Distribution of adult trees and seedlings along a tropical elevational transect in Xishuangbanna, southwest China

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Response of tree species to habitat change

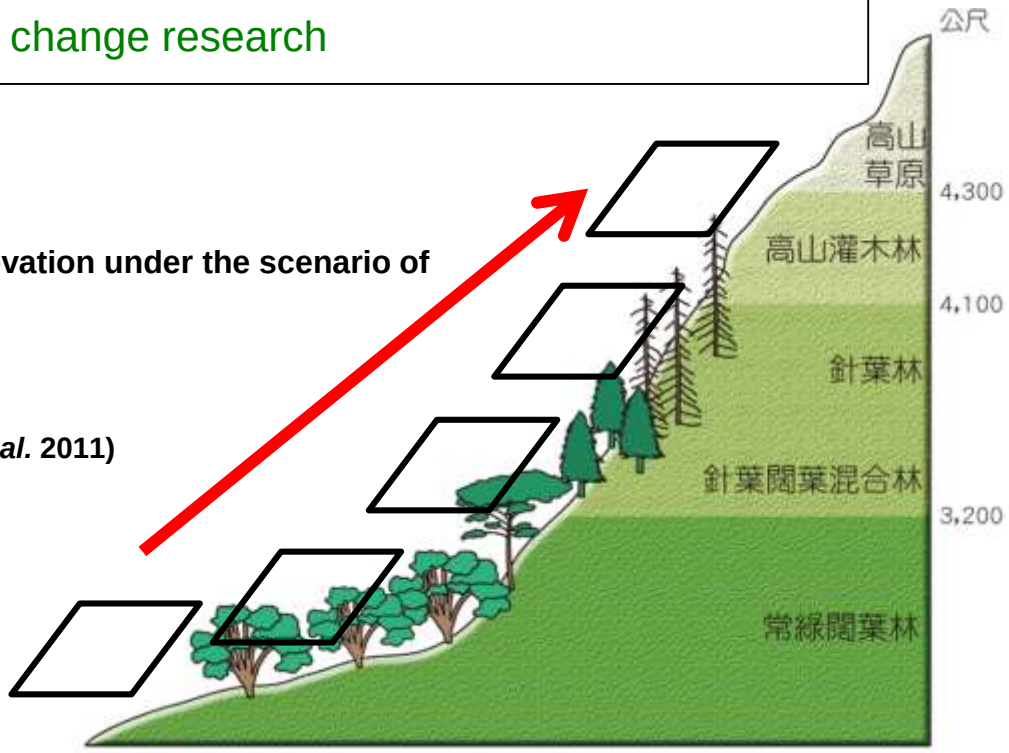
- It is well known that tree species composition changes with latitudinal or elevational transects, which also serve as a revelation in predicting the response of tree species to climate change
- Investigation on the tree species distribution along environmental gradients plays an important role in climate change research

Distribution

1. **Shifts towards higher latitude or higher elevation under the scenario of warming (Lenoir *et al.* 2010b)**
2. **Water gradients (Crimmins *et al.* 2011)**
3. **Lag behind the climate change (Bertrand *et al.* 2011)**

Growth

1. **Facilitation (Wagner *et al.* 2014)**
2. **Prohibition (Bowman *et al.* 2014)**



Thomas *et al.* 2004; Malcolm *et al.* 2006; Colwell *et al.* 2008; Feeley & Silman 2010

Tree seedlings in forest understory

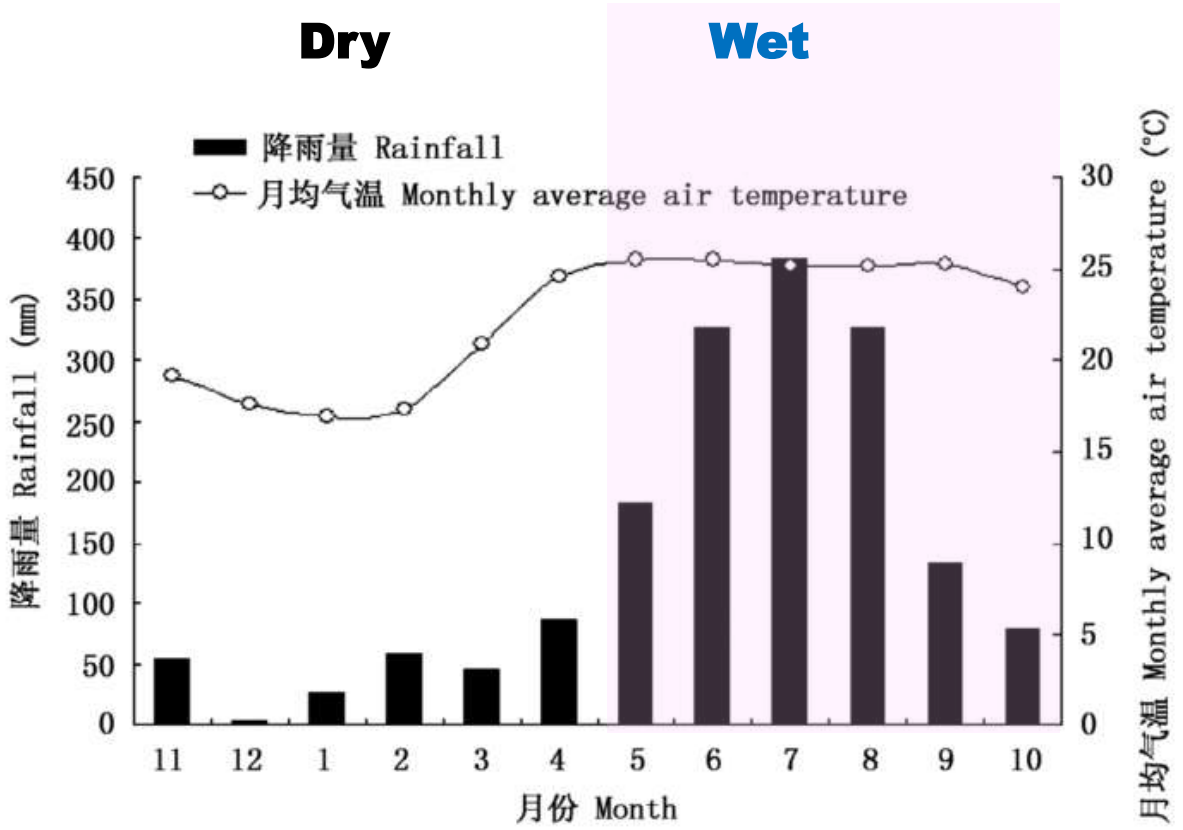
- **Important component of forest ecosystem, vital role in forest regeneration (Teketay 1997; Li *et al.* 2010; Bace *et al.* 2012)**
- **Vulnerable phase in the life history of tree development. Their roots are sensitive to the variation of soil moisture and nutrients (Lewis & Tanner 2000)**
- **The population dynamics of tree seedlings respond to environmental change (Pedersen 1998; Jump *et al*. 2007; Peñuelas *et al*. 2007)**
- **It reflects potential change in species composition and abundance of trees in forests (Capers *et al.* 2005)**

Background

- **Xishuangbanna: Northern edges of tropical Asia + Mountainous environment**
- **Biomes: Transition between the tropics and subtropics — Coupling of species pools**
- **Monsoon climate: Dry season + Wet season (rainy season)**

Sensitive + Vulnerable

Seasonal variation of temperature and rainfall



Questions and objective

1. **Impacts of elevation on the distribution of tree seedlings?**
2. **Response of tree seedlings to monsoonal rhythms? (Dry season vs. Wet season)**
3. **How do air temperature and soil moisture influence the distribution of tree seedlings in an elevational gradient?**

To reveal the response of distribution of tree seedlings to montane environmental variations and monsoon climate!

Hypothesis

1. The species richness and abundance of tree seedlings tend to decrease with elevation.

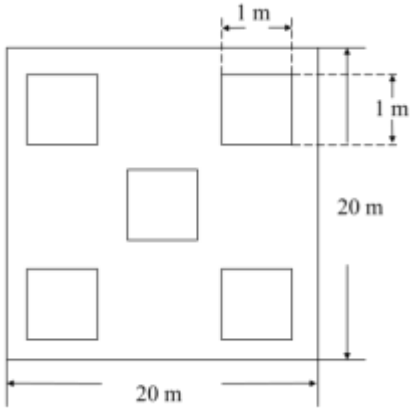
2. Due to the higher temperature and rainfall in wet season, the species richness and abundance of tree seedlings are higher than those in dry season. In addition, the relative growth rate (RGR) of tree seedlings in wet season is higher than that in dry season.

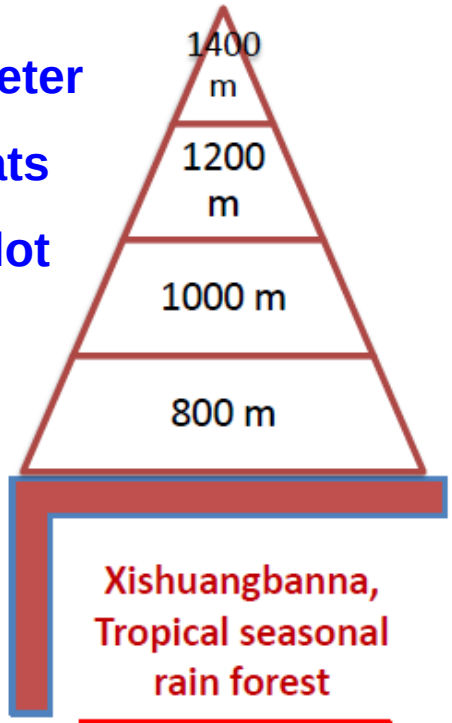
3. In view of the warming and drying trends of local climate, the distributional ranges of drought-tolerant tree seedlings would be expanded, and those of drought-intolerant tree seedlings would be compressed or reduced, in contrast.

Study sites and data collection

Adult tree: DBH ≥ 5 cm

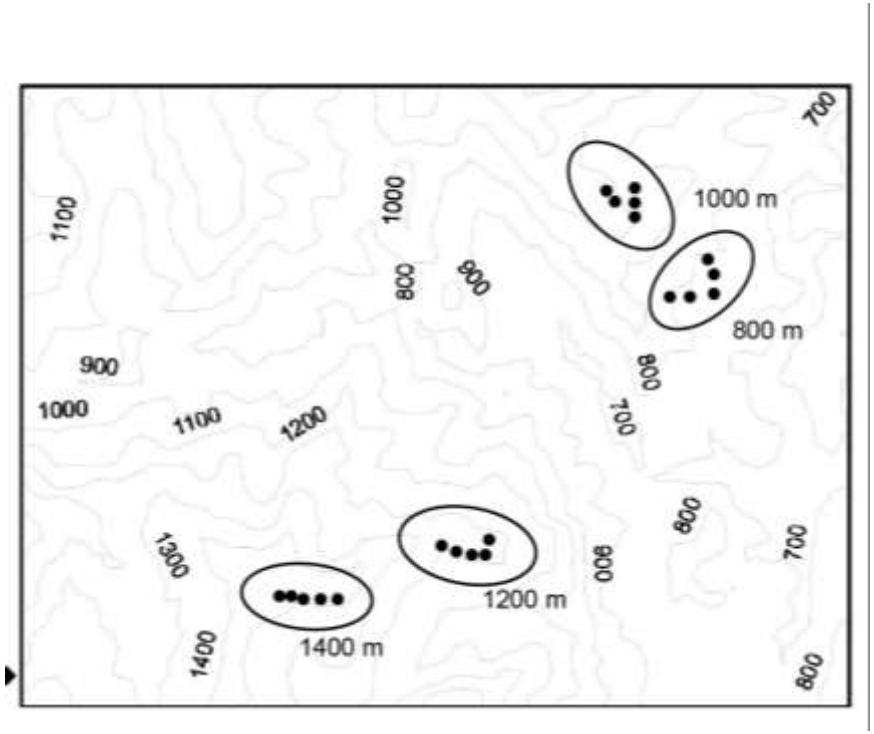
Seedling: basal diameter < 1 cm, five quadrats of 1x1 m in each plot





Xishuangbanna, Tropical seasonal rain forest

101.56 E, 21.48 N



Alt.	Lat.	Lon.	Forest types
800 m	N 21° 36.83′	E 101° 34.73′	Seasonal rain forest
1000 m	N 21° 37.22′	E 101° 34.38′	Montane rain forest
1200 m	N 21° 35.66′	E 101° 33.60′	Montane evergreen broad-leaved forest
1400 m	N 21° 35.46′	E 101° 32.82′	

- 5 20x20 m plots at each altitude
- 20 plots in total

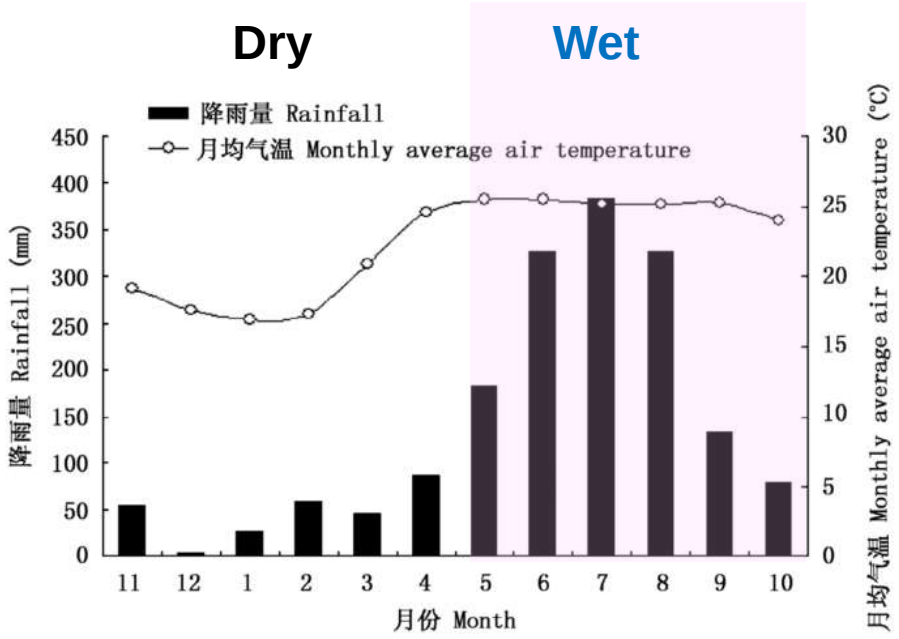
Study sites and data collection

Air temperature:

Thermo-logger (iButton DS1293) at 1.3 m height, hourly

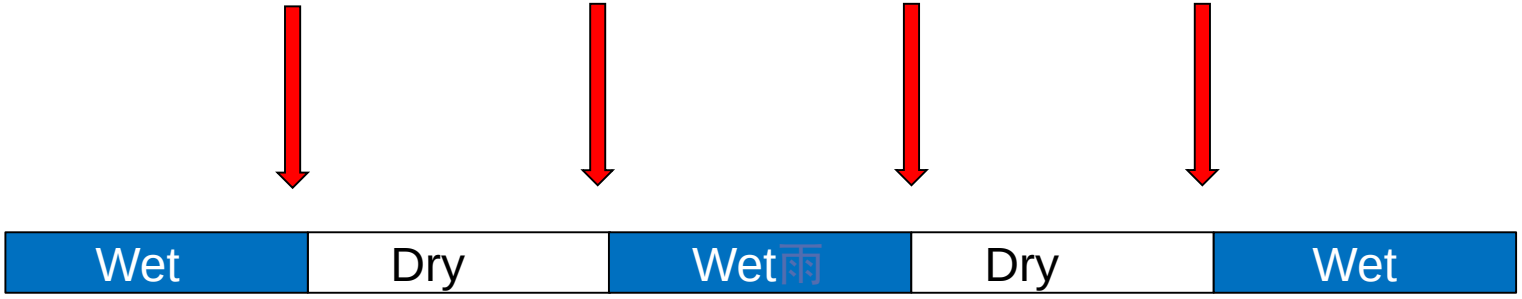
Soil moisture:

Conductivity probe (at 5 cm depth, ends of the two seasons)



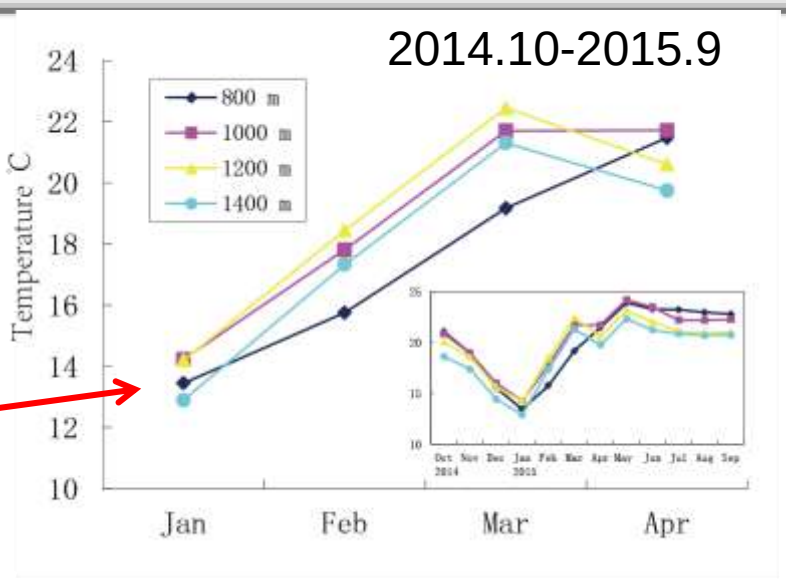
Seedling census

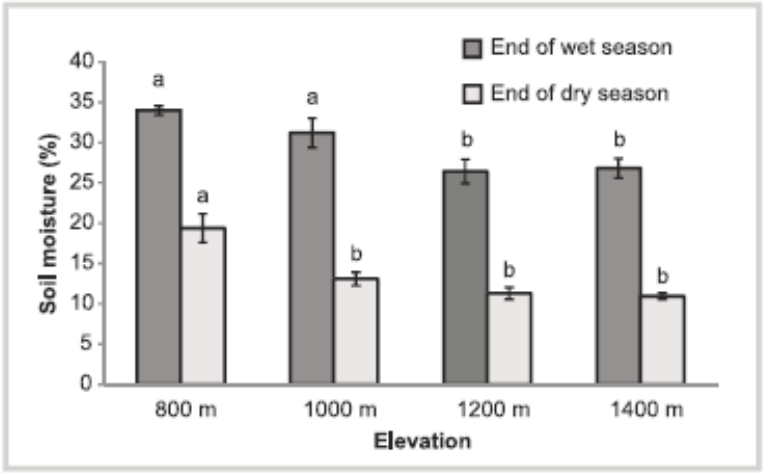
Oct. 2013 – Apr. 2015



Results – Temperature and soil moisture

- Temperature decreased with elevation. However, temperature inversion in dry season was observed.
- Soil moisture decreased with elevation. This tended to be more significant in dry season.



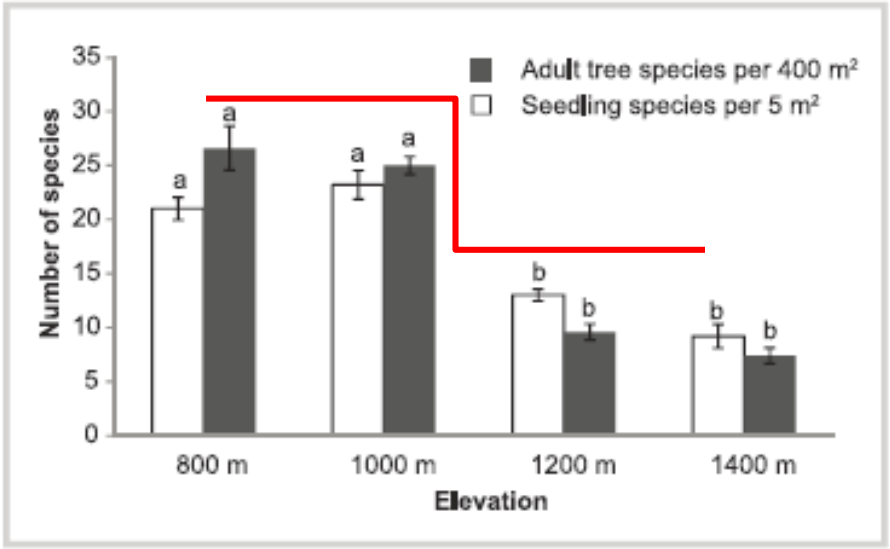


Song et al. 2016b, Song et al. 2016a

Results – Species diversity of adult trees and seedlings

Song et al. 2016a

- In general, species richness and species diversity decreased with elevation.

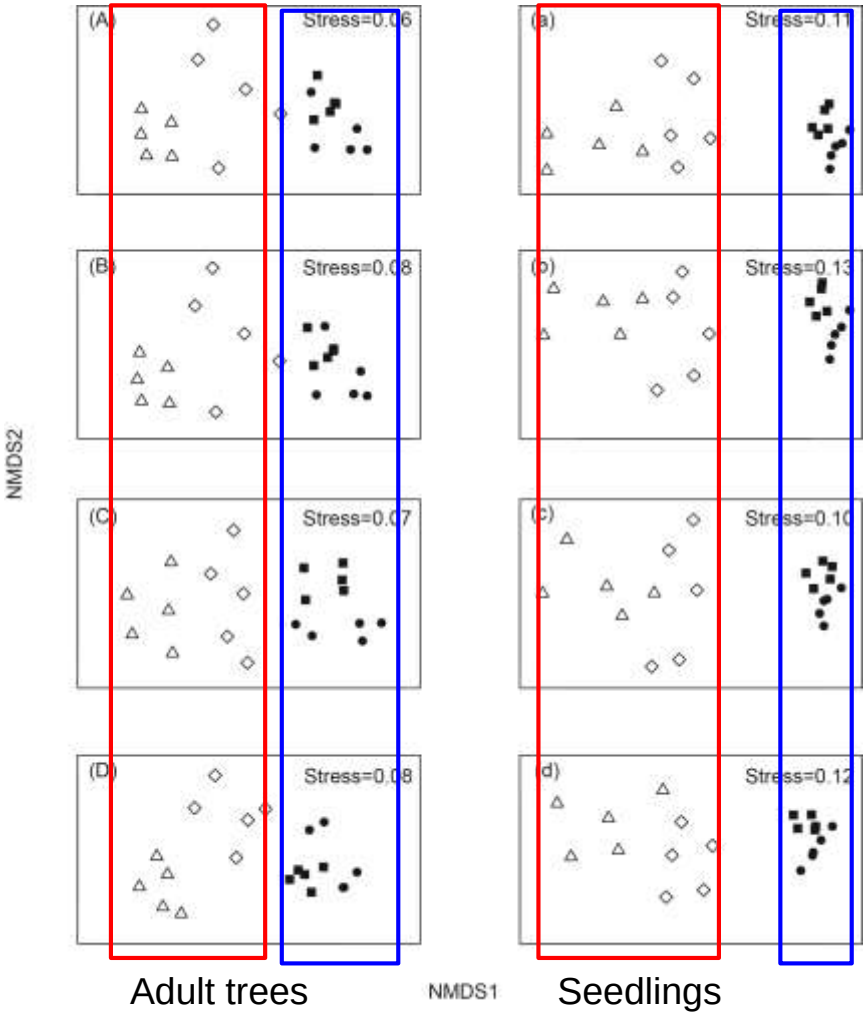


2013.12

Index	Specimen type	800 m	1000 m	1200 m	1400 m
Shannon-Wiener	Adult trees	3.111 ± 0.206a	3.075 ± 0.12a	2.132 ± 0.166b	1.873 ± 0.196b
	Seedlings	2.902 ± 0.087a	2.985 ± 0.112a	2.327 ± 0.11b	2.010 ± 0.358b
Simpson	Adult trees	0.946 ± 0.014ab	0.946 ± 0.01a	0.871 ± 0.022bc	0.832 ± 0.029c
	Seedlings	0.937 ± 0.003ab	0.941 ± 0.006ab	0.879 ± 0.015c	0.836 ± 0.069bc
Pielou	Adult trees	0.951 ± 0.017a	0.956 ± 0.015a	0.949 ± 0.009a	0.946 ± 0.027a
	Seedlings	0.955 ± 0.012ab	0.951 ± 0.008ab	0.908 ± 0.013c	0.918 ± 0.034bc

Results – Elevational variation (NMDS)

△800 m; ◇1000 m; ■ 1200 m; ● 1400 m



Song et al. 2016a

Low elev. sp.

Transitional sp.

Sp. from high elev. occurring in low elev.

High elev. sp.

	IndVal	indicative of:	800 m	1000 m	1200 m	1400 m
Trigonostemon thyrsoideum	**60%**	**800 m**	0. 05			
	- *	-	0. 01			
Artabotrys hongkongensis	- *	-				
	60%	**800 m**	0. 04			
Diospyros hasseltii	**60%**	**800 m**	0. 05			
	60%	**800 m**	0. 04			
Diospyros nigrocortex	- *	-	0. 03			
	60%	**800 m**	0. 12			
Pometia tomentosa	**80%**	**800 m**	0. 13			
	60%	**800 m**	0. 05			
Pseuduvaria indochinensis	- *	-	0. 01			
	100%	**800 m**	0. 11			
Parashorea chinensis	**87%**	**800 m**	0. 50	0. 03		
	63%	**800 m**	0. 14	0. 04		
Antidesma montanum	**60%**	**800 m**	0. 03			
	- *	-		0. 01		
Nephelium chryseum	**80%**	**800 m 1000 m**	0. 04	0. 11		
	-*	-		0. 02		
	80%	**800 m 1000 m**	0. 22	0. 12		
	90%	**800 m 1000 m**	0. 30	0. 10		
Baccaurea ramiflora	**80%**	**800 m 1000 m**	0. 09	0. 08		
	-*	-	0. 04			
Dichapetalum gelonioides	-*	-	0. 03			
	80%	**800 m 1000 m**	0. 12	0. 05		
Knema furfuracea	**70%**	**800 m 1000 m**	0. 04	0. 10		
	-*	-		0. 08		
	70%	**800 m 1000 m**	0. 08	0. 10		
	-*	-	0. 02	0. 02	0. 01	0. 02
	-*					
	60%	**1000 m**		0. 03		
	-*	-				
Tabernaemontana corymbosa	**64%**	**1000 m**		0. 04		0. 02
Syzygium cumini	**80%**	**1000 m**		0. 07		
	-	-				
Alseodaphne petiolaris	**60%**	**1000 m**		0. 21		
	-*	-	0. 02	0. 02		
Actinodaphne henryi	**60%**	**1000 m**		0. 11		
	-*	-		0. 03	0. 01	
Aporusa yunnanensis	**90%**	**1000 m 1200 m**		0. 18	0. 37	
	80%	**1000 m 1200 m**		0. 06	0. 14	
Castanopsis calathiformis	-*	-				0. 05
	81%	**1200 m 1400 m**		0. 05	0. 12	0. 43
Castanopsis echidnocarpa	**90%**	**1200 m 1400 m**			0. 53	0. 33
	64%	**1200 m**		0. 20	0. 81	0. 09
Castanopsis mekongensis	**78%**	**1200 m 1400 m**		0. 10	0. 43	0. 91
	-*	-				0. 03
Olea europaea	–*	-				
	80%	**1200 m**			0. 07	
Schima wallichii	-*	-				
	80%	**1200 m**			0. 06	
	69%	**1200 m**			0. 20	0. 04
	-*	-			0. 01	
Olea rosea	**60%**	**1200 m**			0. 10	
	-*	-			0. 02	
Lindera metcalfiana var. *dictyophylla*	-*	-	0. 01	0. 03	0. 07	0. 12
	84%	**1200 m 1400 m**		0. 01	0. 31	0. 34
Lithocarpus truncatus	**100%**	**1200 m 1400 m**			0. 47	0. 60
	-*	-				
Schima argentea	**100%**	**1200 m 1400 m**			0. 36	0. 35
	-*	-				
Vernonia solanifolia	-*	-				
	60%	**1400 m**				0. 07

Results – Seasonal dynamics of seedlings

Species richness

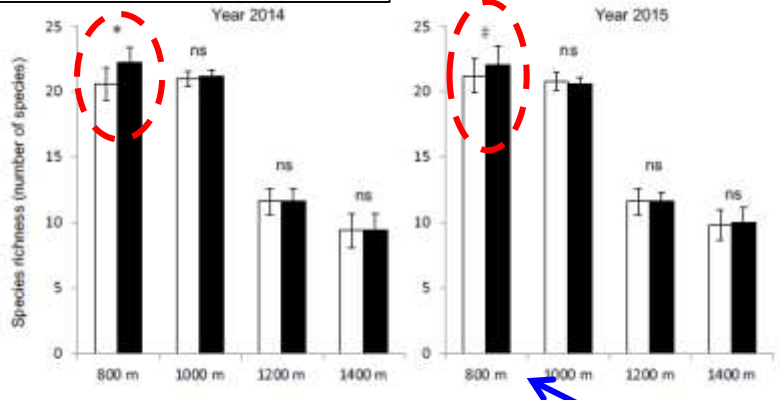


Figure 1. Species richness of tree seedlings in dry and rainy seasons along the elevational transect. Bars correspond to standard errors (□Dry season, ■Rainy season; *P-value < 0.05; # P-value < 0.1; ns, not significant).

Abundance

Song et al. 2016b

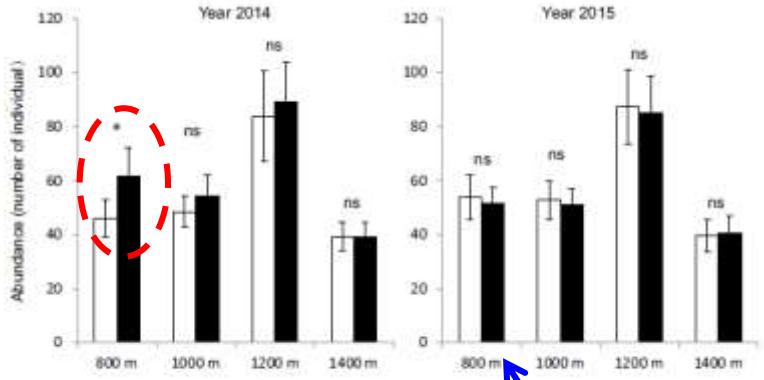


Figure 2. The abundance of tree seedlings in dry and rainy seasons along the elevational transect. Bars correspond to standard errors (□Dry season, ■Rainy season; *P-value < 0.05; # P-value < 0.1; ns, not significant).

RGR

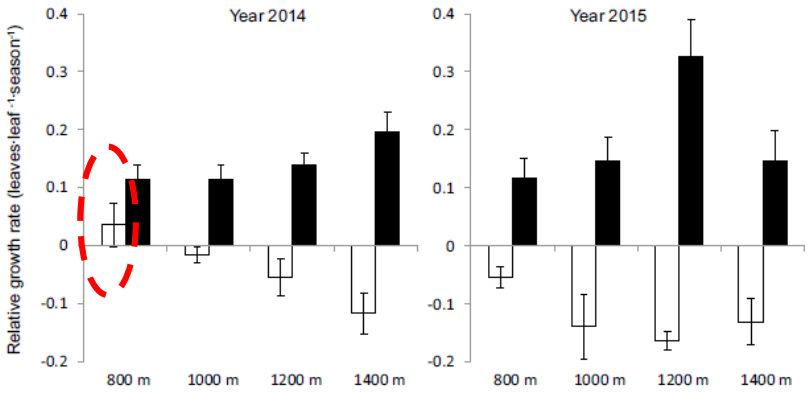
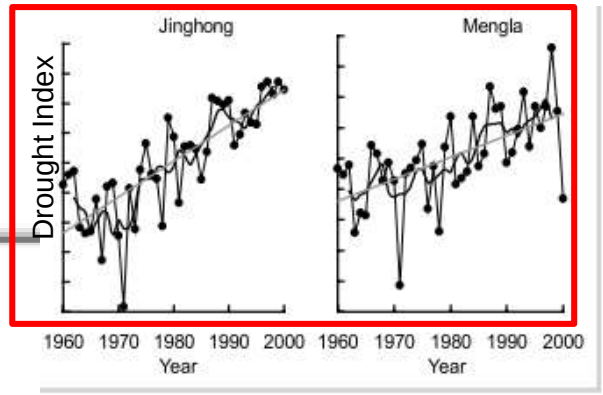


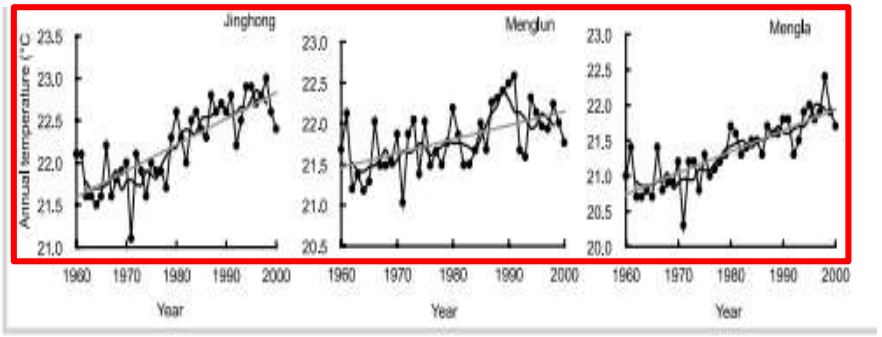
Figure 3. Relative growth rate of seedlings in dry and rainy seasons along the elevational transect. Data are means over plots. Bars correspond to standard errors (□Dry season, ■Rainy season).

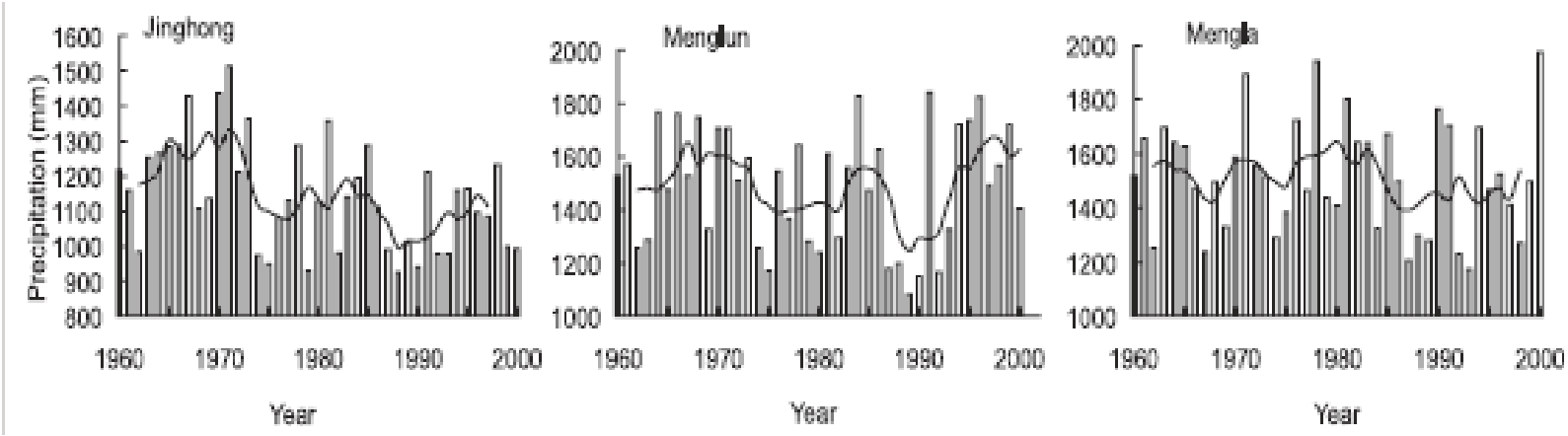
- **Species richness and abundance: Differences were significant at 800 m, but insignificant for the rest.**
- **RGR: Higher at 800 m than other elevations in dry season.**

Background of local climate change



1. Annual mean temp. and mean monthly temp. in dry season keep increasing since 1960
2. Number of days of rainfall tends to decline, and the frequency of rainstorm and downpour increases. Number of fog days decreases
3. Frequency of high temp. or drought increases





1960-2000

He & Zhang 2005; Cheng and Xie 2008

Conclusion

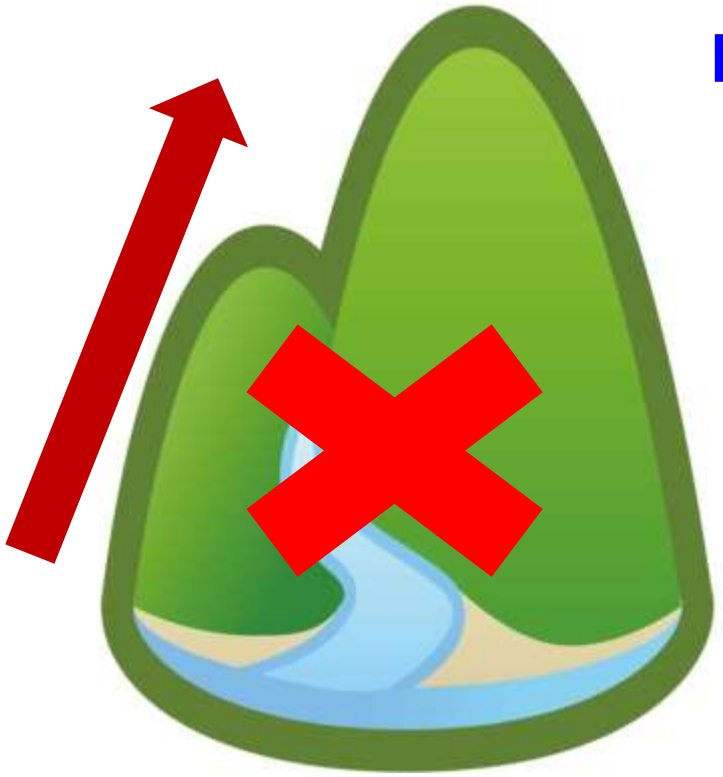
1. In general, air temperature and soil moisture decreased with elevation. However, we observed "temperature inversion" in dry season, temperature at 800 m was lower than that at higher elevations.

2. Species richness and abundance of tree seedlings in wet season were significantly higher than those in dry season. This was more distinct at low elevation.

3. RGR of seedlings in dry season increased with soil moisture, suggesting that soil moisture affects RGR in dry season.

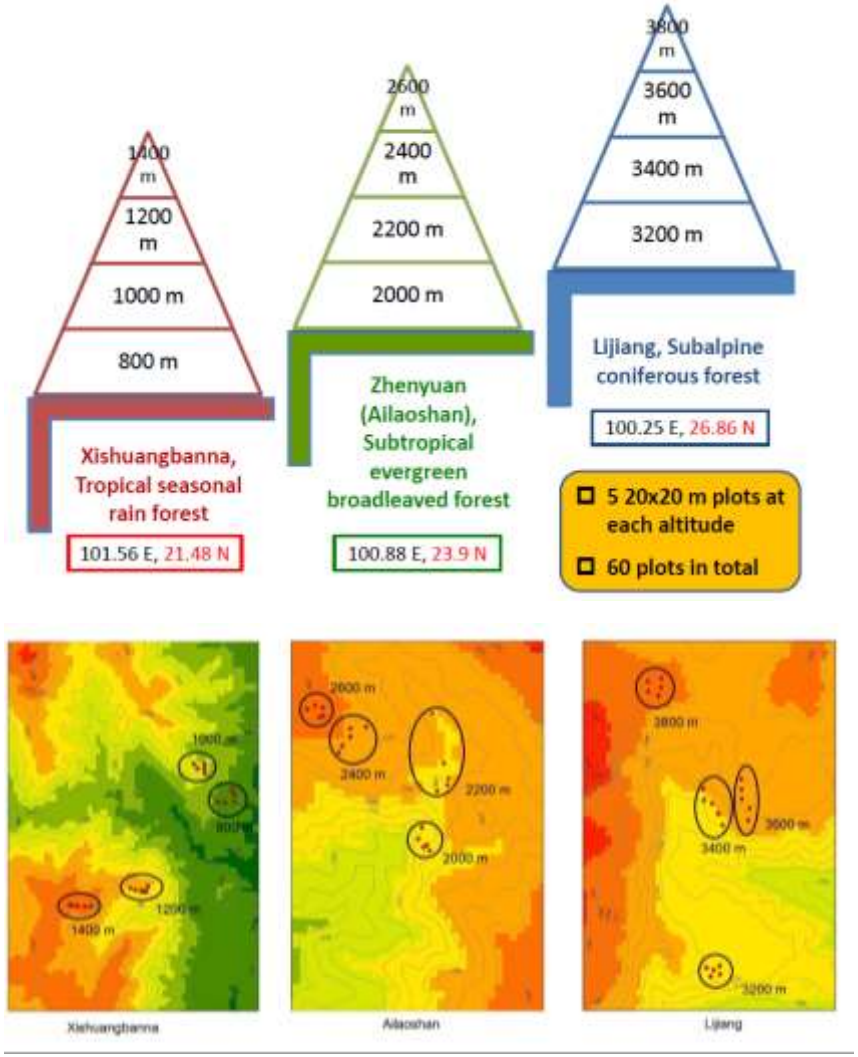
4. It is assumed that the drying and warming trends in local climate would lead to the downward extension of tree species from high elevations. Consequently, the distribution of tree species at low elevations would be further compressed, which would reduce the area of tropical rain forest in this region.

Findings



Warming leads to upward shift of tree species from low elevations

Warming leads to downward shift of tree species from high elevations, which would constantly reduce the distributional ranges of tropical rain forests



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部分参考文献

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