臺灣東北部亞山地雨林樹木組成之微地形分化現象

Micro-topographic Differentiation of Tree Species Composition in a Subtropical Submontane Rainforest in Northeastern Taiwan

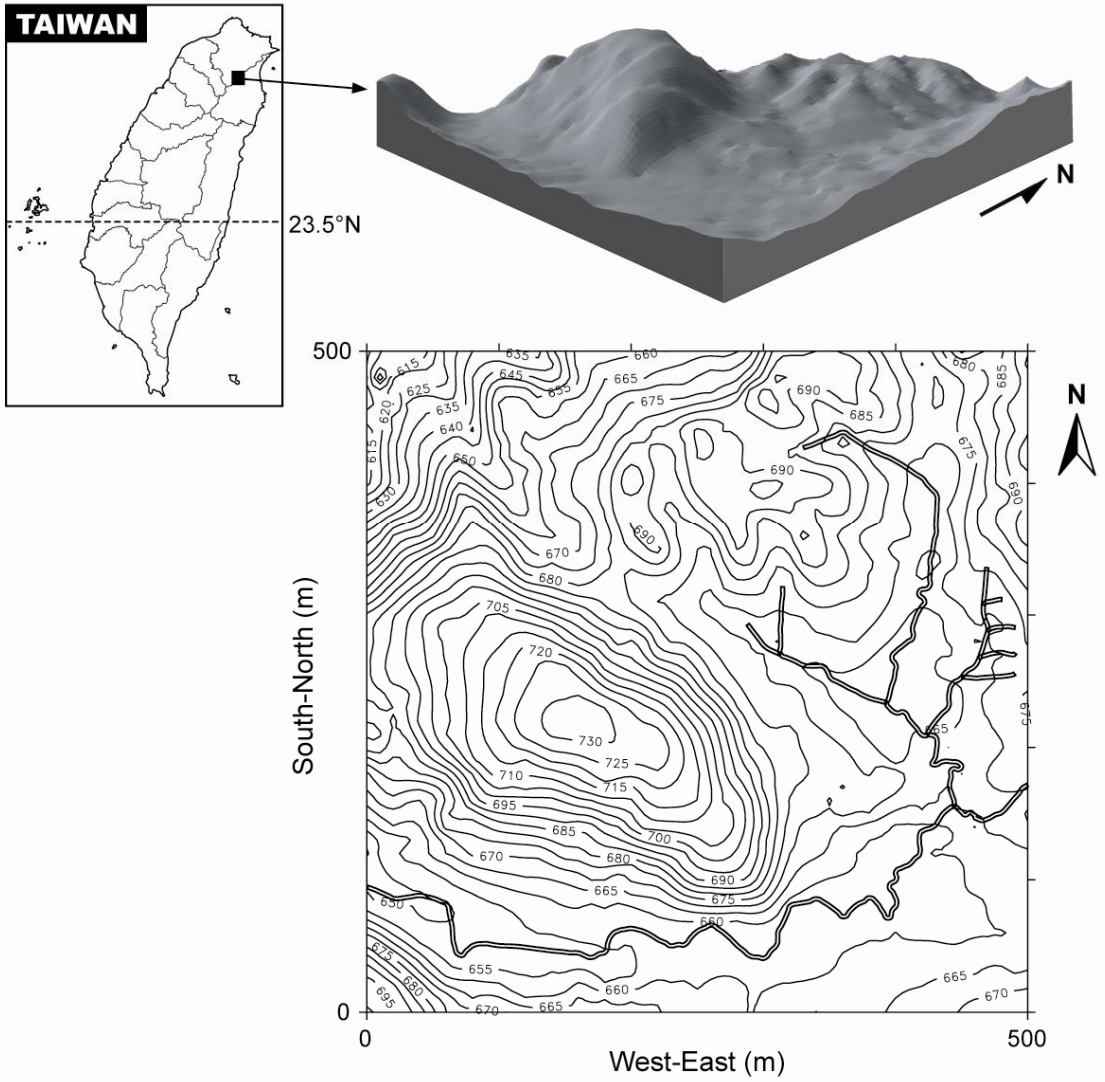
蘇聲欣、王相華、謝長富、張楊家豪、
呂佳陵、關秉宗

Niches for forests in Taiwan

- At medium to large scale (>10 km)
  - Governed by climatic factors
    - Geographic regions (Su 1985)
    - Altitudinal zonations (Hsieh 1997, Su 1984)
- At small scale (stand-level)
  - Topography?

- Aims
  - How is tree species composition associated with micro-topography?
  - Which micro-topographic factors are of great importance?
  - Do species spatial pattern show distinct association with habitats?

Fushan Forest Dynamics Plot



Data

- FDP tree census datasets
  - 48 of 110 species
  - Rare species (<10 individuals/ha) were excluded
- Topography survey data (CTFS & ArcMap)
  - Seven micro-topographic variables (20m x 20m)
    - Mean elevation
    - Slope
    - Index of convexity
    - Four aspect indices
      - Northness (N), Eastness (E), Northeastness (NE)

Methods

- Single-species analysis → Classification And Regression Tree (CART)
- Habitat classification → Multivariate Regression Tree (MRT)
- Indicator species analysis → Indicator Value method (INDVAL)
- The above data processing and analyses were carried out on the R statistical platform

Topographic survey

1. Mean elevation: the mean value of elevations at the four corners of 20 m $\times$ 20 m quadrat

2. Slope: the mean angle of inclination of four triangular planes composed of any three quadrat corners

3. Index of convexity (IC): the mean elevation of the focal quadrat minus the mean elevation of its eight surrounding quadrats. A positive IC indicates a convex terrain, whereas a negative one represents a concave terrain (Valencia et al. 2004)

Topographic survey

4. Four indices of aspect:

Due to its circular property (counting from 0° to 359°), aspects (θ) were then transformed trigonometrically into four indices with values from -1 to 1:

(1) Northness (N) = *cos*(θ); (north=1, south=-1)

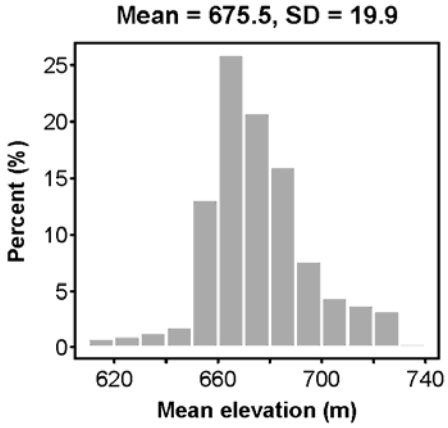
(2) Eastness (E) = *sin*(θ); (east=1, west=-1)

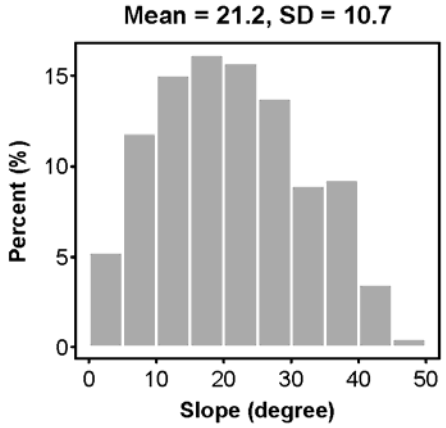
(3) Northeastness (NE) = *sin*(θ +45°)

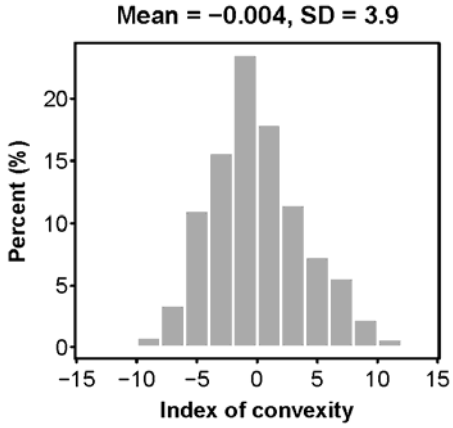
(4) Southeastness (SE) = *sin*(θ -45°)

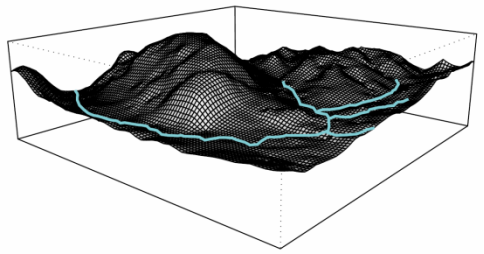
Results – topographic features

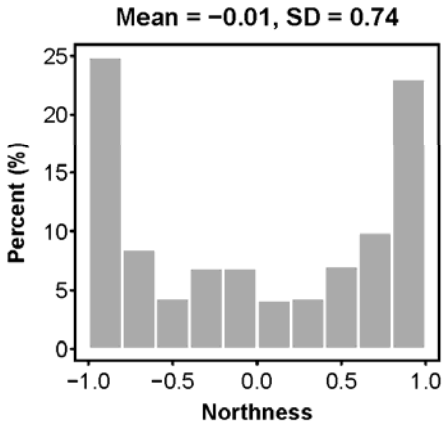
- Heterogeneous in micro-topography

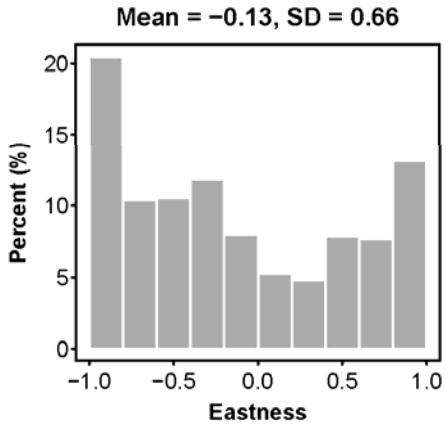


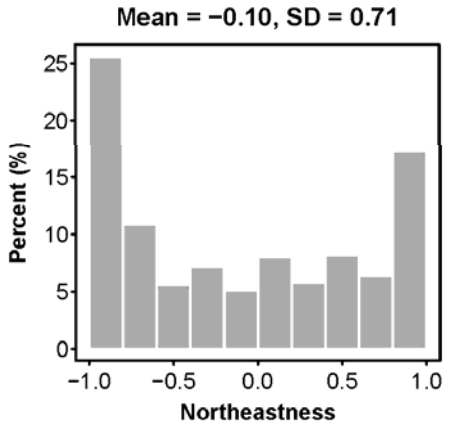


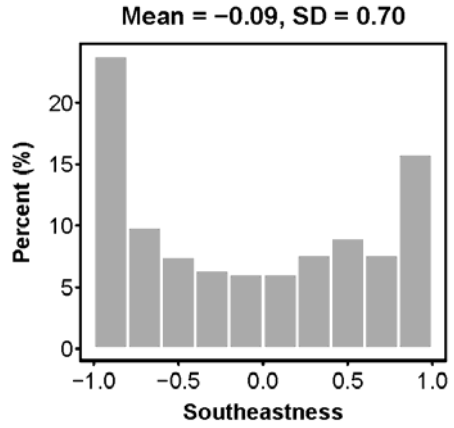












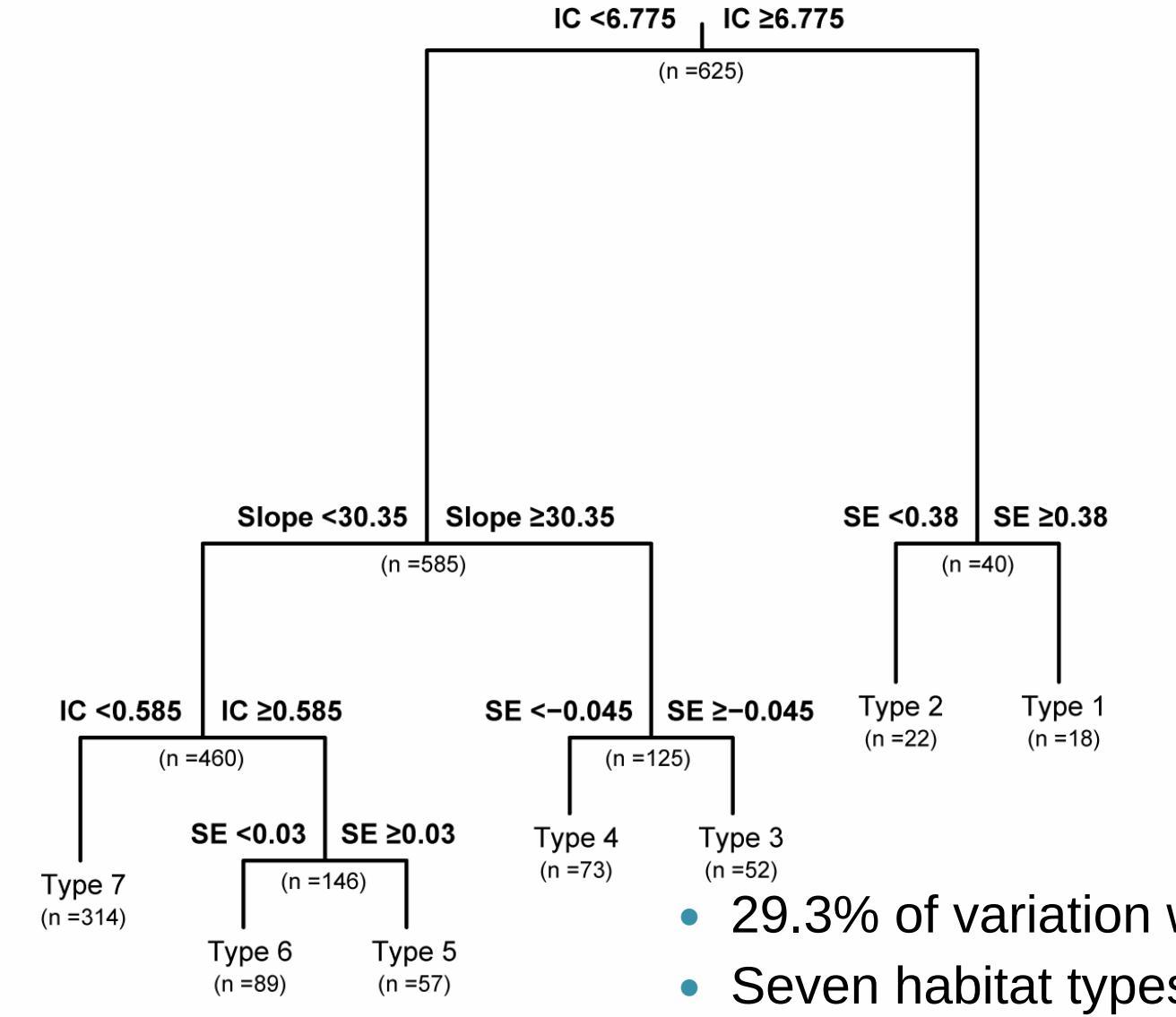
- 600-733 m in elevation
- >82% of the area is >10° in slope
- >78% of the area is uneven (out of the bound of 0 ± 1 in **IC**)
- U-shaped distributions in the aspect indices

Results – CART analyses

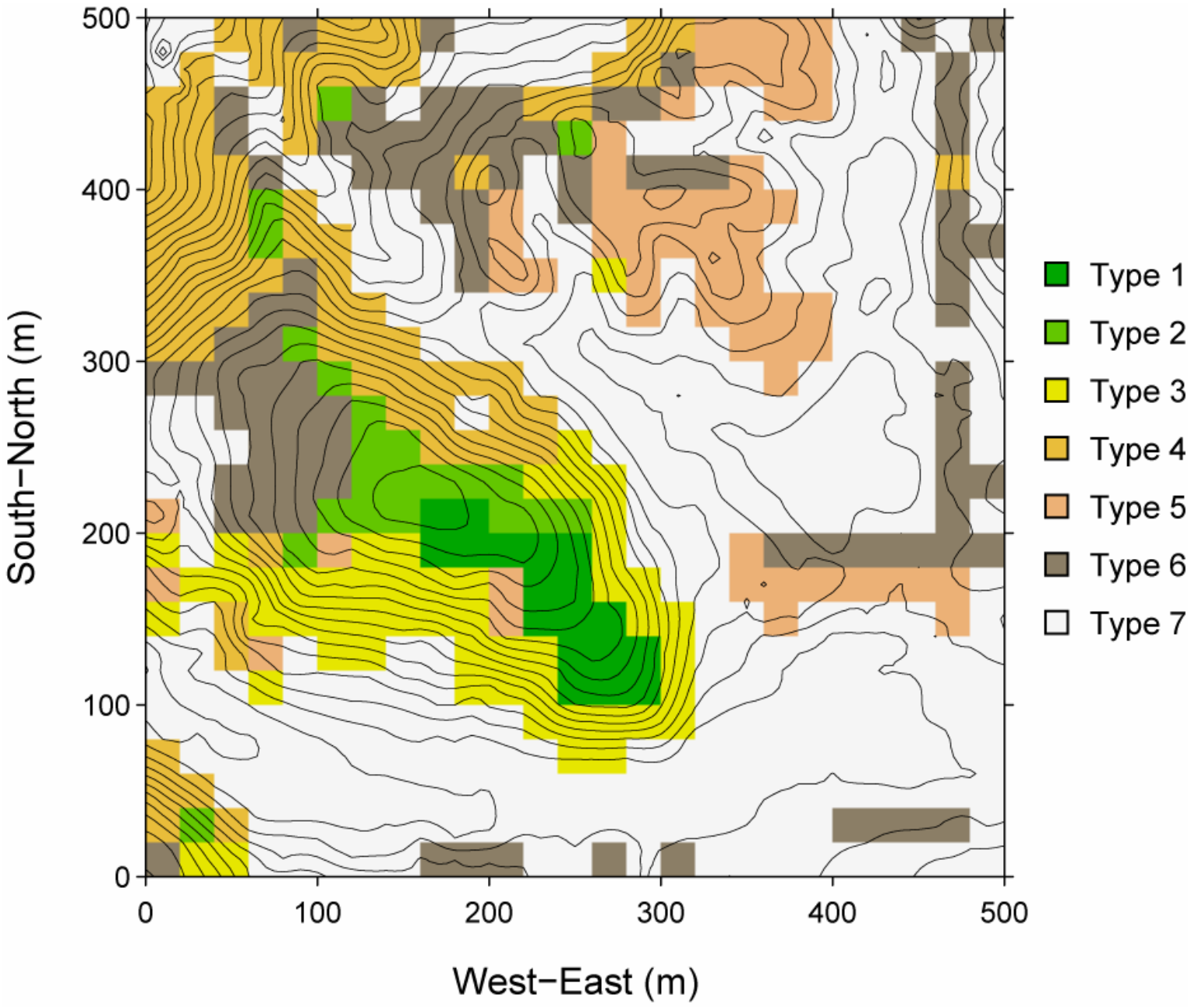
- **IC, SE, slope** were still the dominant effective factors in models (+ mean elevation)

Family	Species	Chinese name	Lifeform category	Abund-ance	Basal area (m^2/ha)	% variation explained	Micro-topographic parameters						
							Mean elevation	IC	slope	E	N	NE	SE
Myrtaceae	*Syzygium buxifolium*	小葉赤楠	SB	396	0.03	64.6		○					○
Theaceae	*Pyrenaria shinkoensis*	烏皮茶	C	4725	2.20	62.5		○					○
Theaceae	*Cleyera japonica*	紅淡比	SB	1528	0.59	59.3	○	○	○		○		○
Elaeocarpaceae	*Elaeocarpus japonicus*	薯豆	C	1327	0.80	59.3	○	○	○	○			
Lauraceae	*Machilus thunbergii*	紅楠	C	2984	2.72	46.3	○	○	○				○
Cyatheaceae	*Cyathea podophylla*	鬼柊欐	F	2524	1.79	46.3	○		○			○	
Myrsinaceae	*Myrsine seguinii*	大明橘	SB	2735	0.45	45.4		○					
Elaeocarpaceae	*Elaeocarpus sylvestris*	杜英	C	581	0.09	44.6	○	○	○		○		
Sabiaceae	*Meliosma squamulata*	綠樟	C	3633	2.61	41.0		○					

Results – Multivariate Regression Tree (MRT)



- 29.3% of variation was explained
- Seven habitat types


South–North (m)
West–East (m)
0
100
200
300
400
500
Type 1
Type 2
Type 3
Type 4
Type 5
Type 6
Type 7

- The species diversity and forest structure significantly differed

	MRT habitat classification						
	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7
Area (ha)	0.72	0.88	2.08	2.92	2.28	3.56	12.56
Species richness	40 ± 4^{a}	38 ± 5^{ab}	35 ± 6^{bcd}	33 ± 7^{ce}	39 ± 5^{ad}	31 ± 7^{e}	28 ± 7^{f}
Density (individuals/ha)	8971 ± 1667^{a}	6684 ± 1739^{b}	5054 ± 1768^{c}	4625 ± 1933^{c}	6697 ± 1748^{b}	4543 ± 1514^{c}	3719 ± 1494^{d}
Basal area (m^2/ha)	43 ± 5^{a}	49 ± 12^{a}	44 ± 10^{a}	44 ± 13^{a}	48 ± 13^{a}	43 ± 13^{a}	38 ± 15^{b}
Proportion of multi-stemmed trees (%)	19 ± 6^{a}	22 ± 5^{ab}	28 ± 5^{ce}	26 ± 8^{bc}	22 ± 5^{ad}	25 ± 7^{bd}	30 ± 8^{e}

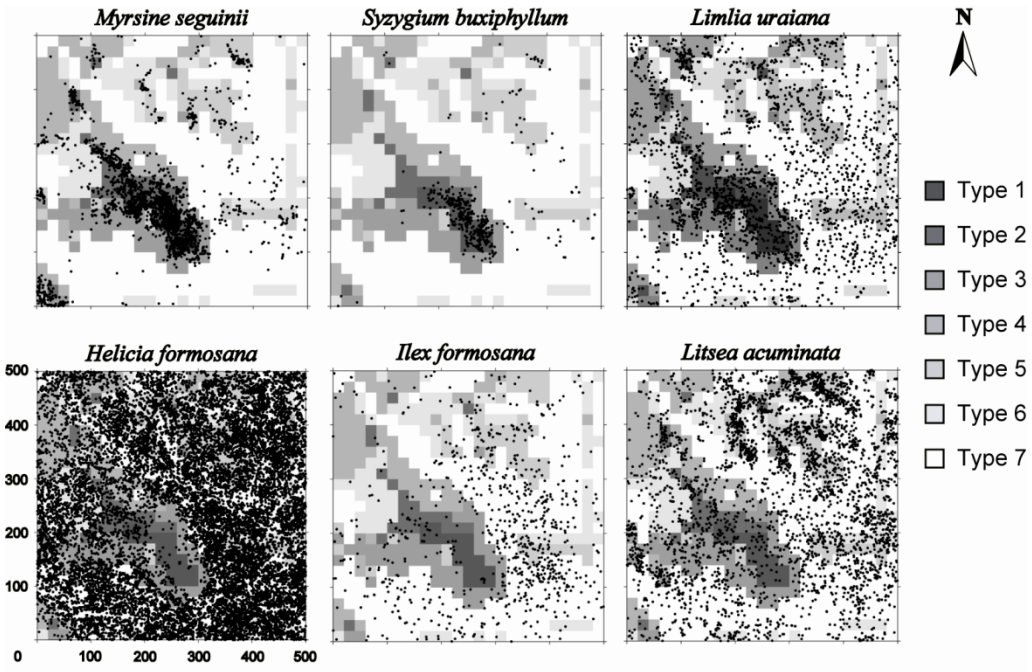
Results – indicator species

- 92% of 48 species were statistically significant indicative of MRT habitat type

- From the viewpoint of associated habitats
  - 11 MRT habitat groups
  - Habitat type 1 had the most indicator species

Habitat type	No. of indicator species	Primary indicator species	INDVAL
1	20	*Syzygium buxifolium*	88.9***
2	7	*Cinnamomum subavenium*	40.3**
3	1	*Prunus phaeosticta*	25.1***
4	3	*Saurauia tristyla*	31.2***
5	3	*Litsea acuminata*	32.7***
7	1	*Helicia formosana*	37.4***
1+2	30	*Myrsine seguinii*	89.9***
3+4	5	*Cyathea podophylla*	47.5***
5+6	3	*Litsea acuminata*	32.0**
5+6+7	4	*Helicia formosana*	59.3***
3+4+5+6+7	4	*Helicia formosana*	77.8***

- From the viewpoint of indicator species
  - *Myrsine seguinii* showed the highest INDVAL (88.9) with type “1+2”
  - Some species revealed complementary patterns (e.g. *Helicia formosana* vs. *M. seguinii*)



Summary

- Slope, inclination, and aspect were the decisive factors of micro-topography
- Niche differentiation of tree species composition along micro-topographic gradients in subtropical Taiwan
- Most species were shown to be indicative of specific habitats but performed dissimilarly both in the magnitude and breadth of habitat association

Question

- Why SE not NE
- How about the other 70%

- There might be other potential mechanisms co-regulating the forest community
  - Undetected micro-topography (niche)
  - Recruitment limitation
  - Historical events
  - Random drift

Thank You

- The detailed methods of topographic survey and tree census followed an unified protocol adopted by the CTFS plots network (Condit 1998; Su et al. 2007)

- The detailed methods of topographic survey and tree census followed an unified protocol adopted by the CTFS plots network (Condit 1998; Su et al. 2007)

- To investigate the niche differentiation of tree species composition, we applied the classification and regression trees (CART) (De'ath 2002) method to examine the relationship between tree abundance data of single species and environmental factors. CART explains variation of a response variable by repeatedly partitioning the data into more homogeneous subsets through various combinations of explanatory variables

- The multivariate regression tree (MRT) analysis is a multivariate extension of CART (De'ath 2002). It is a constrained clustering method that constructs a dichotomous tree model for multidimensional data in response to selected explanatory variables

- Species associated with habitat types were then identified using the indicator value (INDVAL) method (Dufrêne and Legendre 1997). INDVAL calculation combined the relative abundance and frequency for a species occurring in specific MRT-defined habitat type and tested the statistical significance