

Restoration of riparian vegetation in the Hunhe River basin, Liaoning, China

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Acknowledgements



Analysis of Nitrogen and Phosphorus Content
Characteristic in Woody Plant and Vegetation Restoration
Research in Riparian Zone of Hun River

By
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A Dissertation Submitted to
The University of Chinese Academy of Sciences
In partial fulfillment of the requirement
For the degree of
Doctor of Ecology

Institute of Applied Ecology, Chinese Academy of Sciences

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Outline

1. Introduction
2. Situation & Problems
3. Solutions
4. Application

Introduction

Deforestation in Amazon

Deforestation in Pará, Brazil



What is conservation biology?

Conservation biology is the study of attempts to protect and preserve **biodiversity***.

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- determining ecosystems and species whose conservation is a high priority.

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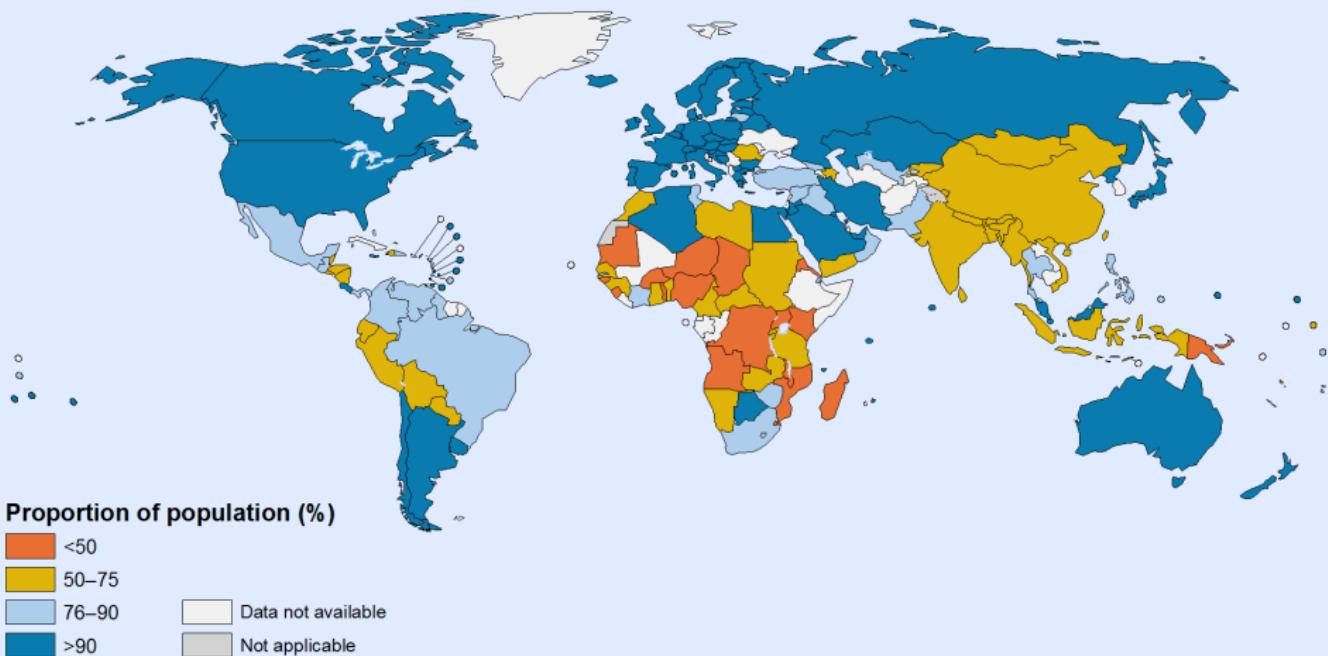
It has two central goals

- to evaluate human impacts on biodiversity,
- to develop practical approaches to prevent the extinction of species [Wilson, 1992].

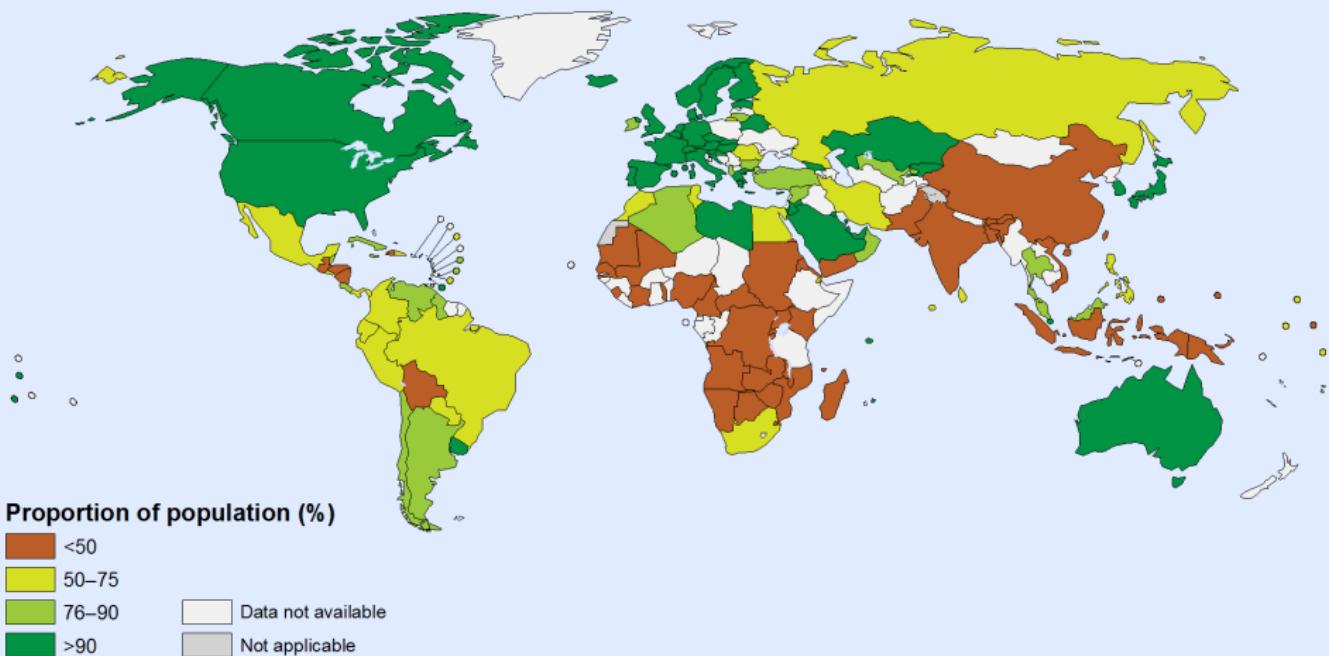
Why to preserve biodiversity?

- Modern extinction rates are at 100 to 1000 times greater than background extinction rates calculated over the eras [Hambler and Speight, 2004, Pimm et al., 2014].
- Existing species go extinct at a rate 1000 times that of species formation*.
- The primary cause of today's loss of biodiversity is habitat alteration caused by human activities.

Proportion of population using improved drinking water sources (%), 1990



Proportion of population using improved sanitation facilities (%) (%), 1990



Proportion of population (%)

<50

50–75

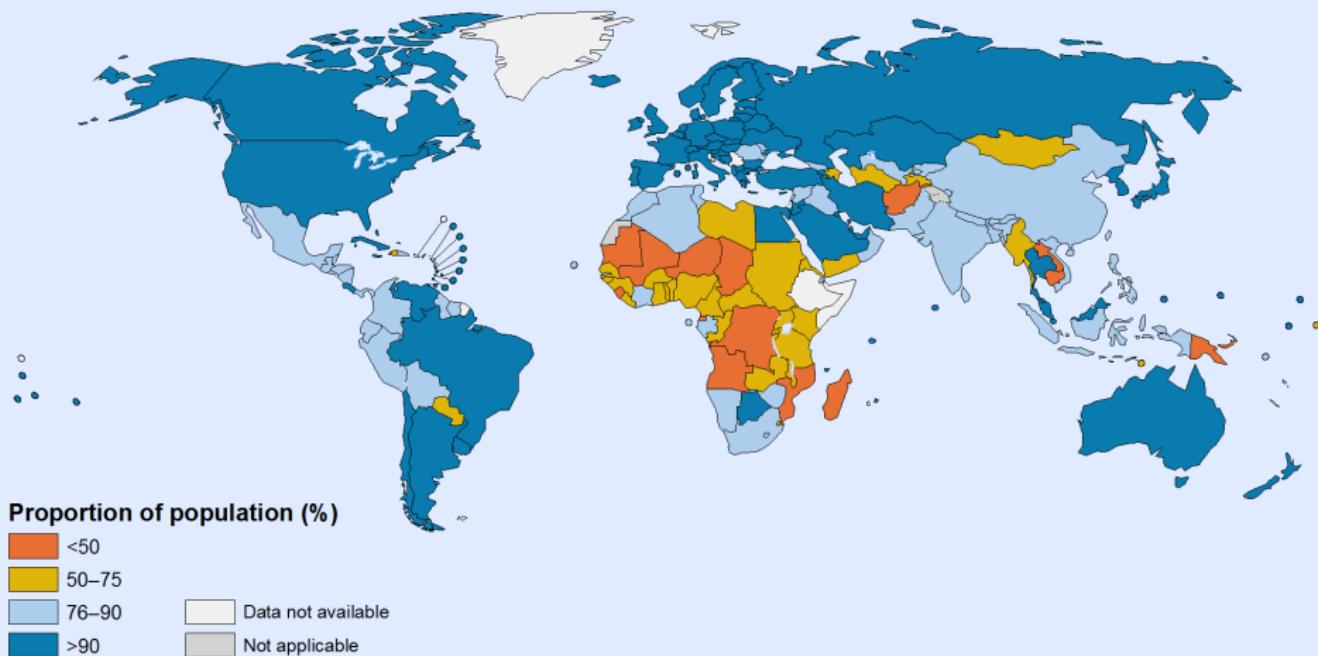
76–90

>90

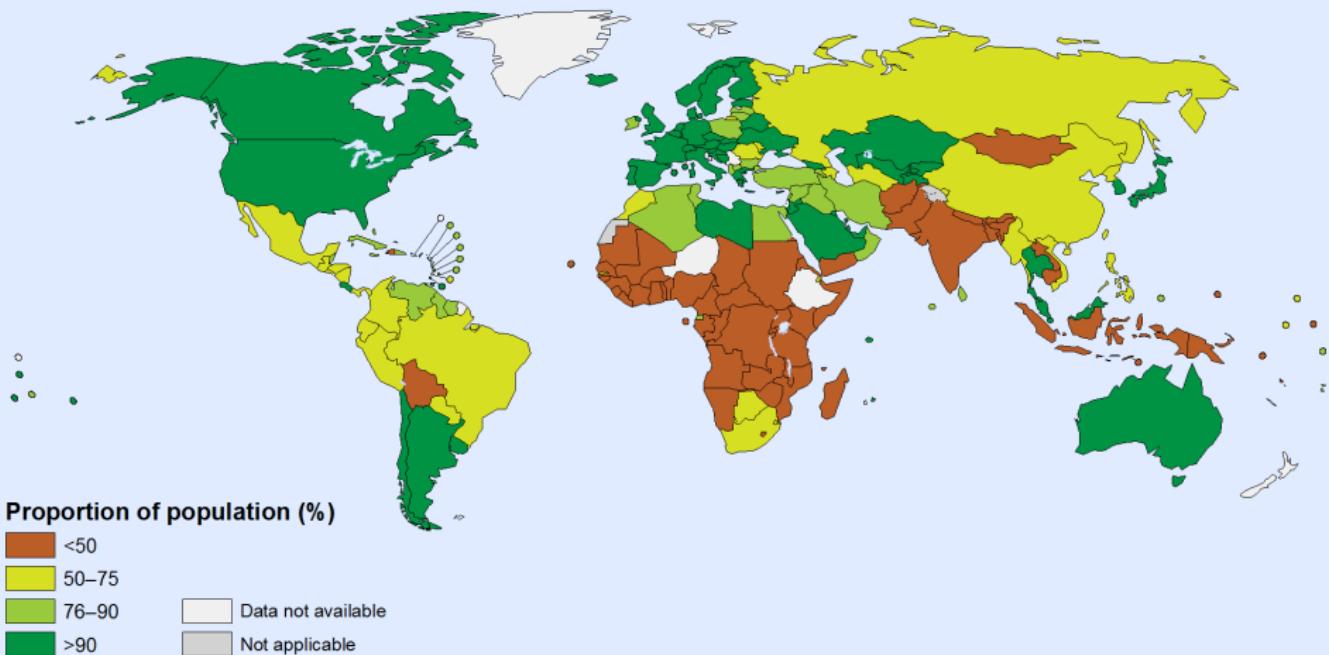
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Proportion of population using improved drinking water sources (%), 2000



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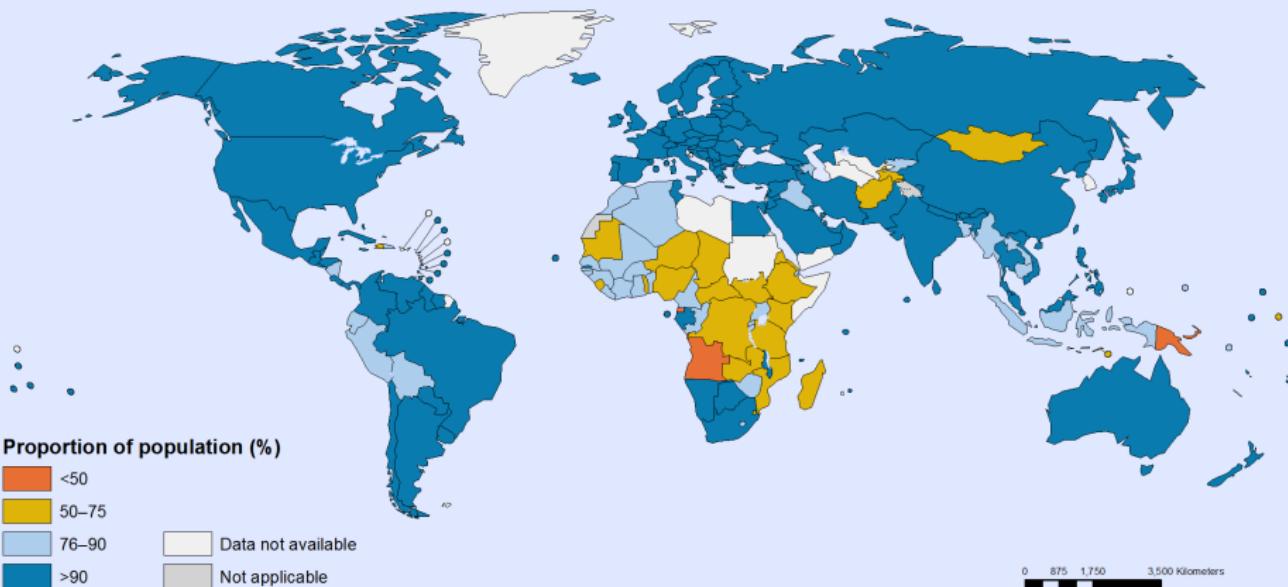


Proportion of population (%)

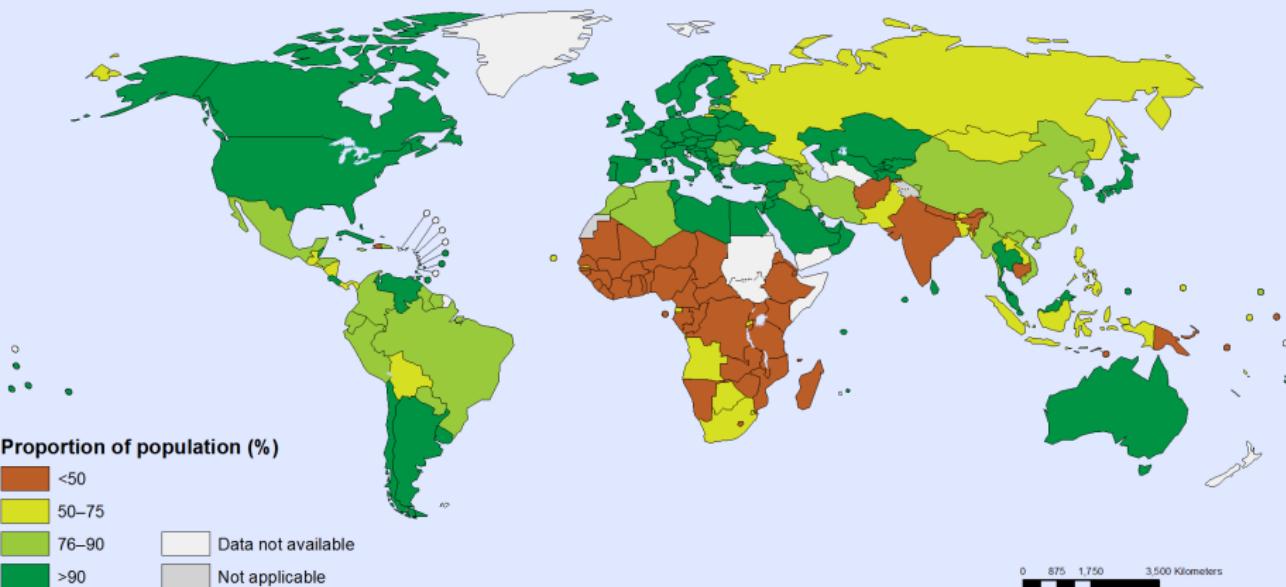
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- >90

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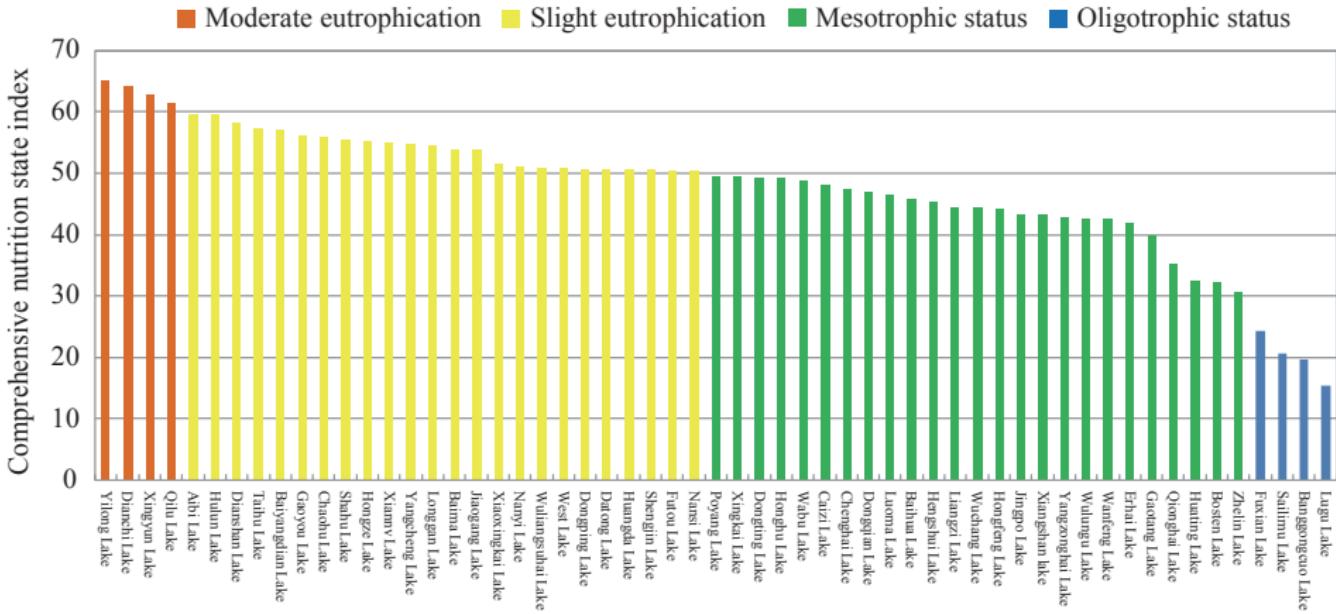
Proportion of population using improved drinking water sources (%), 2015



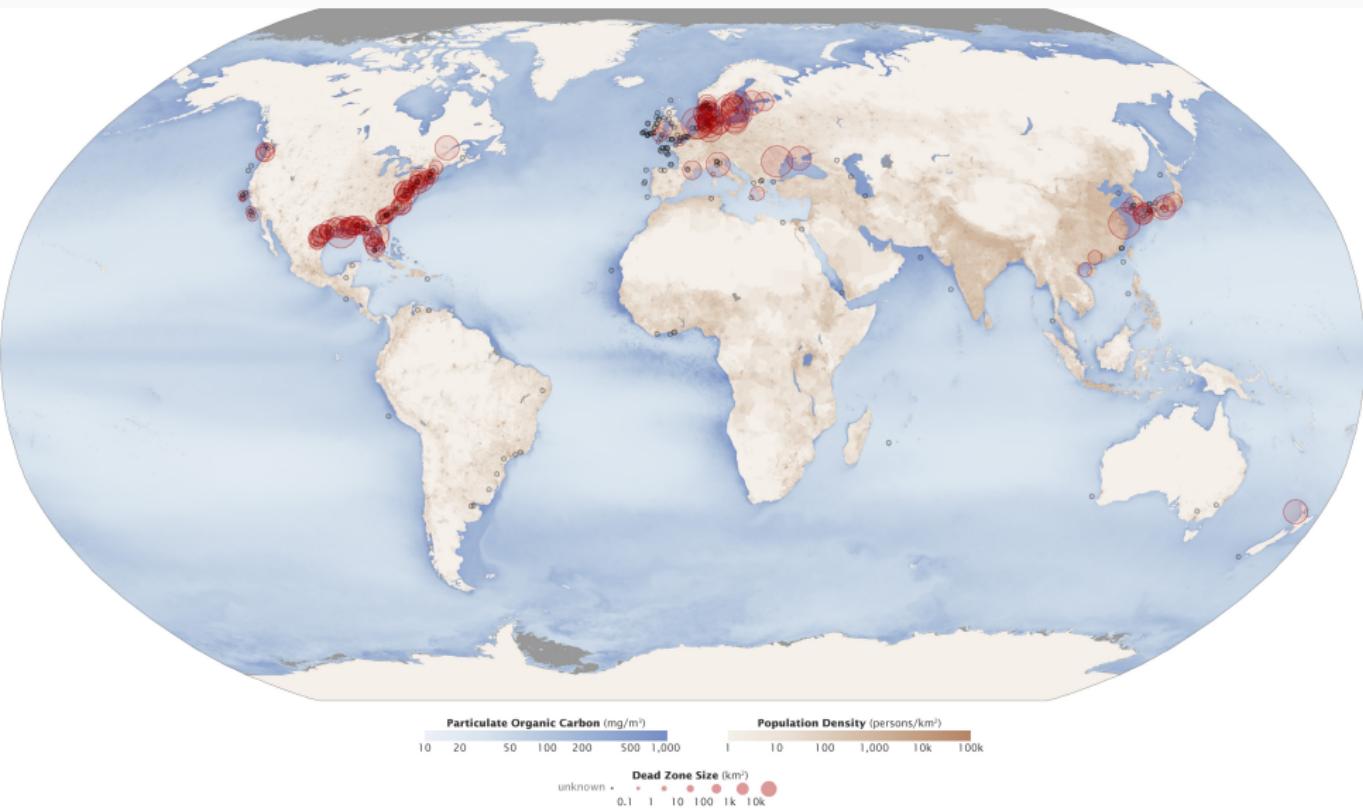
Proportion of population using improved sanitation facilities (%), 2015



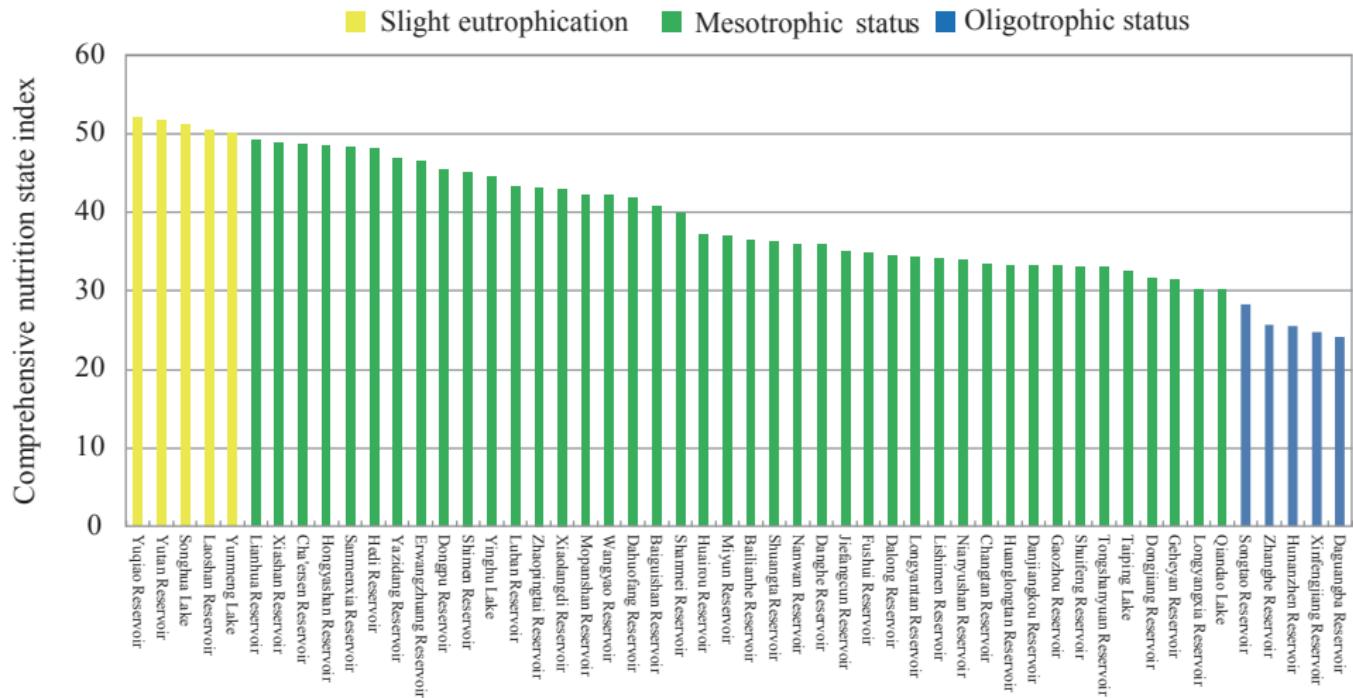
Trophic level index of China's major lakes in 2017



Dead zones around the world

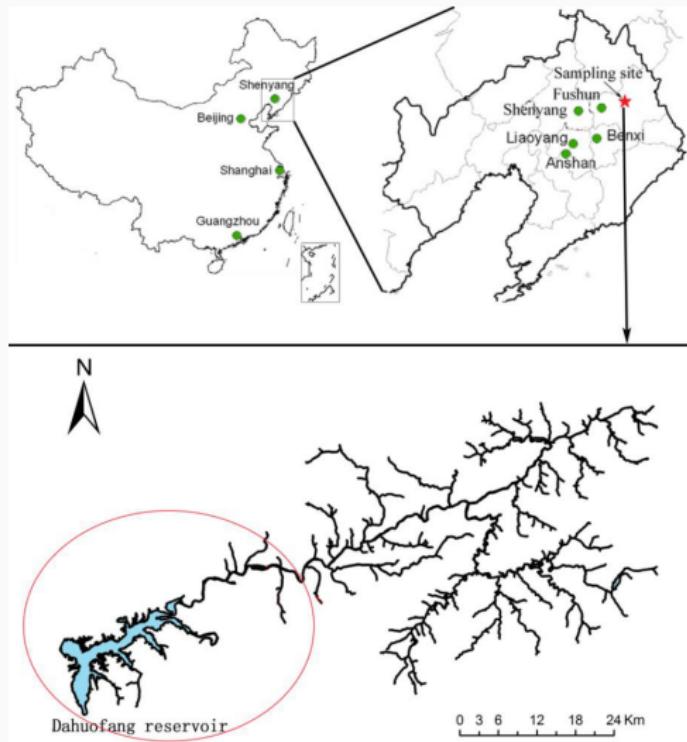


Trophic level index of China's major reservoirs in 2017



Situation & Problems

Current situation



- Built in 1954–1958, first reservoir “Made in P. R. China” (not first one in China)
- Water source of city group in the lower reaches
- Surface: 110 km^2 , 7 bil. m^3 water for **12 mil.** inhabitants per year
- Dahuofang Water Tunnel, built in 2006–2009, 85.3 km long, 8 m in diameter, **cost: \$750 mil.***

*https://en.wikipedia.org/wiki/Dahuofang_Water_Tunnel

Main problems

- Water pollutants: NH₃-N (9.73 mg/L, 3.87 times higher) and TP (0.84 mg/L, 1.1 times higher)

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- River bank damaged, riparian vegetation destroyed
- Wetland degraded, soil and water conservation capacity decreased
- Water-conservation-stands (WCS) structure single and simple, ecological functions lost



Solutions

Project workflow

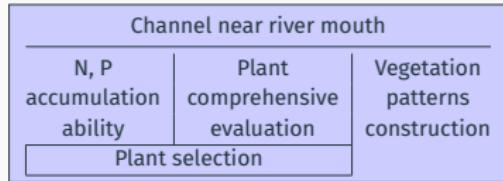


Figure 1: Project workflow.

Project workflow

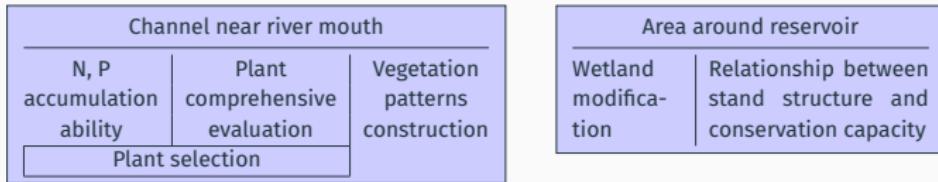


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Project workflow

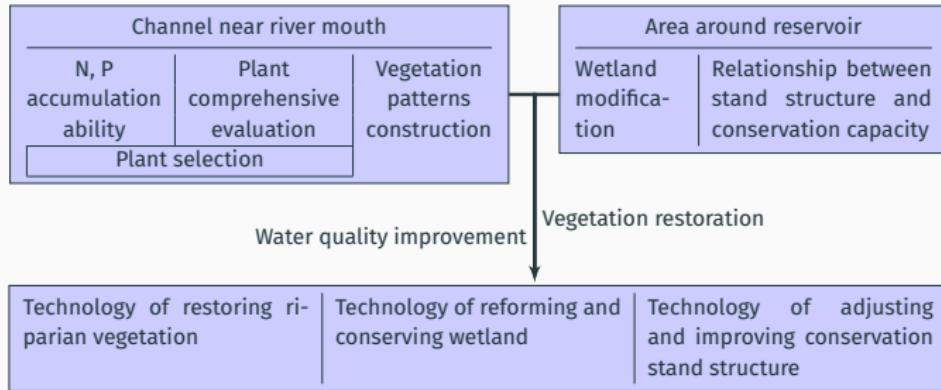


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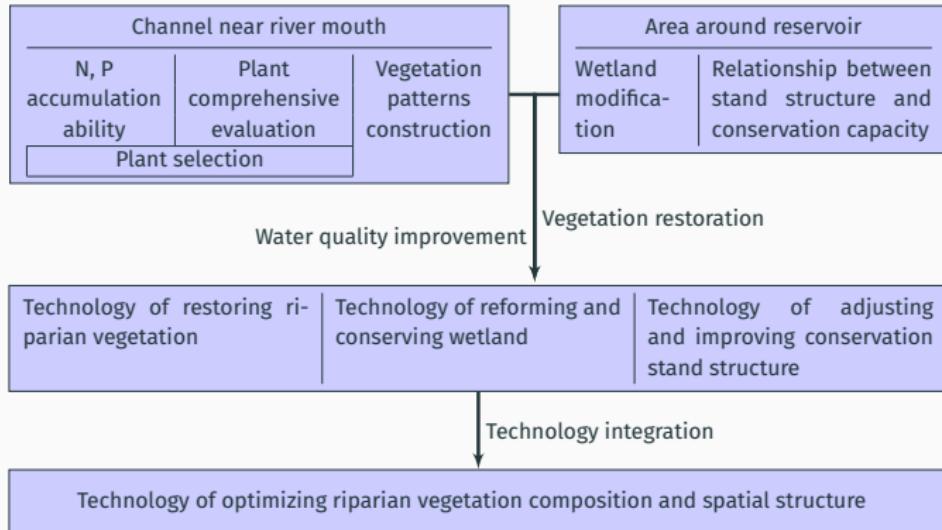


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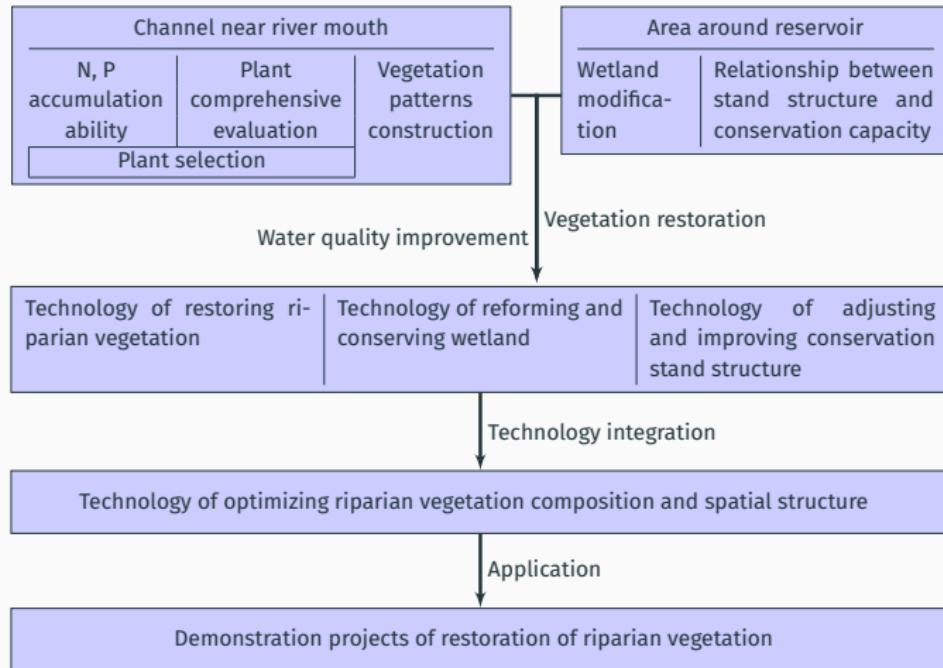


Figure 1: Project workflow.

Experiments on N, P accumulation ability

Table 1: Experimental plants

Plant	Number
Tree	27
Shrub	21
Herb	20
Total	68

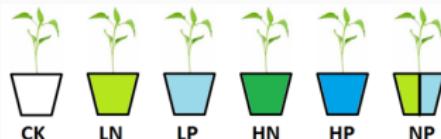


Fig 1. Pot Experiment Treatment

CK= Control HN=High Nitrogen

LN= Low Nitrogen HP=High Phosphorus

LP= Low Phosphate NP=Nitrogen and Phosphorus

Table 2: Experimental design

Treat- ment	TN (mg/L)	TP (mg/L)
LN	14	0
HN	56	0
LP	0	3
HP	0	12
NP	14	3



N, P accumulation ability of the plants

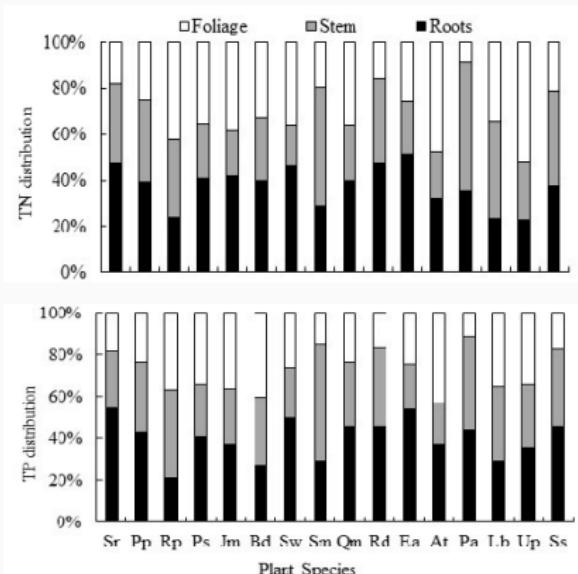
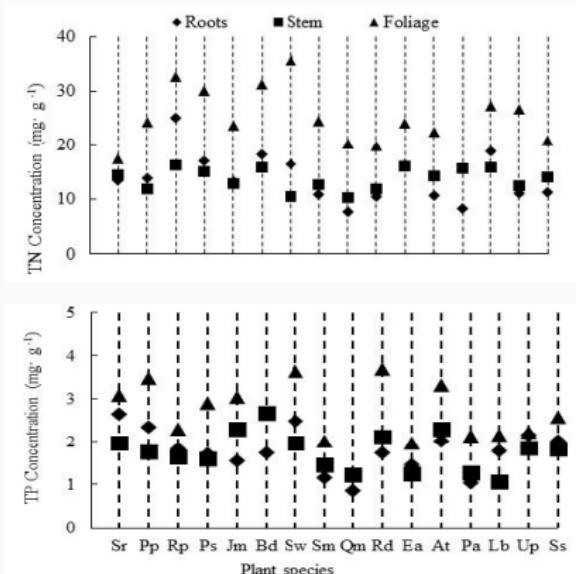


Figure 2: Concentration and distribution of total nitrogen (TN) and total phosphorus (TP) in plants [Yu et al., 2014].

Plant selection protocol (Analytic Hierarchy Process)

	A-B W_i	Index	B-C W_{ij}	A-C TW
Comprehensive evaluation index (A)	0.47	Cold tolerance (C11)	0.31	0.14
		Poor soil tolerance (C12)	0.12	0.05
		Shade tolerance (C13)	0.23	0.10
		Flooding tolerance (C14)	0.24	0.11
		Drought tolerance (C15)	0.11	0.05
Ecological (B ₂) Resistance (B ₁) Criteria	0.44	N absorbing ability (C21)	0.23	0.10
		P absorbing ability (C22)	0.21	0.11
		Biomass accumulation (C23)	0.38	0.18
		Water conservation ability (C24)	0.09	0.04
		Soil conservation ability (C25)	0.10	0.05
Aesthetic (B ₃)	0.08	Leaf shape (C31)	0.20	0.02
		Flower shape (C32)	0.09	0.01
		Fruit shape (C33)	0.08	0.01
		Canopy shape (C34)	0.43	0.04
		Shape in winter (C35)	0.20	0.02

$A-B: \lambda_{max} = 3.0037, CI = 0.0036, RI1 = 0.58, CR = 0.0620 < 0.1; B_1-C: \lambda_{max} = 5.4118, CI1 = 0.0919, RI1 = 1.12, CR1 = 0.0820 < 0.1$
 $B_2-C: \lambda_{max} = 5.2180, CI2 = 0.0587, RI2 = 1.12, CR2 = 0.0524 < 0.1; B_3-C: \lambda_{max} = 5.3876, CI3 = 0.0865, RI3 = 1.12, CR3 = 0.0772 < 0.1$
 Total rank: $CI = W_1 * CI1 + W_2 * CI2 + W_3 * CI3 = 0.0349, RI = W_1 * RI1 + W_2 * RI2 + W_3 * RI3 = 0.8651, CR = 0.0403 < 0.1$

List of selected plants

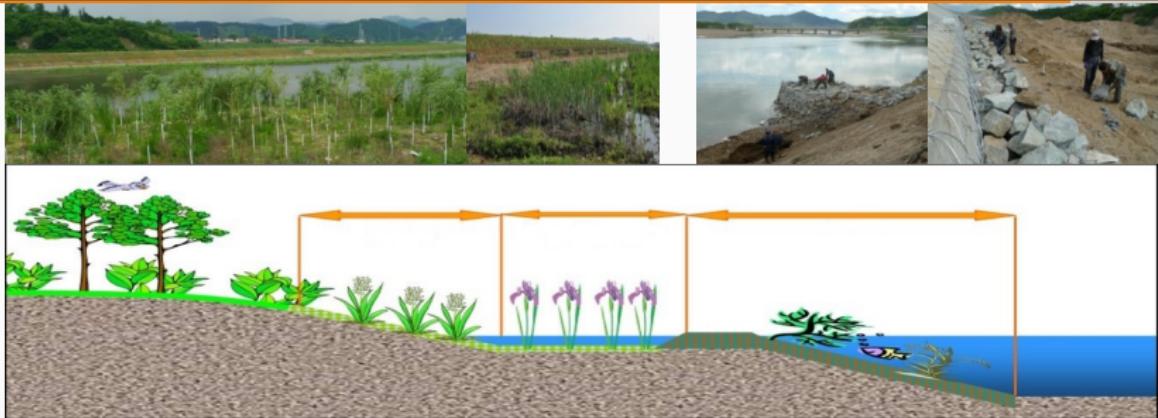
Tree	Shrub	Herb
1. <i>Ulmus pumila</i>	1. <i>Lespedeza bicolor</i>	1. <i>Phragmites australis</i>
2. <i>Syringa reticulata</i>	2. <i>Lonicera chrysanthia</i>	2. <i>Artemisia capillaris</i>
3. <i>Salix matsudana</i>	3. <i>Sambucus williamsii</i>	3. <i>Sparganium stoloniferum</i>
4. <i>Robinia pseudoacacia</i>	4. <i>Sorbaria sorbifolia</i>	4. <i>Impatiens noli-tangere</i>
5. <i>Salix babylonica</i>	5. <i>Amorpha fruticose</i>	5. <i>Polygonum persicaria</i>
6. <i>Juglans mandshurica</i>	6. <i>Salix viminalis</i>	6. <i>Iris pseudacorus</i>
7. <i>Berberis dielsiana</i>	7. <i>Acer ginnala</i>	7. <i>Acorus tatarinowii</i>
8. <i>Morus alba</i>	8. <i>Salix integra</i>	8. <i>Monochoria korsakowii</i>
9. <i>Fraxinus mandschurica</i>	9. <i>Flueggea suffruticosa</i>	9. <i>Iris sanguinea</i>
10. <i>Acer mono</i>	10. <i>Euonymus maackii</i>	10. <i>Lythrum salicaria</i>

Tending the water-conservation stands

Table 3: Effects of tending intensity on species diversity and water-holding capacity of water-conservation stands (WCS)

Treatment	Species number						Water storage (t/hm^2)	
	First year			Second year			Total	Non-capillary
	Tree	Shrub	Herb	Tree	Shrub	Herb		
CK	14	7	3	15	7	3	1022	220
Weak	15	7	3	16	8	3	1054	260
Medium	16	8	4	18	8	4	1085	295
Intense	18	8	4	20	10	5	1100	324

Technology: restore riparian vegetation near river mouth



- Reservoir shoal:

Salix viminalis, Iris sanguinea, Phragmites australis, Sparganium stoloniferum, Artemisia capillaris, Polygonum persicaria

- Barren area:

Salix viminalis, Lespedeza bicolor, Sorbaria sorbifolia, Artemisia capillaris, Polygonum persicaria, Iris sanguinea

- Flat fertile area:

Juglans mandshurica, Fraxinus mandschurica, Ulmus pumila, Sorbaria sorbifolia, Lonicera chrysanthia, Sambucus williamsii, Impatiens noli-tangere, Sparganium stoloniferum, Iris pseudacorus, Phragmites australis, Monochoria korsakowii, Lythrum salicaria

- Steep hilly area:

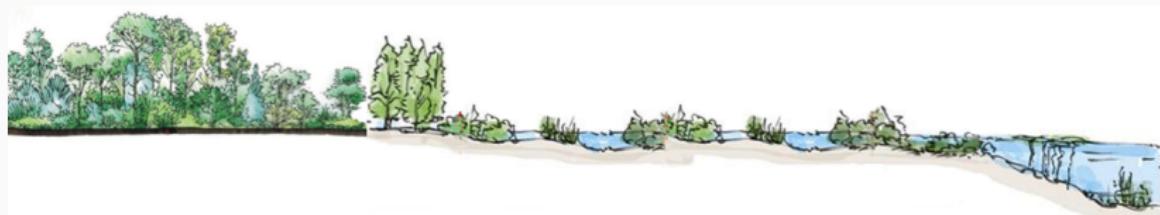
Salix viminalis, Berberis dielsiana, Robinia pseudoacacia, Salix babylonica, Syringa reticulata, Amorpha fruticosa, Sorbaria sorbifolia

Vegetation type	Distance/ density
Tall tree	4–6 m
Dwarf tree	2–3 m
Shrub	1–2 m
Herb	0.4–1.2 m
Macrophyte	2–10 / m ²

Technology: reform and conserve wetland around reservoir



Ecological protection zone	Buffer zone	Shoal	Reservoir
Terrestrial Partially fenced area	Water 40–90 cm Buffer ponds	Water < 40 cm Littoral zone	
<i>Ulmus pumila</i> <i>Fraxinus mandschurica</i> <i>Acer ginnala</i>	<i>Nelumbo nucifera</i> <i>Alisma plantago</i> <i>Lythrum salicaria</i> <i>Iris sanguinea</i>	<i>Scirpus validus</i> <i>Typha angustifolia</i>	



Technology: adjust and improve structure of WCS

Chinese pine (*Pinus tabulaeformis*) stand:

- Block thinning
- Interplant distance 3.5 m
- Forest gap 10–15%
- Dominant with young and mid-aged trees



Larch (*Larix gmelinii*) stand:

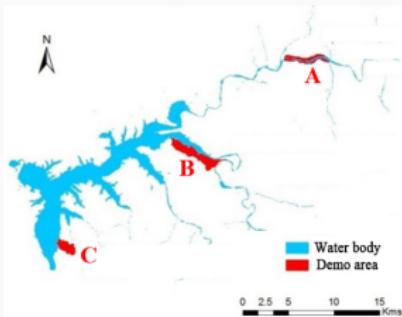
- Selection-felling with strip reform
- Replant Chinese pine and local broadleaf trees
- Canopy density 0.5–0.7
- Mixed coniferous forest dominant with trees and shrubs



Application

Demonstration projects and evaluation

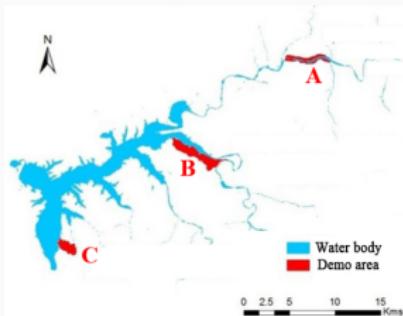
- A Restoration of riparian vegetation near the river mouth, 3 km²



- A Riparian vegetation near the river mouth restored

Demonstration projects and evaluation

- A Restoration of riparian vegetation near the river mouth, 3 km^2
- B Reform and conservation of wetland around the reservoir, 5 km^2



- A Riparian vegetation near the river mouth **restored**
- B Wetland around the reservoir **recovered**

Demonstration projects and evaluation

- **A** Restoration of riparian vegetation near the river mouth, 3 km^2
- **B** Reform and conservation of wetland around the reservoir, 5 km^2
- **C** Adjustment and improvement to the structure of WCS, 2 km^2



- **A** Riparian vegetation near the river mouth **restored**
- **B** Wetland around the reservoir **recovered**
- **C** Structure of conservation stand **improved**

Demonstration projects and evaluation

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Evaluation

- Number of plant species increased by 30%
- Water- and soil-conservation capacity increased
- Water quality improved: typical pollutants reduced by 20%
- Removal of TN and TP: 4.12 t/y

Take-home message

- This study showed how to systematically select plant species for riparian vegetation restoration.
- It provides experience and knowledge for improving spatial vegetation structure of water-conservation stands.
- The project worked, but was expensive.

Questions?



Scan to download the slides

Thanks for listening!

List of 68 plant species used in this study

Tree	Shrub	Herb
1. <i>Ulmus pumila</i> 2. <i>Syringa reticulata</i> 3. <i>Salix matsudana</i> 4. <i>Robinia pseudoacacia</i> 5. <i>Salix babylonica</i> 6. <i>Juglans mandshurica</i> 7. <i>Berberis dielsiana</i> 8. <i>Morus alba</i> 9. <i>Fraxinus mandshurica</i> 10. <i>Acer mono</i> 11. <i>Fraxinus rhynchophylla</i> 12. <i>Prunus padus</i> 13. <i>Ulmus davidiana</i> 14. <i>Armeniaca mandshurica</i> 15. <i>Pterocarya stenoptera</i> 16. <i>Aralia elata</i> 17. <i>Quercus mongolica</i> 18. <i>Malus baccata</i> 19. <i>Gleditsia microphylla</i> 20. <i>Crataegus pinnatifida</i> 21. <i>Acer negundo</i> 22. <i>Celtis bungeana</i> 23. <i>Populus alba</i> 24. <i>Acer truncatum</i> 25. <i>Betula allegheniensis</i> 26. <i>Tilia mandshurica</i> 27. <i>Salix koreensis</i>	1. <i>Lespedeza bicolor</i> 2. <i>Lonicera chrysanthra</i> 3. <i>Sambucus williamsii</i> 4. <i>Sorbaria sorbifolia</i> 5. <i>Amorpha fruticose</i> 6. <i>Salix viminalis</i> 7. <i>Acer ginnala</i> 8. <i>Salix integra</i> 9. <i>Flueggea suffruticosa</i> 10. <i>Euonymus maackii</i> 11. <i>Lonicera maackii</i> 12. <i>Philadelphus pekinensis</i> 13. <i>Cerasus tomentosa</i> 14. <i>Corylus heterophylla</i> 15. <i>Actinidia arguta</i> 16. <i>Rosa davurica</i> 17. <i>Ampelopsis glandulosa</i> 18. <i>Euonymus alatus</i> 19. <i>Rhamnus ussuriensis</i> 20. <i>Acanthopanax sessiliflorus</i> 21. <i>Celastrus flagellaris</i>	1. <i>Phragmites australis</i> 2. <i>Artemisia capillaris</i> 3. <i>Sparganium stoloniferum</i> 4. <i>Impatiens noli-tangere</i> 5. <i>Polygonum persicaria</i> 6. <i>Iris pseudacorus</i> 7. <i>Acorus tatarinowii</i> 8. <i>Monochoria korsakowii</i> 9. <i>Iris sanguinea</i> 10. <i>Lythrum salicaria</i> 11. <i>Potentilla cryptotaeniae</i> 12. <i>Polygonatum odoratum</i> 13. <i>Viola mandshurica</i> 14. <i>Corydalis bungeana</i> 15. <i>Astilbe chinensis</i> 16. <i>Trifolium repens</i> 17. <i>Arisaema peninsulae</i> 18. <i>Ranunculus chinensis</i> 19. <i>Bidens biternata</i> 20. <i>Agrimonia pilosa</i>

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