

4th International Symposium on Mapping Asia Plants

Plant diversity in temperate Asia

Zhiheng Wang

Zhiheng.wang@pku.edu.cn

2026.08.31 @ Northeast Forestry University

北京大学生态研究中心
PEKING UNIVERSITY INSTITUTE OF ECOLOGY

Outline

1 Plant diversity: from China to the world
(植物多样性：从中国到全球)

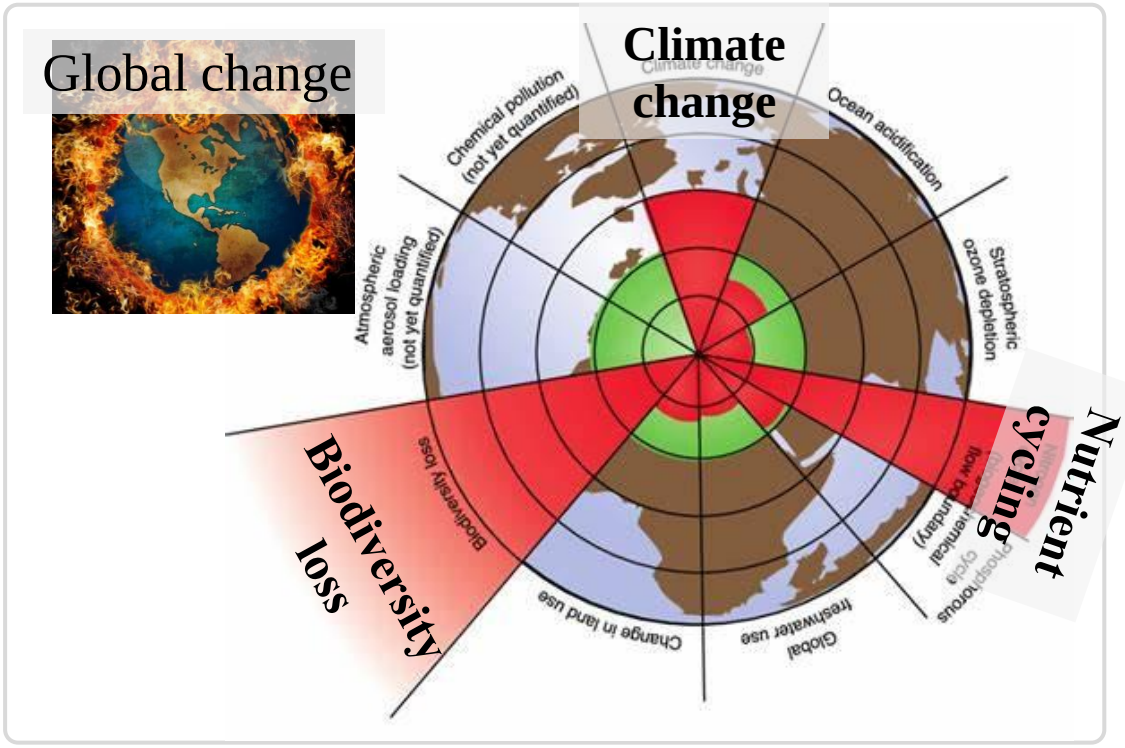
2 Evolution of the temperate Asian flora
(温带亚洲植物区系的演化)

3 Drivers of plant diversity patterns in temperate Asia
(温带亚洲植物多样性格局及其主导因子)

4 Promote future collaborations
(提升未来合作)

The biodiversity crisis

- **Biodiversity**: the degree of variation of life in a given region
- **The Anthropocene:** Biodiversity loss has exceeded the planetary boundaries, emerging as one of the greatest threats to human society.

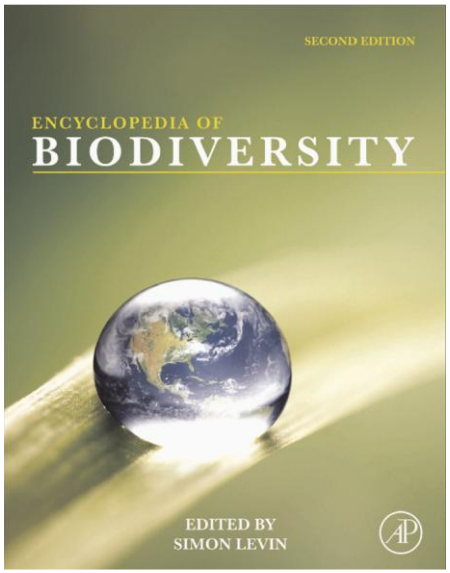


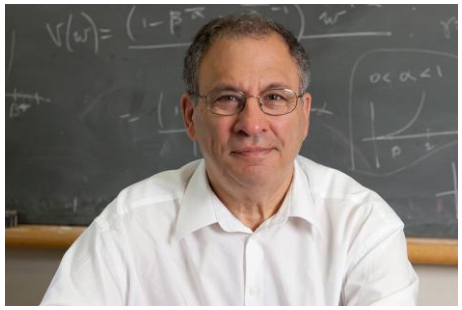
Steffen et al. (2015) *Science*

The science of biodiversity has become the science of our future.

生物多样性科学是关于人类未来的科学

S. Levin (2013) Encyclopedia of Biodiversity

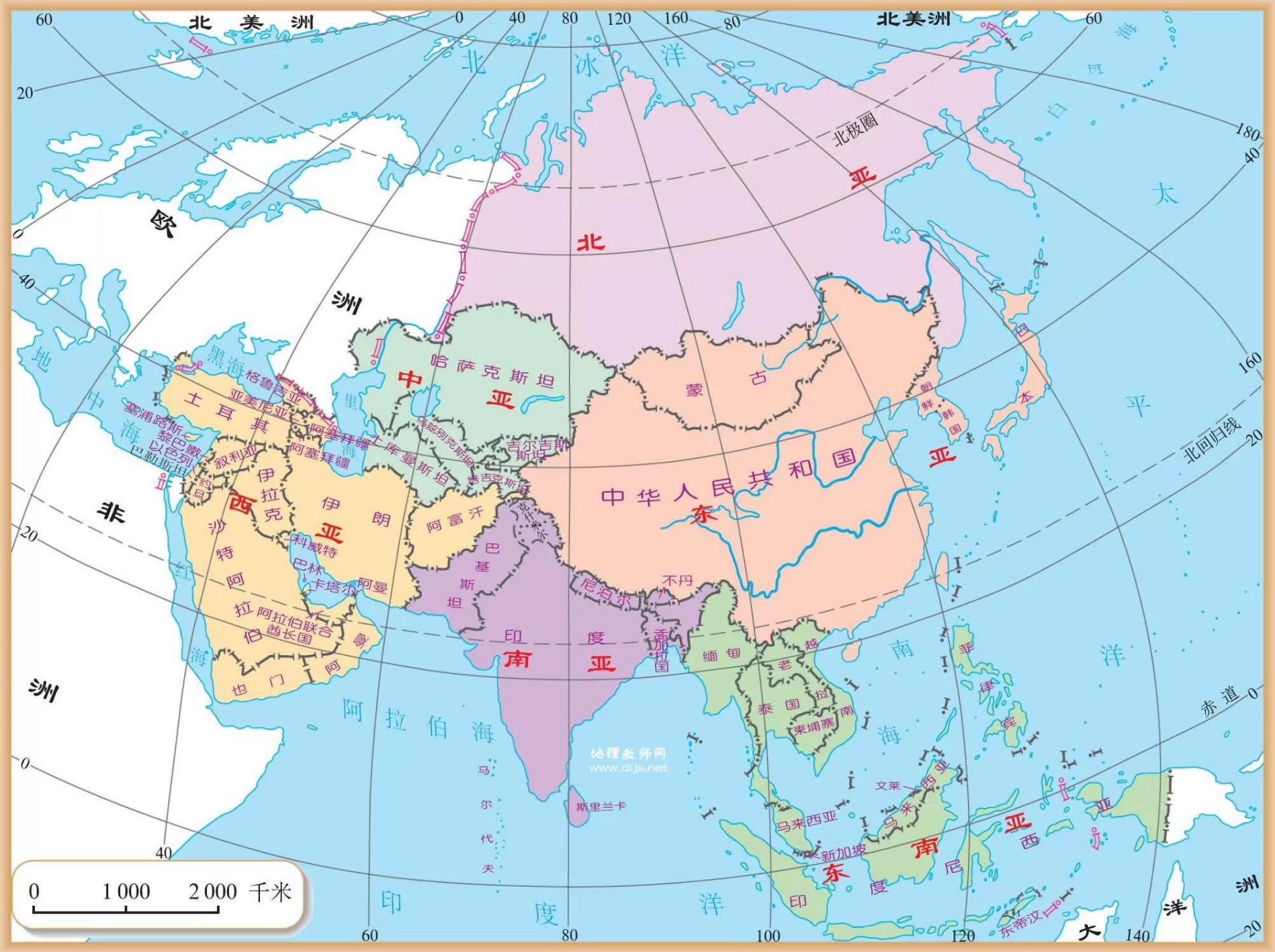




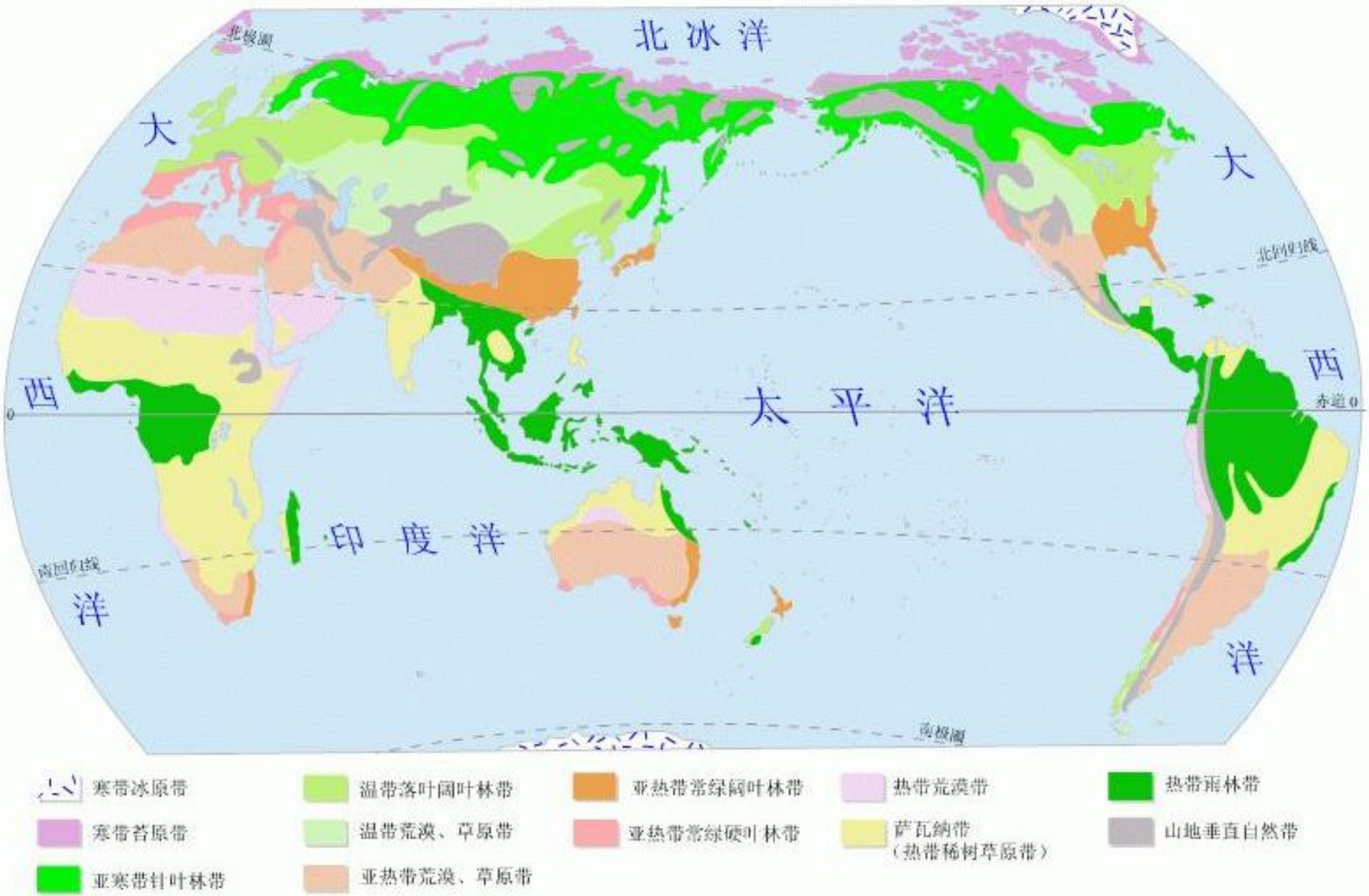
Simon Levin, NAS member
Princton University
James S. McDonnell Distinguished University Professor

瓶颈：数据不足已成为生物多样性科学发展的瓶颈

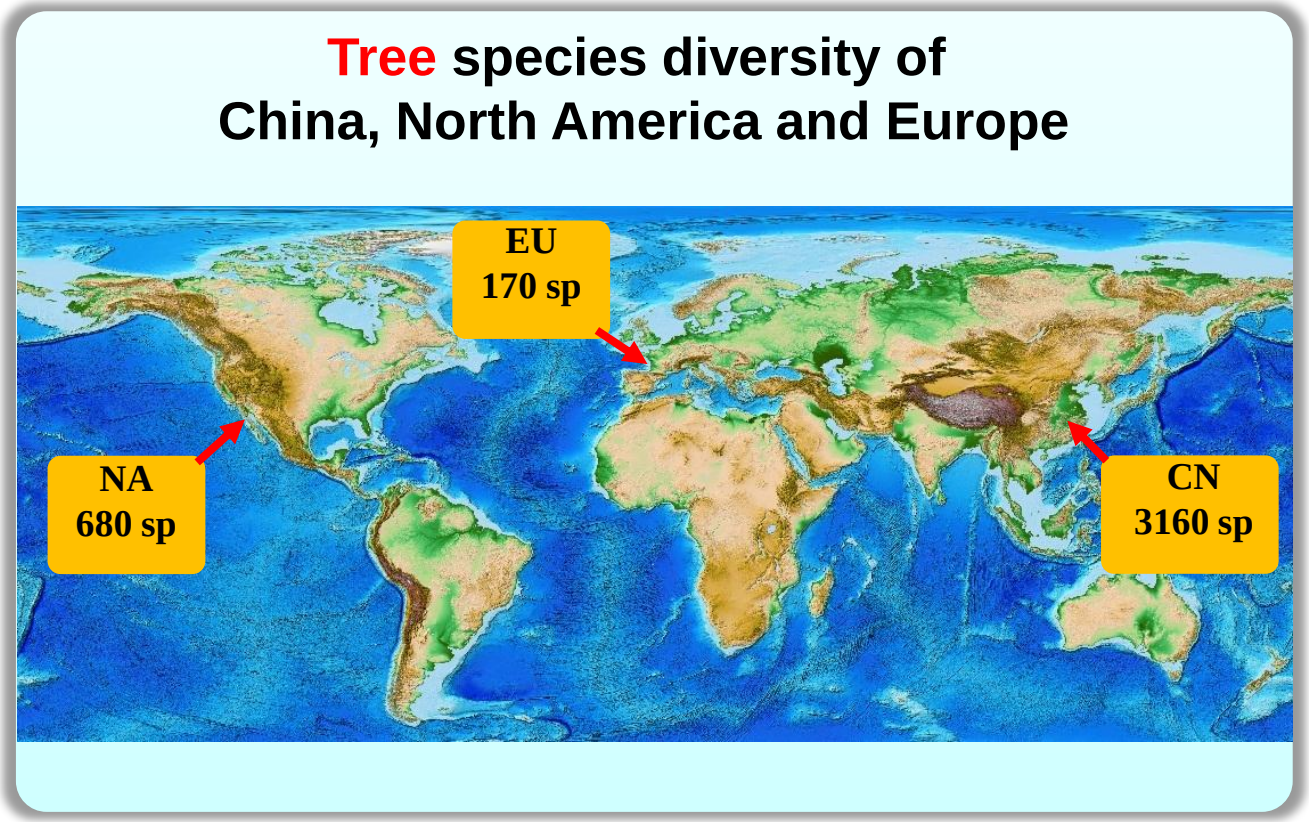
Lack of data is the bottleneck of biodiversity science.


北美洲
北冰洋
北极圈
欧洲
北亚
中亚
哈萨克斯坦
蒙古
中华人民共和国
东亚
朝鲜韩国
日本
太平洋
北回归线
赤道
黑海
格鲁吉亚
亚美尼亚
土耳其
塞浦路斯
黎巴嫩
以色列
巴勒斯坦
叙利亚
约旦
阿塞拜疆
阿塞拜疆
里海
土库曼斯坦
乌兹别克斯坦
吉尔吉斯斯坦
塔吉克斯坦
伊拉克
伊朗
西亚
阿富汗
巴基斯坦
克什米尔
沙特阿拉伯
科威特
巴林
卡塔尔
阿曼
阿拉伯联合酋长国
也门
阿曼
阿拉伯海
尼泊尔
不丹
印度
南亚
孟加拉国
缅甸
老越
泰国
柬埔寨
南海
菲律宾
马来西亚
文莱
马来西亚
新加坡
东南亚
印度尼西亚
东帝汶
大洋洲
印度洋
马尔代夫
斯里兰卡
地中海
红海
非洲
0 1 000 2 000 千米

Eastern Asian vegetation



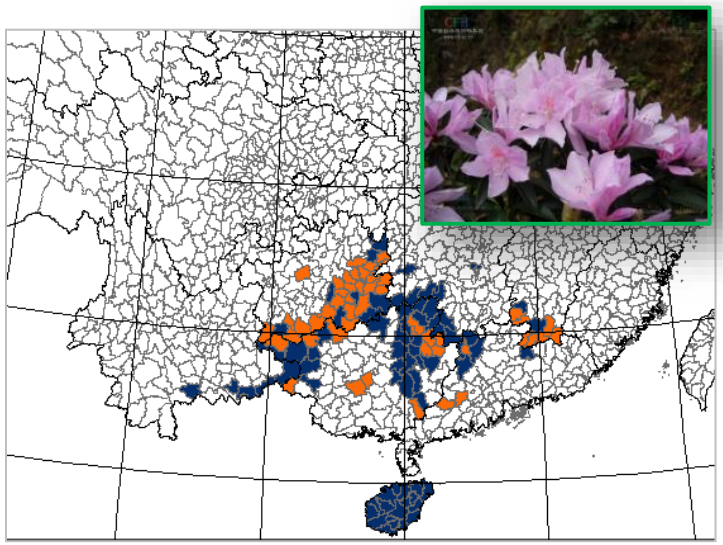
Region selection bias in studies of species diversity patterns

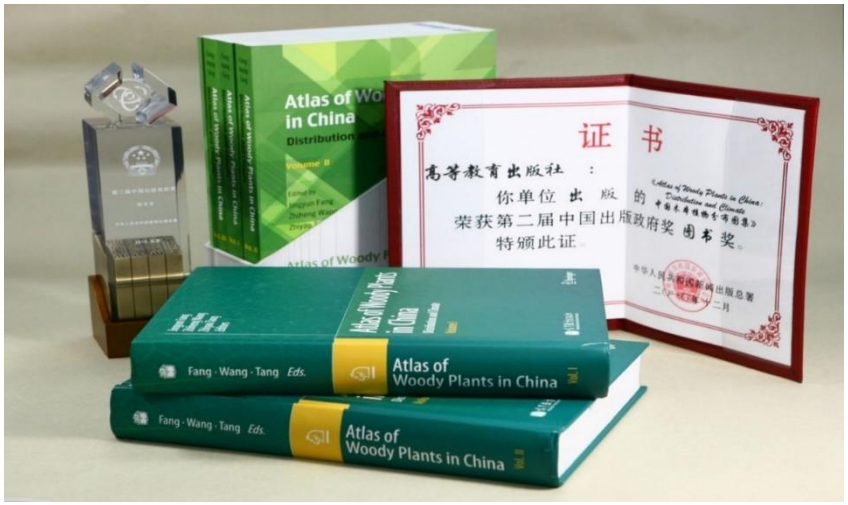


Limitation： **Lack of fine species distribution data**

Compiled the "*Atlas of Woody Plants in China*"

- Based on "*Database of China's Woody Plants*", containing all 11,405 woody species in China
- Time spent: ~8 years
- Chinese version (4 vol) + English version (2 vol)
- Awards: Government Publishing Award—China's highest publishing award



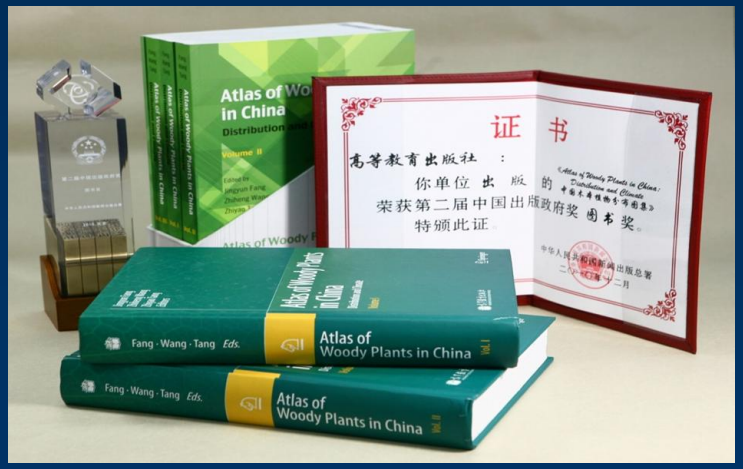


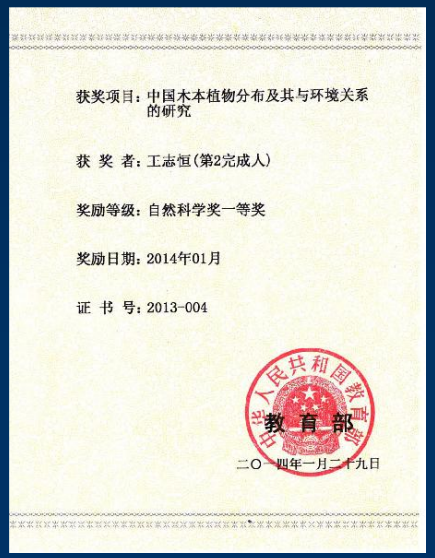
>> 中文版

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




获奖项目：中国木本植物分布及其与环境关系的研究

获 奖 者：王志恒(第2完成人)

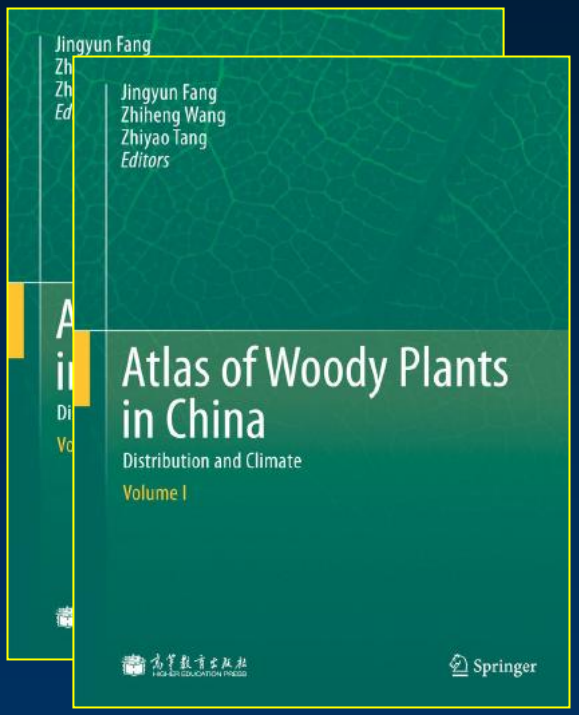
奖励等级：自然科学奖一等奖

奖励日期：2014年01月

证 书 号：2013-004

教 育 部

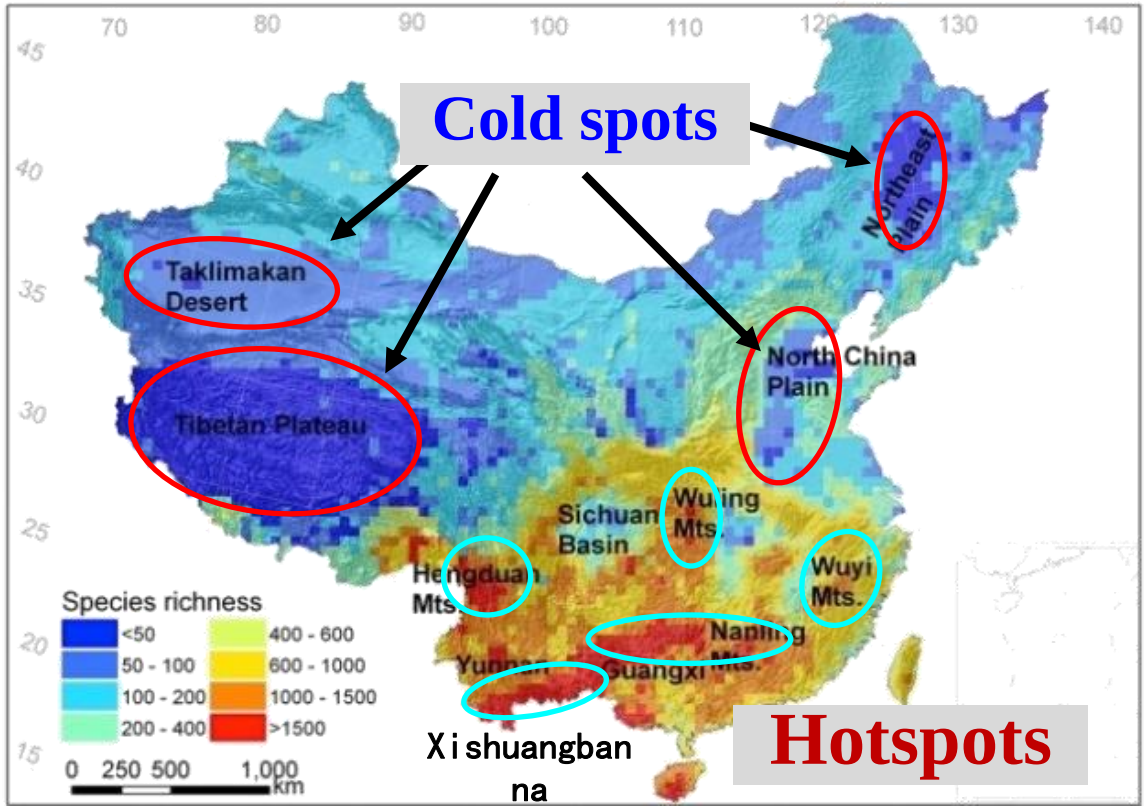
二〇一四年一月二十九日



- 中国出版政府奖 (2011)
- 教育部自然科学一等奖 (2014)

Estimated the patterns of woody plant diversity in China for the first time. Identified "hotspots" and "coldspots" of plant diversity

- **Resolution: 50 * 50 km^2**



Mountains have strong impacts on plant diversity in china
植物多样性受到地形的显著影响

Wang et al. (2011) Proceedings B; Wang et al. (2012) Ecography

Macroecology: Think Bigger

Taxonomic coverage

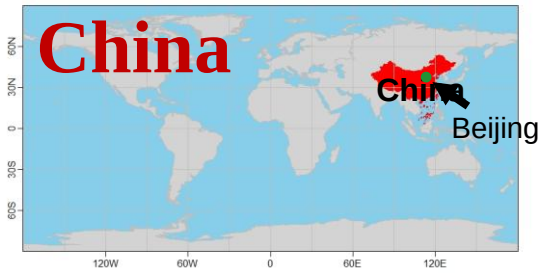
Woody Species + **Herbaceous Species**



- Evolutionary rate
- Ecological adaption
- Reproduction
- Distribution



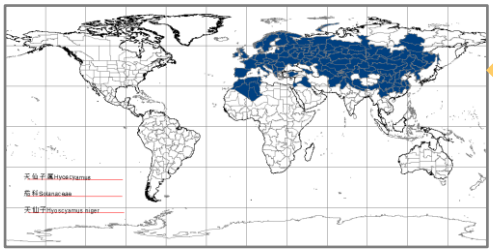
Spatial coverage



Eurasia



Global



Finished the "Global Data Platform for the Ecology and Evolution of Seed Plants (GEEP)"

- Spatial extend:

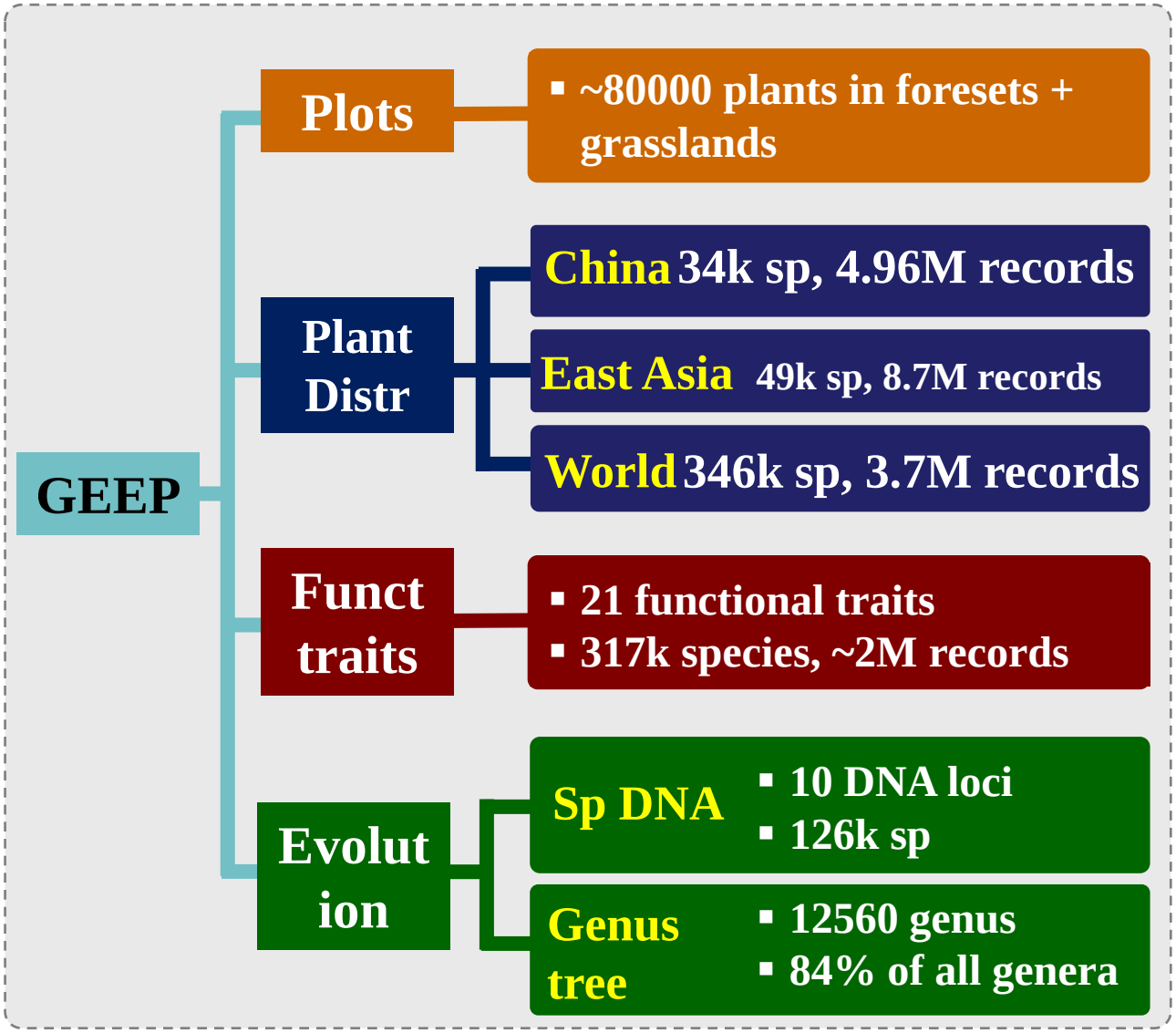
  China→Asia→World

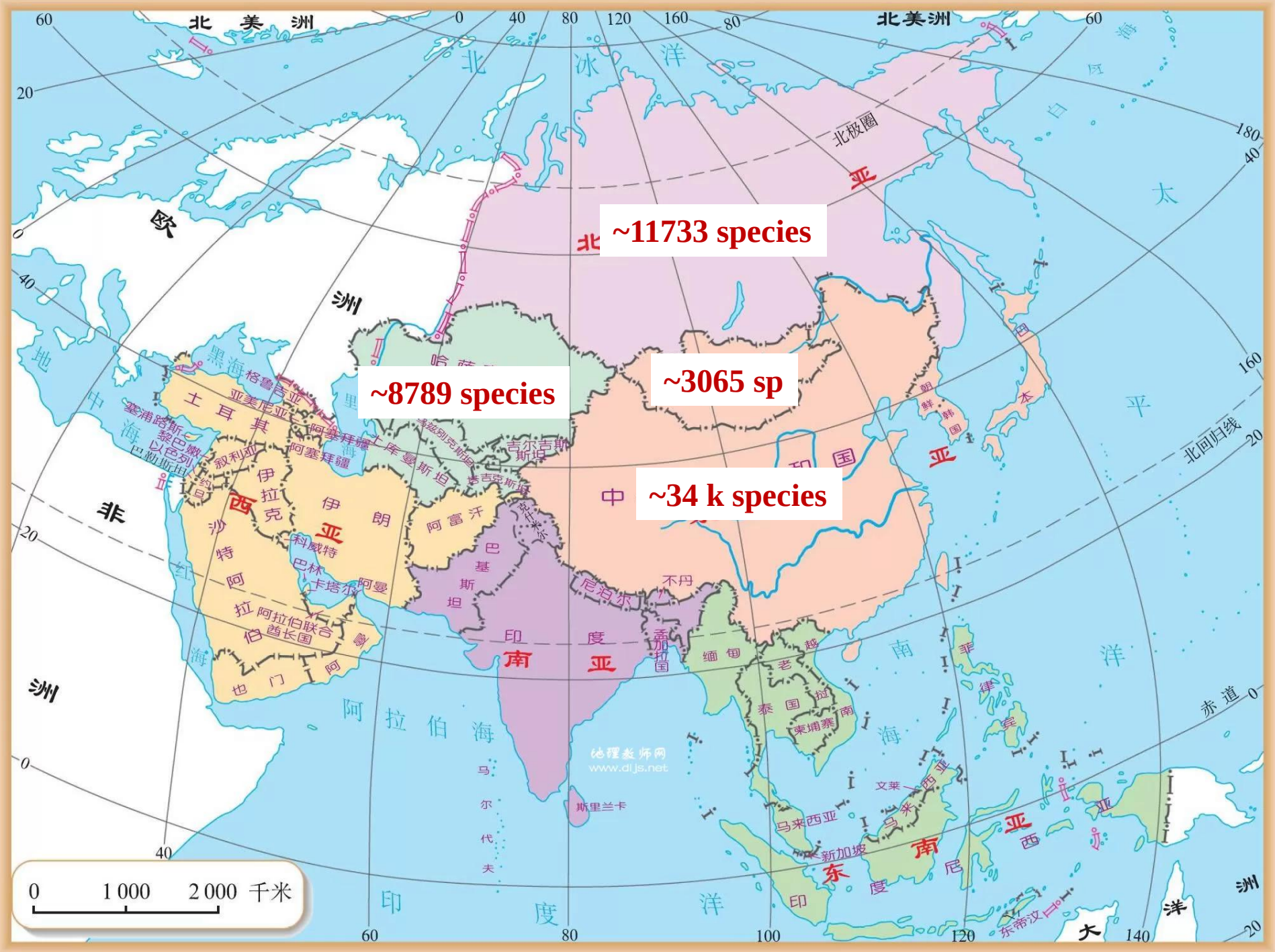
- Taxonomic extend:

  All seed plants

- Characteristics:

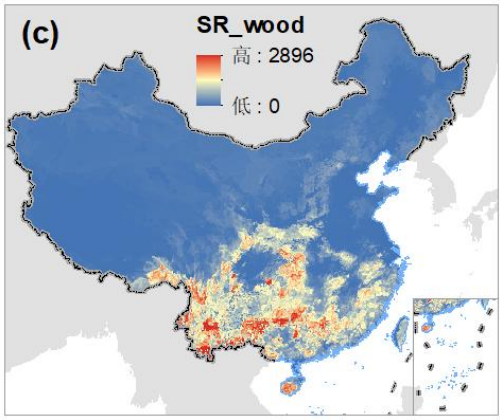
  Most comprehensive seed plant data platform



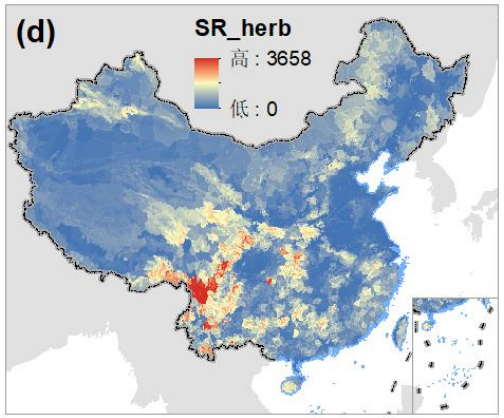

~11733 species
~8789 species
~3065 sp
~34 k species
北美洲
北冰洋
北极圈
欧洲
非洲
地中海
黑海
土耳其
格鲁吉亚
亚美尼亚
塞浦路斯
黎巴嫩
以色列
巴勒斯坦
叙利亚
伊拉克
伊朗
阿塞拜疆
阿塞拜疆
土库曼斯坦
吉尔吉斯斯坦
塔吉克斯坦
阿富汗
巴基斯坦
科威特
巴林
卡塔尔
阿曼
沙特阿拉伯
阿拉伯联合酋长国
也门
阿拉伯海
印度
南亚
尼泊尔
不丹
孟加拉国
缅甸
老越
泰国
柬埔寨
南海
菲律宾
马来西亚
新加坡
文莱
马来西亚
东南亚
印度尼西亚
东帝汶
马尔代夫
斯里兰卡
印度洋
南海
太平洋
北回归线
赤道
大洋洲
0 1 000 2 000 千米
地理教师网
www.dijs.net

Woody vs. herbaceous plant diversiy in China

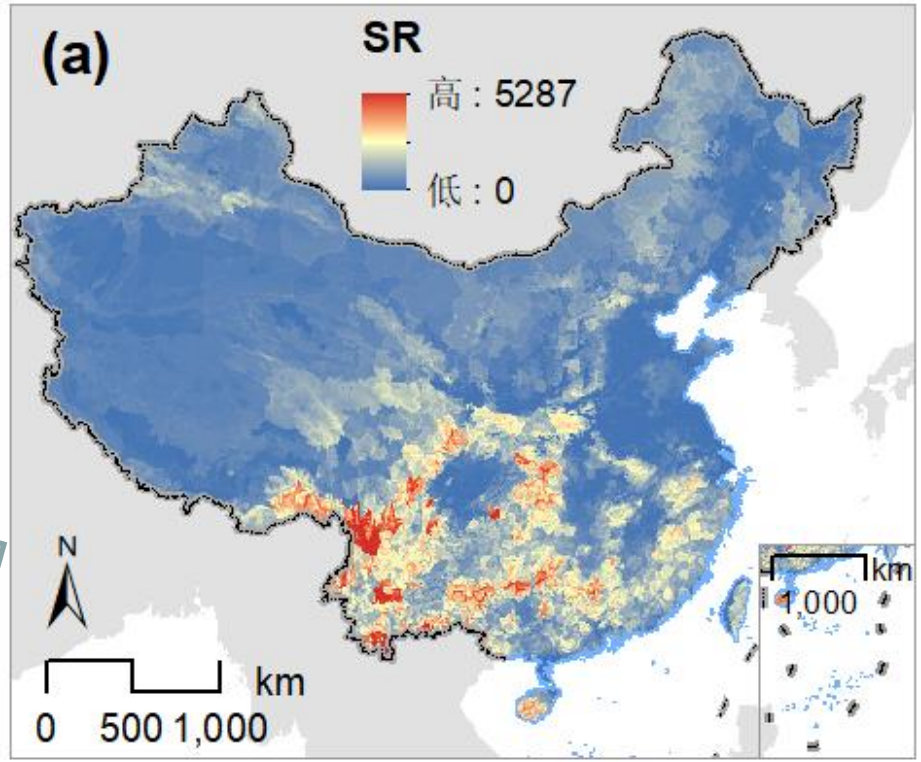
Woody, ~12 k sp



Herbs, 19372 sp



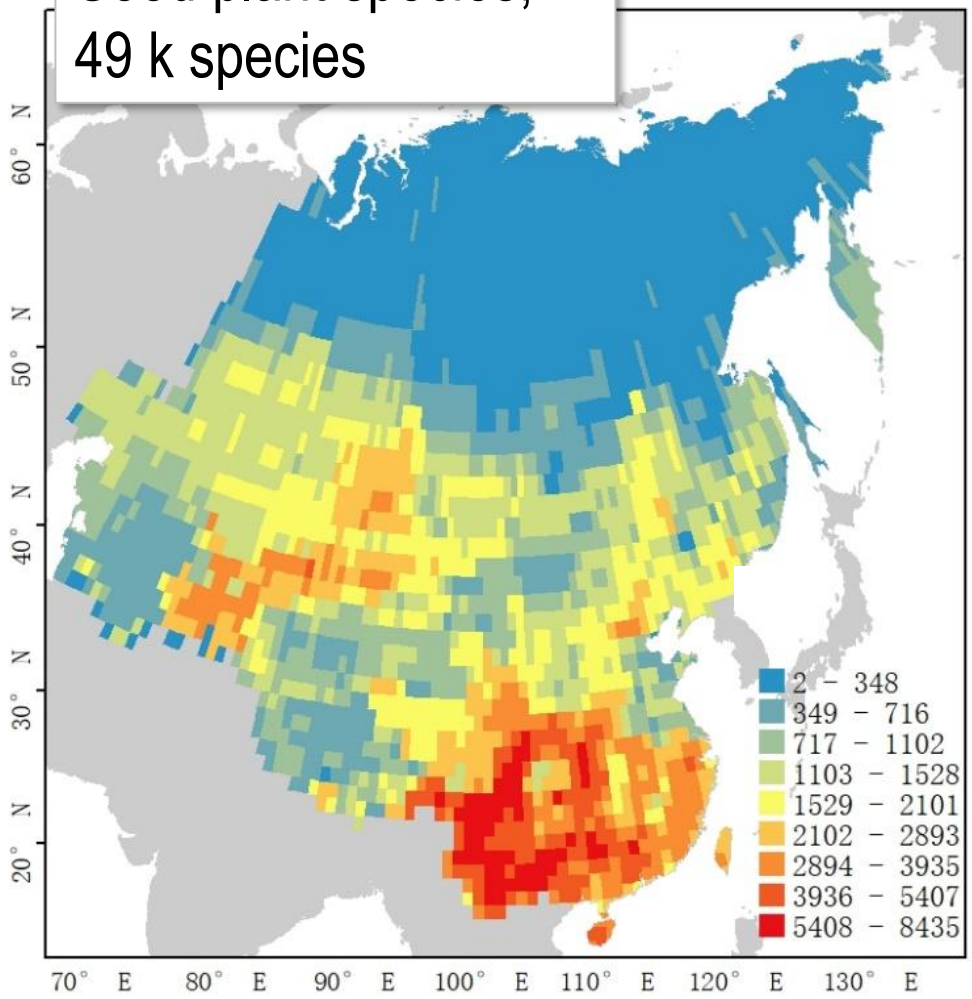
All seed plants



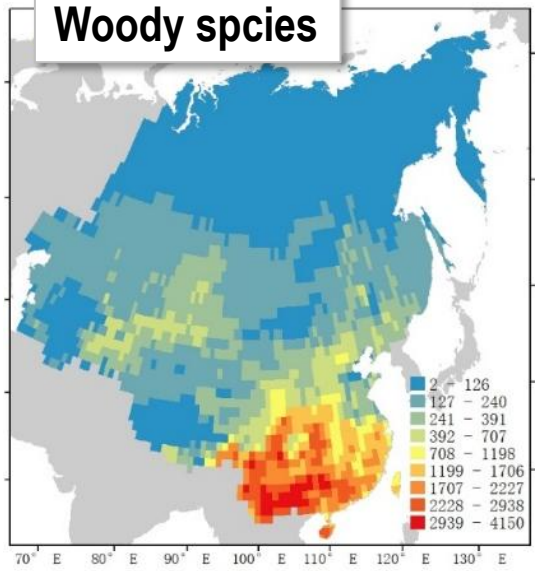
Spatial resolution: 10 * 10 km^2

Species diversity patterns in temperate Asia

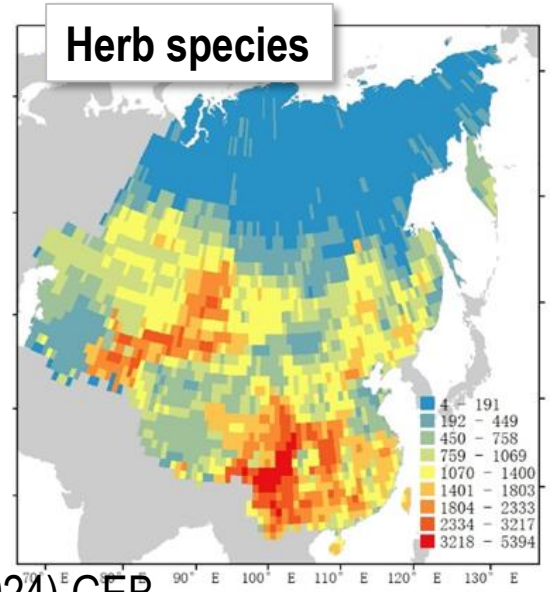
Seed plant species,
49 k species



Woody spcies



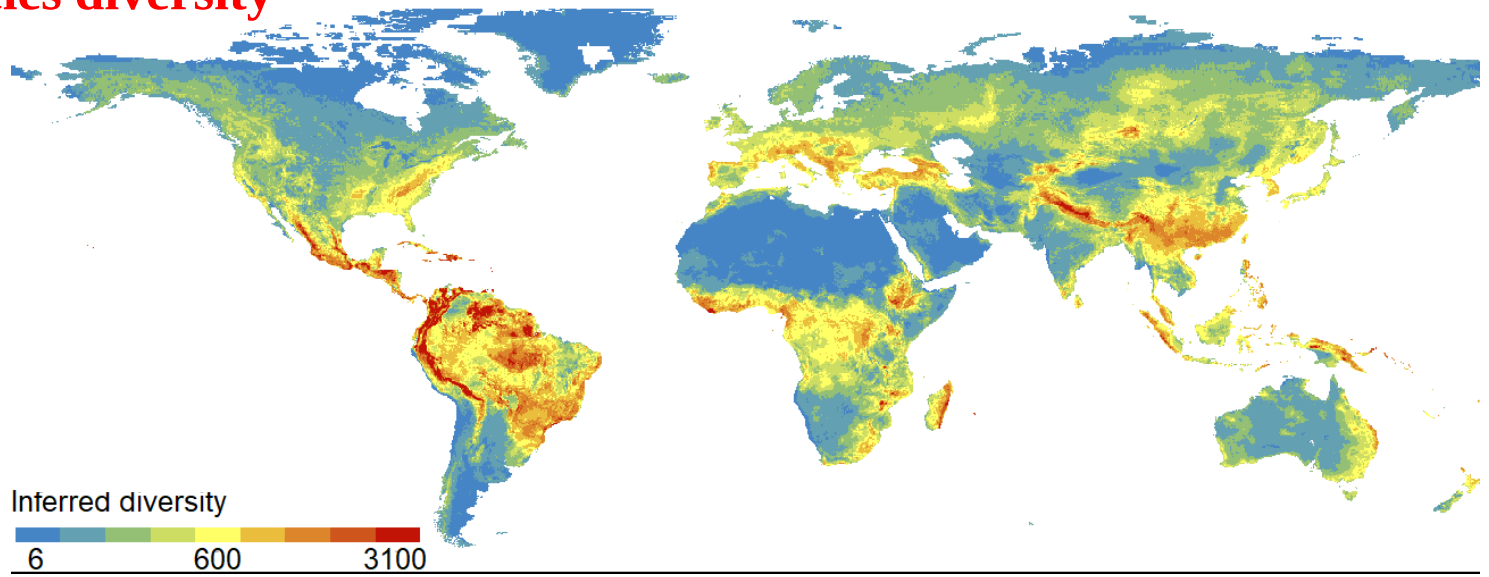
Herb species



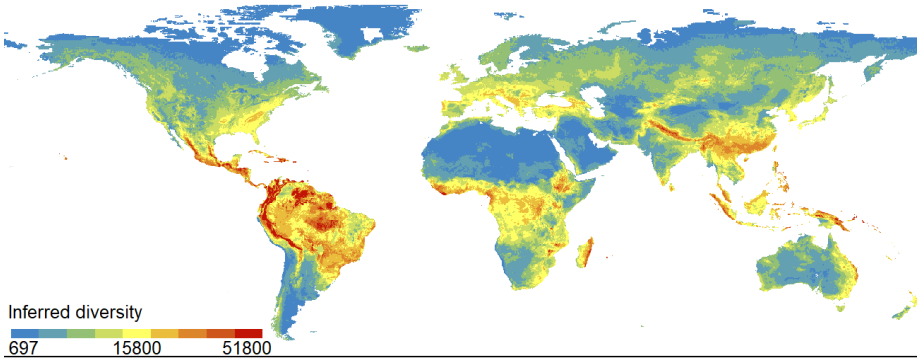
Su et al. (2020); Song et al. (2024) Ecography; Song et al. (2024) GEB

Global patterns in seed plant diversity

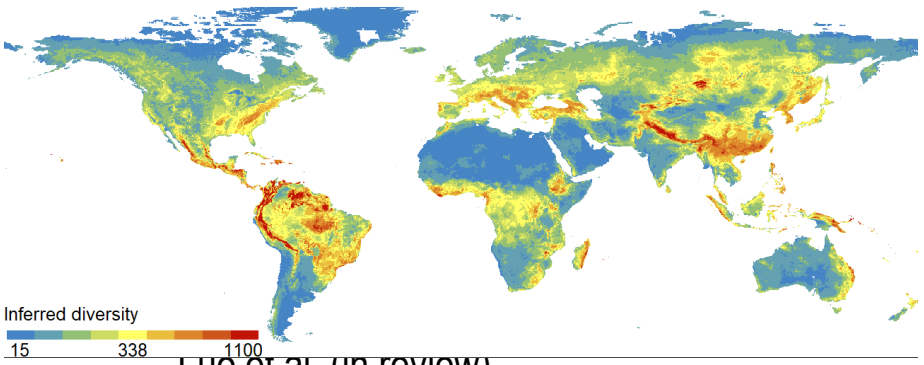
Species diversity



Evolutionary diversity



Functional diversity



Luo et al. (in review)

Luo *et al.* (2023) ***Science China Life Science***

Outline

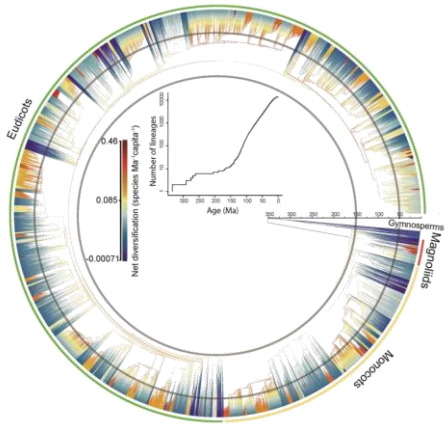
1 Plant diversity: from China to the world
(植物多样性：从中国到全球)

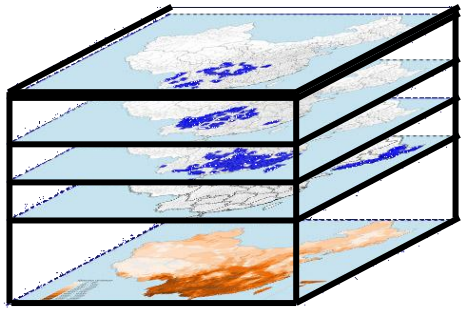
2 Evolution of the temperate Asian flora
(温带亚洲植物区系的演化)

3 Drivers of plant diversity patterns in temperate Asia
(温带亚洲植物多样性格局及其主导因子)

4 Promote future collaborations
(提升未来合作)

Methods for floristic regionalization



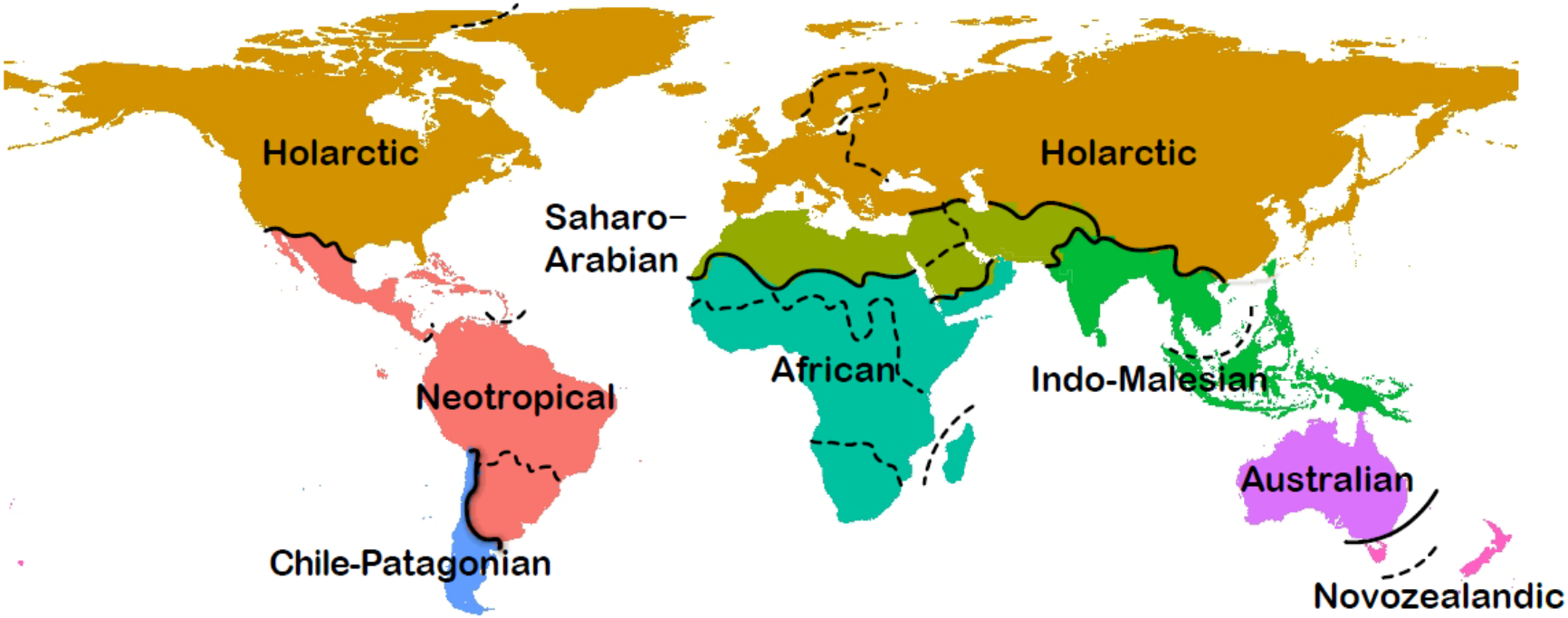


1) Phylo beta diversity: estimate the phylogetic differciation between grid cells

2) Clustering: identify major floristic regions and their boundaries

Liu, ..., Wang* (2023) *Nature Communications*

A new regionalization scheme of "8 realms and 16 sub-realms"



I Saharo-Arabian Realm: 1 Iran-Pakistan Sub-realm; 2 Saharo-Arabian Sub-realm

II Holarctic Realm： 3 North American Sub-realm; 4 European Sub-realm; 5 Asian Sub-realm

III Chile-Patagonian Realm: 6 Chile-Patagonian Sub-realm

IV Neotropical Realm: 7 Brazilian Sub-realm; 8 Subtropical American Sub-realm

V Indo-Malesian Realm: 9 Malaysian Sub-realm; 10 Indian Sub-realm

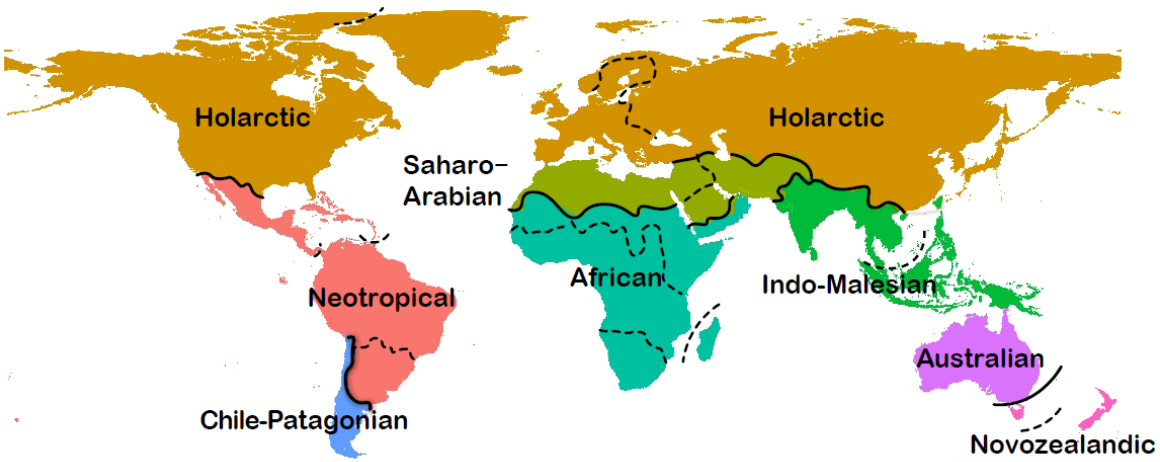
VI African Realm: 11 Madagascan Sub-realm; 12 Guineo-Congolian Sub-realm; 13 Sudanio-Zambezian Sub-realm

VII Australian Realm: 14 Australian Sub-realm

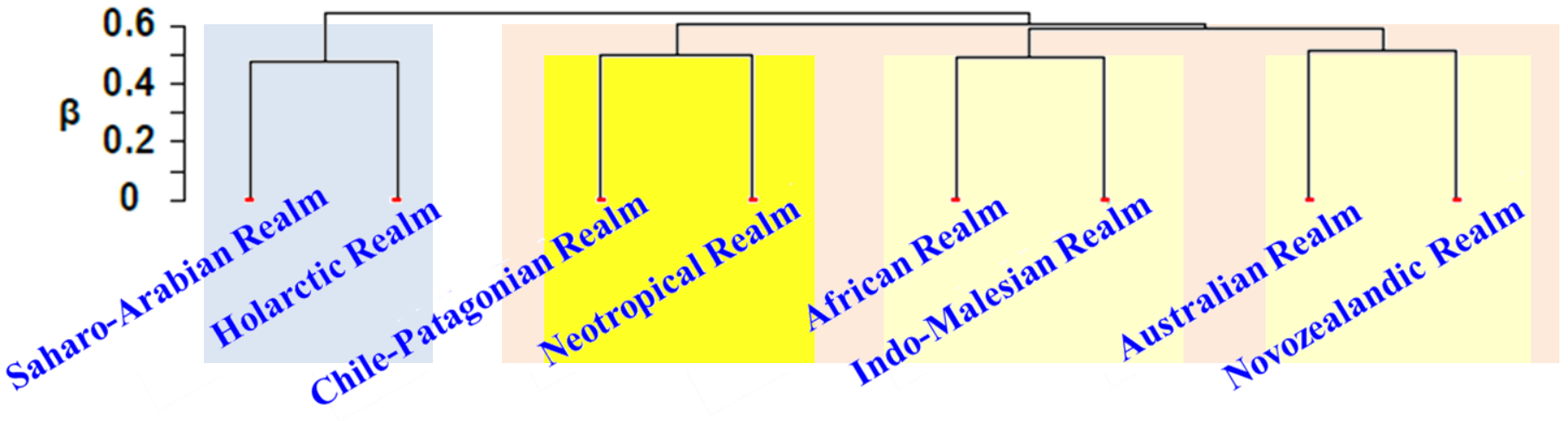
VIII Novozealandic Realm: 15 Novozealandic Sub-realm; 16 Tasmanian Sub-realm

Liu et al. (2023) *Nature Communications*

Relationships between different floristic regions

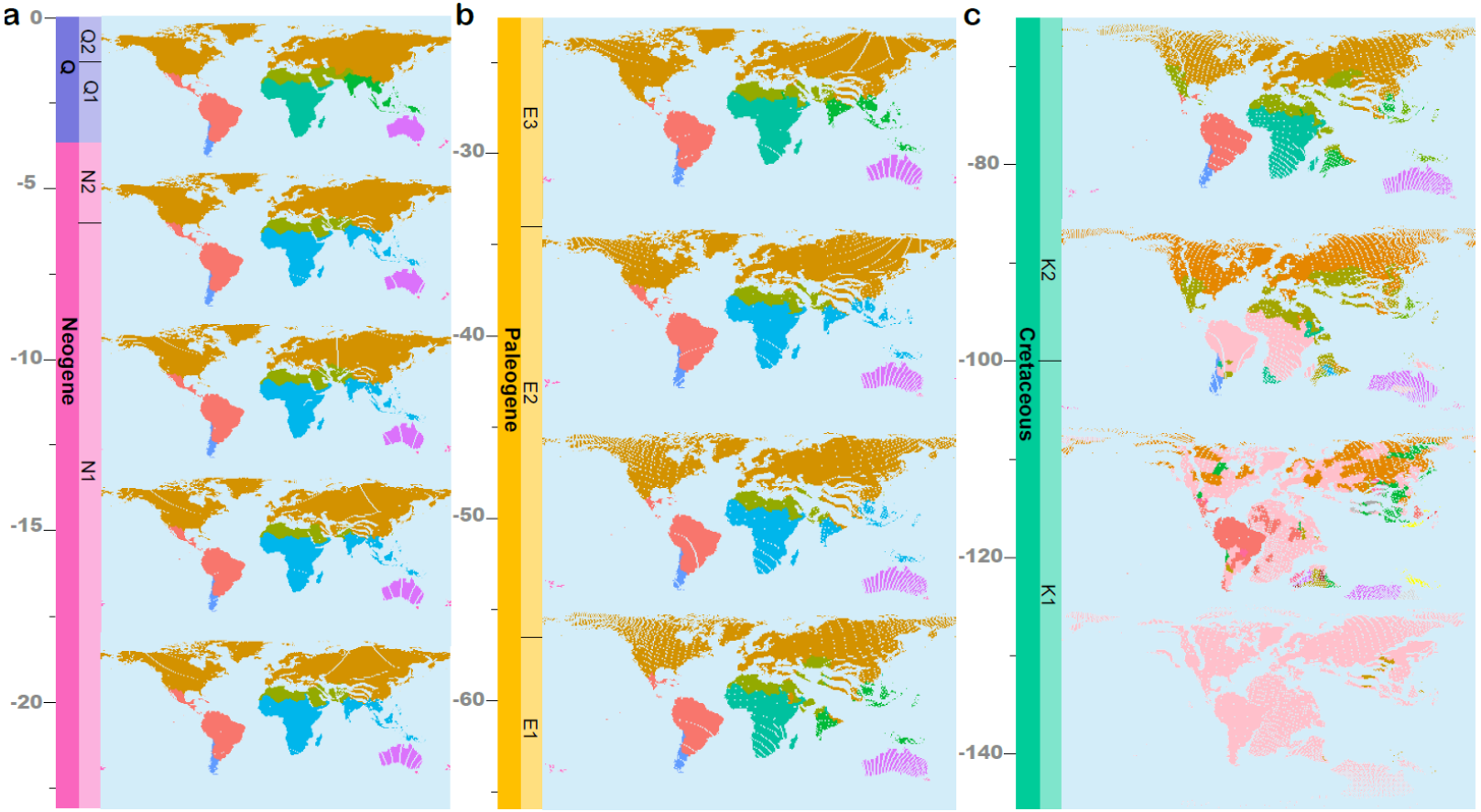






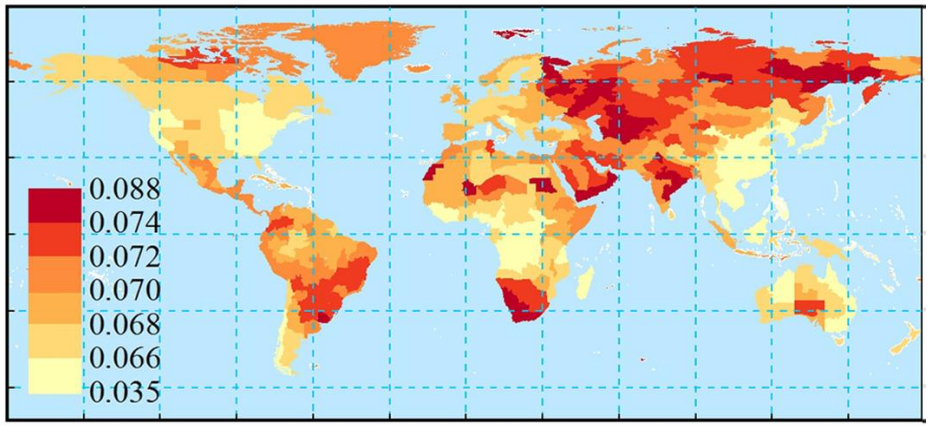
Evolution of floristic regions since the Cretaceous

- By 80 Ma, Holartic, African and Neotropical realms formed
- By 60 Ma, modern plant realms had largely taken shape
- Between 5 and 20 Ma, African and Indo-Malayan realms amalgamated into the Paleotropical Realm, only to diverge again by 0 Ma



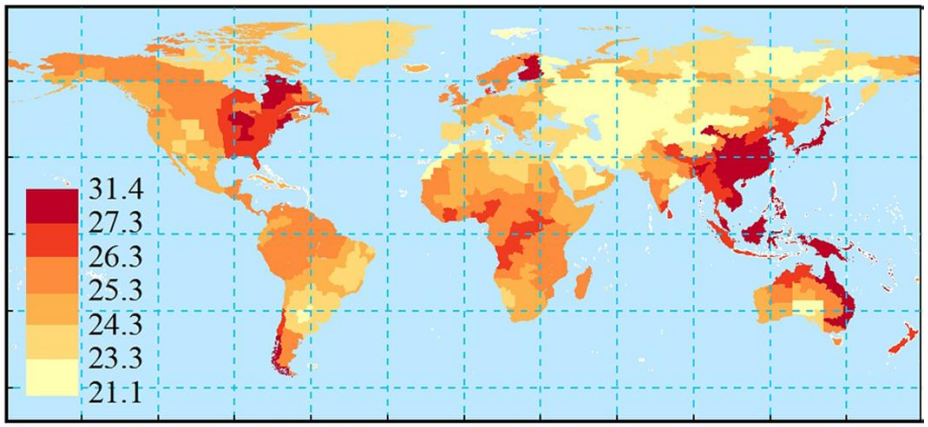
Patterns in evolutionary rates of extant angiosperms

Diversification rate



- Temperate and arid regions have highest diversification rates
- Closely linked to environmental change

Mean genus age



- Tropical and subtropical regions harbor older species

Dimitra, ..., Wang* (2023) *Nature Communications*

Outline

1 Plant diversity: from China to the world
(植物多样性：从中国到全球)

2 Evolution of the temperate Asian flora
(温带亚洲植物区系的演化)

3 Drivers of plant diversity patterns in temperate Asia
(温带亚洲植物多样性格局及其主导因子)

4 Promote future collaborations
(提升未来合作)

Future research work

Response and Conservation of Multidimensional Plant Diversity to Global Change

Key questions:

- Spatiotemporal patterns and drivers of mutildimensional plant diversity
- Consistency in the responses of different dimensions to global change
- Protection capacity and expansion strategy for conservation of different dimensions

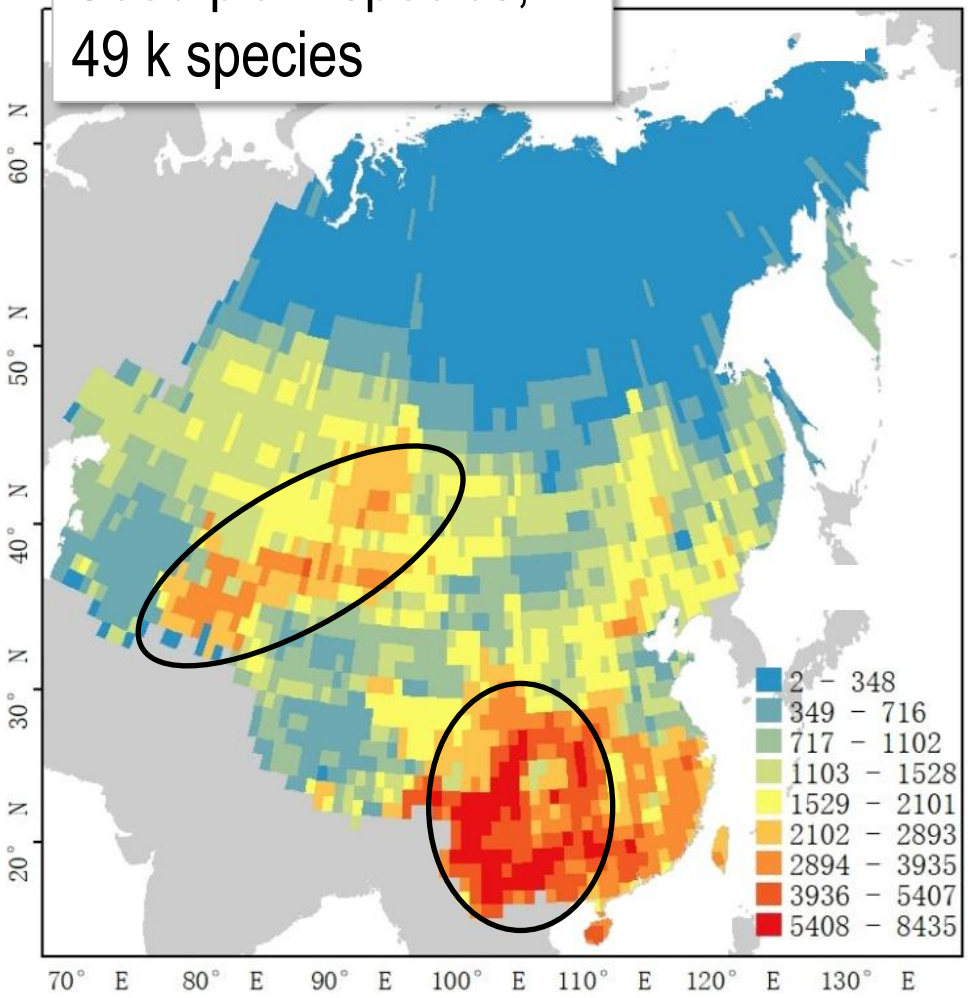
Diminsions of biodiversity



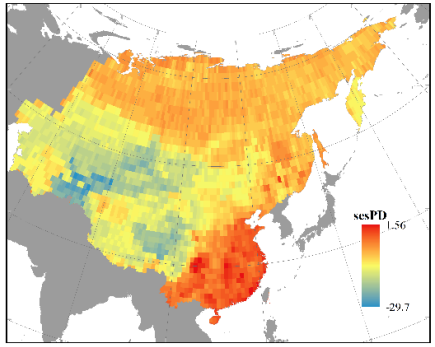


Species diversity patterns in temperate Asia

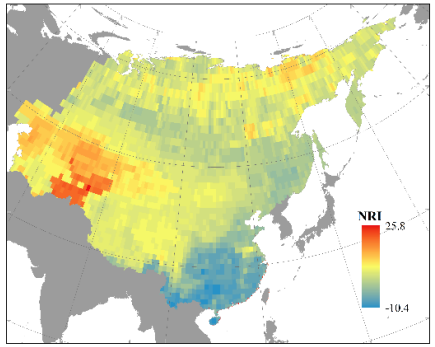
Seed plant species,
49 k species



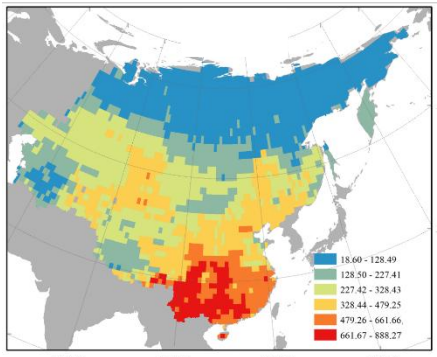
Phylogenetic diversity



Phylogenetic structure (NRI)



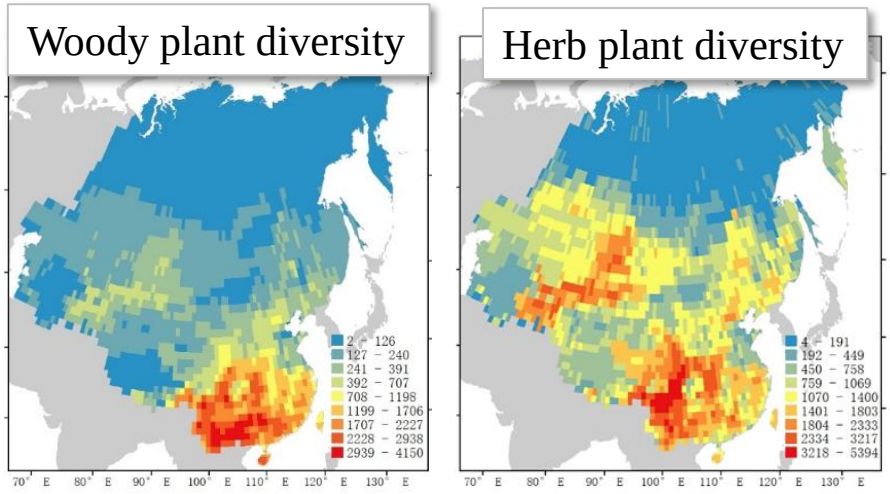
Functional diversity

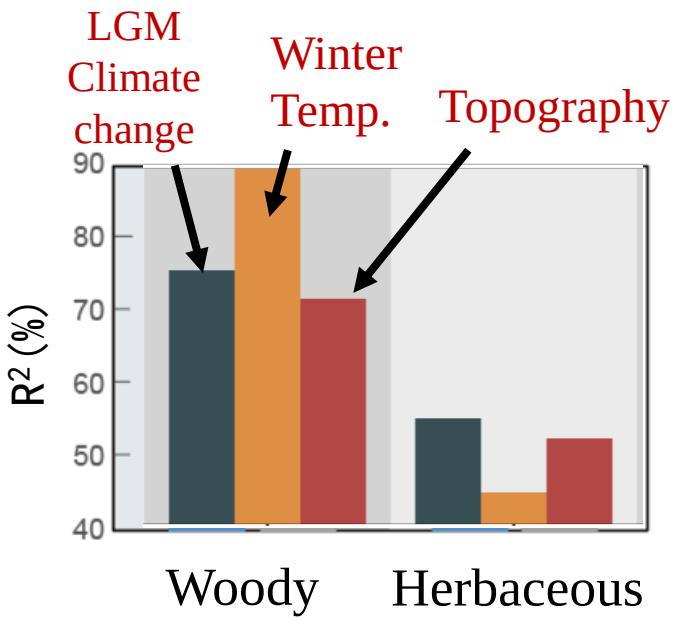


Su et al. (2020); Song et al. (2024) Ecography; Song et al. (2024) GEB

Elucidated new mechanisms of plant diversity patterns

- **Approach:** **Integrating species distribution, phylogenetic methods with paleoclimatic data**
- **Findings:** **Woody plant diversity is driven by winter coldness, but herbaceous plant diversity by climate change since the LGM and topography.**

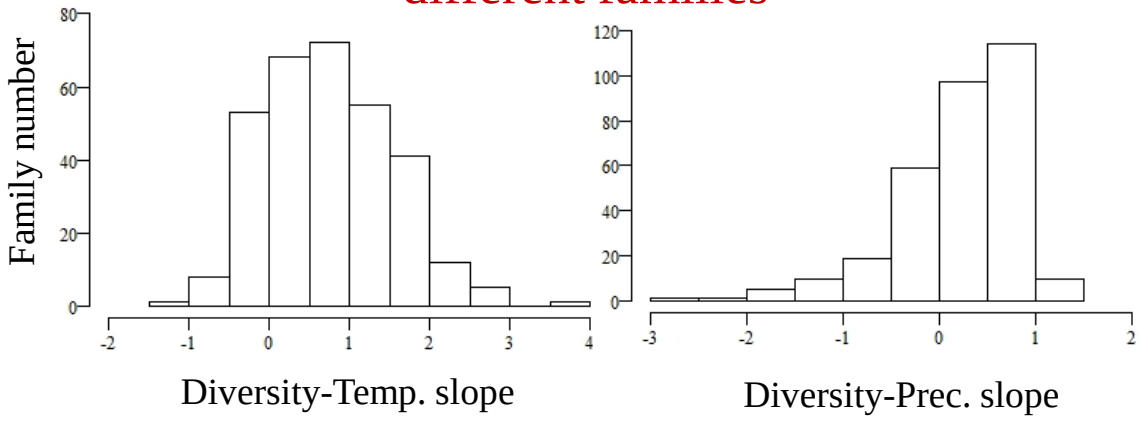




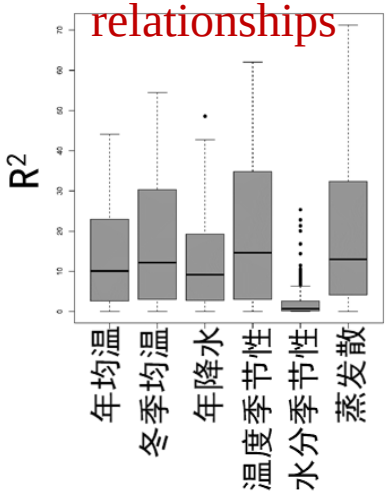
Diversity and Distributions (2017); Ecography (2019, 2020)

Challenge: A unified theory explaining the relationship between species diversity and climate remains elusive

Slopes of diversity-climate relationships for different families



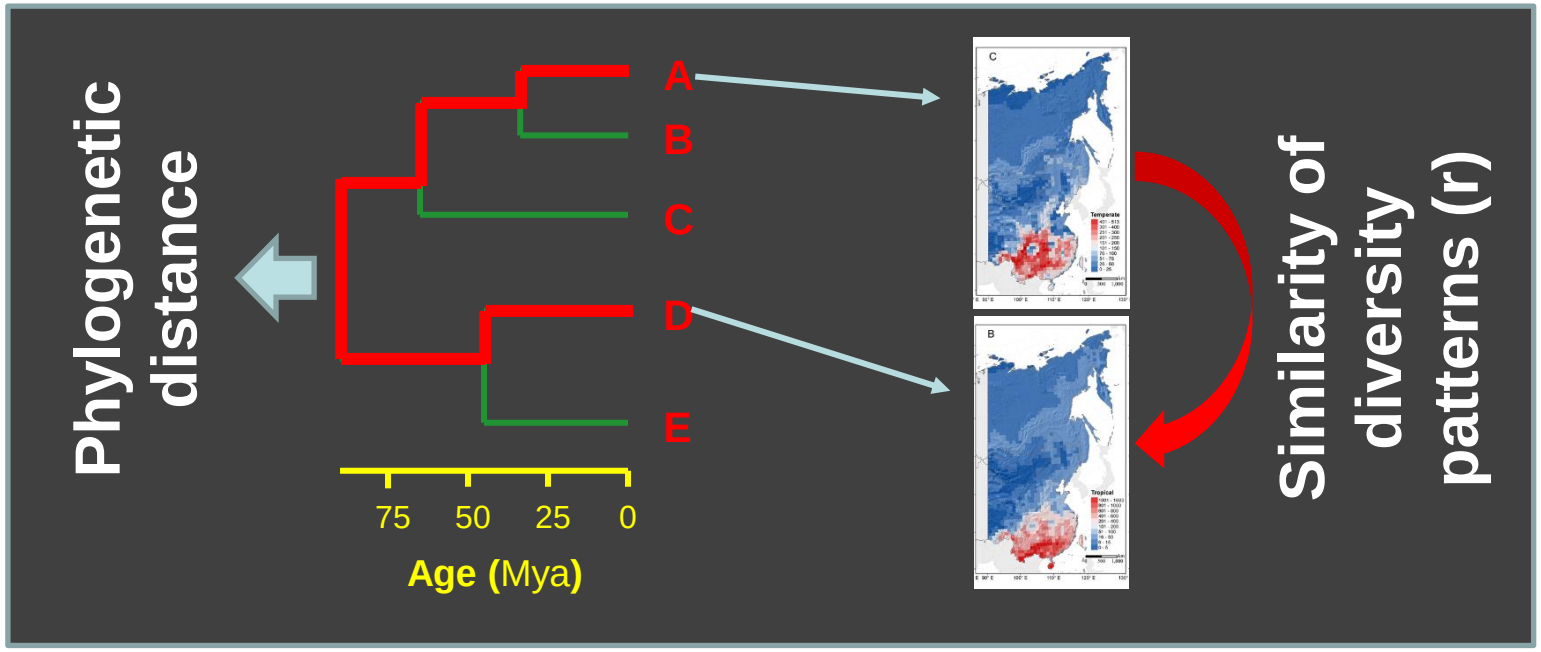
R^2 of diversity-climate relationships



- ❑ **Evolutionary processes (evolutionary rate, age)**
- ❑ **Niche difference**

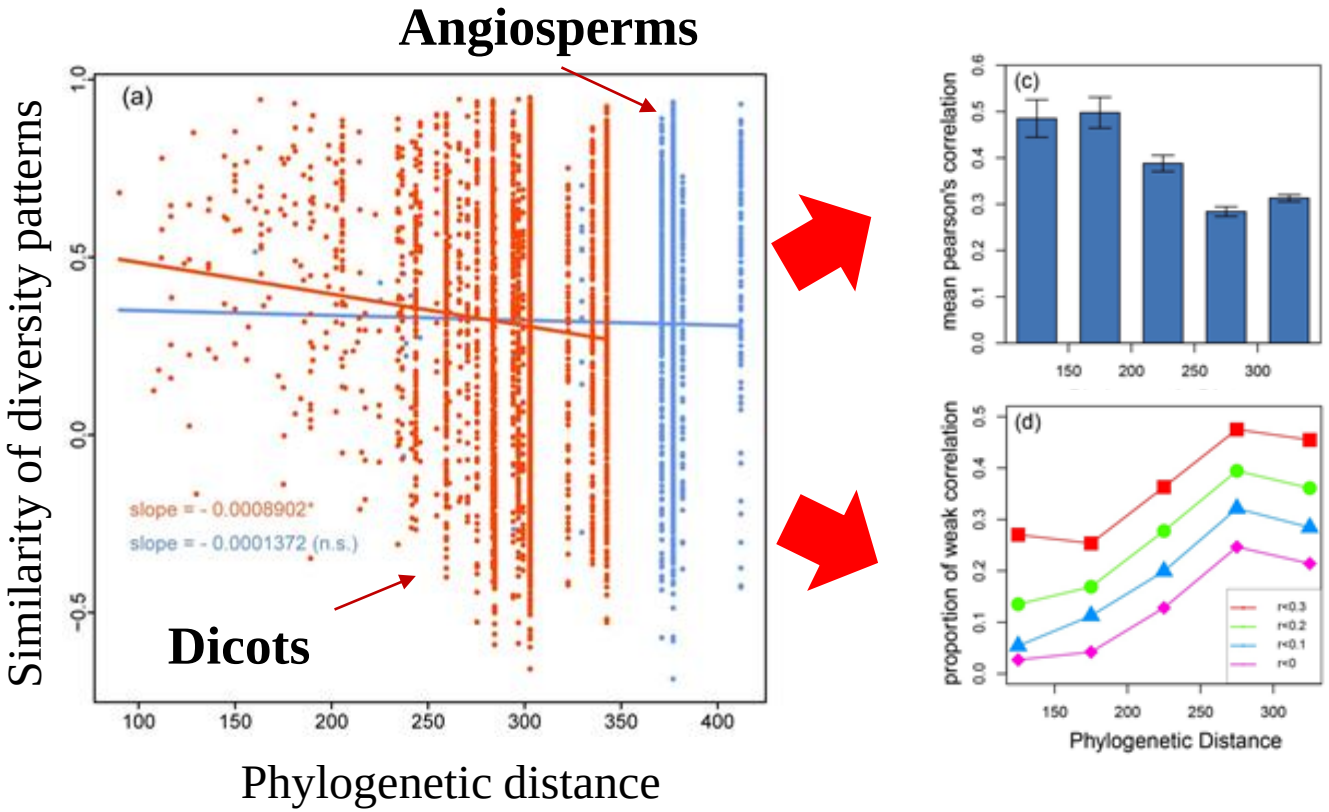
Su *et al*. (2020) *Ecography*; Wang *et al*. (2021) *Ecography*; Jiang *et al*. (2023) GEB

Evolution of species diversity-climate relationships



Su *et al*. (2020) *Ecography*; Wang *et al*. (2021) *Ecography*; Jiang *et al*. (in prep)

Phylogenetic conservatism of diversity patterns

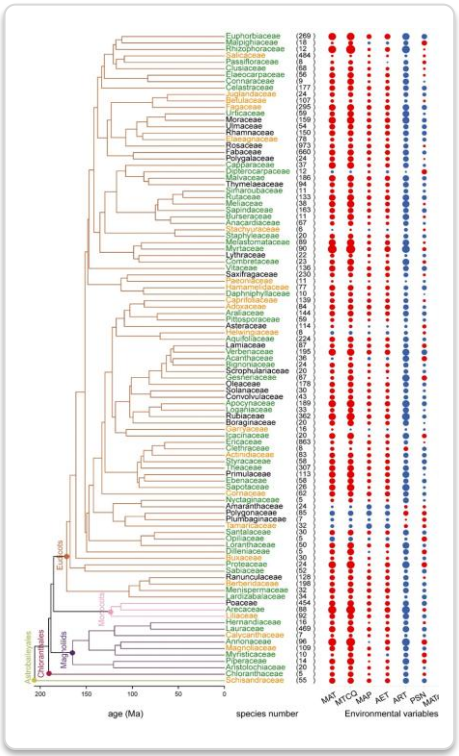


Diversity patterns are more similar between phylogenetically close families.

Su *et al*. (2020) *Ecography*

Phylogenetic conservatism of diversity-climate relationships

	Temperate Asia		World	
Variable	*K*	p	*K*	p
MAT	0.822	0.015	0.658	0.008
MTCQ	0.838	0.005	0.700	0.002
MAP	0.756	0.029	0.631	0.020
AET	0.767	0.103	0.687	0.012
ART	0.828	0.017	0.726	0.001
PSN	0.697	0.151	0.480	0.727



- **Closely related taxa have more similar diversity–climate relationships**

Su *et al*. (2020) *Ecography*; Wang *et al*. (2021) *Ecography*; Jiang *et al*. (2023) *GEB*

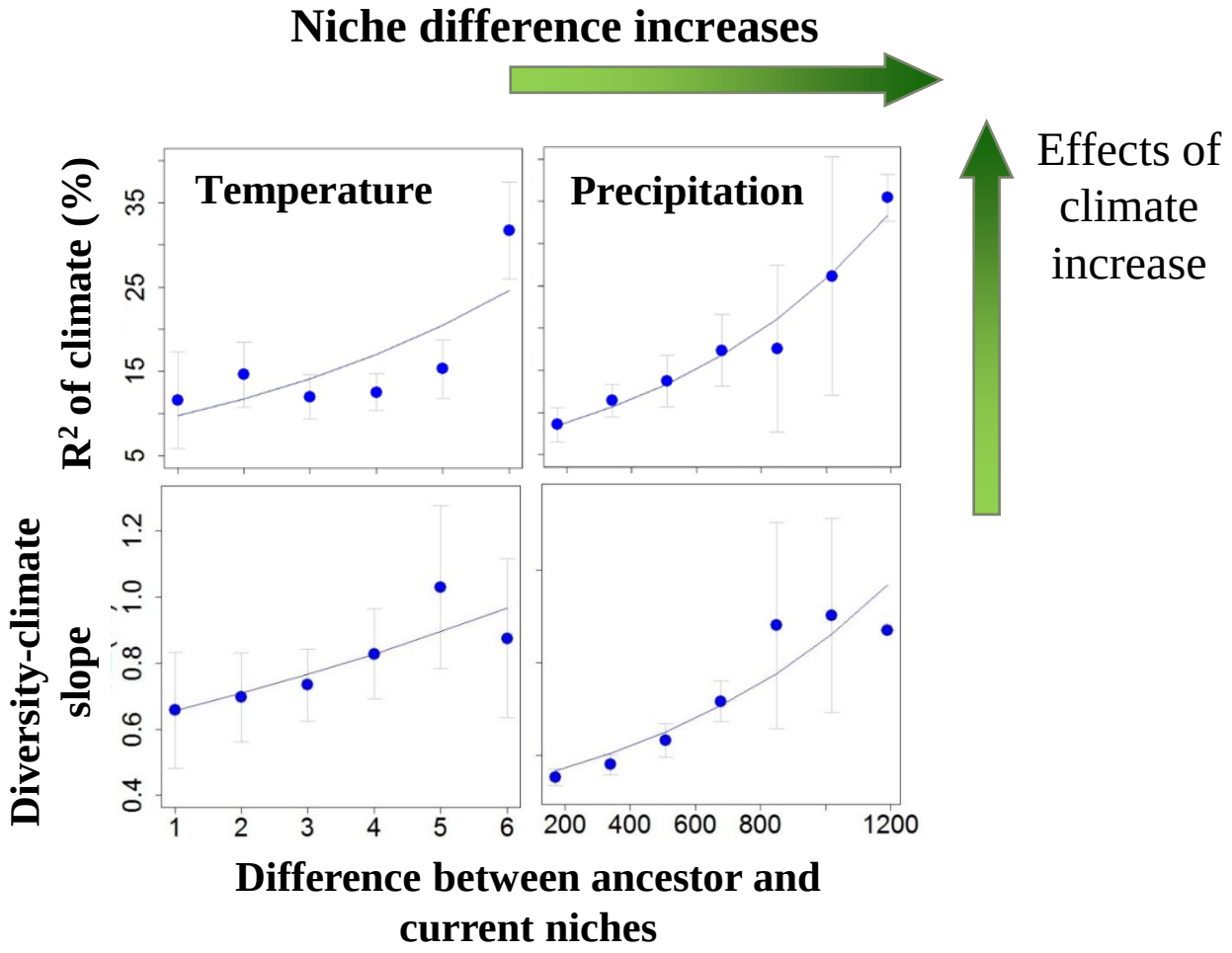
Niche conservatism led to the conservatism of diversity-climate relationships

	Impact factors	Coef.	R^2
Diversity-winter temp. slope	Difference between ancestor and current niches	-0.0504	0.26***
	Diversification rate	7.9816	0.08**
	Age	0.0017	0.00^{ns}
Diversity-precipitation slope	Difference between ancestor and current niches	-0.0004	0.15***
	Diversification rate	2.9462	0.09**
	Age	-0.0007	0.00^{ns}
Diversity-temp. seasonality slope	Difference between ancestor and current niches	0.0050	0.28***
	Diversification rate	-7.8021	0.13***
	Age	0.0004	0.00^{ns}

- ❑ Difference between ancestor and current niches dominated variaitons in diversity-climate slopes

Su *et al*. (2020) *Ecography*; Wang *et al*. (2021) *Ecography*; Jiang *et al*. (2023) *GEB*

Niche conservatism affects diversity-climate relationships



❑ **Finding: Evolution of diversity–climate relationships is driven by niche conservatism.**

Su *et al*. (2020) *Ecography*; Wang *et al*. (2021) *Ecography*; Jiang *et al*. (2023) *GEB*

Outline

1 Plant diversity: from China to the world
(植物多样性：从中国到全球)

2 Evolution of the temperate Asian flora
(温带亚洲植物区系的演化)

3 Drivers of plant diversity patterns in temperate Asia
(温带亚洲植物多样性格局及其主导因子)

4 Promote future collaborations
(提升未来合作)

Suggestions for future collaborations

1) Promote the sharing of plant distribution data, including floras, specimen data and ecological community surveys

2) Conduct joint ecological monitering and field surveys using the same protocals

3) Advocate for respective foundations to sponsor collaborative research and exchange visits

Thank you for your attention !

Macroecology Group @ Peking University



研究组公众号

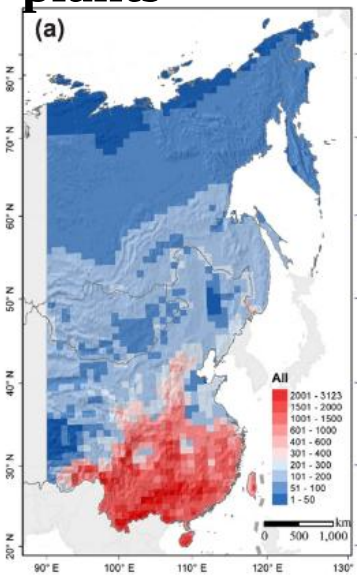
国家自然科学基金委员会
National Natural Science Foundation of China

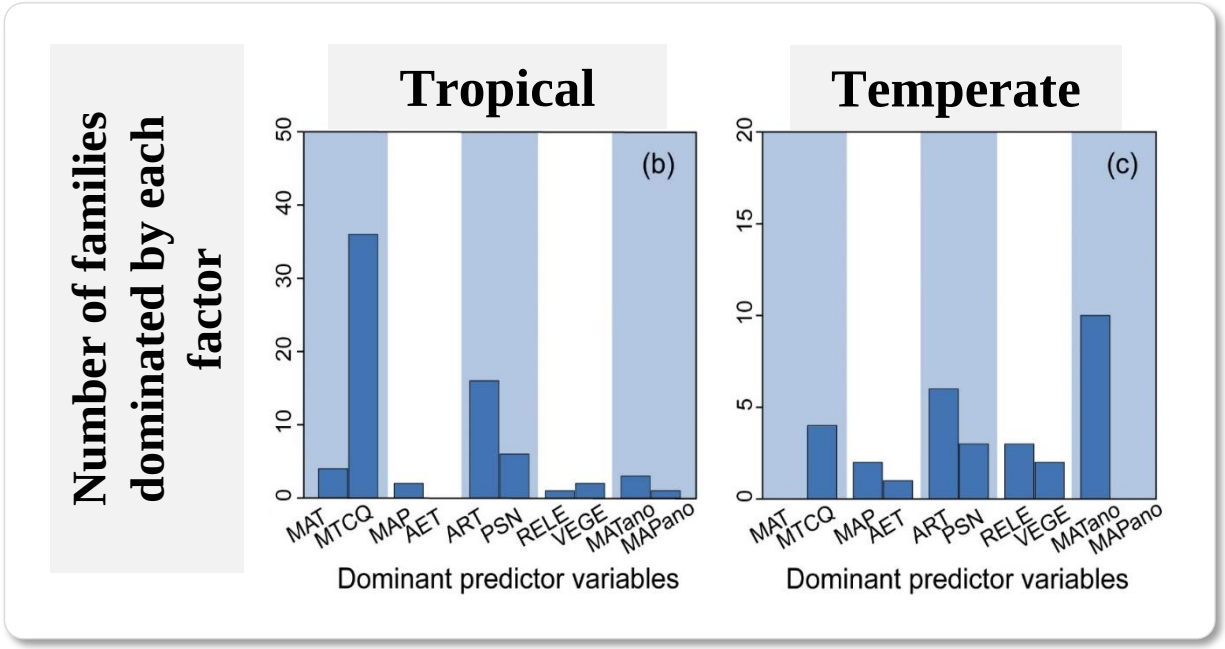
中华人民共和国科学技术部
Ministry of Science and Technology of the People´s Republic of China

千人计划
RECRUITMENT PROGRAM OF GLOBAL EXPERTS

Effects of winter temperature: tropical *vs*. temperate families

East Asia woody plants





- Tropical families are mainly determined by winter coldness
- Temperate families are mainly determined by climate change since the LGM

Su *et al*. (2020) *Ecography*