The 6th International Conference on Biodiversity and Conservation

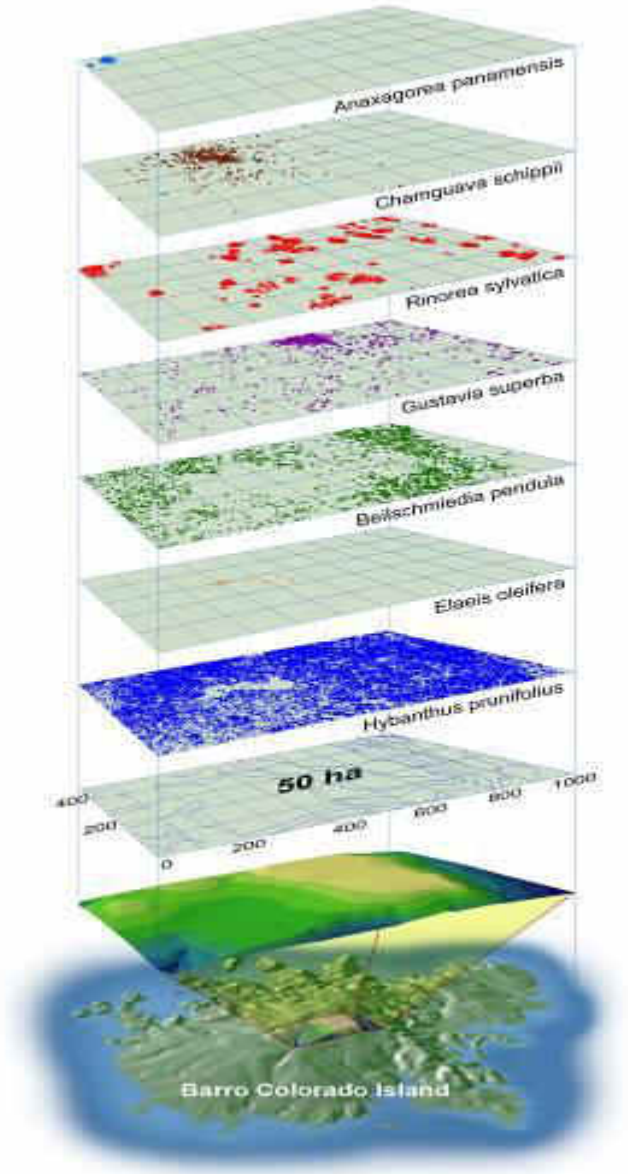
Functional and Phylogenetic temporal beta diversity in young growth and old growth forest in Northeast China --Based on Changbaishan Temperate Forest Plots

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27 Apr., 2017; Dubai, UAE

Forest Dynamics Plot

- ✓ **BCI 50ha Plot in 1980**
- ✓ **Large scale (1-50 hectares)**
- ✓ **Every free-standing stem≥1 cm DBH mapped, measured, tagged, and identified to species**
- ✓ **Entire plot recensus every 5 years**
- ✓ **Provides baseline data on natural forest dynamics**
- ✓ **Detailed information of biotic and abiotic factors**



Center for Tropical Forest Science (CTFS—GEO BON)

http://www.ctfs.si.edu



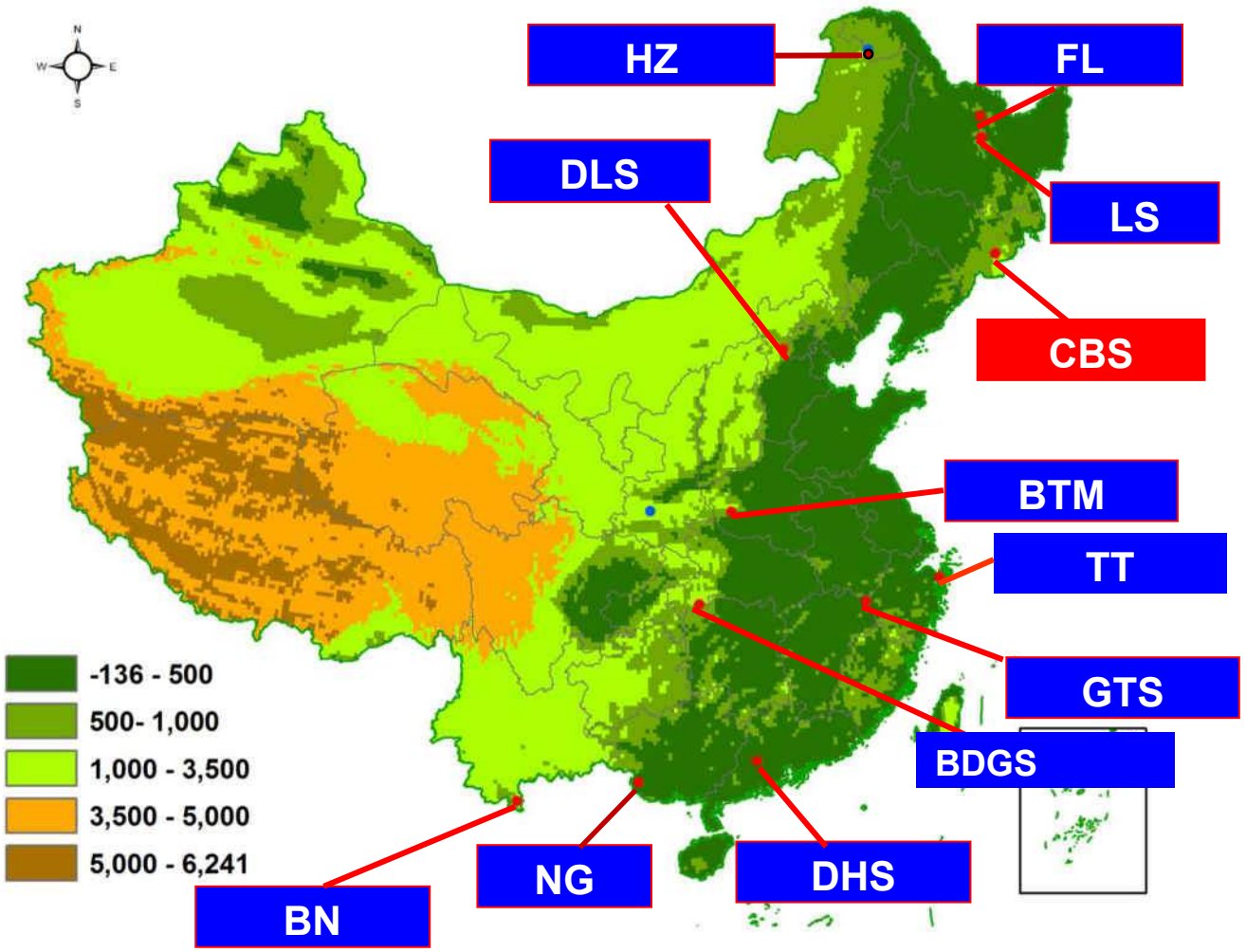
The Center for Tropical Forest Science (CTFS) is a global network of forest research plots and scientists dedicated to the study of tropical and temperate forest function and diversity.

63 Plots 24 Countries 6 Million Trees 10,000 Species

How is FDP useful for forest ecology and management?

- Provide important information for forest structure and species composition
- Ethnobotanical database
- Understanding of species habitat requirements
- Provide quantitative data for testing theories and hypothesis in population and community ecology
- Long-term demographic information for development of sustainable management plans
- Foundation for countless other research in ethnobotany, reproductive ecology, and conservation biology
- Capacity building

Chinese Forest Biodiversity Monitoring Network (CForBio)

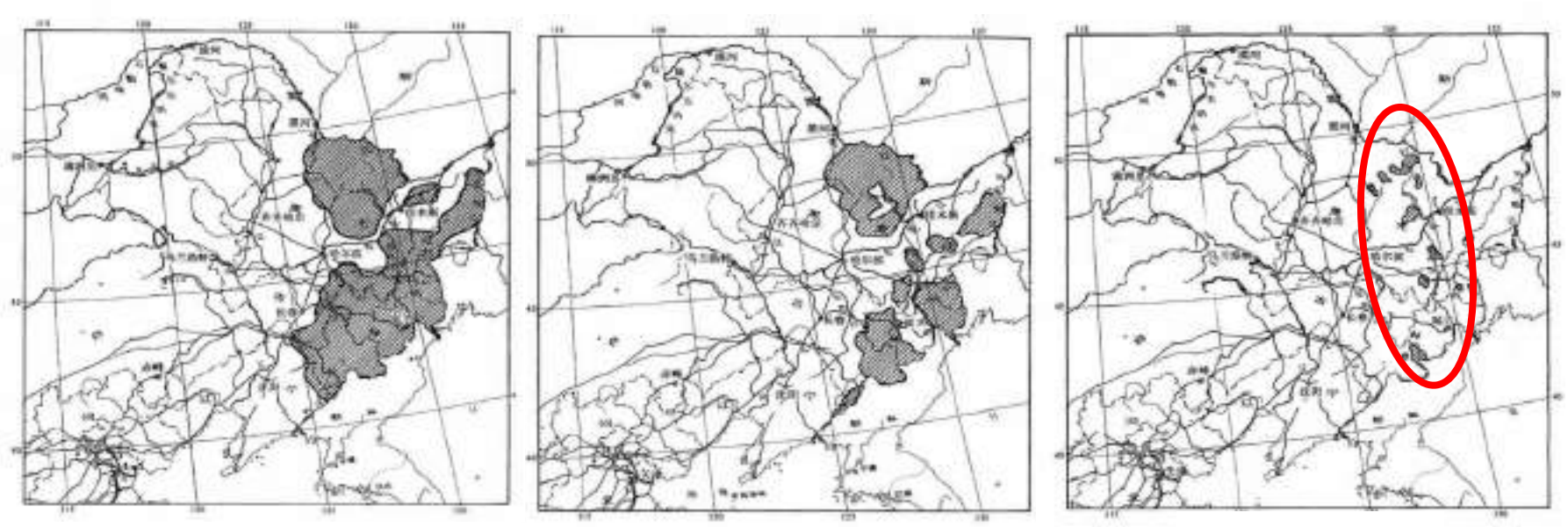


18 Plots 540 ha 2.27 Million Trees 1,737 Species

Chinese Forest Biodiversity Monitoring Network (CForBio)

Plot	Vegetation	Established	Area	latitude	Species	Ind./ha
HZ	Larix Forest	2011	25	51.8	18	8391
FL	Temperate mixed forest	2009	30	48	46	3164
LS-C	Coniferous Forest	2006	9	47.2	44	4153
LS-B	Temperate mixed forest	2005	9	47.18	48	2376
CBS	Temperate mixed forest	2004	25	42.5	52	1556
DLS	Temperate mixed forest	2010	20	40	50	2581
BTM	Subtropical evergreen forest	2010	25	33.5	122	2388
TTS	Subtropical evergreen forest	2010	20	29.8	152	4730
BDGS	Subtropical evergreen forest	2011	25	29.5	238	7462
GTS	Subtropical evergreen forest	2005	24	29	159	5862
DHS	Subtropical evergreen forest	2005	20	23.17	210	3581
NG	Tropical Karst rain forest	2011	15	22.5	217	4447
XTBG	Tropical rain forest	2007	20	21.6	468	4792

Temperate Mixed forests in Northeast China



1600-1700　　1949 Y　　1990 Y

- **Broad-leaved Korea pine mixed forests: 500,000 km^2**
- **Vascular plant 1900 species，Woody species 150 species**

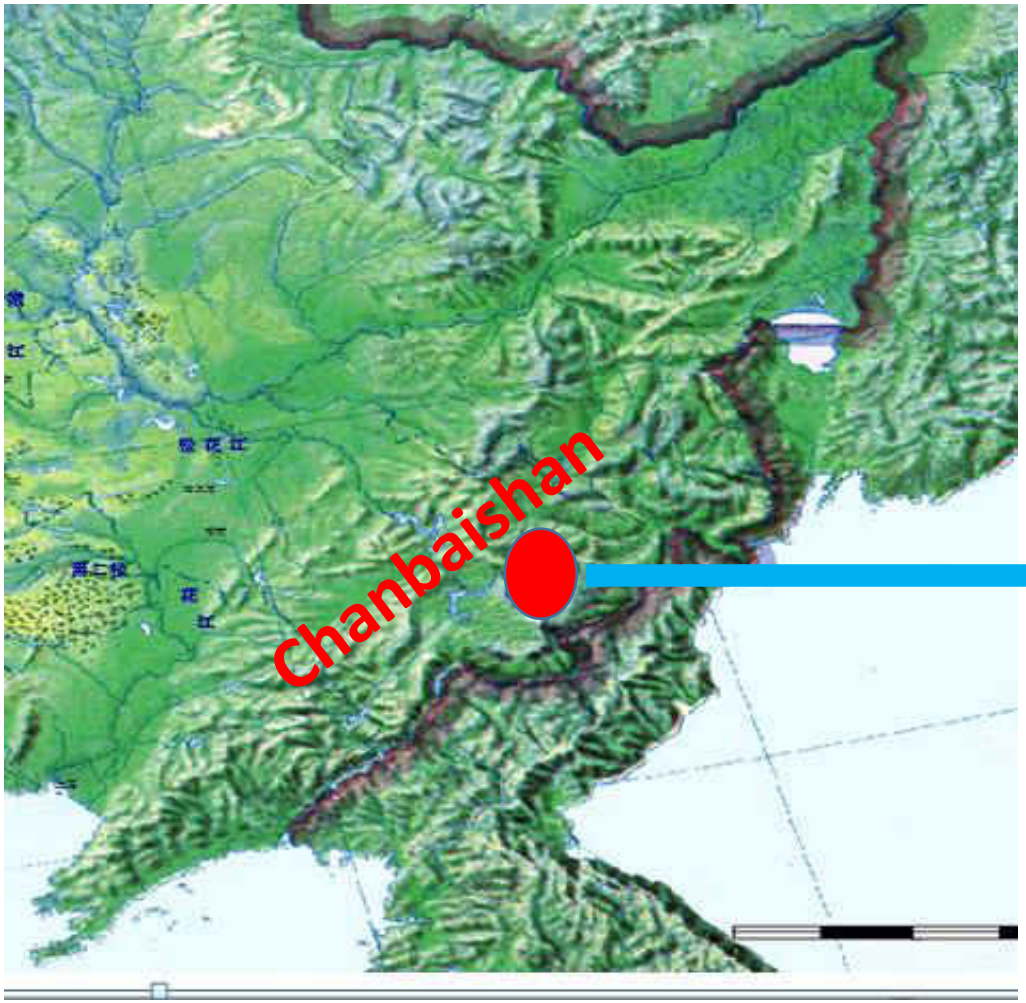


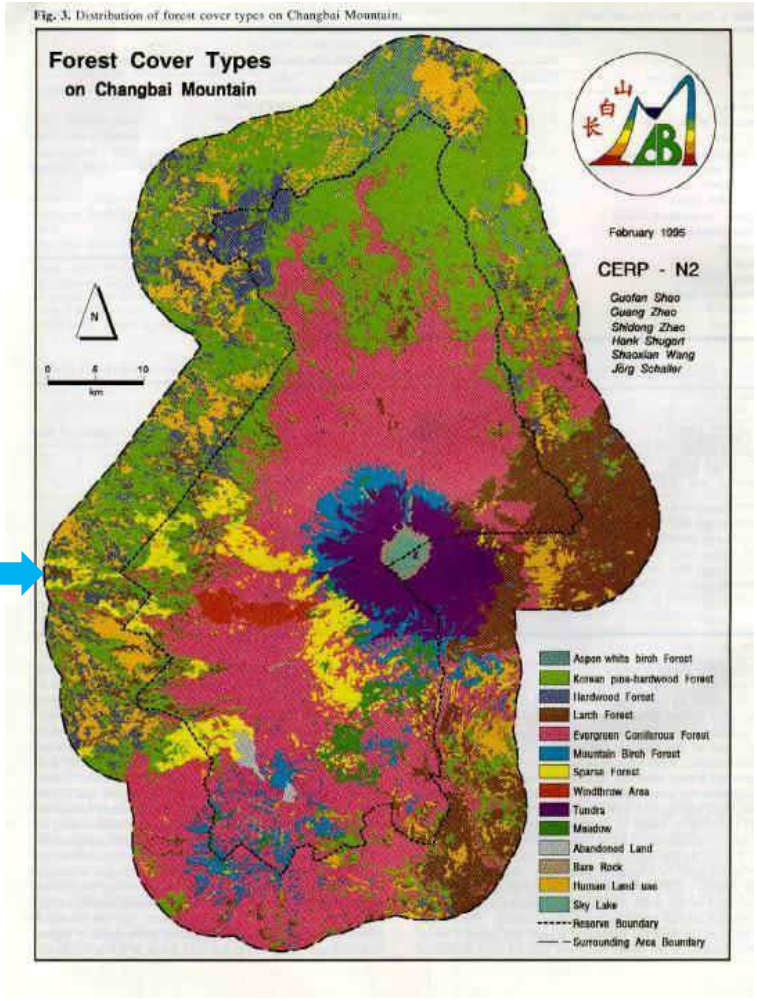




Changbaishan National Nature Reserve

196,465 ha, Established in 1960, MAB in 1979









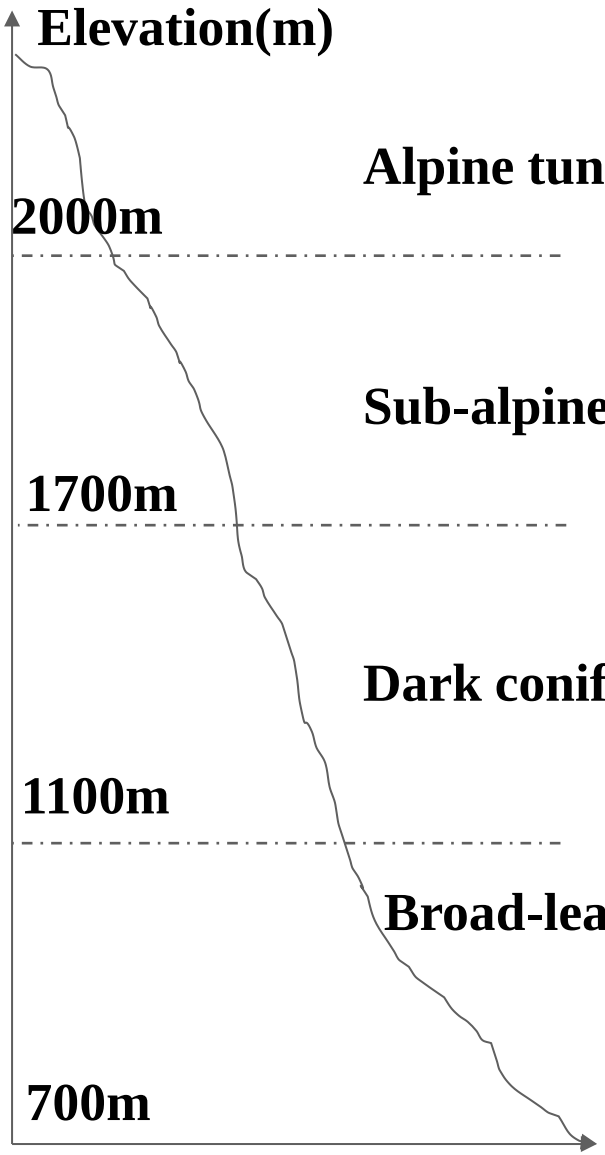

Vegetation vertical distribution zonation











Forest Monitoring Plots: Forest Type

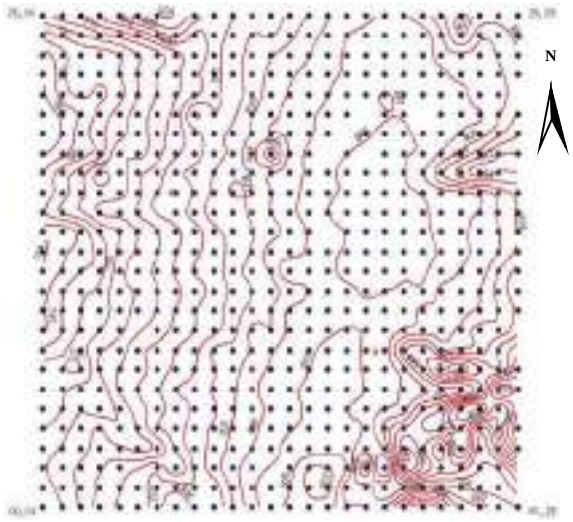
- **Broad-leaved Korean pine mixed forest**
- **Successional gradient**
  - **5 ha Secondary aspen-birch forest plot (2005; enlarged to 24 ha in 2016)**
  - **25 ha Broad-leaved Korean pine forest plot (2004）**
  - **1 ha Korean pine forest plot (2010)**
- **4 ha Spruce-fir forest (2010)**
- **4 ha Larch forest plot (2010)**



25 ha Broad-leaved Korean pine forest plot

- Species : 52 (Tree: 28; Shrub: 22; Vine: 2), 18 family, 32 genus
- Individual: ≥1cm:38902 (Stem: 59121)

  (DBH<10cm:28374; ≥10cm:10527; ≥30cm:4606; ≥50cm: 1680)
- Basal area: 43.23 m^2/ha; Mean DBH: 10.52 cm
- Elevation: 801.5m, Difference 17.7m
- Location: 42º12'N , 128º32'E
- Census: 2004, 2009, 2014







5 ha secondary aspen-birch forest plot

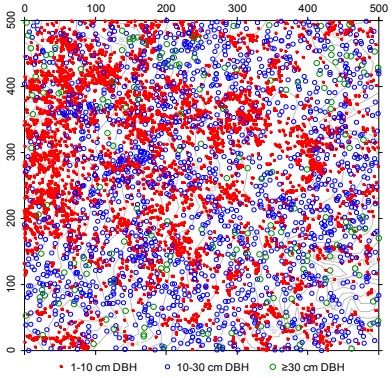
- **Area: 5 ha (200m × 250m)； Age: 80~ years**
- **Species: 44 (Tree: 26; Shrub: 18)， 16 family， 28 genus**
  35 species same to the 25 ha plot
- **Individual: ≥1cm: 16565 (Multiple-stem: 20101)**
  (DBH<10cm:12065;≥10cm:4500;≥30cm:145;≥50cm:6)
- **Basal area: 28.42 m^2/ha; Mean DBH: 7.43 cm**
- **Elevation: 796.3m, Difference 12m；**
- **Location: 42º22'N, 128º00'E**
- **Census: 2005, 2010, 2015 *(enlarged to 24 ha in 2016)***



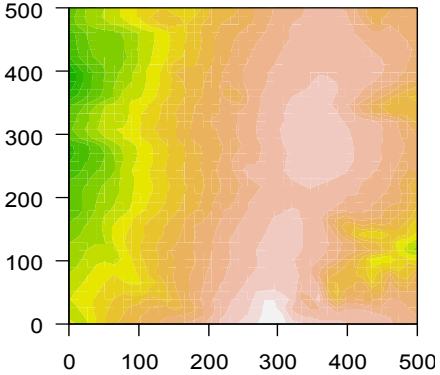
Forest Dynamics Plots in Changbaishan (CBS)

Plot	Year	Area（ha）	Lat.	Longit.	SP	Ind.	DBH（cm）	BA m^2/ha
CBS	2004	25	42°23′ N	128°05′ E	52	38092	10.52	43.23
D	2005	5	42°22′ N	128°00′ E	44	16565	7.43	28.42
L	2010	4	42°04′ N	128°14′ E	22	8640	11.92	41.13
Y	2010	4	42°09′ N	128°08′ E	22	3696	16.47	54.73
F	2010	1	42°21′ N	127°59′ E	25	1054	13.23	44.91
A	2012	0.8	40°54′ N	124°47′ E	41	1436	9.8	28.63
B	2012	0.6	41°19′ N	124°54′ E	44	1699	8.13	28.22
C	2012	0.5	41°49′ N	124°54′ E	34	978	10.73	33.37
K	2013	1	42°12′N	128°10′E	21	2345	9.46	49.31
I	2012	1	42°12′ N	128°10′ E	38	1640	10.65	40.79
H	2012	1	42°14′ N	127°52′ E	33	1946	9.81	43.31
E	2013	1	42°21′ N	126°28′ E	46	4385	4.29	24.77
J	2012	1	42°28′ N	127°51′ E	35	1150	12.72	45.94
G	2013	1	43°10′ N	126°13′ E	45	1798	8.34	26.02
M	2013	1	43°23′ N	130°09′E	34	1913	8.74	25.43
N	2013	1	44°03′ N	127°56′E	39	1548	10.63	31.97

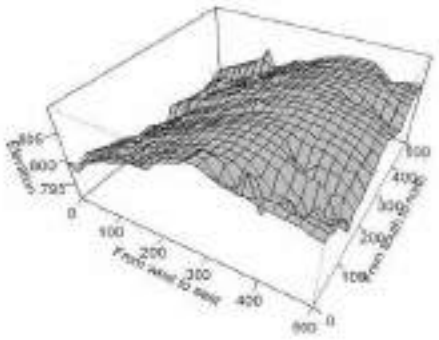
Data collection



Woody plant（dbh>1cm)



Soil



Topography



Seedling (DBH<1cm)



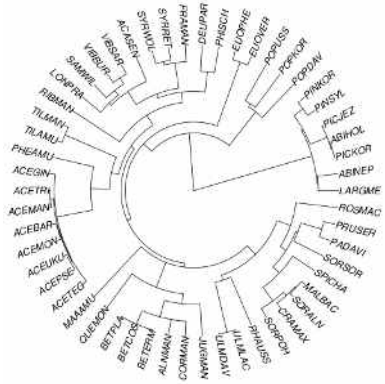
Seed and litter



Dendrometer

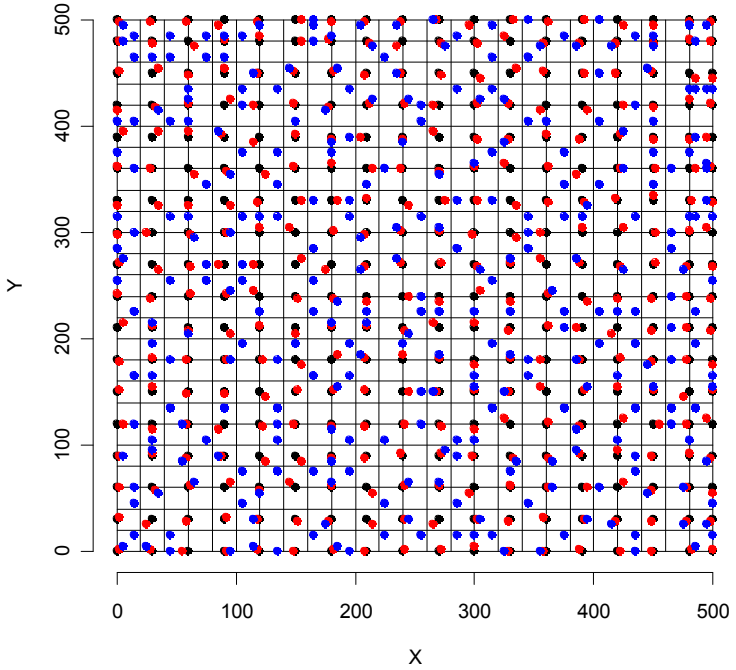


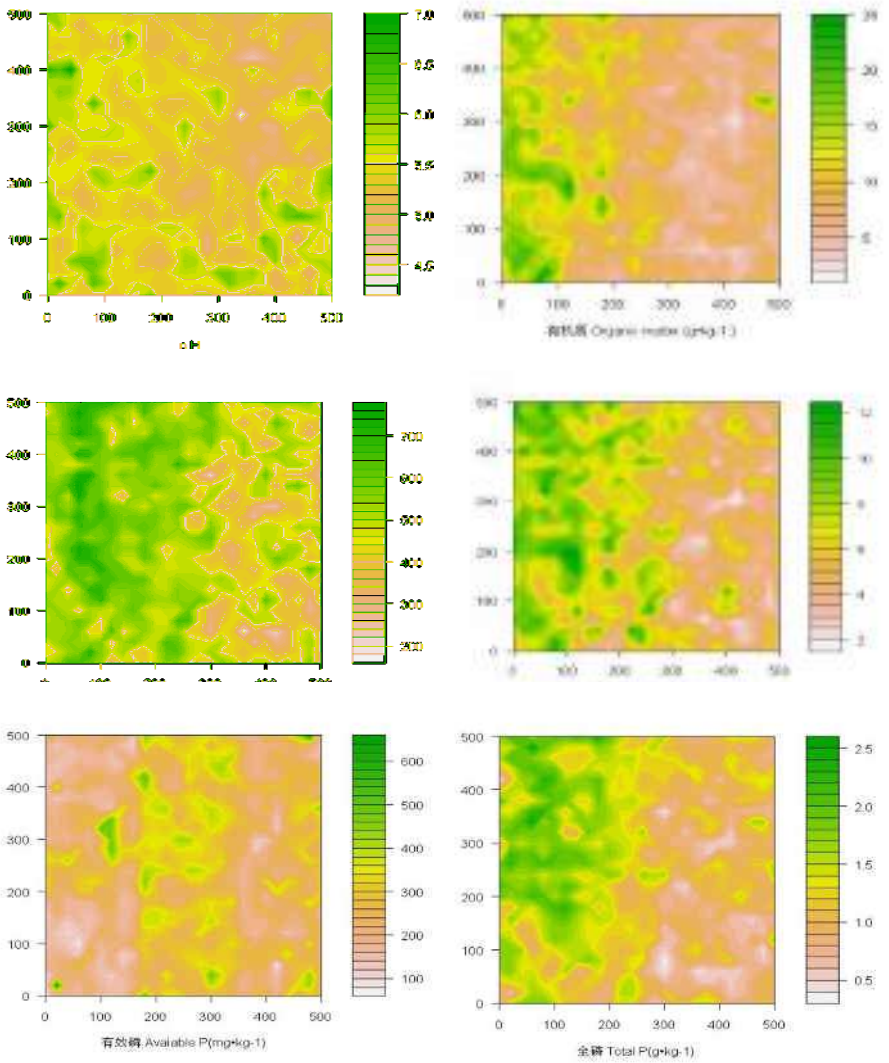
Functional traits



Phylogenetic tree

Soil mapping





Soils were sampled using a regular grid of points every 30 m. Two additional sample points at 2, 5, or 15 m were selected in a random compass direction from the grid point to capture variation in soil nutrients at finer scales. 972 points.

Seed 、 Seedling and Litter

25ha plot:

- **Seed and litter：**

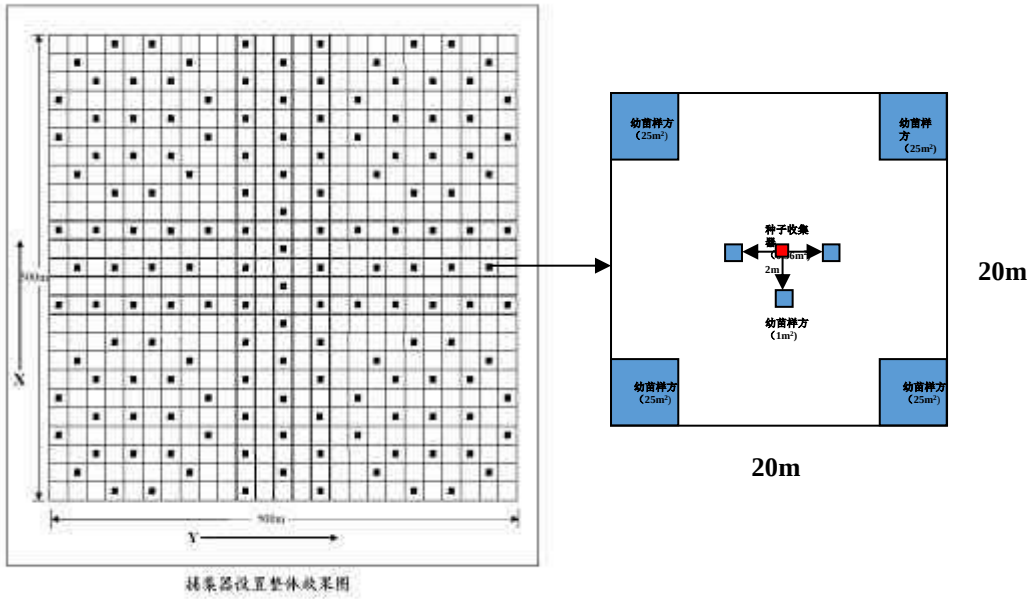
  150 traps (75cm × 75cm)

  Every 2 weeks since 2006

- **Seedling：**

  450 quadrats (1m×1m)

  600 quadarts (5m×5m)



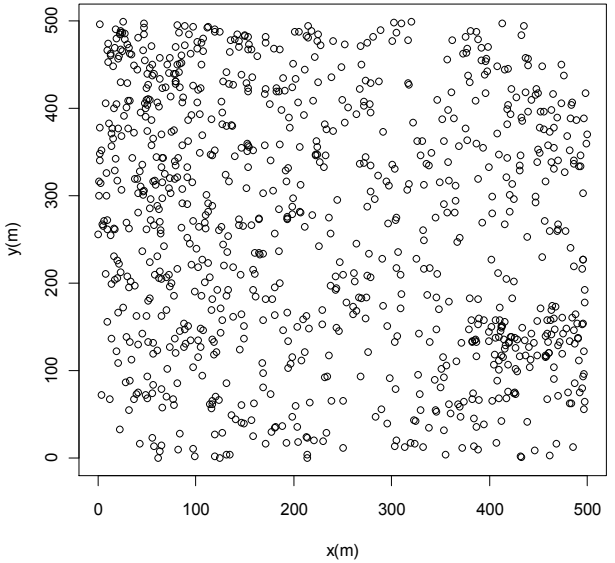
5ha plot:

- **30 traps were set up in the 5ha secondary aspen-birch forest in 2009.**



Dendrometer

- **Dendrometers were installed on 1940 trees of 30 species in 4 plots**
- **Measure once per month since 2010**





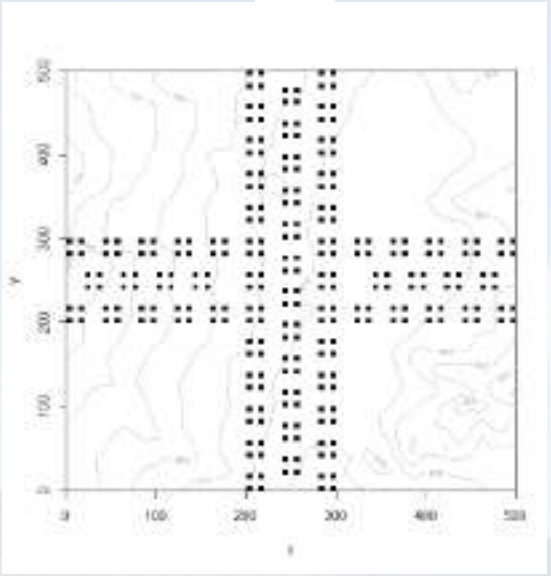


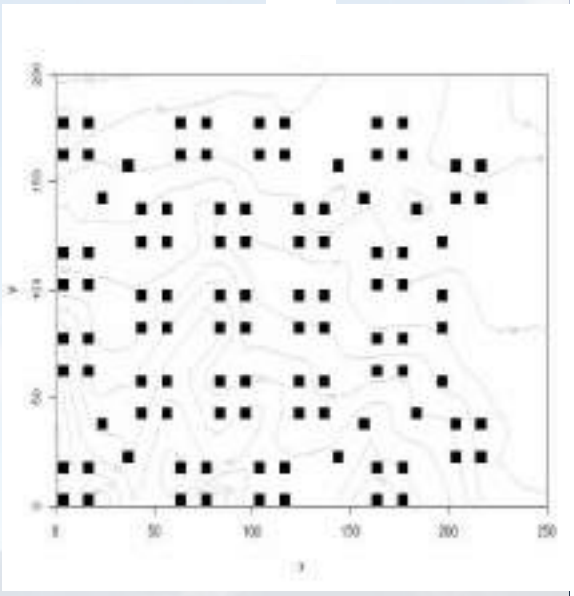


Canopy structure monitoring - Hemispherical photographs

Height: 1m
Fisher lens: FC-E8

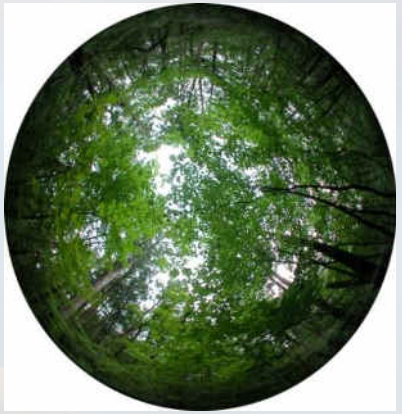












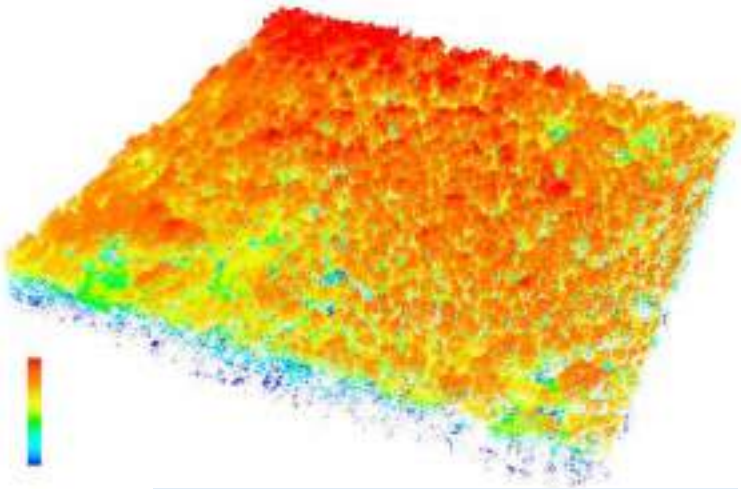


May June August October

Canopy Structure-- LiDAR



Airborne LiDAR



Canopy Surface Model



Terrestrial LiDAR



Canopy Crane

Monitoring projects

- **DBH≥1cm：15 plots, 70ha, 70 species, 100,000 trees**
- **DBH<1cm：4 plots, 800 5m×5m quadrats (2ha),50000 individuals**
- **Fallen wood and dead standing trees：40ha, measure and locate**
- **Seed and litter：including flower, fruit, seed, branch and leaf.**

  1) 25ha plot: 150 traps, census every two weeks since 2006; 2) 5ha plot: 30 traps were set up since 2009 ; 3) two 4ha plots: 20 traps since 2010.
- **Dendrometer：4 plots, 30 species, 1443 trees**
- **Functional traits：60 species; leaf, seed and wood density**
- **Soil mapping：20 factors-soil bulk, moisture, pH, density, total C, total N, total P, total K, available N, available P, available K, etc.**
- **DNA barcodes: 70 species were obtained to construct a robust community phylogeny in 2010 and 2011.**
- **Canopy Structure-- LiDAR**







The research progress: publications

- ✓ **Vertical structure and spatial associations** *(For. Ecol. Manage. 2007; Basic and Applied Ecology, 2011)*
- ✓ **Co-occurrence patterns** *(For. Ecol. Manage., 2009)*
- ✓ **Spatial pattern and association** *(Acta Oecologica, 2008; Can.J. of For. Res., 2010; Oikos,2011; J. of Ecology, 2011)*
- ✓ **Spatial variation** *(Ecol. Res., 2008; Acta Oecologica, 2010)*
- ✓ **Tree size distribution** *(Oikos, 2009; J. of plant Ecology, 2014)*
- ✓ **Habitat heterogeneity** *(Geoderma, 2013)*
- ✓ **Soil elemental stoichiometry** *(Plant & Soil, 2016)*
- ✓ **Density dependence** *(Annals of Forest Science, 2009)*
- ✓ **Species Association** *(J. of Ecology, 2010; Ecology, 2013)*
- ✓ **Seed dispersal and regeneration** *(Plos One, 2011; Oecologica, 2012;JVS, 2017)*
- ✓ **Phylogenetic and functional diversity** *(Geography, 2013; Glob. Ecol. Biogeogr. 2014, Ecology, 2015)*
- ✓ **Stochastic dilution effects** *(Ecology, 2016)*
- ✓ **Productivity and bioversioty** *(Acta Oecologica,2016; Oecologica, 2016)*

Patterns, dynamics and maintenance mechanisms of woody species in temperate forests

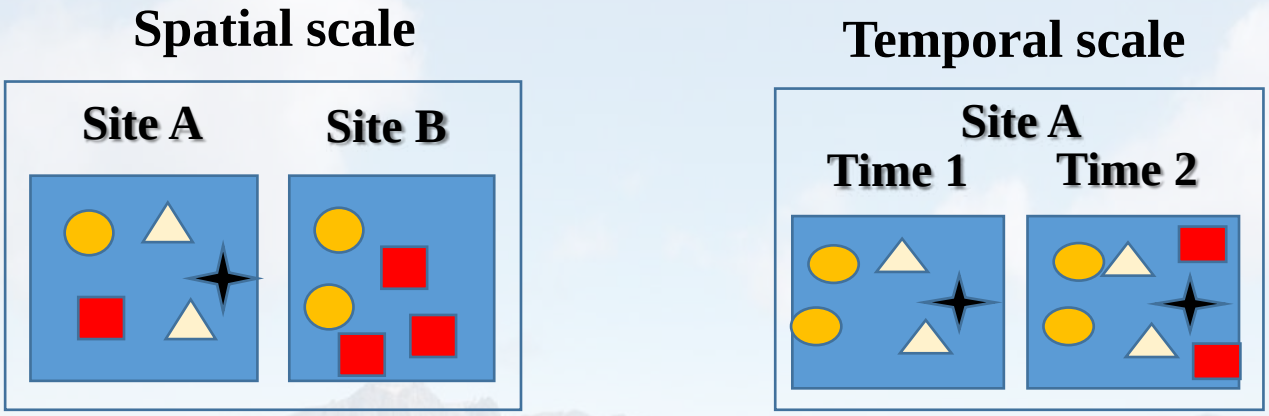
Functional and Phylogenetic temporal beta diversity in young growth and old growth forest





Community beta diversity: scale issue

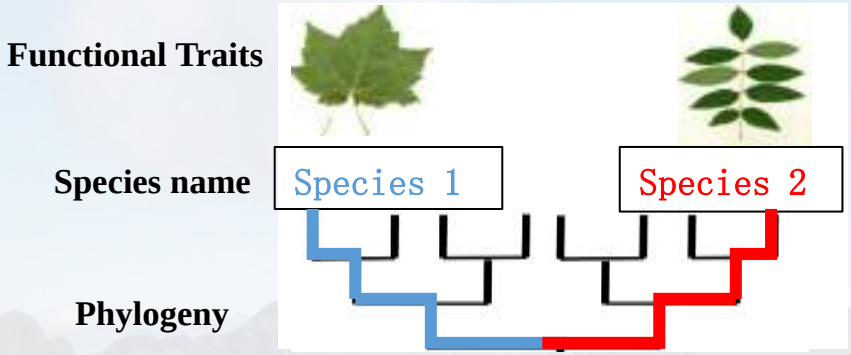
- Community composition can be different across spatial and temporal scale.

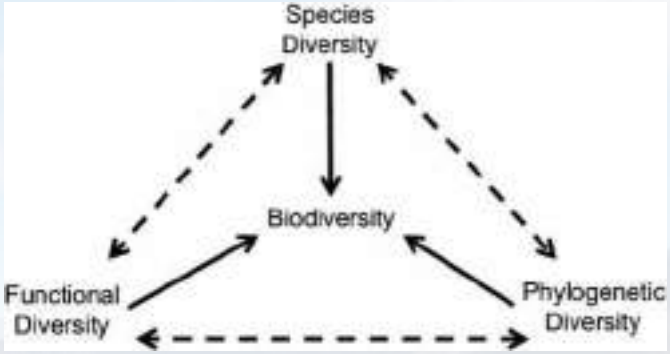


- **Beta diversity:** The quantification of community composition difference
- Most community beta diversity researches focused on spatial scale
  - Metrics of beta diversity(Anderson et al., 2006; Chao et al., 2010; Baselga 2010; Cardoso et al., 2014)
  - Pattern of beta diversity(Dungan *et al*., 2002;Legendre et al., 2005; Swenson et al., 2012)
  - Mechanism underlying beta diversity(Hewitt wt al., 2005; Myers et al., 2013; Wang et al., 2015)
- Research focus on temporal beta diversity can describe the dynamic properties of communities

Community beta diversity: similarity issue

- **Species name** was widely used to quantify species similarity
- However, every species had their specific characters(**Functional traits**) and evolutionary history(**Phylogeny**)





Difference among three beta diversity facets

	Community 1				Community 2				Beta diversity
Species	Sp1	Sp2	Sp3	Sp4	Sp5	Sp6	Sp7	Sp8	8
Trait									0.8
Phylogeny									80

* How functional and phylogenetic beta diversity will be, especially for **temporal** beta diversity?

Community beta diversity: stage issue

- **Composition temporal beta diversity can be significantly influenced by dominate process (Huang et al. 2013; Wang et al. 2013)**
- **The dominate process can vary with successional and ontogenetic stages**

Successional stage

100 YEARS Journal of Ecology

Journal of Ecology 2013, 101, 857–866 doi: 10.1111/1365-2745.12098

Contrasting changes in taxonomic, phylogenetic and functional diversity during a long-term succession: insights into assembly processes

Oliver Purschke[1,2,3,4*], Barbara C. Schmid[1,2], Martin T. Sykes[1], Peter Poschlod[5], Stefan G. Michalski[5], Walter Durka[6], Ingolf Kühn[6], Marten Winter[3,6] and Honor C. Prentice[2]

has been predicted theoretically. Trait-mediated filtering plays an important role in community assembly during the early and early-mid stages of arable-to-grassland succession whereas the relative importance of competitive exclusion increases towards late succession. Phylogenetic diversity, often used as a proxy of functional diversity (Winter, Devictor & Schweiger 2012), did not contribute to inferences

Ontogenetic stage

Ontogenetic shifts in trait-mediated mechanisms of plant community assembly

Jesse R. Lasky ✉, Bénédicte Bachelot, Robert Muscarella, Naomi Schwartz, Jimena Forero-Montaña,



2007). Our findings suggest that local niche partitioning may also play a major role in community dynamics for large trees. Long-term forest plots are essential systems for understanding ontogenetic change and community assembly because ontogenetic environment shifts (e.g., light environments) are dramatic and individuals can be followed across ontogeny. Our approach to identifying

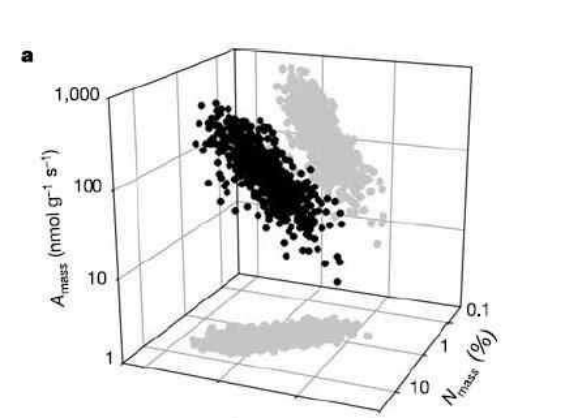
How functional and phylogenetic temporal beta diversity will be at different successional stages and ontogenetic stages (size classes)?

Community beta diversity: trait dimensionality issue

- **Functional traits can characterized different life history strategies.**
- **Trait dimension: Strong correlation among functional traits**

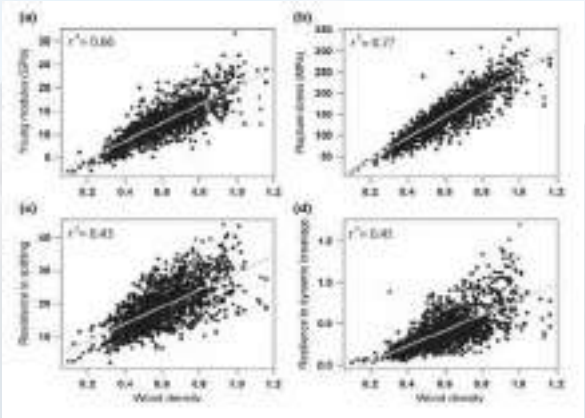
Trait dimension for different plant organ

Leaf economic spectrum



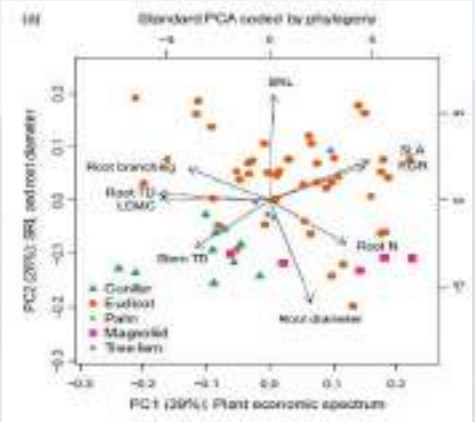
Wright et al. 2004

Wood economic spectrum



Chave et al. 2009

Root economic spectrum



Kramer-Walter et al. 2009

How functional temporal beta diversity of different trait dimensions will be at different successional stages and size classes?

Questions

1. How functional and phylogenetic temporal beta diversity will be at different successional stages and size classes?
2. How environmental factors influence functional and phylogenetic temporal beta diversity at different successional stages and size classes?
3. How functional temporal beta diversity of different trait dimensions will be at different successional stages and size classes?

Study sites

5ha secondary aspen-birch forest plot

Location: 42°22'N, 128°00'E

Elevation: Mean 796 .3m, Difference 12m

Area: 5 ha (250×200m);

Age: ~80 year

25ha Temperate Korean pine broadleaved mixed forest Plot

Location: 42°12'N , 128°32'E

Elevation: Mean 801.5m, Difference 17.7m

Area: 25 ha (500×500m);

Age: ~300 year





	Year	Species	Individuals (ha^{-1})	Death (ha^{-1})	Recruitment (ha^{-1})
25 ha Old Growth Forest Plot	2004	52	1469	137	68
	2009	51	1402		
	2014	52	1383	109	135
5 ha Young Growth Forest Plot	2005	53	3309	365	127
	2010	50	3066		
	2015	54	3129	405	468

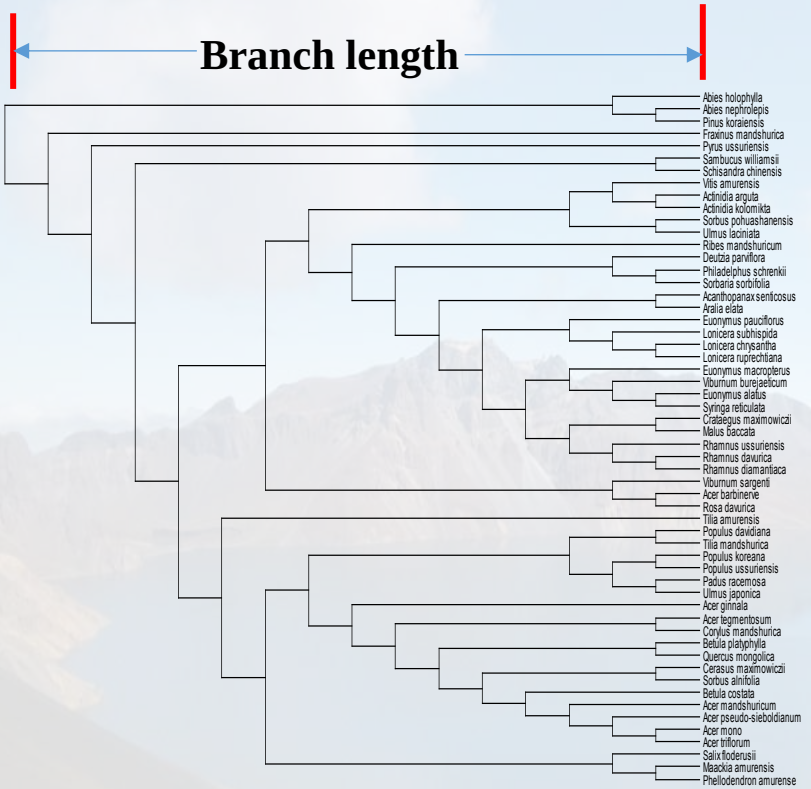
Functional trait data

14 species level functional traits for 66 species in both forest plots

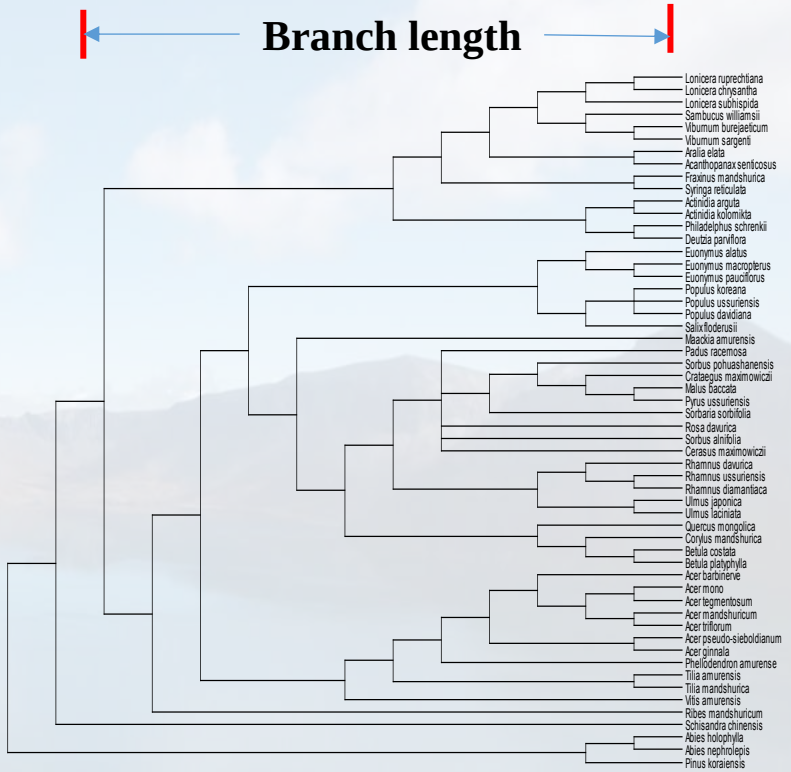
Functional Trait	Abbreviation	Unit	Group
Leaf Dry Matter Content	LDMC	%	leaf
Specific leaf area	SLA	cm^2/g	Leaf
Leaf Area	LA	cm^2	Leaf
Leaf Carbon Content	LCC	mg/g	Leaf
Leaf Nitrogen Content	LNC	mg/g	Leaf
Leaf Phosphorus Content	LPC	µg/g	Leaf
Leaf Potassium Content	LKC	µg/g	Leaf
Foliar δ15N composition	L15N	‰	Leaf
Foliar δ13C composition	L13C	‰	Leaf
Bark Thickness	BT	mm	Wood
Wood Density	WD	g/cm^3	Wood
Specific Root Length	SRL	cm/g	Root
Root Diameter	RD	mm	Root
Maximum Height	MH	m	Whole plant

Functional and phylogenetic similarity

Functional trait dendrogram



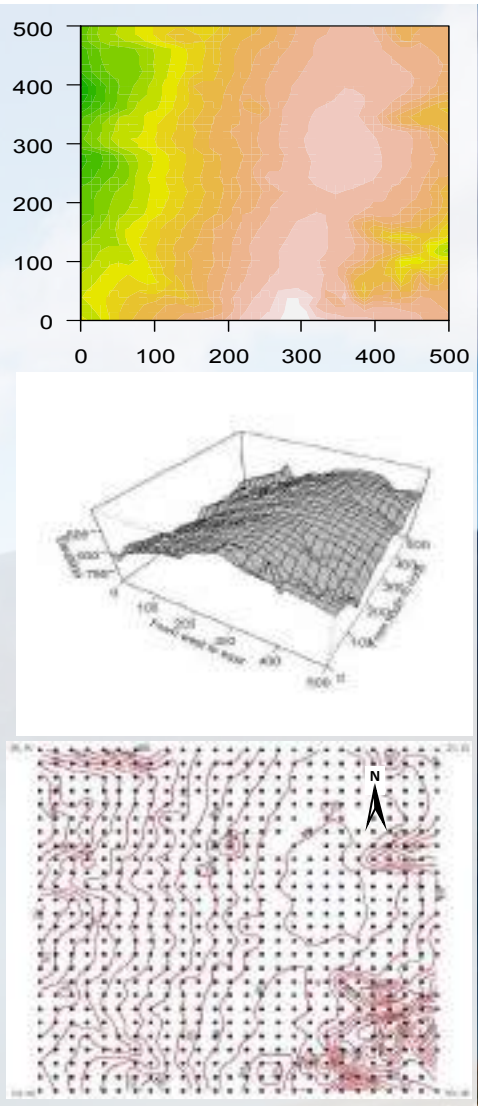
Phylogenetic tree



- **The branch length difference between two species represent functional or phylogenetic similarity**

Abiotic and biotic factors

Variables	Description	Potential process
Abiotic factors		
Soil PC1; Soil PC2	The first two PCA axis of soil factors	Habitat effect
Elevation	Mean elevation	
Aspect	Mean aspect	
Slope	Mean slope	
Biotic factors		
BA	Species basal area (cm^2)	Species interaction
SR	Species richness	
SD	Numbers of tree stems per m^2	



◆All factors were calculated for 20m×20m quadrat

Q1: Functional and phylogenetic temporal beta diversity

Data Analysis

✓**20m×20m quadrats**

✓**Size class: small tree(DBH<10cm) and large tree(DBH≥10cm)**

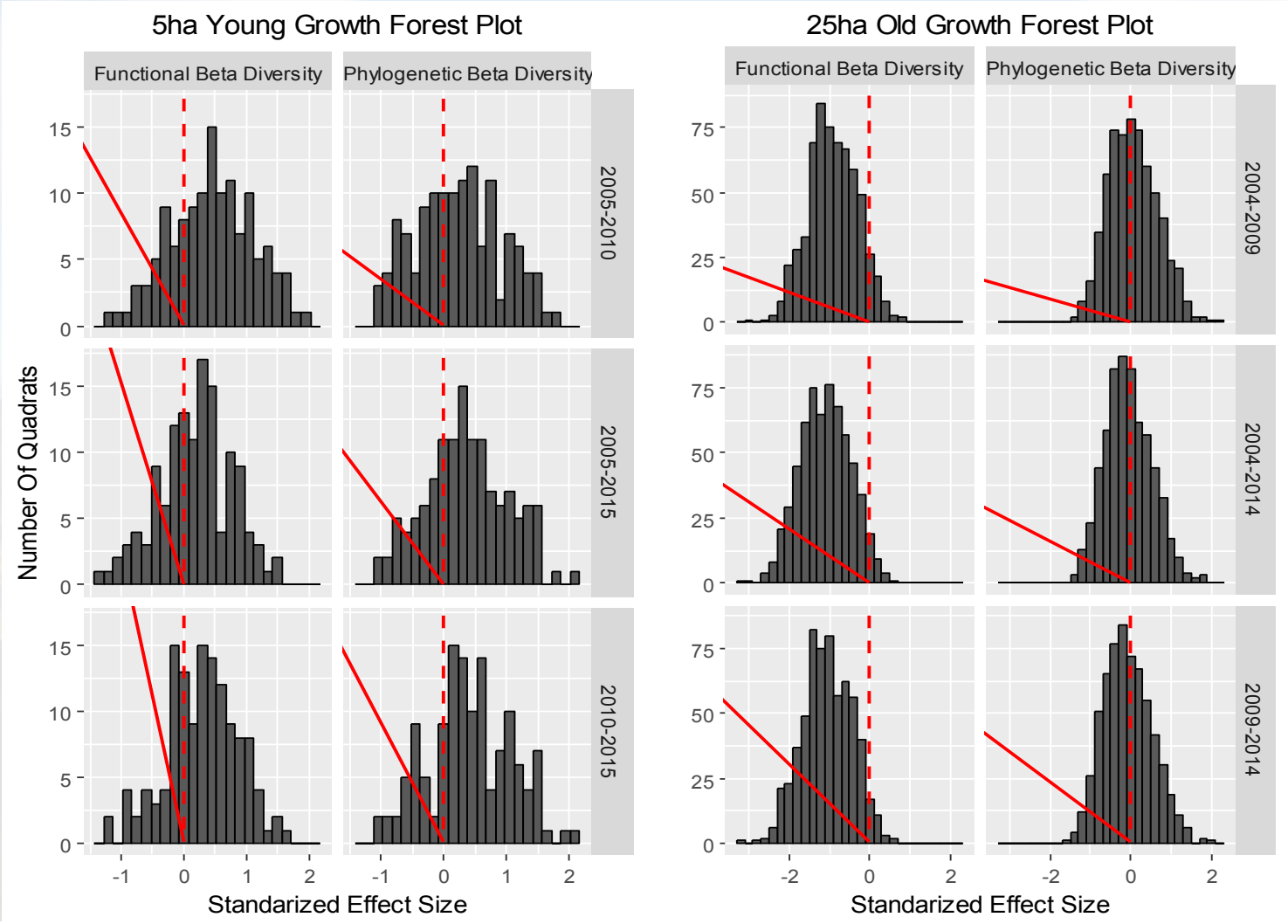
✓**Temporal beta diversity**

- Abundance-weighted Dpw based on null model comparison
- SES.Dpw < 0, composition constrained
- SES.Dpw > 0, composition dynamic change

$$SES.Dpw = \frac{Dpw_{observed} - mean(Dpw_{null})}{sd(Dpw_{null})}$$

Functional and phylogenetic temporal beta diversity: Nonrandom pattern

- ✓ **Functional and phylogenetic temporal beta diversity were almost nonrandom at two successional stages**



Functional and phylogenetic temporal beta diversity: Nonrandom pattern

✓ **Nonrandom pattern also found across size classes at two successional stages**

Young growth forest plot

✓**Small trees**

- Dynamic changing

✓**Large trees**

- Mismatch between beta diversities

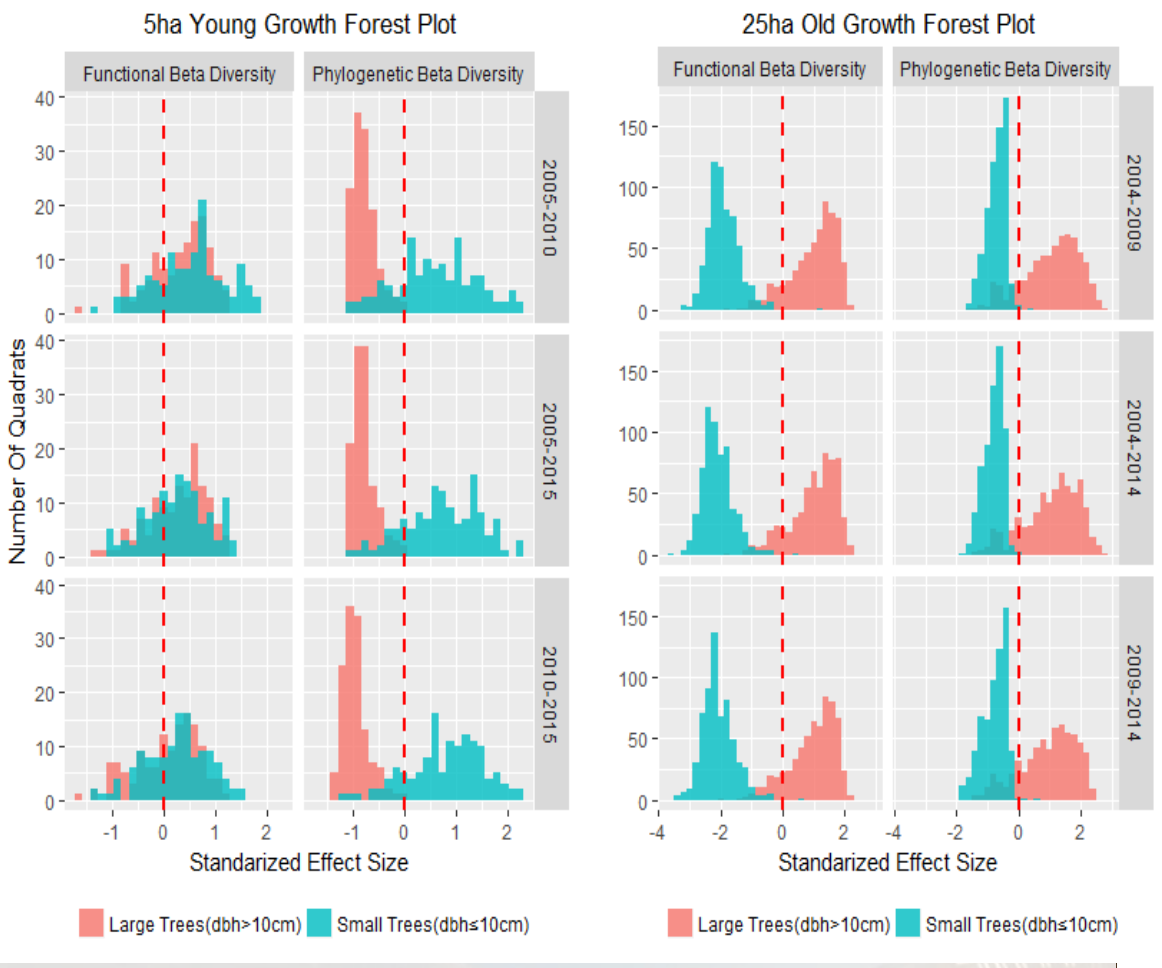
Old growth forest plot

✓**Small trees**

- Constrained

✓**Large trees**

- Dynamic changing



Q2: Relative influence of local environmental factors

Data Analysis

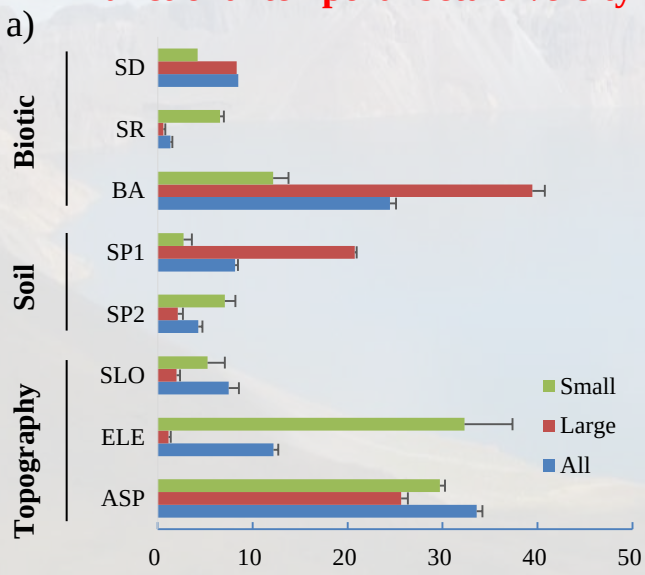
- ✓ **Boosted Regression Tree (BRT) methods**
- ✓ **Relative influence of factors were estimated by 50 repeated BRT models**
- ✓ **All analysis repeated for each size class at two successional stages**

Relative influence of local environmental factors

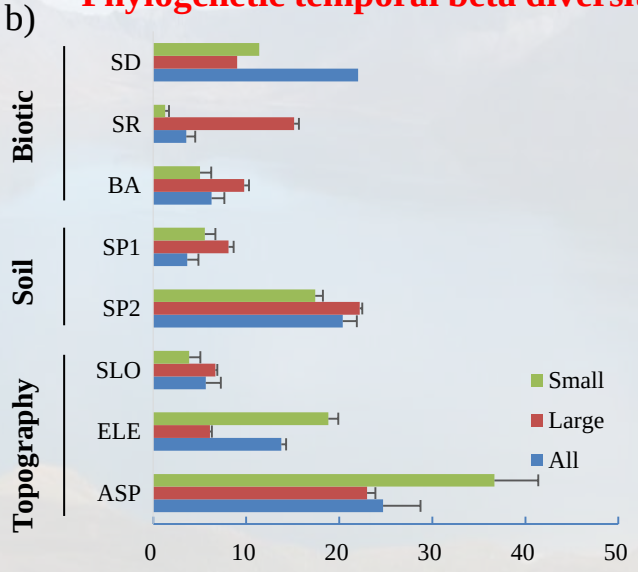
Young Growth Forest Plot

- ✓ **All trees**
  - **Topographic factors were most important for both temporal beta diversity**
- ✓ **Large and small trees**
  - **Topographic factors were more important for small trees**
  - **Biotic factors had more relative influence for large trees**

Functional temporal beta diversity



Phylogenetic temporal beta diversity

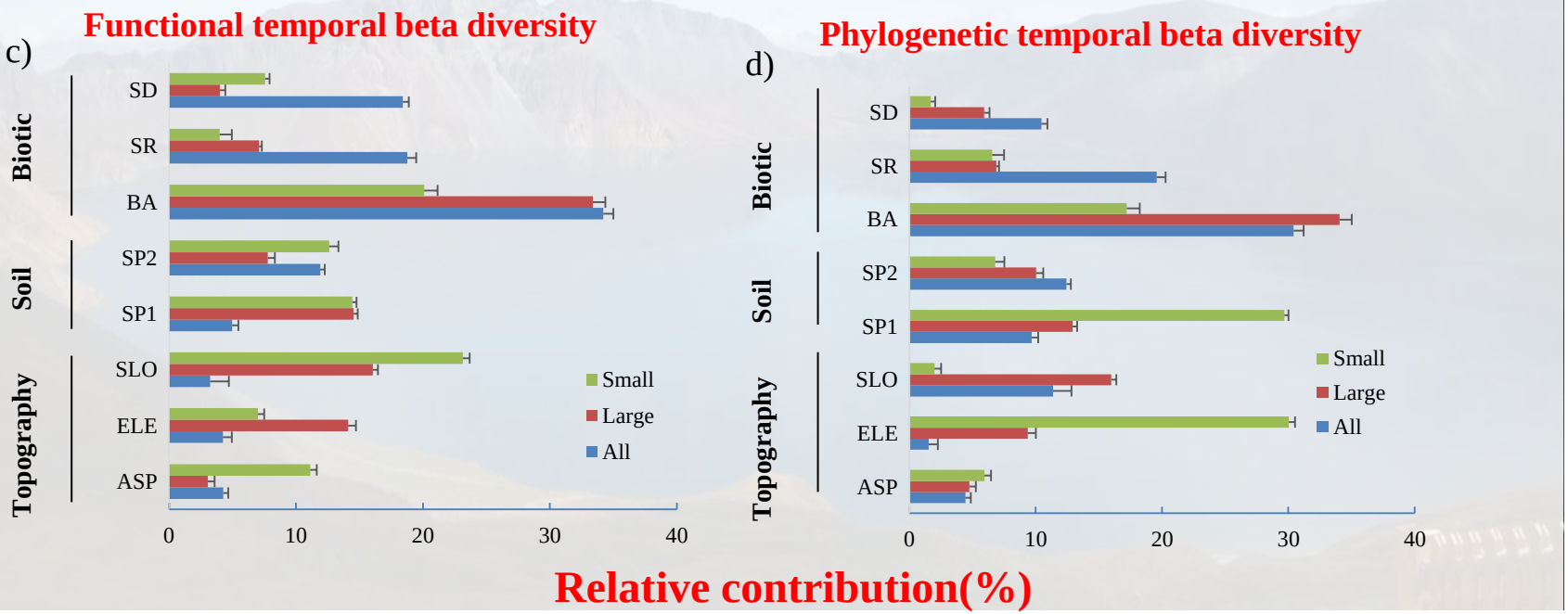


Relative contribution(%)

Relative influence of local environmental factors

Old Growth Forest Plot

- ✓ **All trees**
  - **Biotic factors (especially for basal area) had highest relative importance**
- ✓ **Large and small trees**
  - **Dominate factors were similar with those in young growth forest plot**
  - **Factors changed from topographic to biotic with the increasing of size classes**



Q3: Temporal beta diversity based on different trait dimensions

Data analysis

✓**Trait dimension**

- PCA with rotation for all traits
- Each components represent one trait dimension

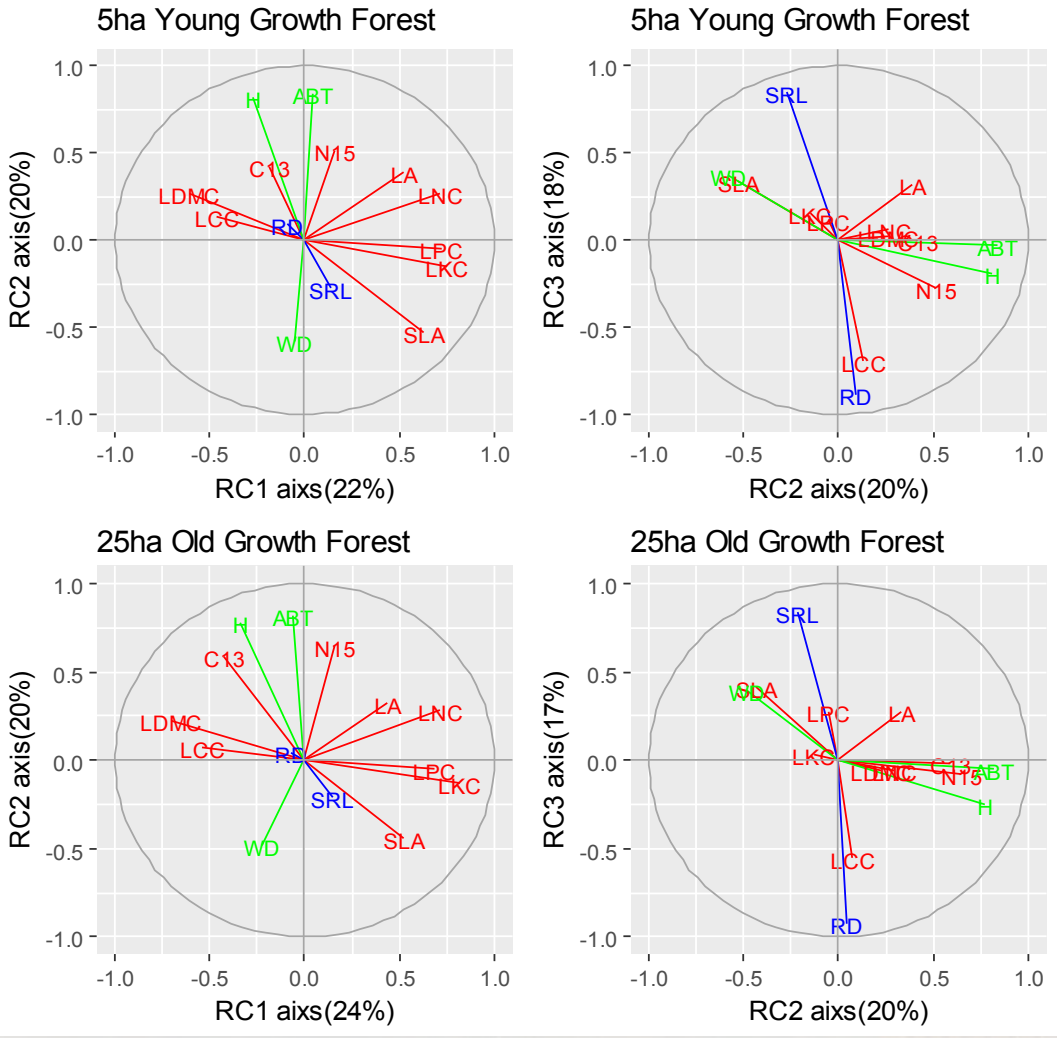
✓**Temporal turnover for each trait dimension**

$$SES.Dpw = \frac{Dpw_{observed} - mean(Dpw_{null})}{sd(Dpw_{null})}$$

Trait dimension

◆ Trait dimensions were similar for both plots

- ✓ **Trait dimension 1:**
  - **Leaf related traits**
  - **Light use efficiency**
- ✓ **Trait dimension 2:**
  - **Wood related traits**
  - **Light competition ability**
- ✓ **Trait dimension 3:**
  - **Root related traits**
  - **Nutrition absorption**



Temporal beta diversity for each trait dimension

Young Growth Forest Plot

- All trees

  Light competition and nutrition absorption traits changed more quickly

- Large and small trees:

  Light competition traits changed dynamically

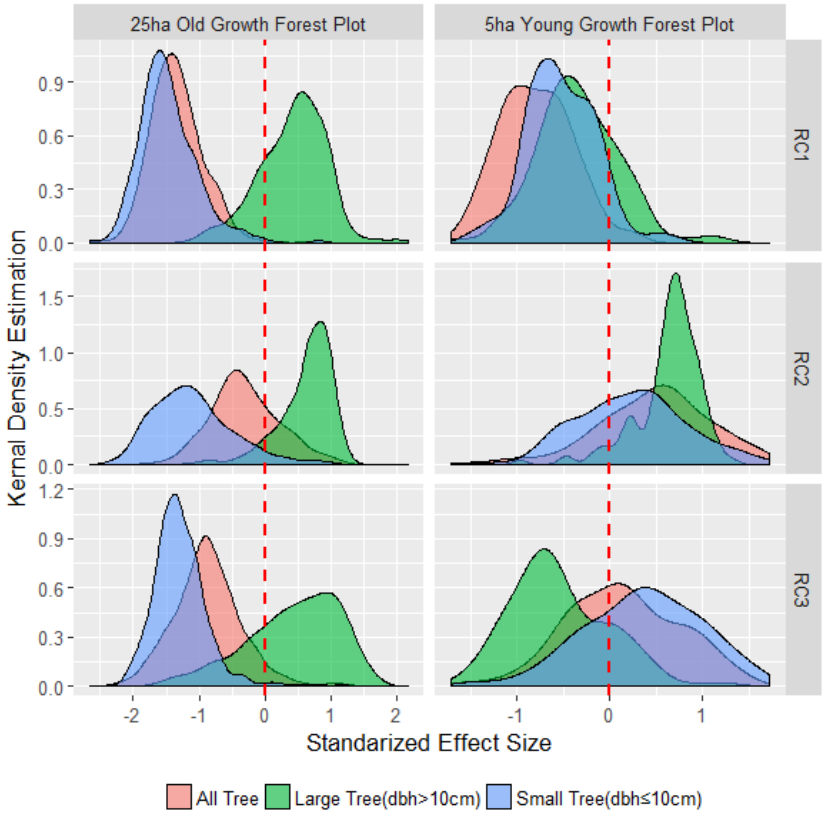
Old Growth Forest Plot

- All trees:

  Three trait dimensions were stable

- Large and small trees:

  Opposite pattern for all dimensions



Discussion & Conclusion

- **Nonrandom process dominate functional and phylogenetic temporal beta diversity in temperate forest at two successional stages and size classes**
- **The importance of abiotic factors at early successional stages and life history stages indicates the dominate role of environmental filtering. While effect of competition might increase at late successional stages and life history stages**
- **Light competition and nutrition absorption may have extremely importance for the succession in our study area**


Thanks for your attention!
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