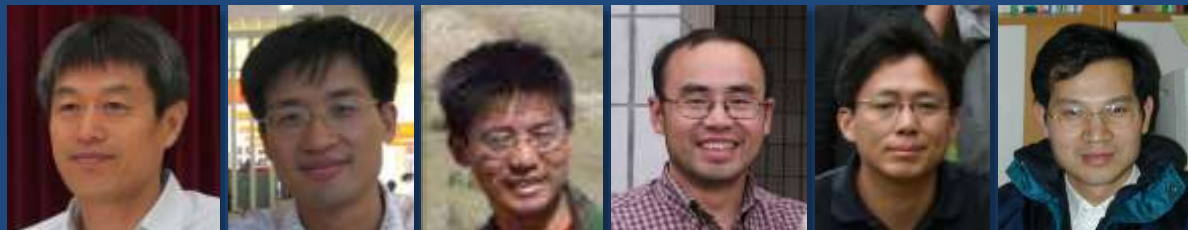


Structural characteristics of forests in China based on PKU-PSD project

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Zehao Shen, Xiangping Wang, Chengyang Zheng

Dept. Ecology, Peking University

Sep 6, 2017



Outline

- 1. Background of the PKU-PSD project**
- 2. Structural characteristics of forests in China**
- 3. Ongoing work**

E20

E60

E100

Elevation: -156~ 8844 m

N60

Russia

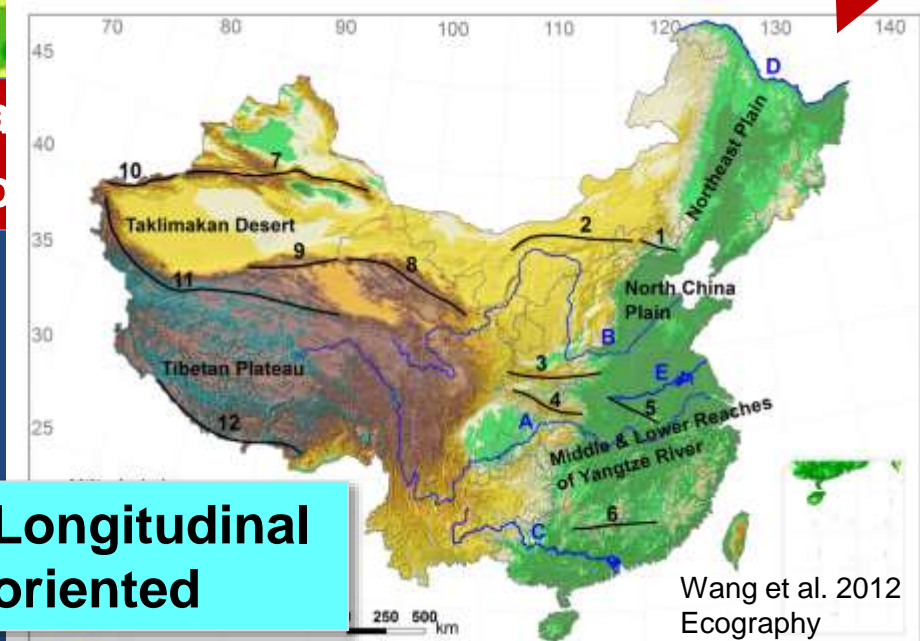
Mongolia

China

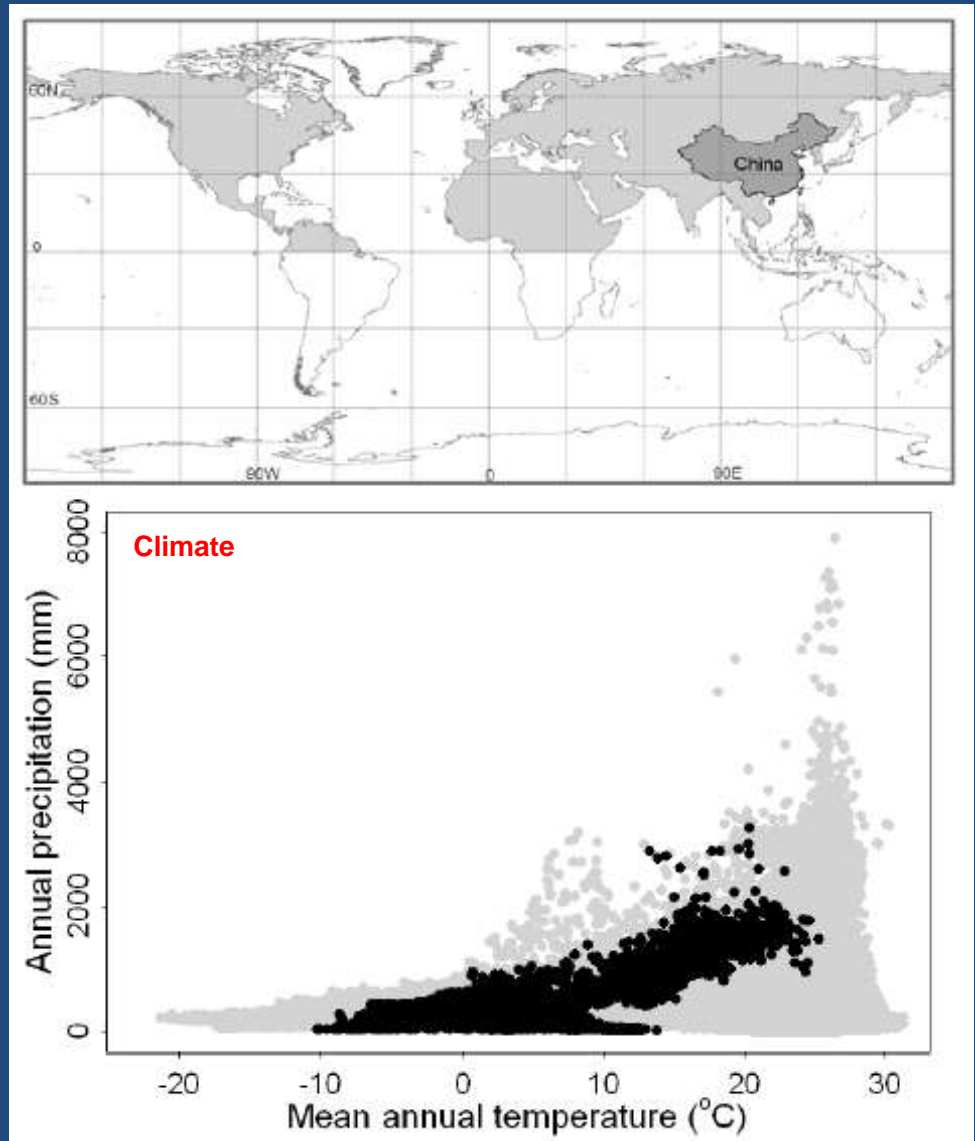
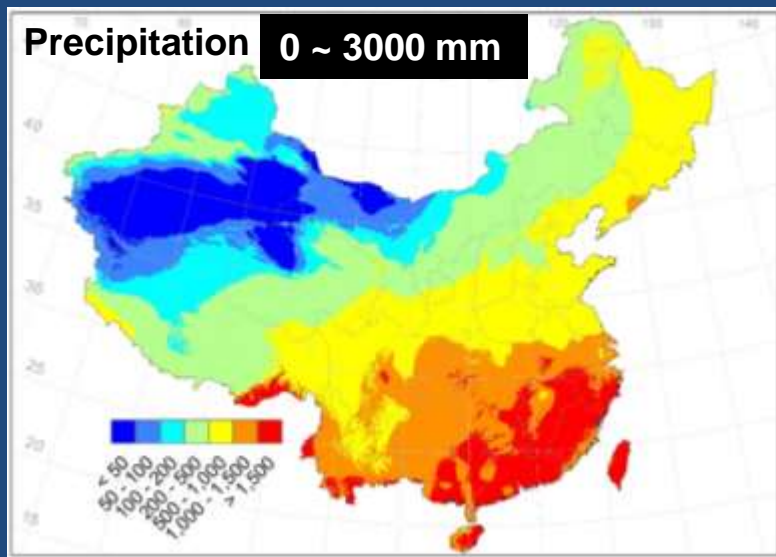
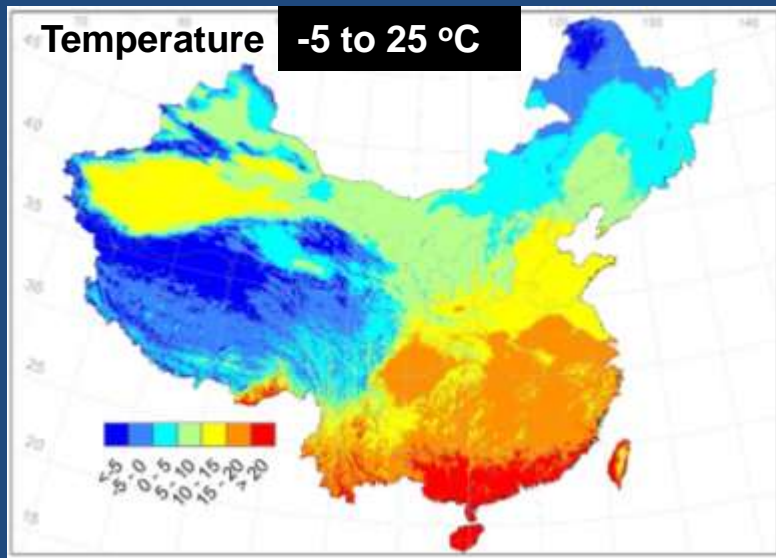
India

3 terrain areas:

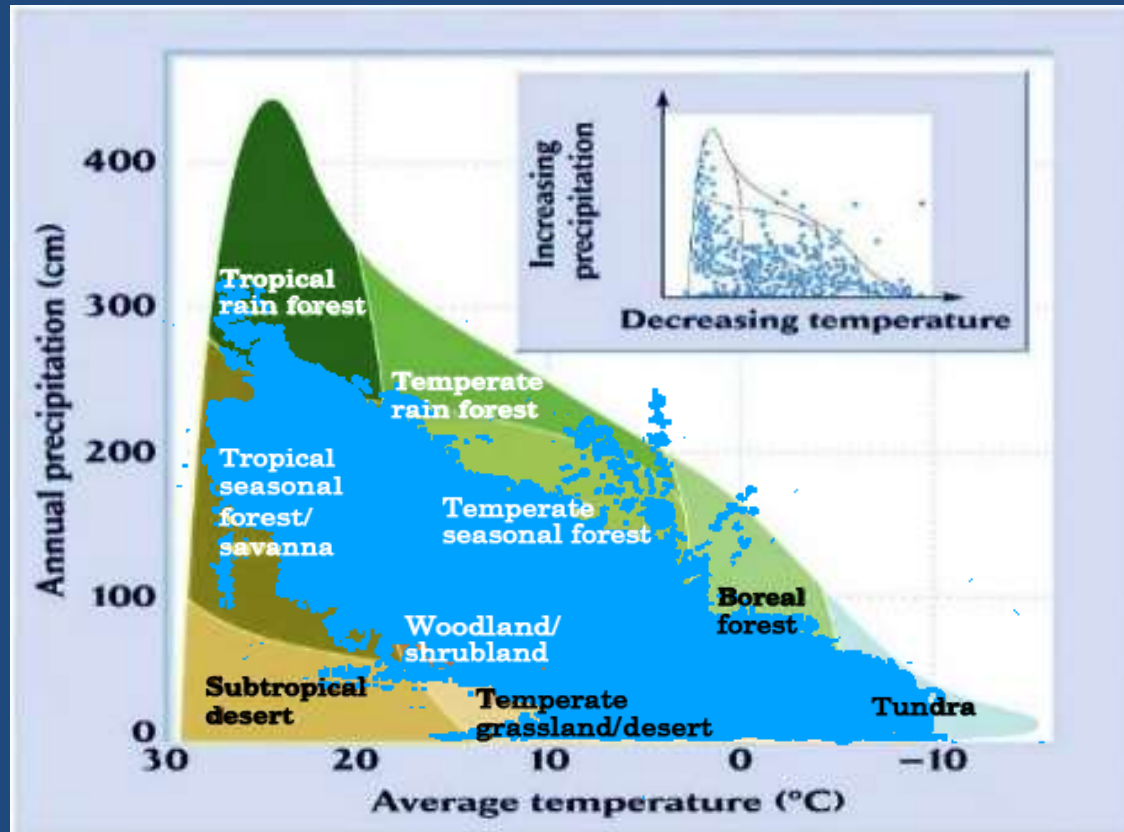
- ☐ Lowlands (<500 m)
- ☐ Mountain areas (~ 1500 m)
- ☐ Qinghai-Tibetan Plateau (>4000 m)

La
Lo**Longitudinal
oriented**Wang et al. 2012
Ecography

Climate of China

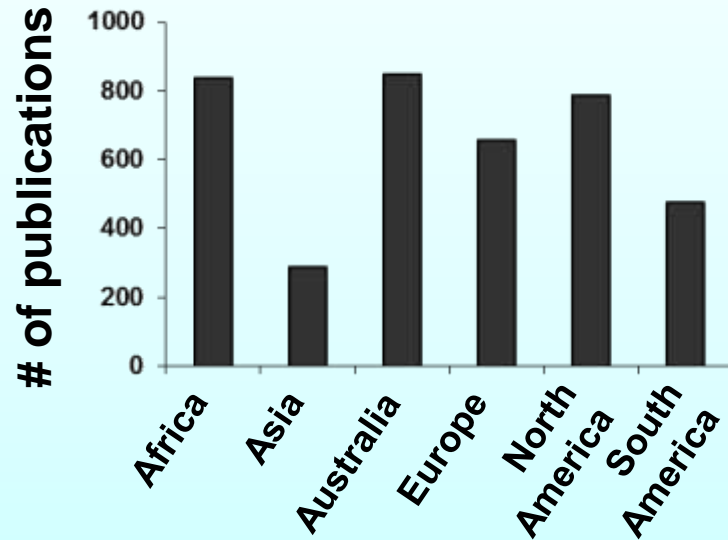


China's locations in the Whittaker global biome scheme



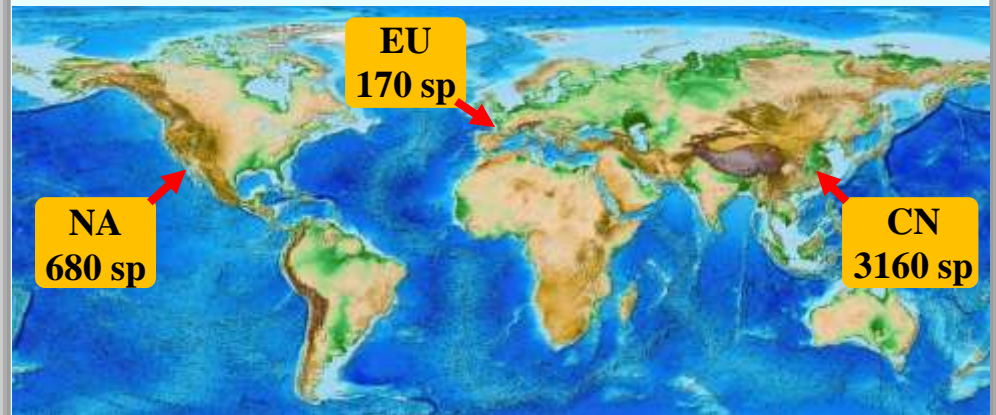
If you study China, you know the world.

Region selection bias



Based on Web of Science

Tree species diversity of China, North America and Europe

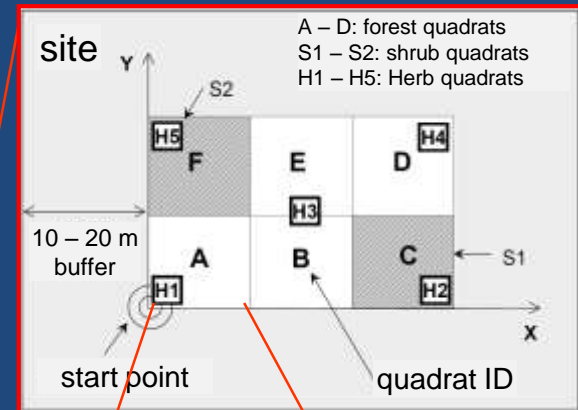
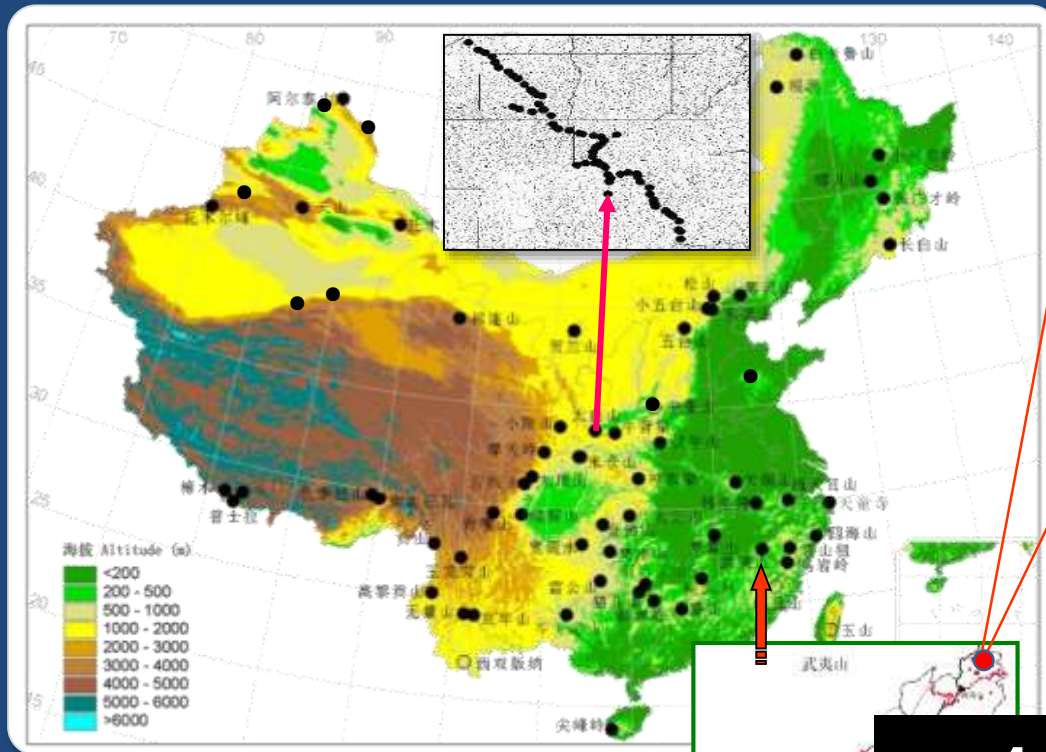


Challenge

Limitation: Lack of fine species distribution data

PKU-PSD project

PeKing University- Plant Species Diversity Project for China's Mountains



- ❑ 1992-up to now
- ❑ 70 mountains
- ❑ ~2000 forest plots

Plot design for PKU-PSD project

(1) Plot area:

Tree layer: 600 m²

Shrub layer: 100m²

Herb layer: 5×1 m²



(2) Items measured:

Trees (DBH \geq 3cm): species, DBH, height

Shrubs: species, coverage and height

Herb layer: species, abundance, coverage



West Tianshan Mt.

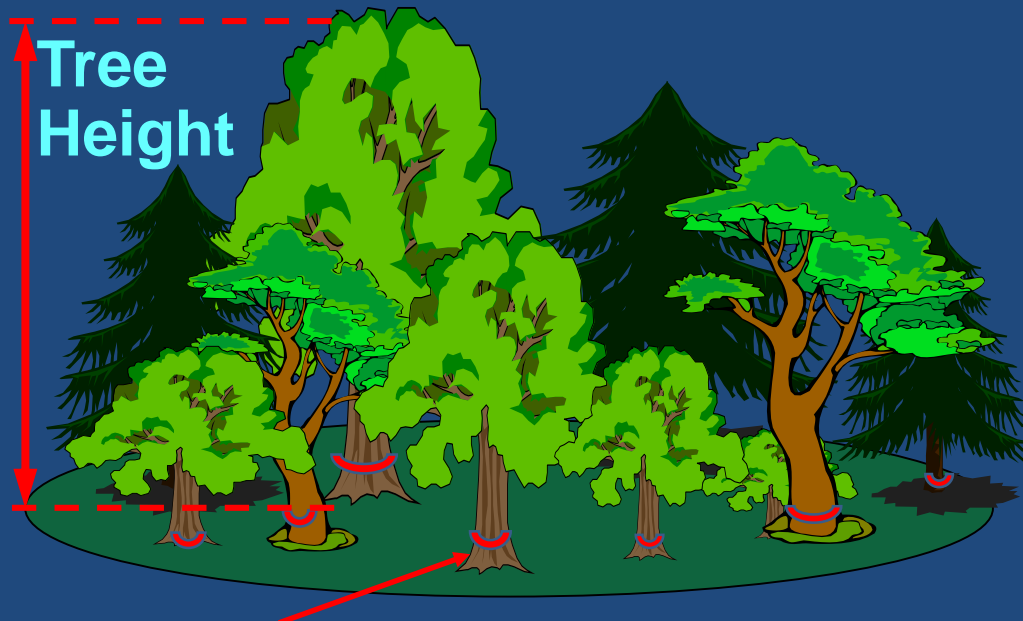


Structural characteristics of forest communities in China



Scientific questions

- (1) How do the structural characteristics in forests vary across China?
- (2) What are the climatic drivers of these structural characteristics?

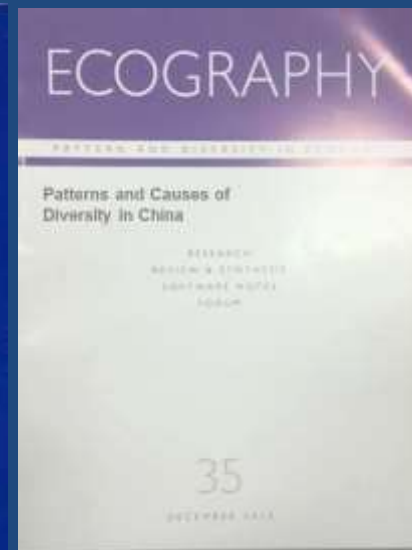
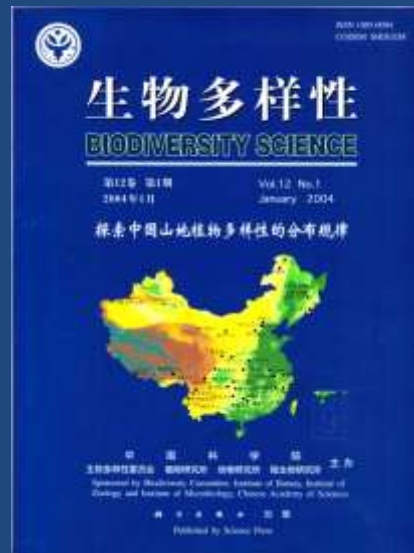


Measurements

- DBH
- Tree height
- # of stems
- Basal area
- Species richness

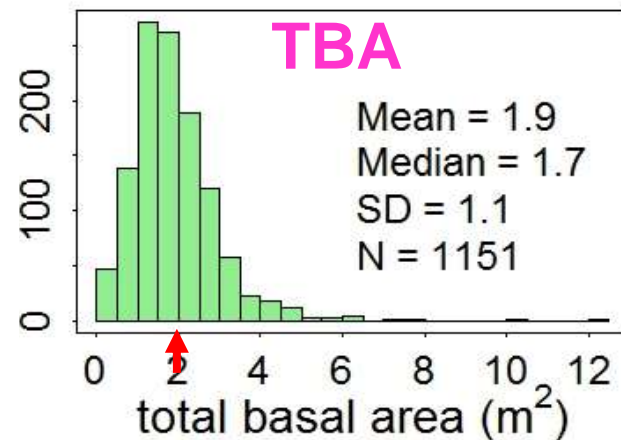
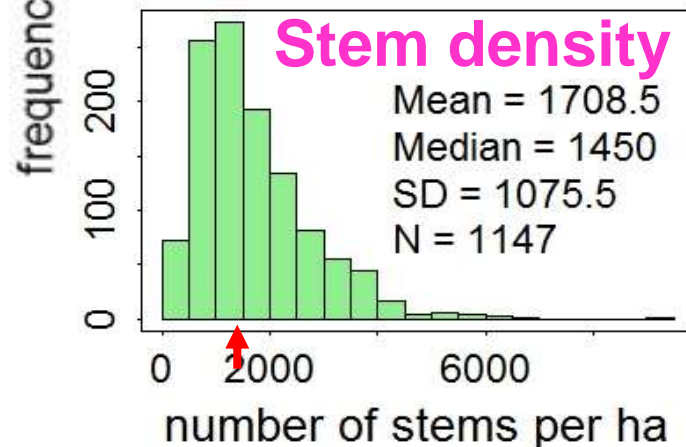
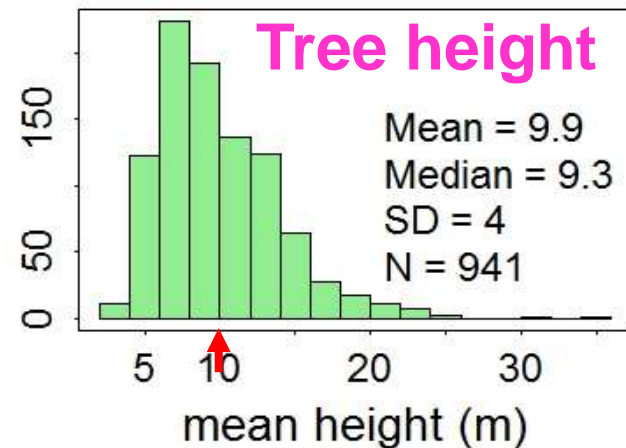
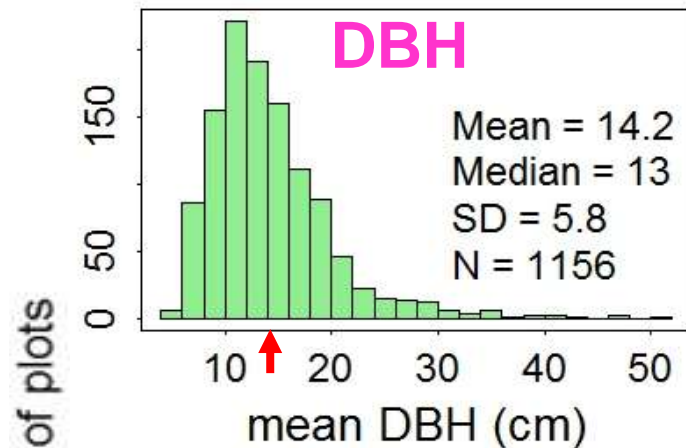
DBH (Diameter at breast height)

- ❑ **Statistics and biogeography of forest structures**
- ❑ **Geographic changes in life forms of trees**
- ❑ **Patterns of species richness and species turnover**



1. Statistics and biogeography of forest structures

Frequency distribution



Biogeography of forest structures

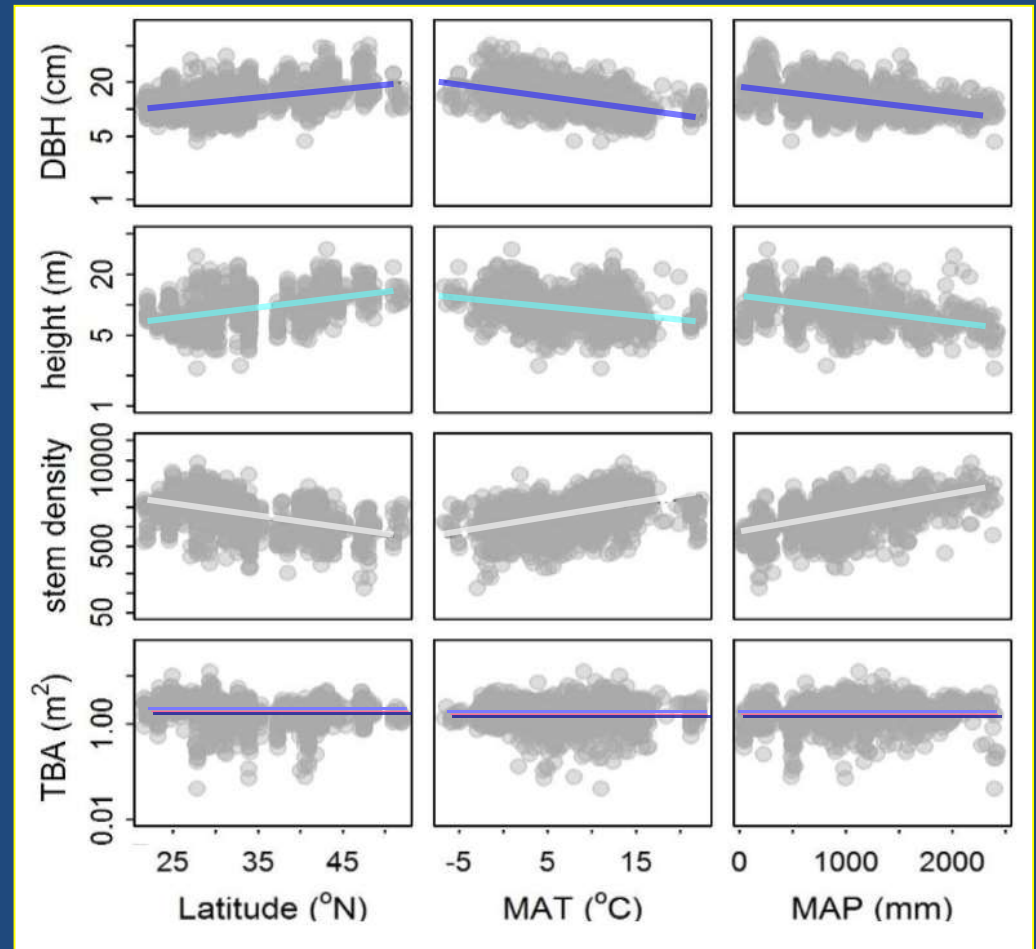
Changes with latitude, temperature and precipitation

DBH

Tree height

Stem density

Total basal area (TBA)



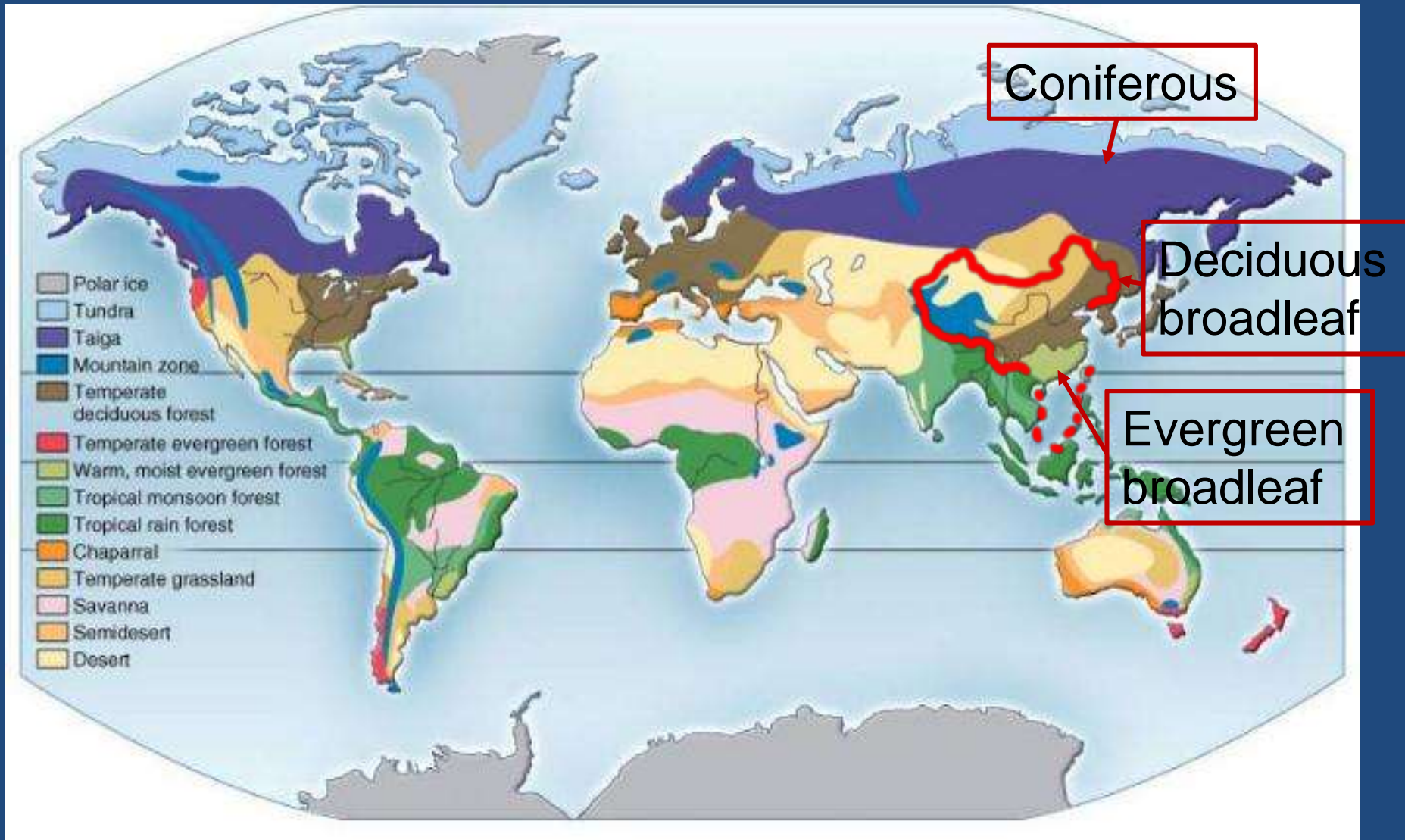
Latitude Temperature Precipitation

Fang et al. Ecography, 2012

Contribution of temperature (MAT) and precipitation (MAP) to forest structures

Item	MAT & AP (%)	MAT pure (%)	MAP pure (%)	Joint (%)
DBH (cm)	26.1	7.1	1.6	17.3
Height (m)	16.4	0.3	6.0	10.2
density (/ha)	30.3	1.3	9.1	16.8
Total Basal Area (cm ² /ha)	2.0	0.8	1.9	-0.8

2. Geographic changes in life forms of trees



2. Geographic patterns of life forms of trees

Broadleaf vs. conifer trees



$$\% \text{ broadleaf trees} = X_{\text{broadleaf}} / (X_{\text{broadleaf}} + X_{\text{conifer}})$$

$$\% \text{ conifer trees} = 1 - \% \text{ broadleaf trees}$$

Evergreen vs. deciduous broadleaf trees



$$\% \text{ evergreen broadleaf trees} = X_{\text{evergreen}} / (X_{\text{evergreen}} + X_{\text{deciduous}})$$

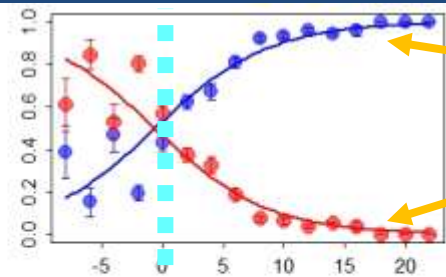
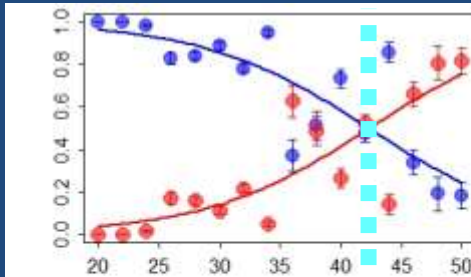
$$\% \text{ deciduous broadleaf trees} = 1 - \% \text{ evergreen trees}$$

Changes in proportions in broadleaf or conifer trees



broadleaf vs. conifer trees

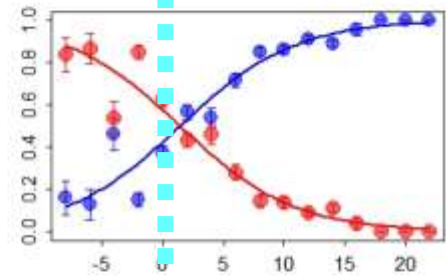
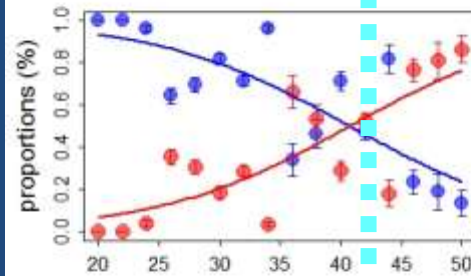
Number of
Stems



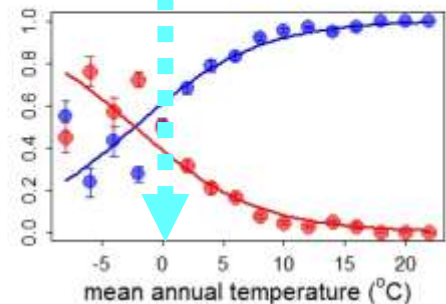
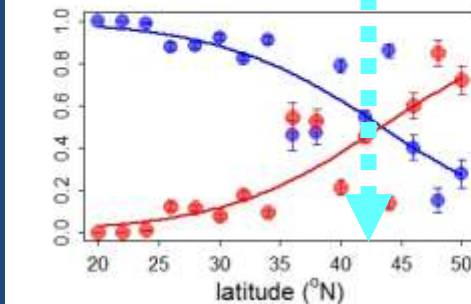
broadleaf

coniferous

TBA



Tree
species
richness



Changes in proportions in evergreen or deciduous trees among broadleaf trees

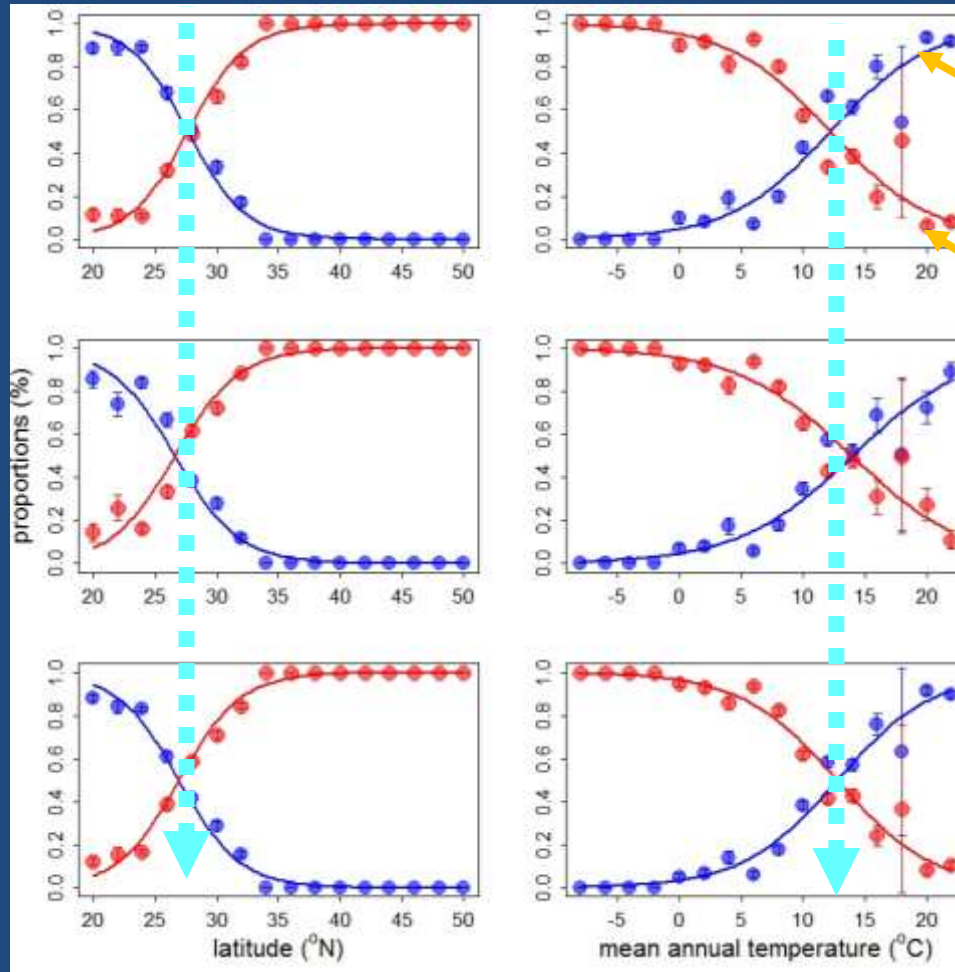
evergreen vs. deciduous trees



evergreen

deciduous

Number of
Stems

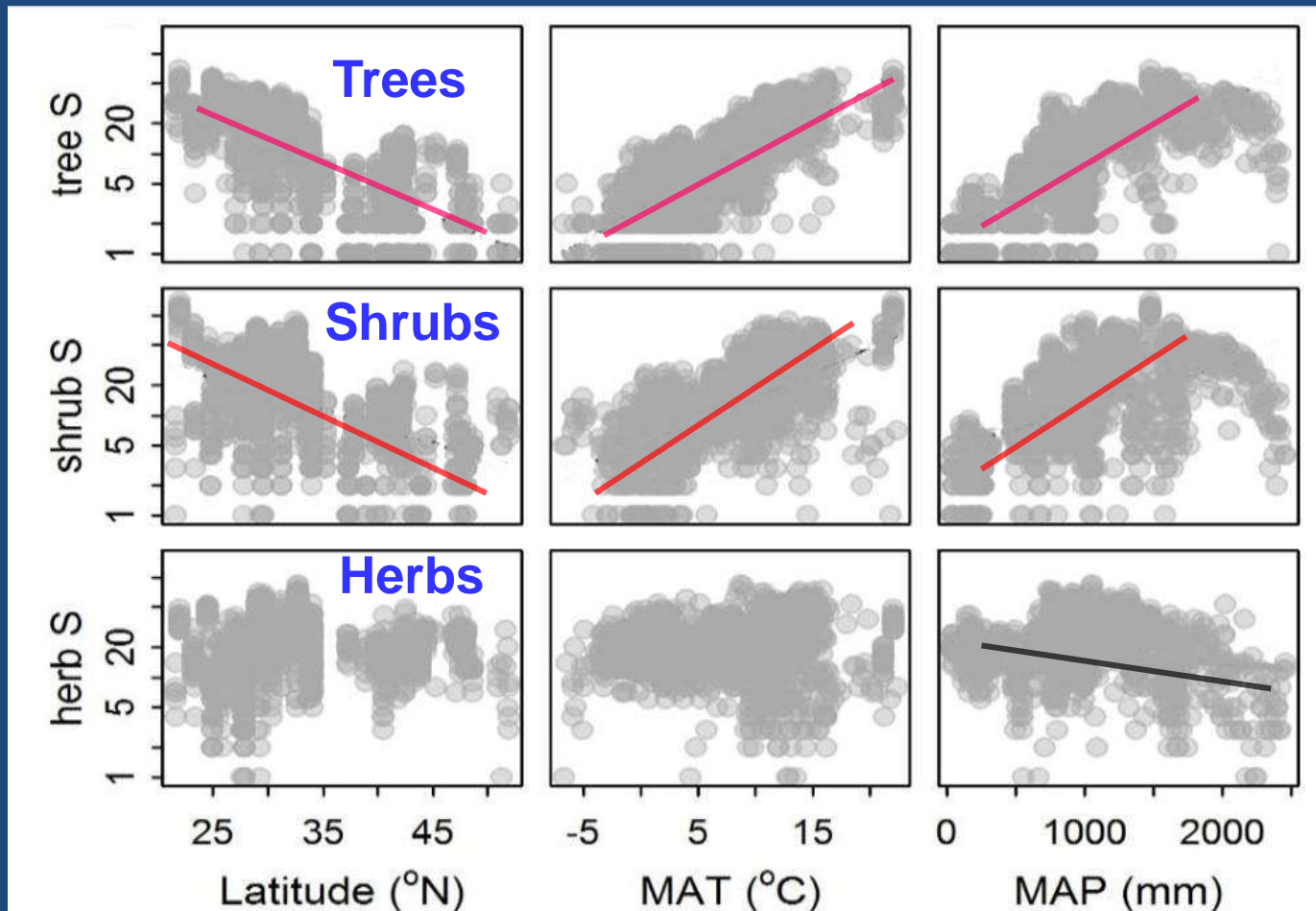


TBA

Tree
richness

3. Patterns of species richness

Species richness changes with latitude, temperature and precipitation



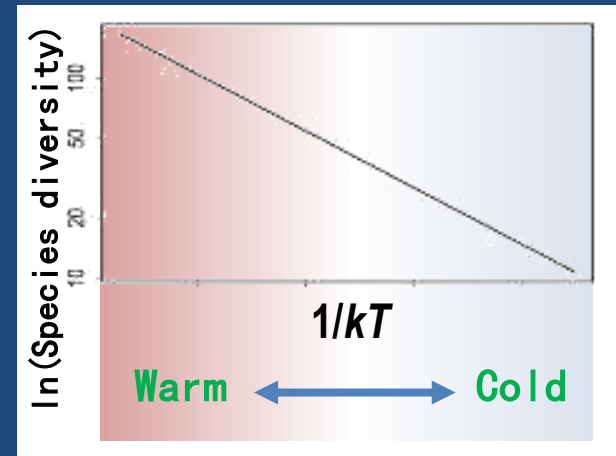
1 species/
600 m².1°N

0.8 species/
600 m².1°N

Metabolic Theory of Ecology (MTE)

MTE explains large-scale patterns of species diversity in terms of metabolism using the following formula.

$$\ln(S) = C_0 + E \frac{1}{kT}$$

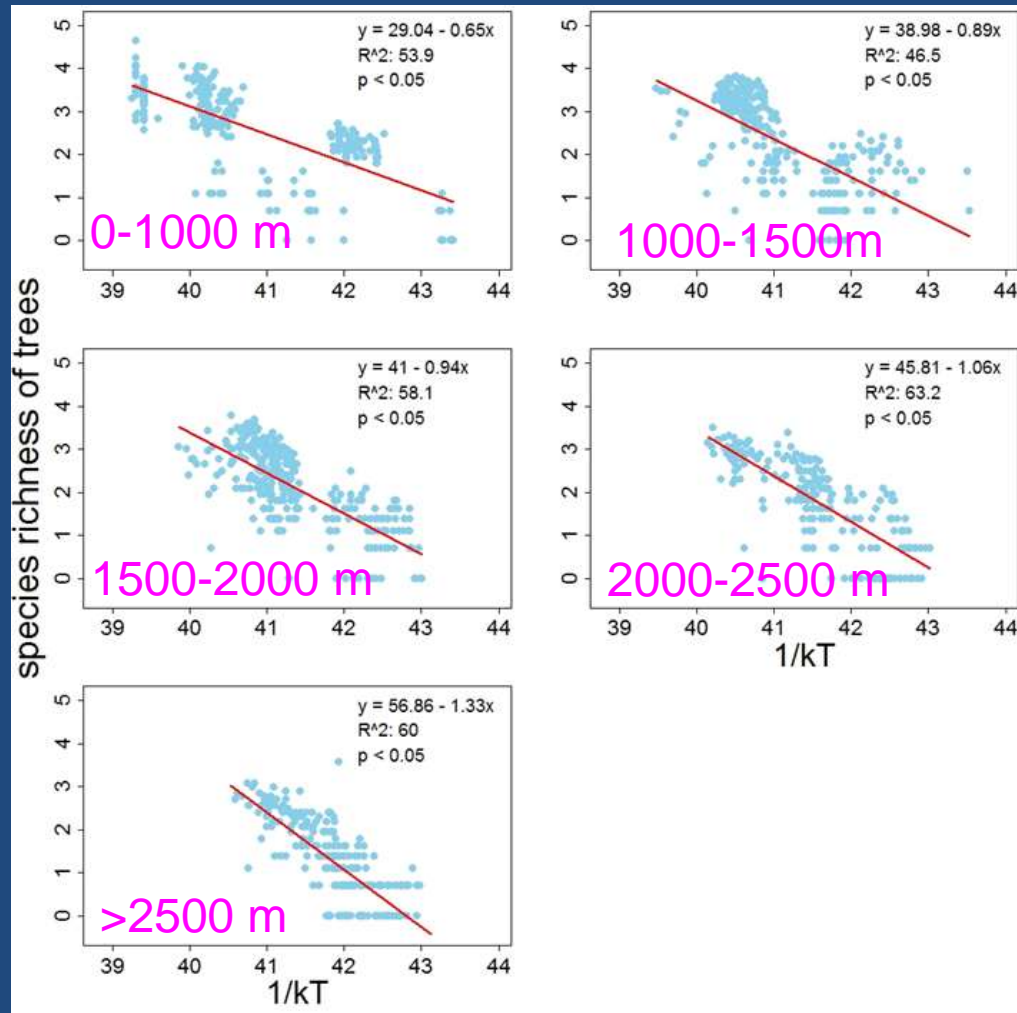


It has two predictions:

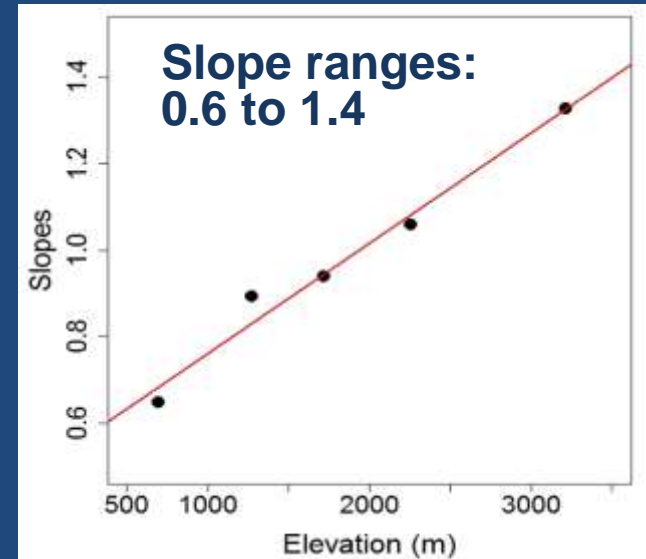
- (1) log(species diversity) is a linear function of $1/kT$ (T is absolute temperature);
- (2) The slope (E) is $0.6 \sim 0.7$ (or $2/3$)

TME at different elevations

Relationship between
log(species richness) and $1/kT$



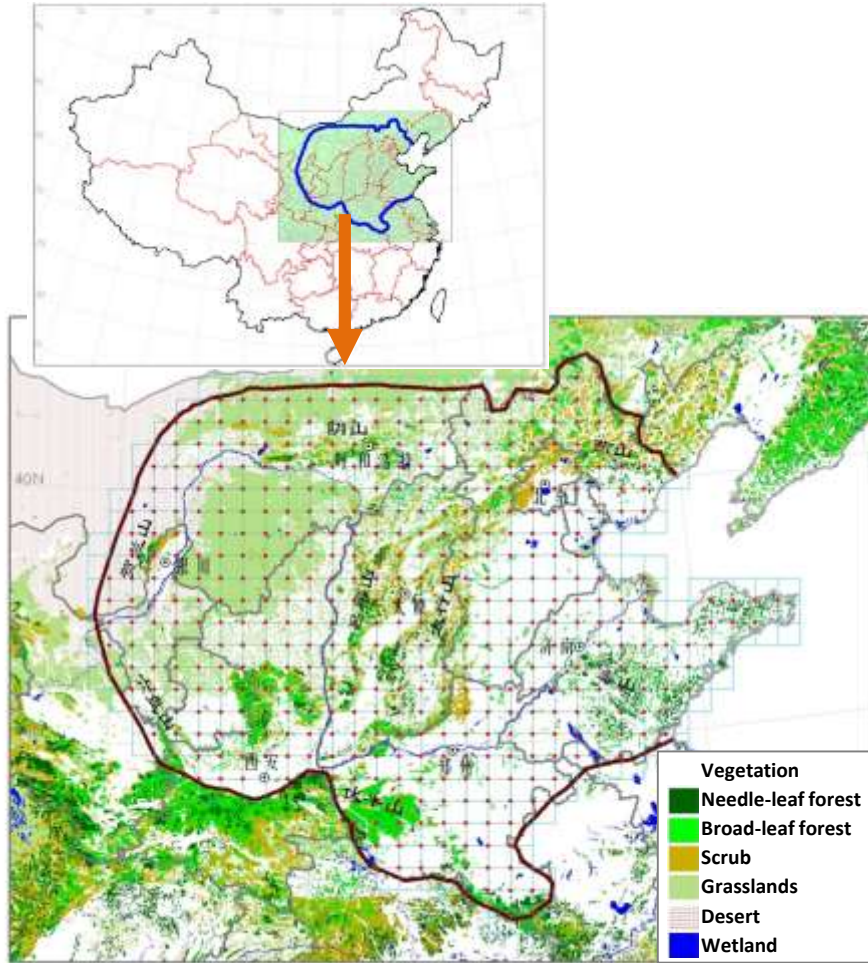
Increase in slopes of
TME with elevations



species turnover is
faster from south to
north at higher
elevations

Ongoing work

Forest community inventory in North China



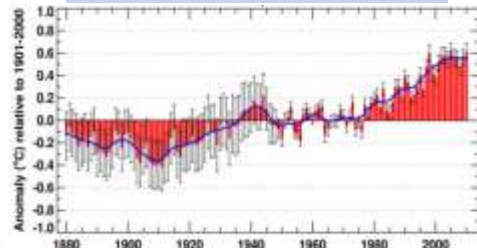
□ Permanent plots

□ Normal plots

	Permanent plots	Other plots
Size	0.1ha (20 × 50 m)	600 m ² (20 × 30 m)
Number	450-500	5500
Location	gridded	Random in all forests
Revisit	Every 5 years	

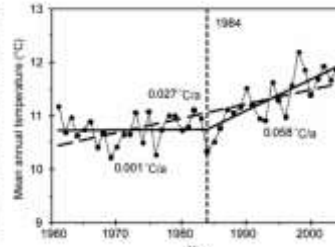
Threats of climate change on woody plant diversity

Global temperature change

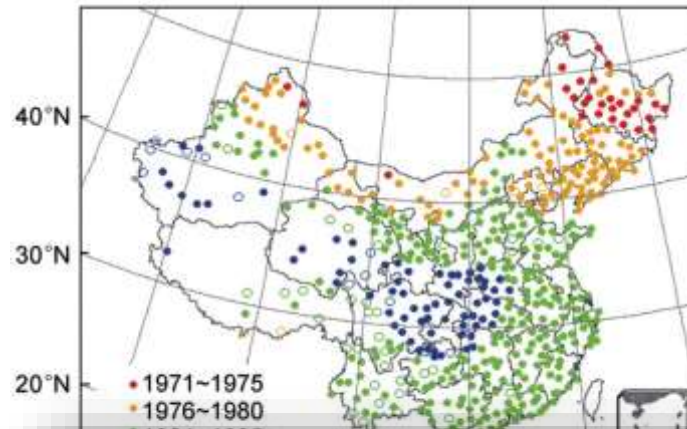


Source: National Climatic Data Center, US

China temperature change



Source: Wang et al. 2010



Musk ox

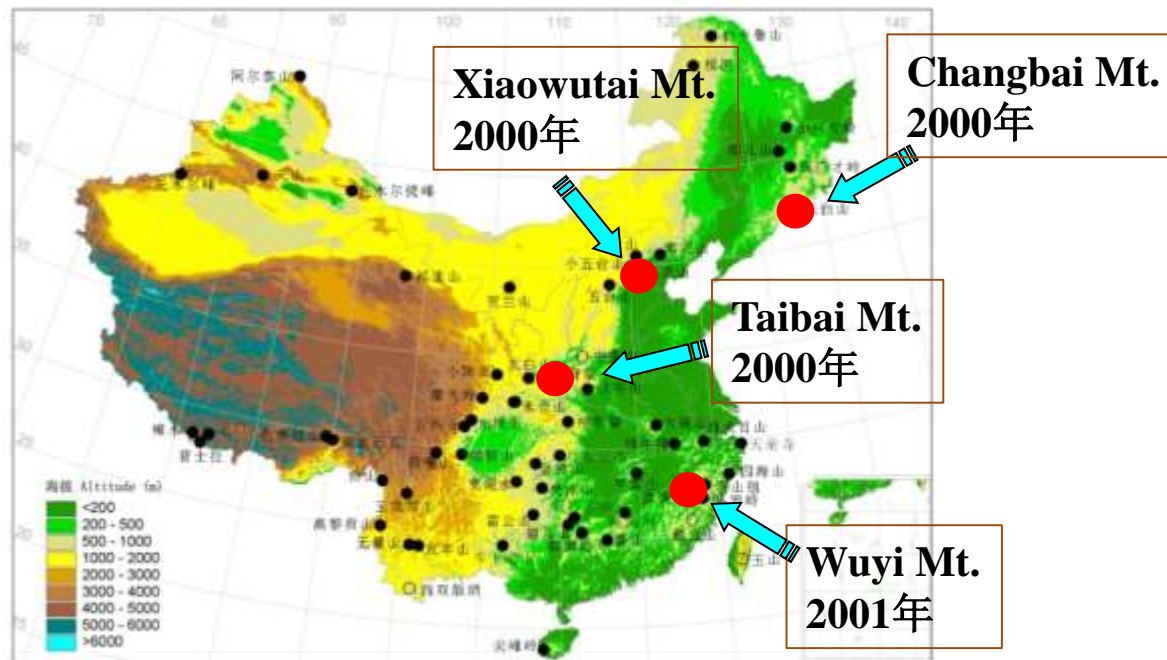


Leads to changes in habitats, growth, phenologies, distributions and migration

How climate change influences plants in China?

Forest plots in China

- 65 major mountains
- ~1600 plots (20×30 m)
- Resample 4-6 mountains
- Setup permanent plots
- Repeat the survey every 5 years



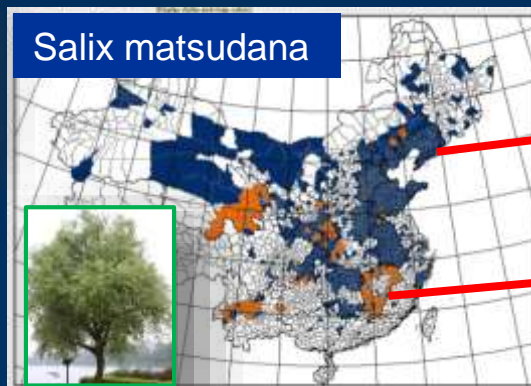
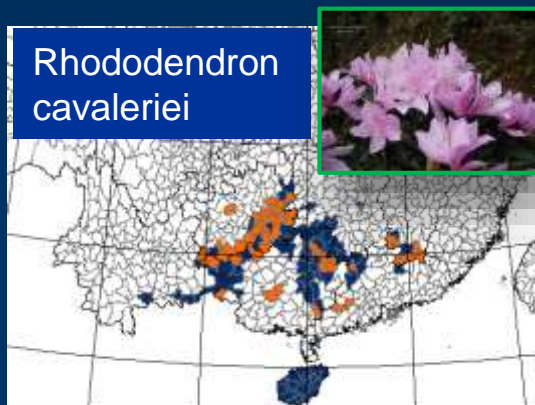


中国木本植物分布数据库

Database of China's Woody Plants

<http://www.ecology.pku.edu.cn/plants/woody/index.asp>

- From “**Database of China's Woody Plants (v2.0)**”
 - compiled from more than 320 national and provincial floras, many local floras and specimen records
 - examined by 21 local experts of plants
 - c.a. 7.5 years
 - **Taxonomy:** *Flora of China (English version)*
 - **Specimen records (~80%) + observation data (~20%)**



Specimen records

observation data



中国木本植物分布数据库

Database of China's Woody Plants

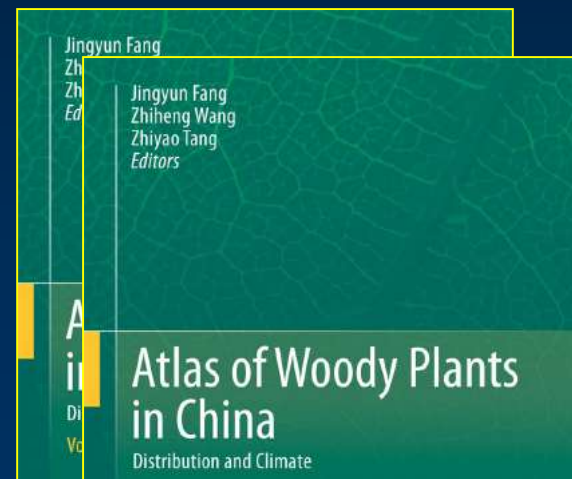
<http://www.ecology.pku.edu.cn/plants/woody/index.asp>

Taxon	Species	Genus	Family
Woody plants	11405	1176	158
Trees	3165	493	104
Shrubs	7205	796	135
Liana	1035	152	46

A software was developed to manage the database



Fang J, Wang Z, Tang Z (2011)
- Winner of the Chinese Government Award for Publishing (2011)
- 教育部自然科学一等奖 (2014)



Review



“... the first comprehensive atlas for woody plants in China”

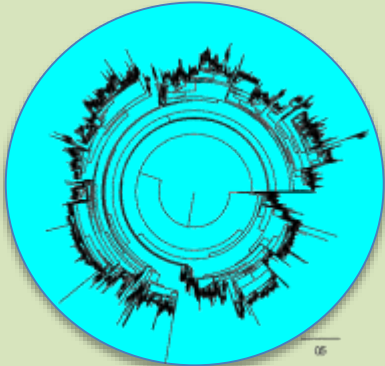
... the first comprehensive atlas for woody plants in China. Professor Fang and associates started in 2003 to collect data



Mechanisms of species assembly

Macroevolutionary data and approaches

- 8 chloroplast and nuclear genes
- 304,000 sequences
- Molecular phylogeny of **11500+** angiosperm genera



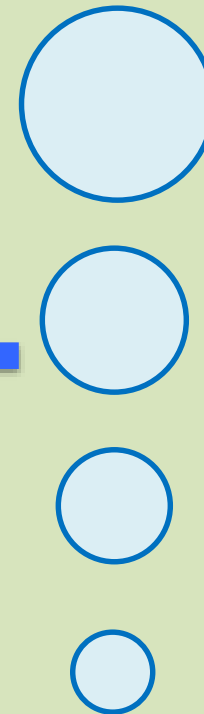
Datasets	# Genera		
	Total	Covered	%
Woody plants	1175	1044	0.89
Trees	438	410	0.94

Community and distribution data

Species assembly

Null models

Species pools



Environmental filtering
Stochastic processes
Competition

Acknowledgement

National Natural Science Foundation of China
Ministry of Science and Technology
Ministry of Education
Peking University

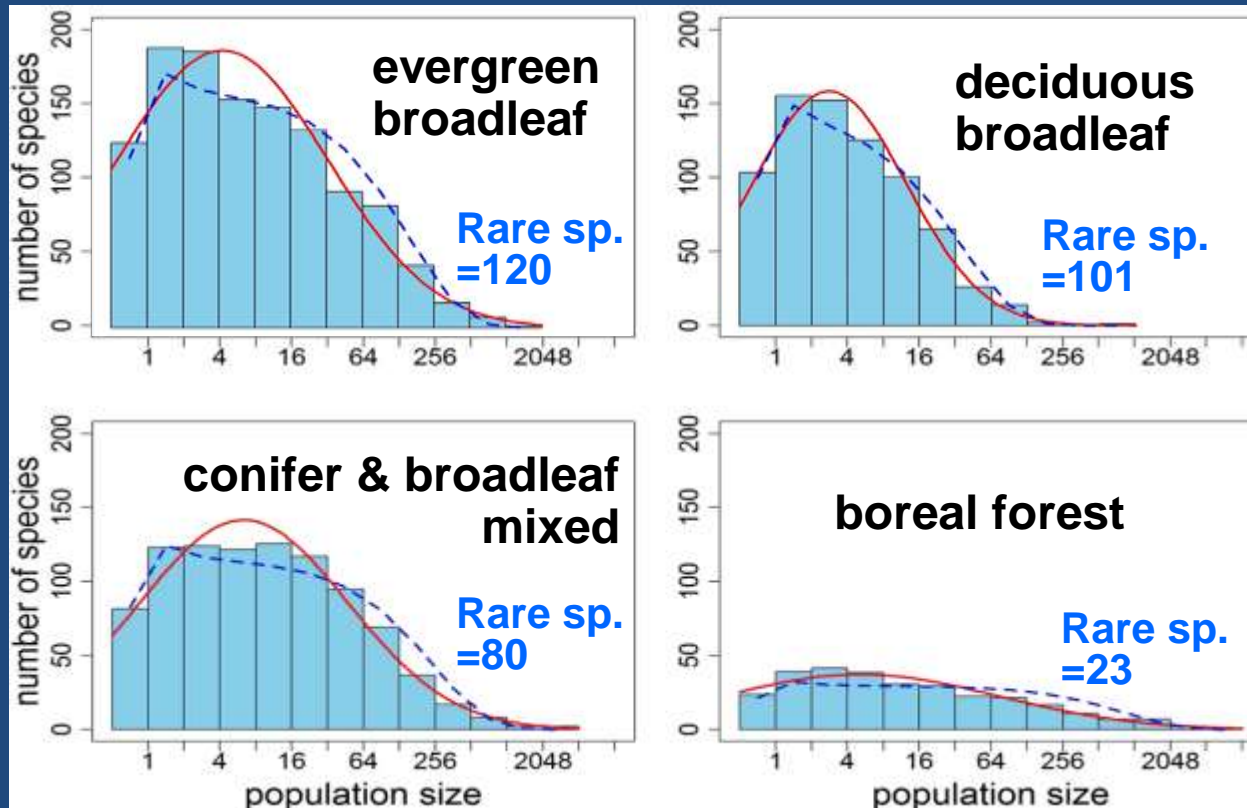


Many participants of the field survey since 1992



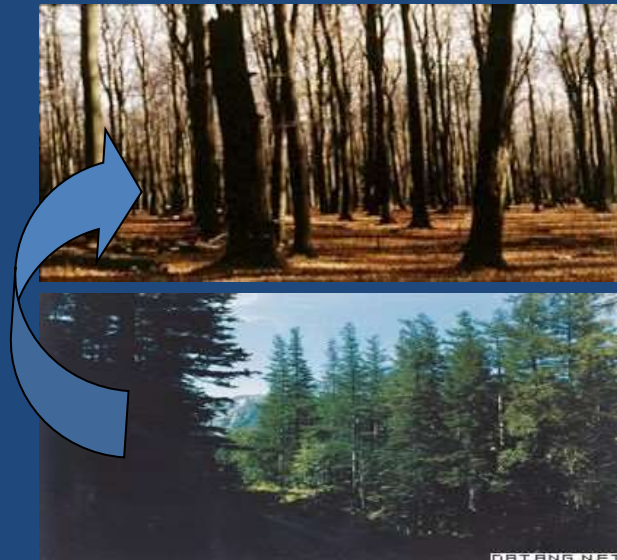
Species-abundance relationship

4 forest types: evergreen broadleaf forest, temperate deciduous broadleaf forest, temperate conifer & broadleaf mixed forest, and boreal forest



4. Patterns of species turnover (or β -diversity)

β -diversity (species turnover): difference in species composition along an environmental gradient, and is expressed as similarity of species composition (usually using **Sørensen index**).

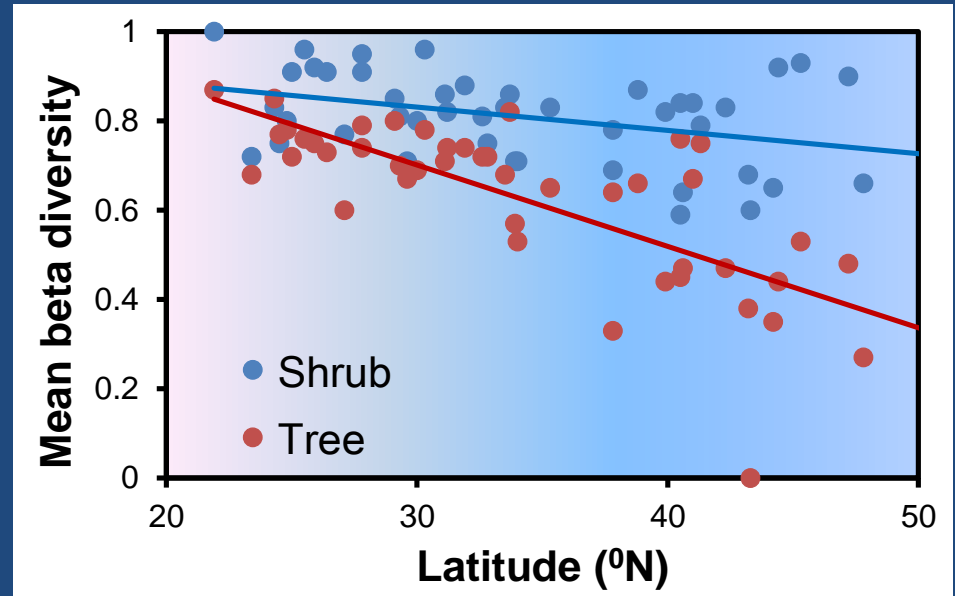


β diversity = 1 - S
(S=Sørensen);

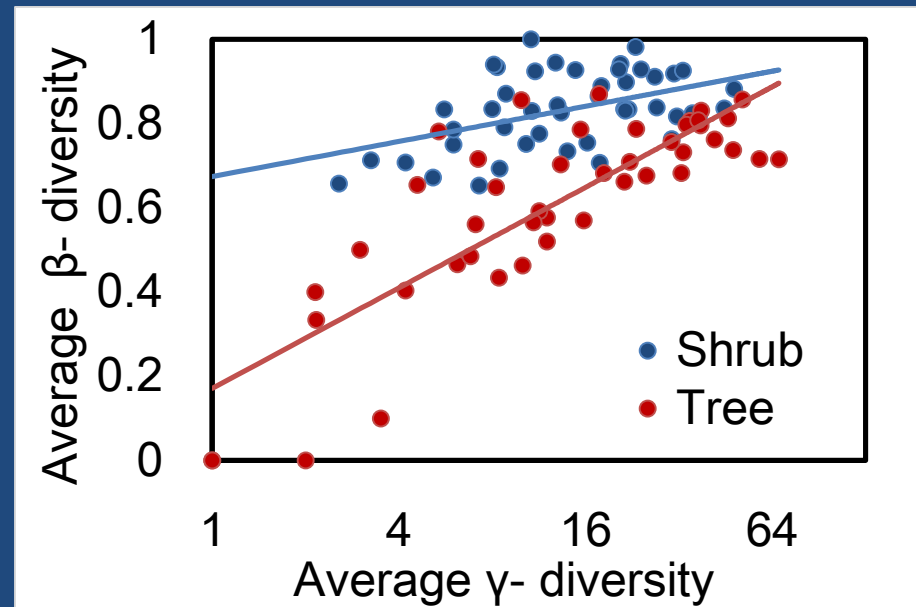
$$S = \frac{C}{(A + B) / 2} \times 100$$

Two key findings:

1. β -diversity of trees and shrubs both decreases with latitude, *i.e.*, species turnover is faster in south than in north.



2. β -diversity of trees and shrubs both increases with regional species pool, suggesting that species turnover is faster in the species-rich mountain.



Statistics of the forest structure (DBH>3cm)

Item	# Plot 样方数	Mean 均值	Range 范围	St-dev 标准差
DBH (cm)	1384	14.2	7.2-29.5	5.8
Height (m)	1113	9.9	4.5-19.9	4.0
Density (/ha)	1375	1450	383-4216	1075
Total basal area (m ² /ha)	1384	1.73	3152- 44142	1.08