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A REVIEW OF PINE WILT DISEASE AND MY DOCTORAL RESEARCH PROGRESS

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forests

Special Issue "Forests Research in Beijing Forestry University: Commemorating the University's 70th Anniversary"

Special Issue Editors:
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PINE WILT DISEASE IN NORTHEAST AND NORTHWEST CHINA: A COMPREHENSIVE RISK REVIEW

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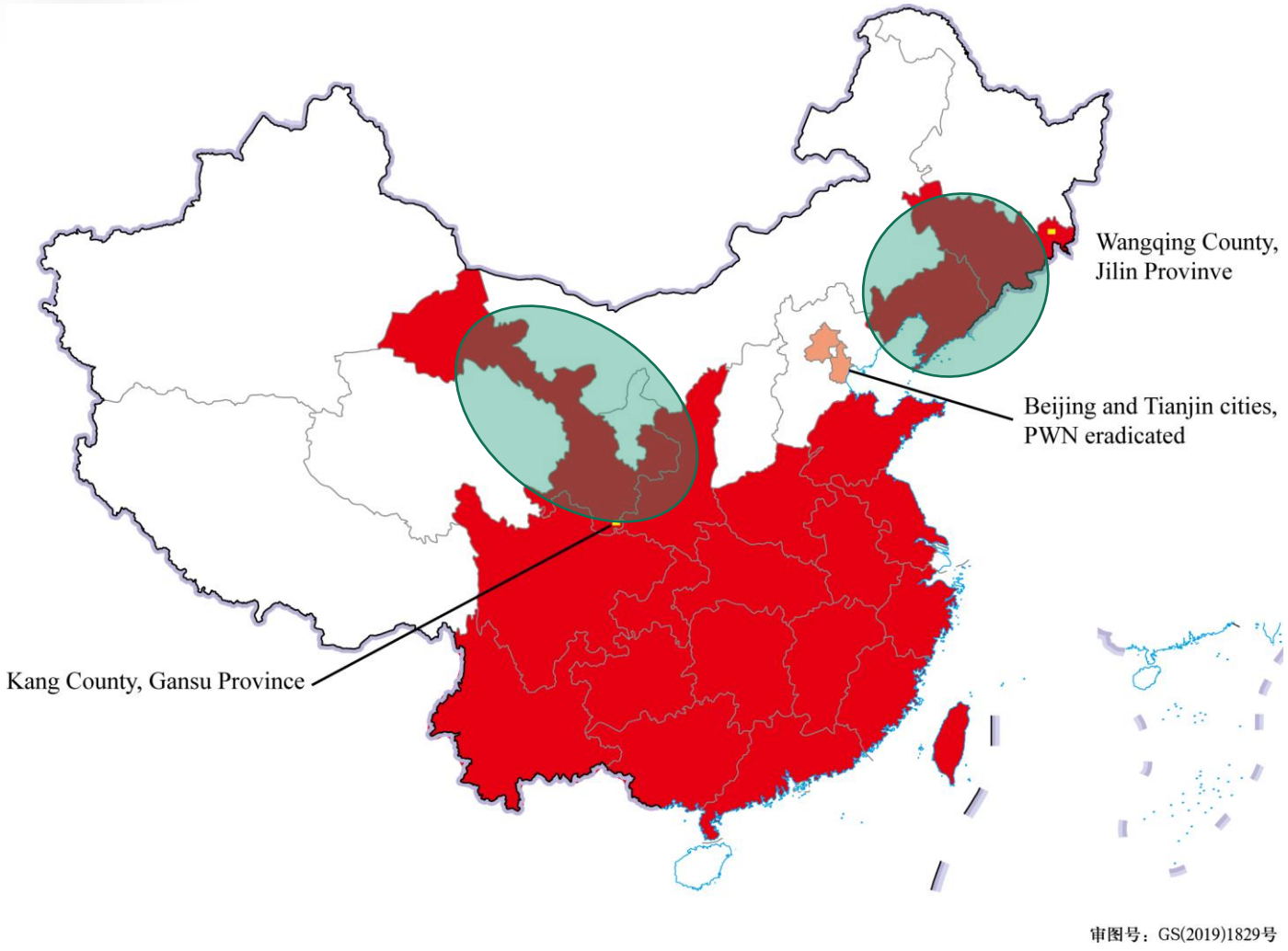
1.1 Spread trend of PWD in Northeast and Northwest China



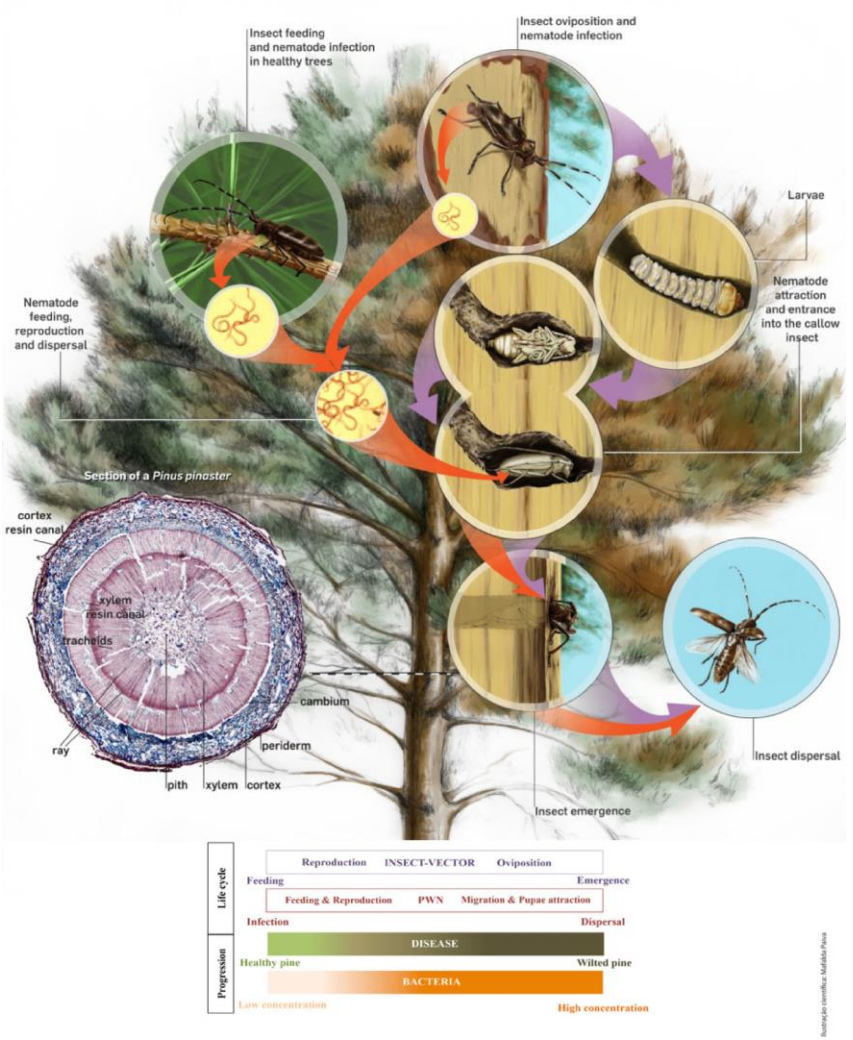
PWD epidemic area in the Chinese Mainland

- 1982-2008: mostly in **sourthern China**
- 2009: Shaanxi Province and Northwest China for the first time.
- 2016: Liaoning Province and Northeast China for the first time by a jump spread crossing North China.
- 2021: Jilin Province in Northeast China and Gansu Province in Northwest China.

a noticeable trend of spreading to the northeast and northwest

1.2 The complexity of PWD

- **Complex plant disease system:** environmental conditions, PWN, host pine trees, vector insects *Monochamus*, microorganisms. And coordinated by complex chemical signals.
- **Human activities** such as transporting diseased trees and wood led to the complexity of PWD occurring on a spatiotemporal scale.
- **Pathogenic differentiation**: geographic strains of PWN, species and pathogenicity of the bacteria on the PWN surface, number of PWNs carried by *Monochamus*, tree species resistance.
- The critical pathogenic factor of PWD is still unknown.
- Challenging to manage and difficult to copy the experience of other areas directly.



Francisco X. Nascimento et al,. 2015

1.3 PWN and temperature

Traditional understanding: not happen where the average summer temperature is higher than 20 ℃ and annual average temperature below 10 ℃

Fact: The average annual temperature in Wangqing County, Jilin Province, the northernmost occurrence point in China at present, is only 3.8-4.7 ℃, far lower than 10 ℃.

Evidence

The nematodehigh tolerance to low temperatures and high stressed conditions.

PWN's ancestor originated from eastern Eurasia's cold region.

The survival rates of propagative and dispersal juveniles of PWN were stable at about 95% in the gradient temperature change to - 15 ℃.

The PWN population in southern China had a solid cold tolerance, indicating that the population invading from southern China to northern China could successfully invade without adaptation.

Sequencing analysis of the whole genome of PWN from different geographic populations in China showed that the geographic-related SNPs were mainly located in the GPCR gene family related to adaptation, which indicated that nematodes had been evolving to adapt to different temperatures.

Conclusion

PWN has the ability and genetic basis for **resisting low temperatures**.

PWN is suitable for all regions of China from temperature factors. **Temperature is not a limiting factor for the spread of PWN in Northeast and Northwest China.**

1.4 PWN and altitude

USA

The highest distribution of PWN is about 1300 meters.

Japan

PWD mainly occurs below 750m.

The highest distribution of PWN is 1150m.

Europe

The highest distribution of the vector insect Monochamus alternatus is 1590m.

China

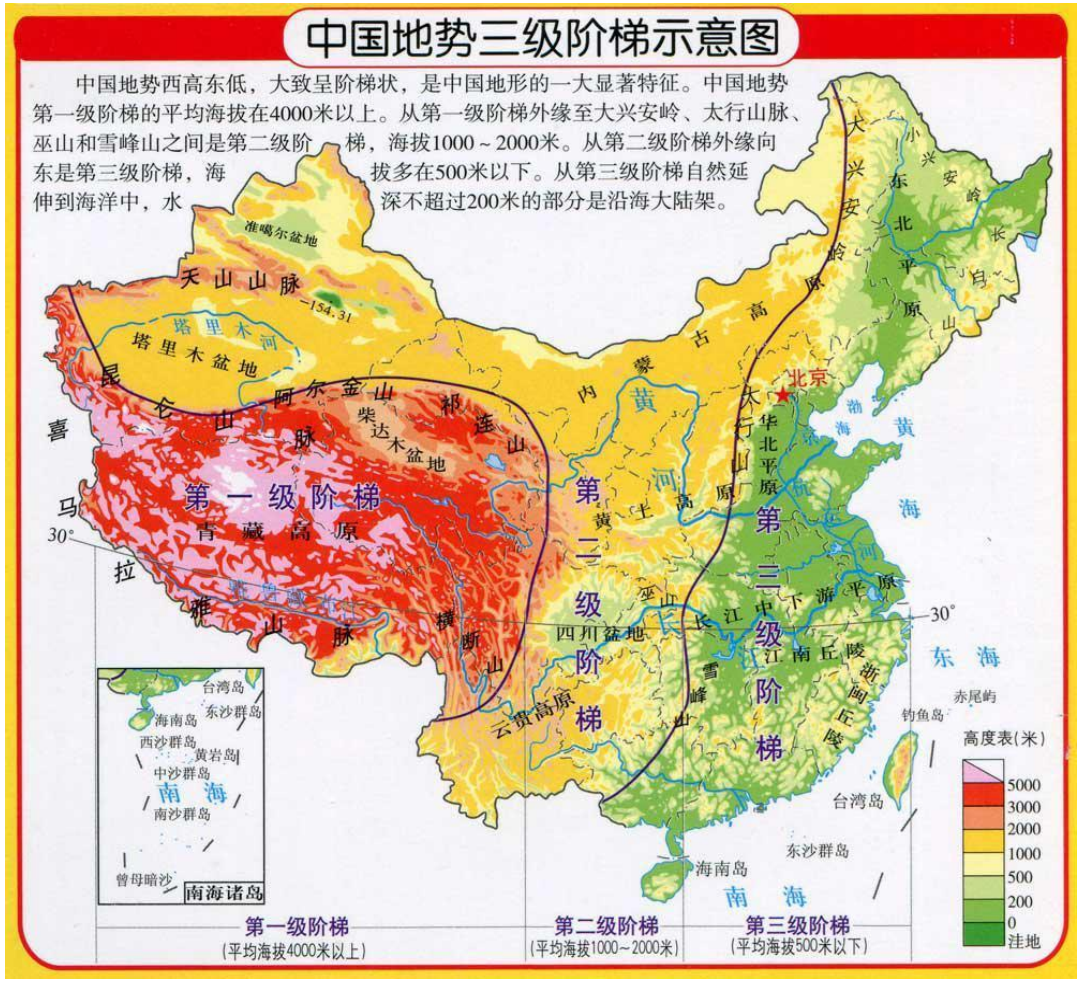
The areas below 400m altitudes are serious, 400-700m are moderate, 700-1000m are sporadic, and more than 1000m are non-occurrence areas.

Only one occurrence was reported at an altitude of more than 1000 meters.

Conclusion

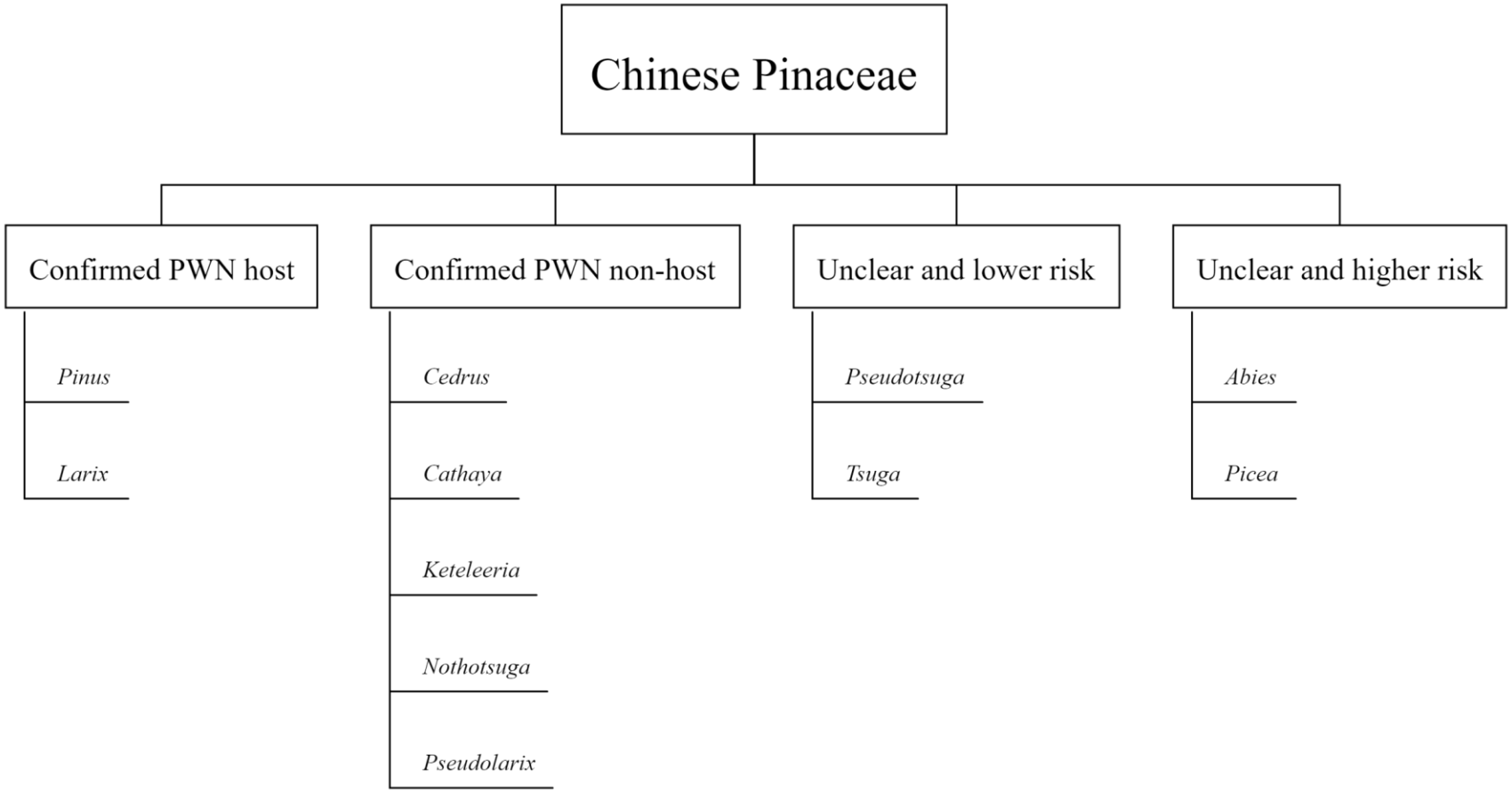
PWD mainly occurs in areas below 1000 altitudes.

The average altitude of the **Qinghai Tibet Plateau** is more than 4000 meters, which **can be considered a low risk of PWD occurrence.**



1.5 PWN and host trees

All 11 genera of Pinaceae are distributed in China: *Abies*, *Cathaya*, *Cedrus*, *Keteleeria*, *Larix*, *Nothotsuga*, *Picea*, *Pinus*, *Pseudotsuga*, *Pseudolarix*, and *Tsuga*.
The relationships between the genera of Pinaceae and PWN in China can be divided into four categories.



1.5 PWN and host trees

Conifer tree species with the lowest distribution altitude below 1000m in Northeast and Northwest China. **They are all distributed in Northeast China.** Therefore, from the perspective of host tree species and altitude distribution, **the coniferous forests in Northeast China are much more threatened by PWD than those in Northwest China.**

Species	Distribution	Lowest distribution altitude /meters
Pinus densiflora var.*ussuriensis*	Heilongjiang Province	50
Pinus koraiensis	Lesser Khingan, Wanda Mountains, Zhangguangcai Range, Changbai Mountain	50
Pinus sylvestris var.*sylvestriformis*	Changbai Mountain	630
Pinus thunbergii	Liaoning Provinve	400
Larix gmelinii	Greater Khingan, Lesser Khingan	300
Larix olgensis	Changbai Mountain	500
Picea jezoensis	Greater Khingan, Lesser Khingan, Zhangguangcai Range, Changbai Mountain	700
Picea koraiensis	Greater Khingan, Lesser Khingan, Wanda Mountains, Zhangguangcai Range, Changbai Mountain	300
Abies nephrolepis	Lesser Khingan, Zhangguangcai Range, Changbai Mountain	500

1.5 PWN and host trees

A complex relationship between PWN strains and *Picea* species in different regions.

Reports on the isolation of PWN from *Picea* and *Abies* tree in the wild and the death of *Picea* and *Abies* by artificial inoculation with PWN.

Country	Isolation	Inoculation
USA (Origin)	*Picea glauca*, *Picea pungens*, *Abies balsamea*	
Canada (Origin)	*Picea glauca*, *Picea mariana*, *Picea rubens*, *Abies balsamea*	*Picea engelmannii*, *Picea glauca*, *Picea mariana*, *Picea rubens*, *Picea sitchensis*, *Abies amabilis*, *Abies balsamea*, *Abies grandis*
Japan (Invasive)	*Picea abies*, *Abies firma*	*Picea abies*, *Picea jezoensis*, *Picea mariana*, *Abies homolepis*, *Abies sachalinensis*

Artificial inoculation with PWN caused lower mortality of *Picea* and *Abies* trees than *Pinus*.

1.6 PWN and vector insects

The vector insects of PWN are all *Monochamus*. Seven *Monochamus* species feed on conifers in China.

Vector insects are not an obstacle to PWD in NE and NW.

Species	Distribution in Northeast (NE) andNorthwest (NW) China	Relationship with PWN (pine wood nematode)
Monochamus alternatus	NE and NW	Confirmed vector in China
Monochamus basifossulatus	No distribution	
Monochamus galloprovincialis	NE	Confirmed vector in Europe
Monochamus guerryi	No distribution	
Monochamus saltuarius	NE and NW	Confirmed vector in China
Monochamus sartor urussovii	NE and NW	
Monochamus sutor	NE and NW	

1.7 Comprehensive risk of PWD in Northeast and Northwest China

From temperature, altitude, host trees, and vector insects, NE has a higher risk than NW.

- PWN has strong adaptability to low temperatures, so it is speculated that it can adapt to various temperature zones in China.
- There are only a few reports of PWD in areas above 1000 meters globally due to the limitation of high altitude on the distribution of host pine trees and vector insects. Therefore, the occurrence risk of PWD in the Qinghai-Tibet Plateau of China is extremely low.
- From the perspective of biological factors of the PWD disease system, the Northeast region has a higher risk compared with Northwest China due to its host tree and vector beetle distribution at lower altitudes.

1.8 Scientific problems to be solved

Pathogenicity of PWN to *Picea* and *Abies*

Some Picea and Abies species in Northeast China are distributed below 1000m, facing a severe risk. Whether PWN can cause spruce and fir death in China is a crucial scientific problem that needs to be solved first. Chinese PWN strains should be used to inoculate Chinese spruce and fir trees and observe the pathogenicity due to PWN's pathogenic differentiation. Moreover, it is also suggested to isolate spruce and fir trees from the PWN epidemic area in Northeast China to see if PWN has infected them but with no wilting symptoms.

Distribution and PWN transmissibility of *Monochamus*

The distribution information of five *Monochamus* species in Northeast and Northwest China needs to be investigated and confirmed. The Monochamus species may spread due to afforestation activities in recent decades. Moreover, the current literature data is relatively old. Studying the distribution of Monochamus species at different altitudes is also necessary, which is of great significance to understanding the altitude distribution limit of PWD in China. In addition, research on their transmission capacity of PWN should also be carried out for the three insects, *M*. *galloprovincialis*, *M*. *sutor*, and *M*. *sartor urussovii*.

PWD contents under study

- **Basic biology and interaction:** 3 master students

Hou-Qidi: **Low-humidity dormancy** habit of *Bursaphelenchus xylophilus* JIII and its effect on **cold tolerance**
Zhang-Xuejiao: **Pathogenicity** of *Bursaphelenchus xylophilus* to ***Picea* and *Abies*** in China
Ren-Jiaru: **PWN Carrying and transmission ability** of ***Monochamus*** in Palaearctic realm

- **Interaction mechanism:** 2 doctoral students

Li-Jiaxing: Response mechanism of ***Monochamus saltuarius*** to *Bursaphelenchus xylophilus* in **growth, development and lipid metabolism**
Ge-Sixun: Mechanism of **microorganisms associated with *Monochamus saltuarius*** in **adaptation** of host pines

- **Monitoring and remote sensing:** 1 doctoral student and 2 master students

Yu-Run: Early Monitoring of *Bursaphelenchus xylophilus* based on **time series UAV hyperspectral images**
Wu-Dewei: Best monitoring window of *Bursaphelenchus xylophilus* based on **different UAV data sources** —— A case study of coastal and mountain pine forests in Yantai, Shandong Province
Kuang-Jinjia: Monitoring of *Bursaphelenchus xylophilus* based on **satellite remote sensing**

Publication:

Yu-Run et al. 2021 FOREST ECOSYSTEMS; 2021 FOREST ECOLOGY AND MANAGEMENT; 2021, INTERNATIONAL JOURNAL OF APPLIED EARTH OBSERVATION AND GEOINFORMATION; 2021 REMOTE SENSING; 2022 FRONTIERS IN PHYSIOLOGY. Ge-Sixun et al. 2021 FRONTIERS IN MICROBIOLOGY; 2022 INSECT SCIENCE. Li-Jiaxing et al. 2022 FRONTIERS IN PHYSIOLOGY. Fu-Ningning et al. 2022 INTERNATIONAL JOURNAL OF BIOLOGICAL MACROMOLECULES

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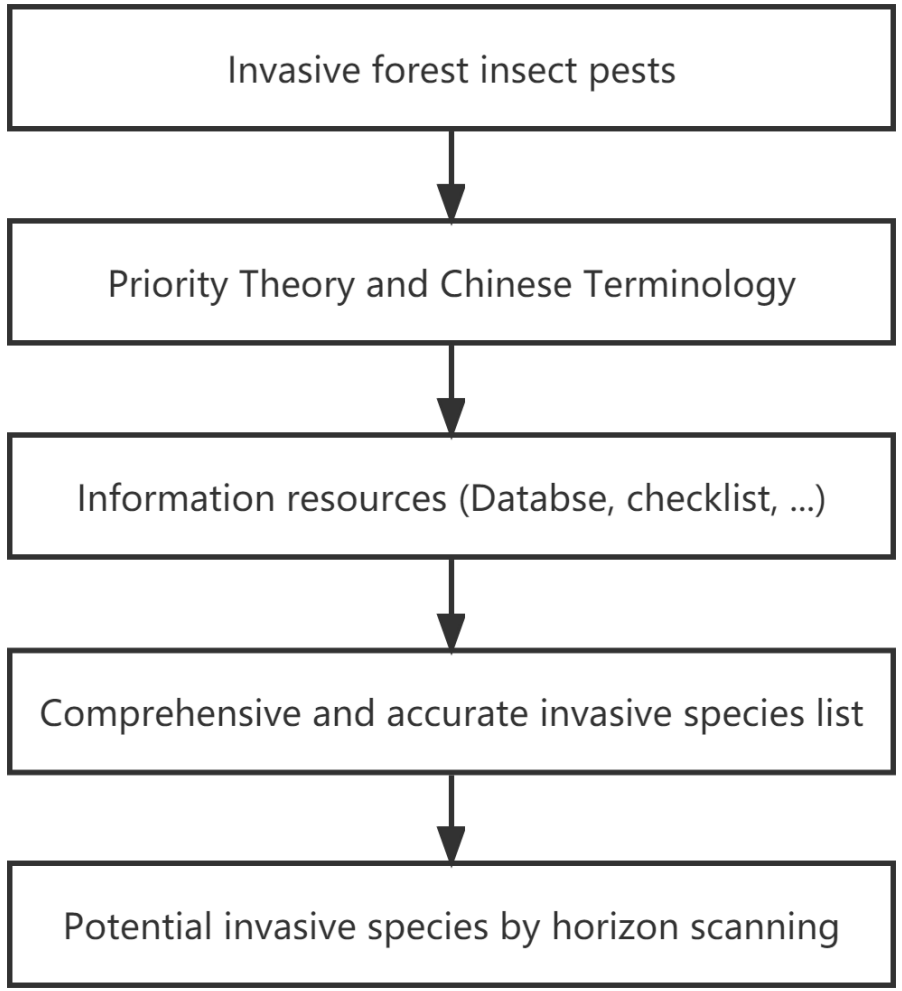
MY DOCTORAL RESEARCH: PRIORITIZATION METHODS RESEARCH OF INVASIVE FOREST INSECT PESTS IN CHINA

Research route

Finished work



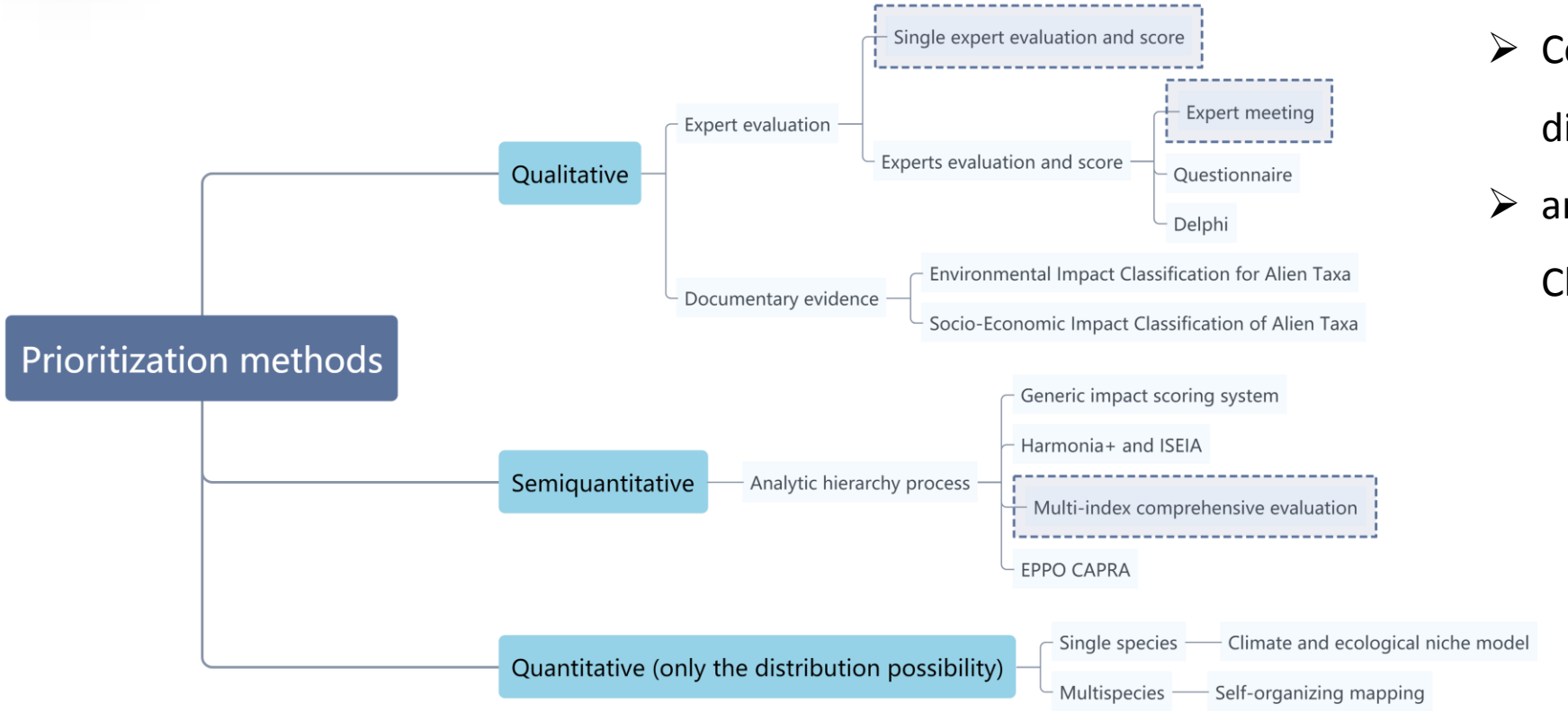
Paper submitting

Paper published

Comparative evaluation of databases of invasive alien species and plant pests in the world

Research route

Planed work



- Comparison, advantages, and disadvantages of these methods,
- and establish a new method for China

2020

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