptera are to be included in biodiversity assessment we need to develop tools for practitioners

Acknowledgements

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