XVIII World Water Congress
International Water Resources Association (IWRA)

Restoration potential of aquatic plant based on ecological functional areas in East Taihu Lake

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XVIII WORLD WATER CONGRESS Water for All Harmony between Humans and Nature
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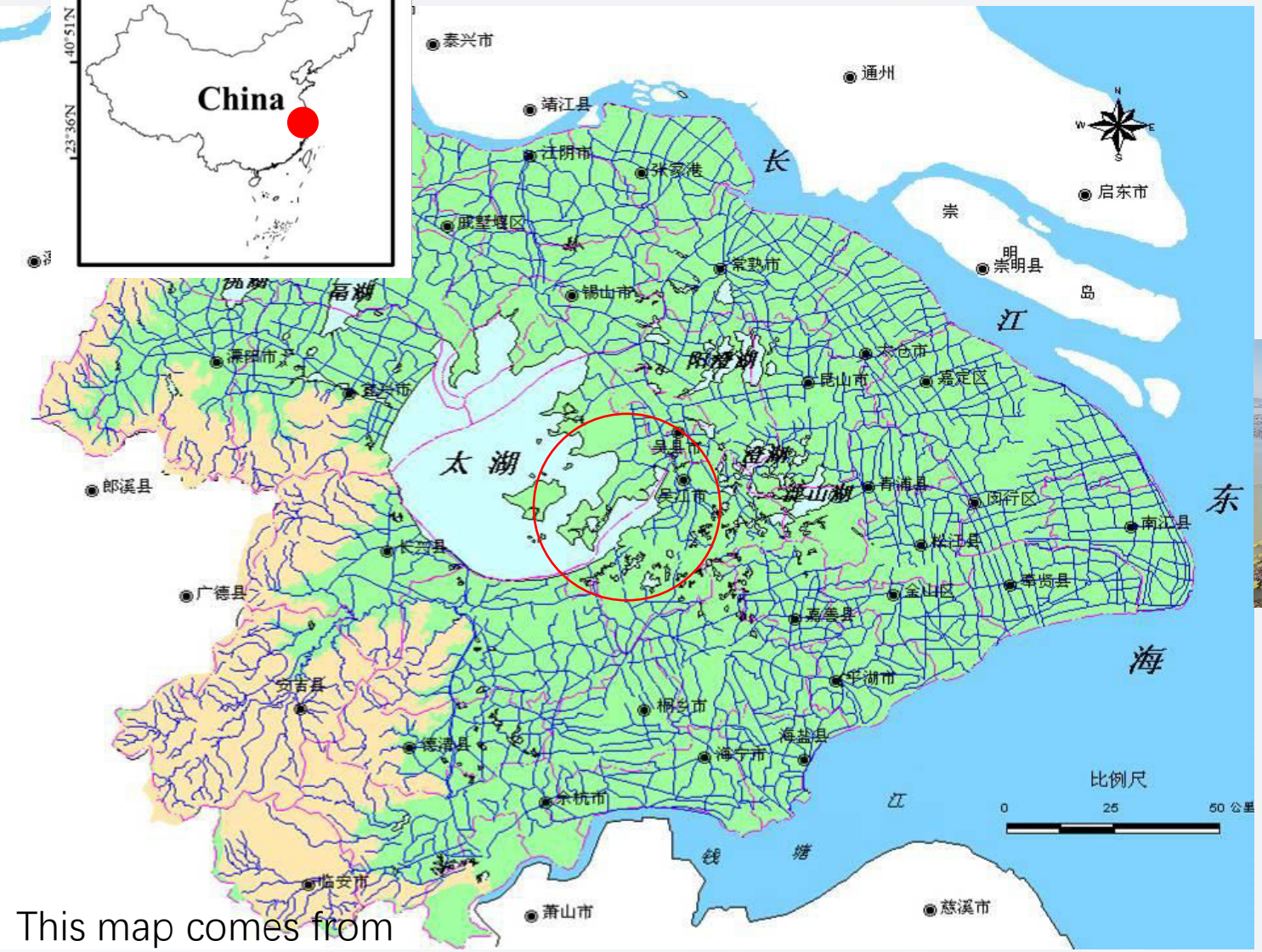
Outline

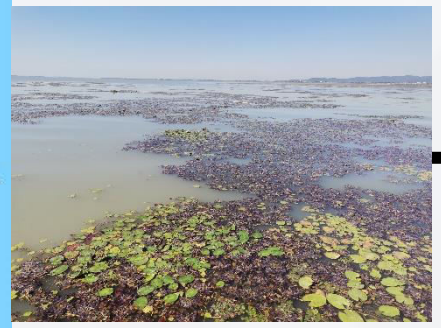
- Background and Study area
- Study on characteristics of aquatic plant, seed bank and substrate
- Study on simulated experiment and comprehensive analysis
- Conclusion and suggestions

Background



This map comes from Professor Junfeng Gao

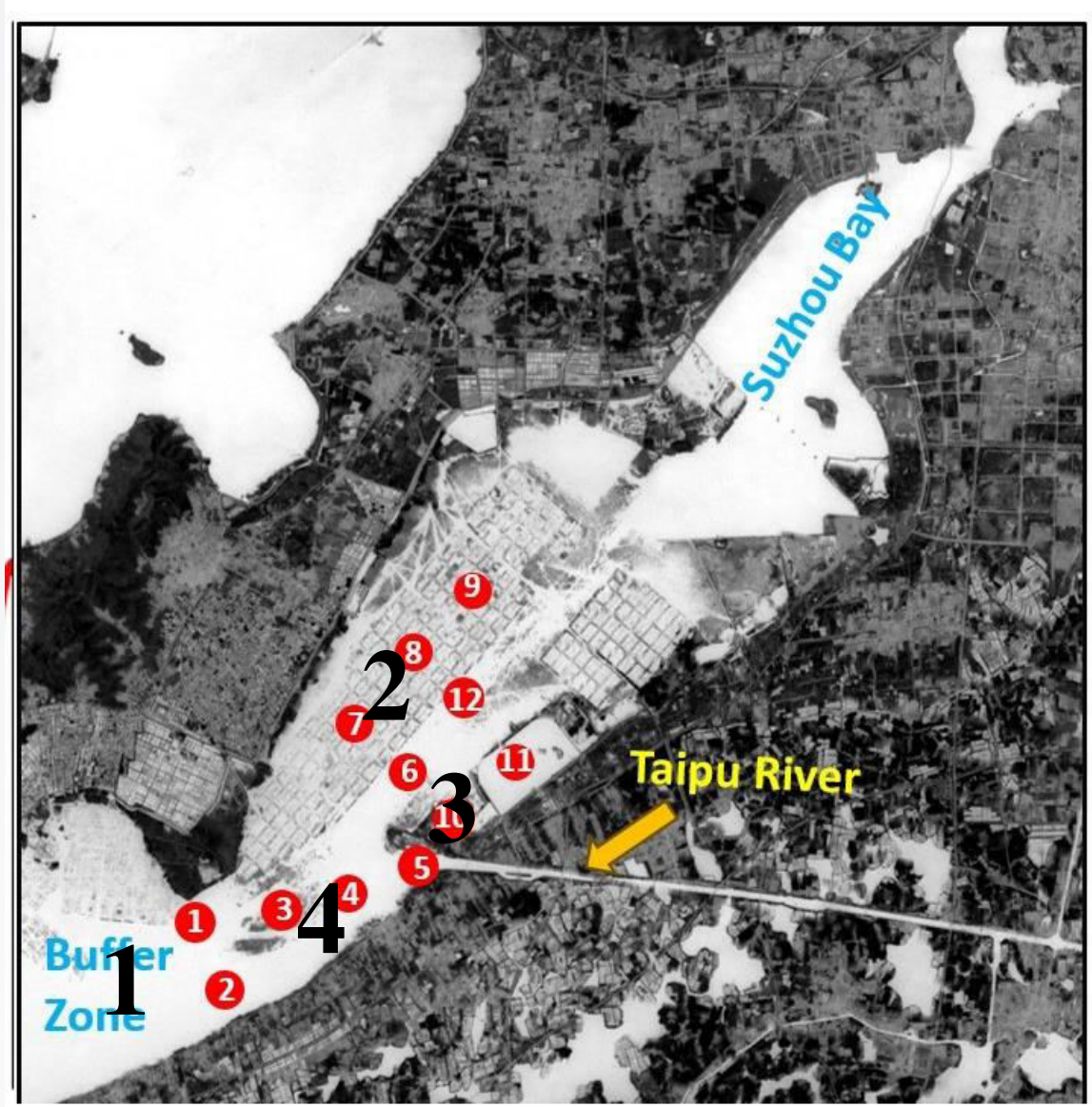
Physical parameter	Tai Lake	East Tai Lake
Area/km2	2338.1	185.4
Mean WD/m	2.1	1.25



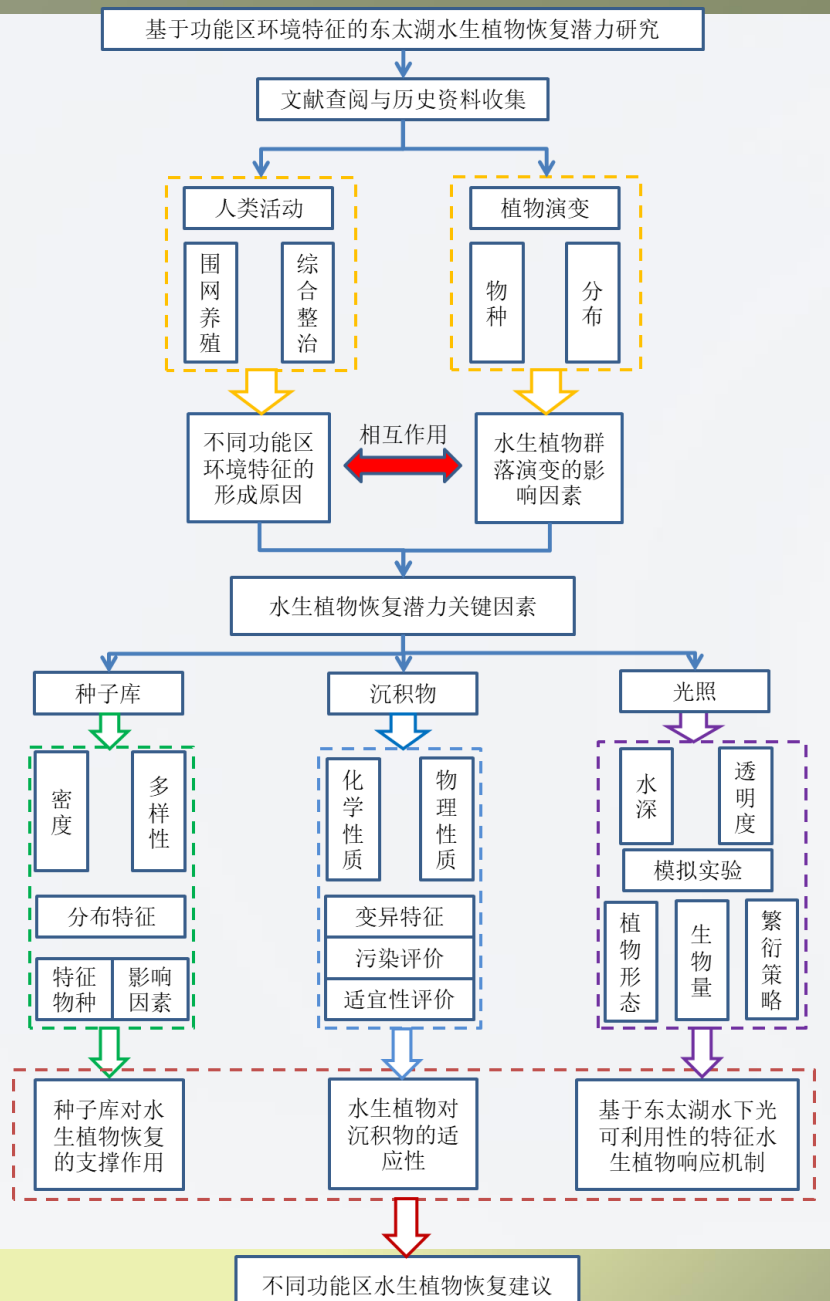
Target:

keep water resource security

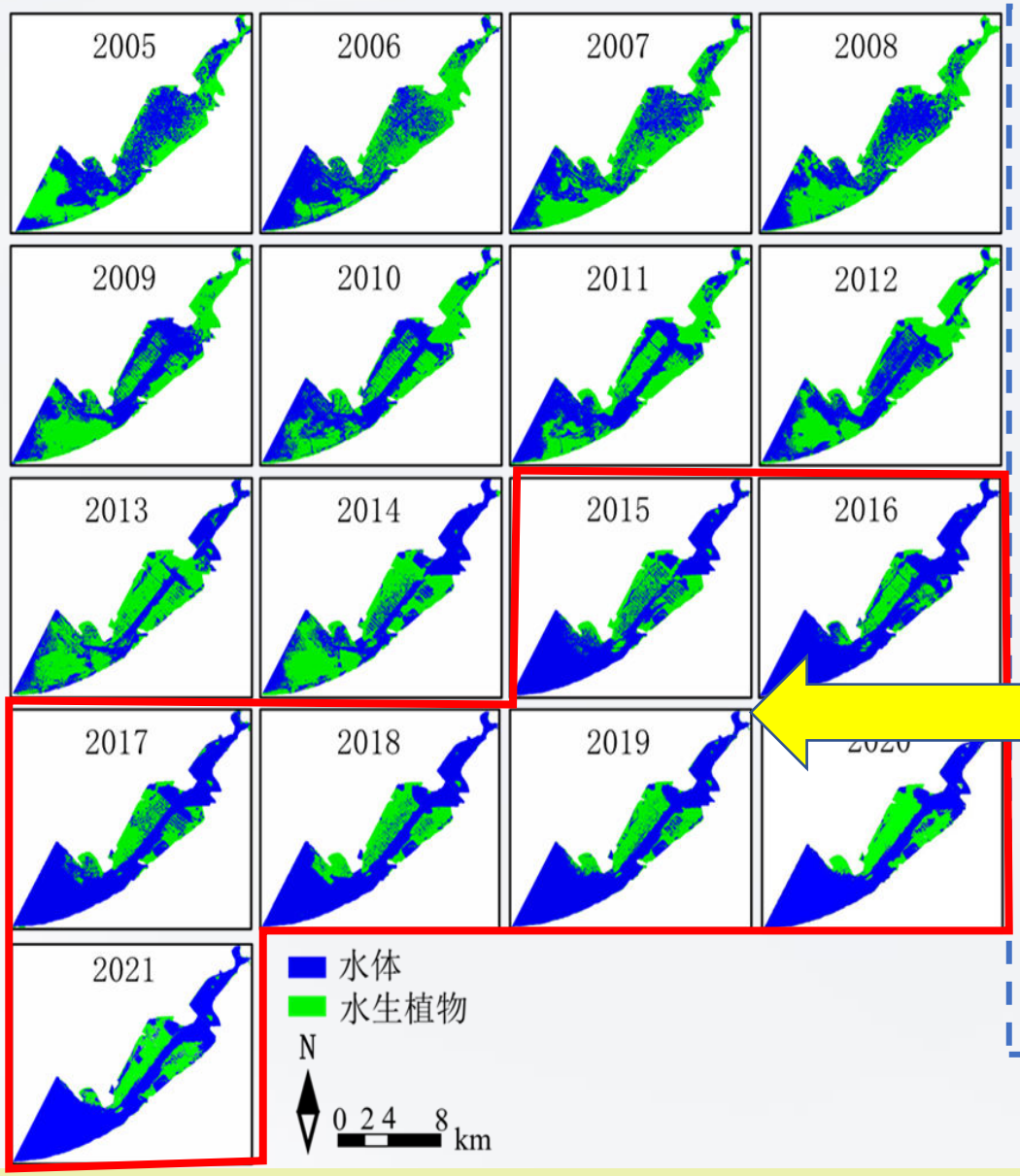
Study area and methods



Technology roadmap



Results: Temporal and Spatial changes of aquatic plants



1. The swamping period of East Taihu Lake

2. Comprehensive renovation period of East Taihu Lake

3. Post-comprehensive regulation period

Results: Temporal and Spatial changes of aquatic plants

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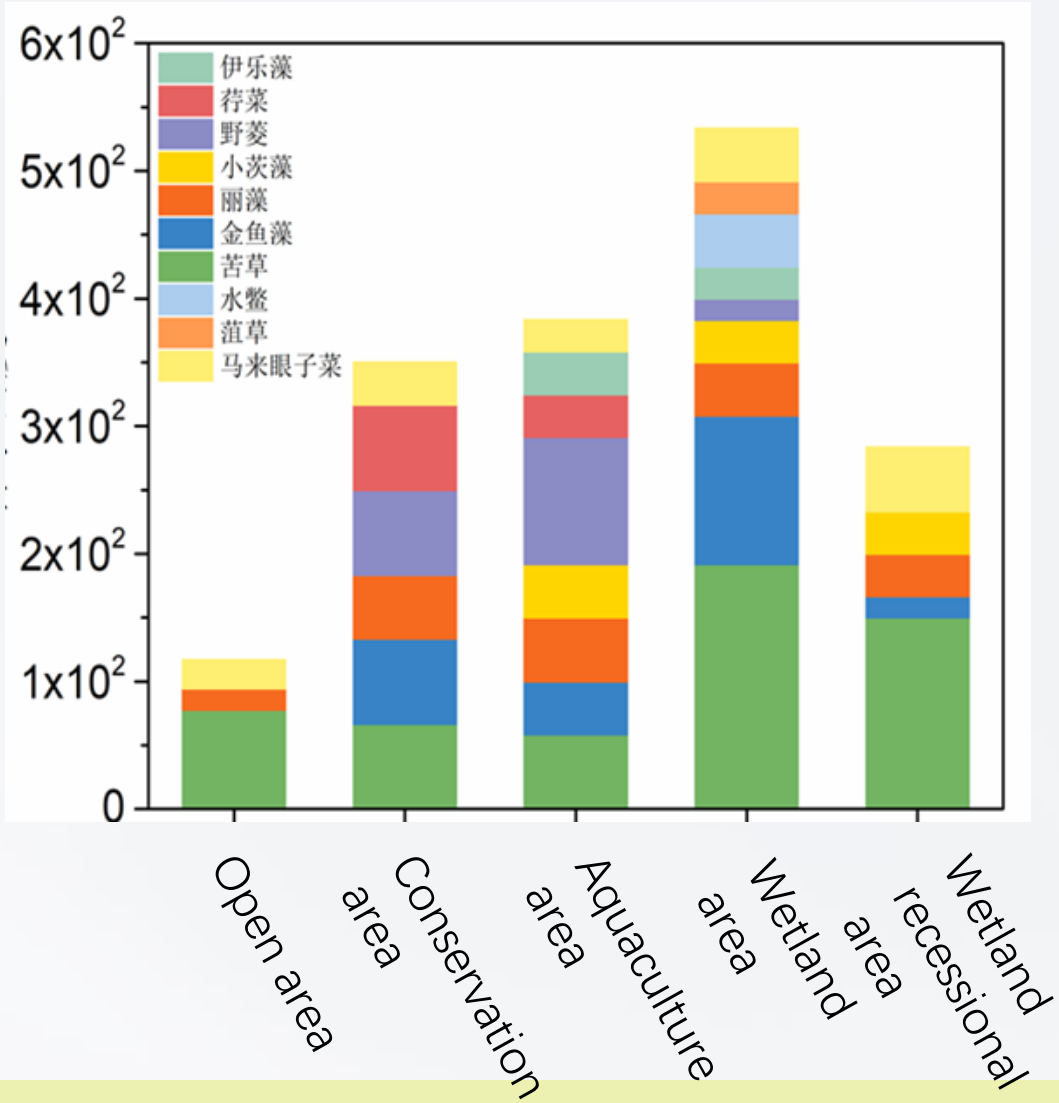
种	2002	2007	2013	2013~2014	2013~2017
金鱼藻 *Ceratophyllum demersum*	+++	+++	+++	+	□
穗花狐尾藻 *Myriophyllum spicatum*	++	++	++	++	□
苦草 *Vallisneria sp iralis*	++	+++	++	+	□
伊乐藻 *Elodea nuttalli*	+++	+++	+++	+++	□
菹草 *Potamogeton orisp us*	++				
轮叶黑藻 *Hydrilla uerticilla ta*	++	++			
马来眼子菜 *Potamogeton malainus*	++	++	++	++	□
龙须眼子菜 *Potamogeton pectinatus*	+				
微齿眼子菜 *Potamogeton macckianus*	++		+		□
荇菜 *Nymphoides peltatum*	+++	++	+++	+++	□
金银莲花 *Nymphoides indica*	++		+++	+++	□
野菱 *Trapa incisa*	++	++	+++	+++	□
凤眼莲 *Eichhornia crassipes*			+	++	□
紫背浮萍 *Spirodela polyrhiza*		+			
水鳖 *Hydrocharis asiaticus*	+	+			
空心莲子草 *Alternanthera philoxeroides*	++		+		□
无根萍 *Wolffia arrhiza*			+	++	□
芦苇 *Phragmites communis*	+				
菰 *Zizania latifolia*	+		++	++	□
莲 *Nelumbo nucifera*	++		+		□

+++: Constructive species， ++: Dominant species，
+: occasional species， ○: Dominance is not indicated

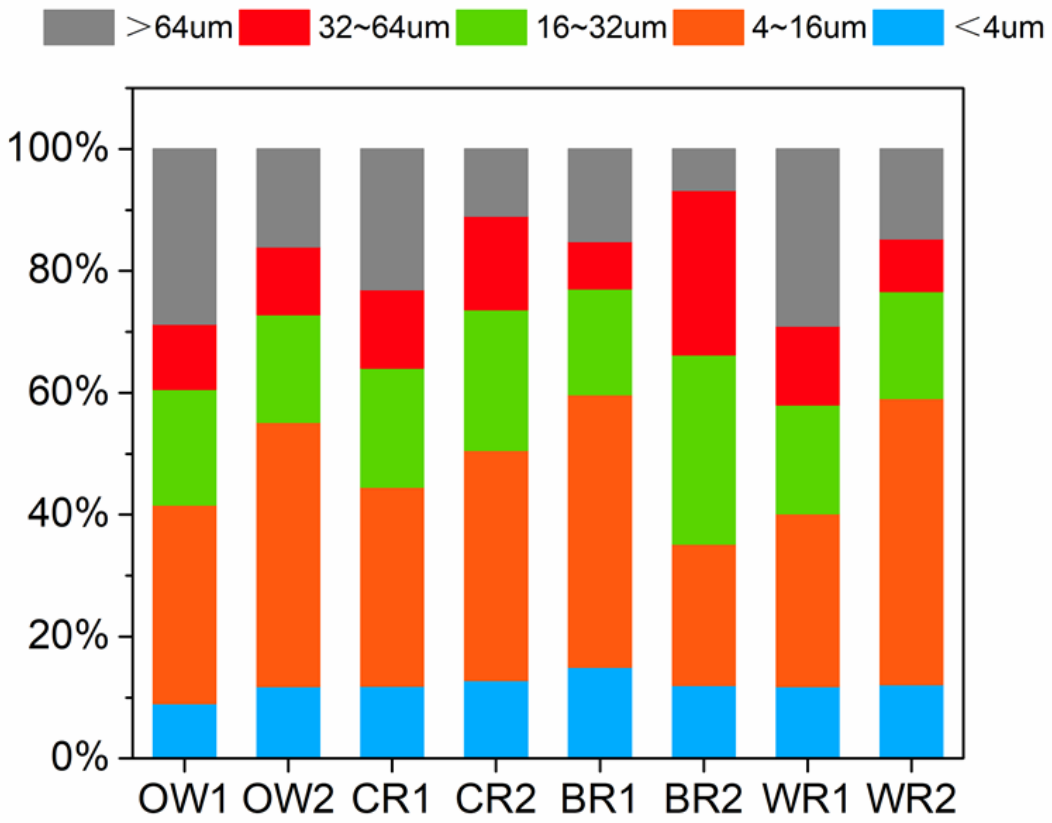
Results: Seed bank distribution of aquatic plant



- Bitter grass is the species with the highest seed density and the widest distribution. And Nymphoides peltata is the representative species of floating-leaved plant. The average seed density of the germinable seed bank was 333.3 seeds /m² (117-533 seeds/m²).
- The open water area had the worst seed density and diversity. The culture area is the main distribution area of floating leaf plants. The density of seed bank was the highest in wet area, and the species of submerged plants were the most abundant.

Results: Substrate properties in different functional area

Particle size analysis



The response of aquatic plant to different substrate

Species植物物种	Response of growth 生长状况
*Elodea nuttalli*伊乐藻	river soil with dirt＞river soil＞ loess
*Potamogeton orisp us*菹草	river soil with sand＞river soil＞sand
*Hydrilla uerticilla ta*轮叶黑藻	clay＞humus＞sandy soil
*Potamogeton orisp us*菹草	clay＞humus＞sandy soil
*Vallisneria sp iralis*苦草	lake soil＞clay＞sandy soil＞river soil
*Elodea nuttalli*伊乐藻	lake soil＞pond sludge＞corase sand＞loess
*Vallisneria sp iralis*苦草	lake soil＞immature soil ＞sand and stone
*Potamogeton malainus*马来眼子菜	lake soil＞immature soil＞sand and stone
*Ceratophyllum demersum*金鱼藻	lake soil＞immature soil＞sand and stone
*Hydrilla uerticilla ta*轮叶黑藻	lake soil＞immature soil＞sand and stone

Results: Comparative analysis of Substrate properties

Loss on ignition analysis

Lake		Year	LOI
East Taihu Lake	Open area	2020	3.93%
	Aquaculture area		6.95%
	Open area	2016	2.70%
	Aquaculture area		5.97%
Taihu Lake watershed	Reservoir	2010	3.07%
	Lake		2.62%
	River		1.71%
Dongting Lake	South part	2016	3.37%
	West part		2.25%
	East part		2.13%
	Entrance		1.83%
Chaohu Lake	East lake	2013	5.52%
	West lake		6.48%

Combining loss on ignition analysis and particle size analysis, we compared some parameters with other periods(2016) and other lakes, the present substrate condition is suitable for aquatic plant.

Results: *in situ* stimulated experiment

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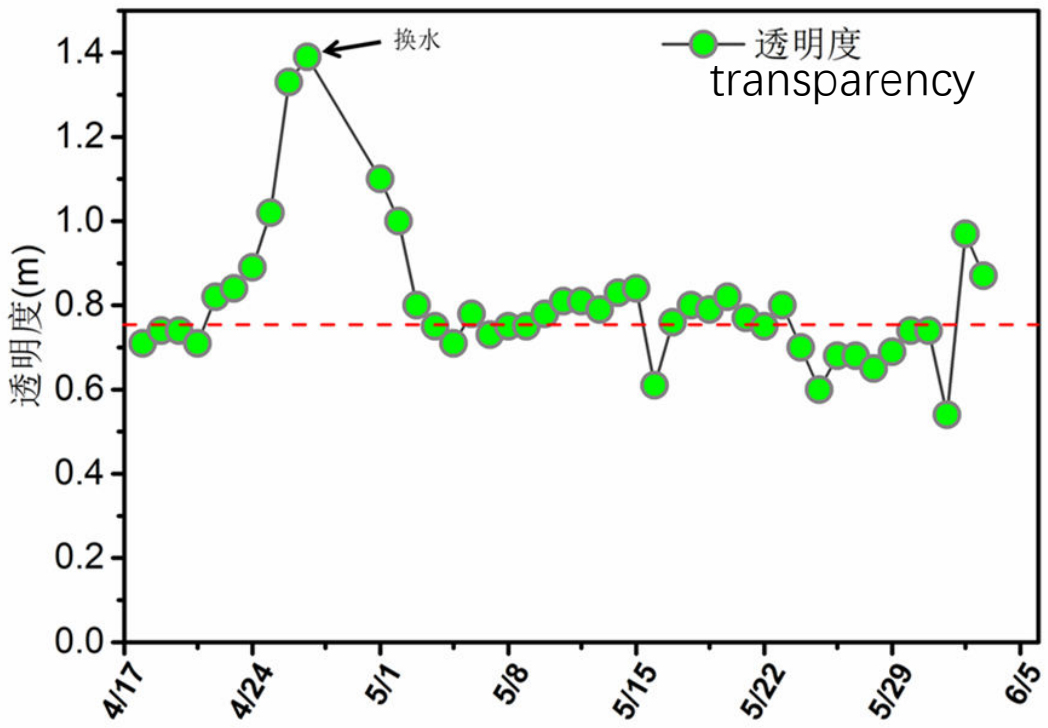
Experimental materials - in situ collection of bitter grass and Nymphoides peltata
Culture substrate: The substrate comes from wet areas.
Experimental water: The pump is used to pump the experimental device from the Taipu River, a tributary of East Taihu Lake.
Transparency measurement: We measured transparency daily at noon.



After processing the abnormal time period Observed during this study, the average transparency of the whole culture period was recalculated to 0.75±0.06 m, which was consistent with the experimental presupposition

Results: *in situ* stimulated experiment

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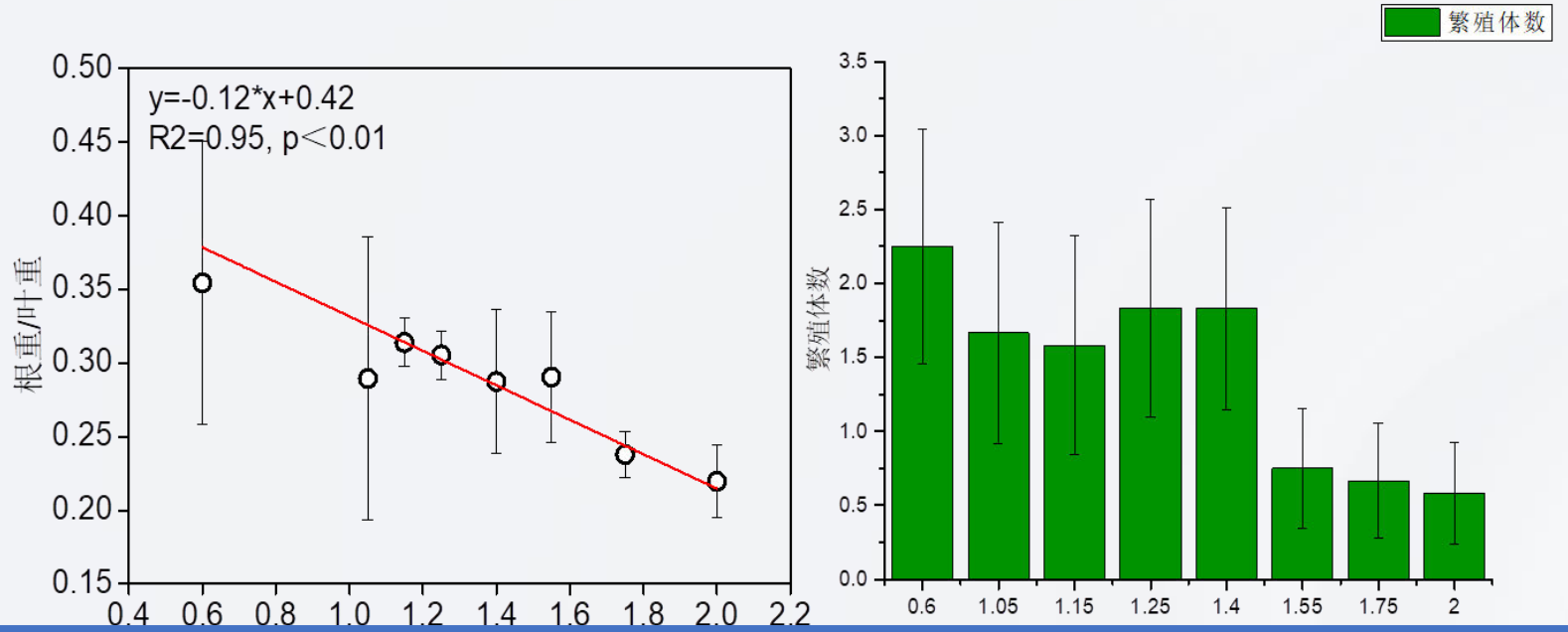
Variety of proportion and propagules with WD of Bitter grass



The water depth of 1.25 m and SD/WD value of 0.6 were the important thresholds for the growth of the seedlings. When the SD/WD ratio was lower than 0.6, the leaf length and biomass of bittergrass decreased significantly, indicating that its growth was inhibited ($P < 0.05$). When the depth is greater than 1.4m, the growth of bitter grass basically stagnates, and only maintains a basic survival state.

Results: *in situ* stimulated experiment

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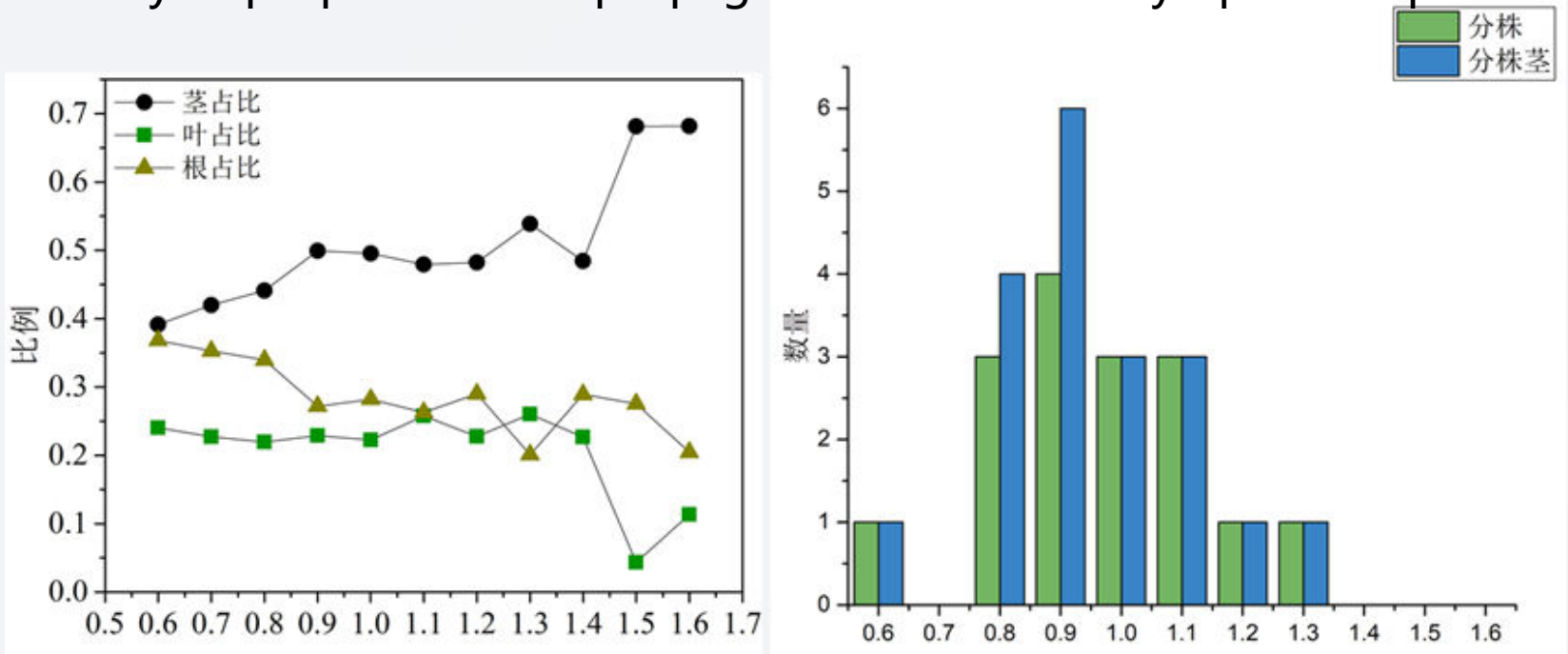
Variety of proportion and propagules with WD of Nymphoides peltata



With a depth gradient of 1.4 m and an SD/WD value of 0.536 were the important thresholds for the growth of the seedlings. Under this threshold, the number of stems and leaves, as well as biomass and leaf, significantly decreased ($P < 0.05$), with no willingness to reproduce, indicating that growth was inhibited. When the depth reached 1.6m, the survival rate of the seedlings dropped dramatically.

Results: Comprehensive analysis

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Grey correlation degree analysis

First level indicator	Second level indicator	No
Substrate	Total nitrogen(TN)	r1
	Total Phosphorous(TP)	r2
	Loss on ignition(LOI)	r3
	Moisture capacity(MC)	r4
	Sand content(Z)	r5
Seed bank	Seed density	r6
	Number of species	r7
Light condition	Transparency(SD)	r8
	Water depth(WD)	r9
	Light availability(SD/WD)	r10

No	r10	r8	r6	r4	r7	r1	r2	r3	r9	r5
correlation	0.775	0.766	0.747	0.732	0.730	0.723	0.668	0.668	0.623	0.616

According to the results, the ranking of correlation degree in the first index was light condition > seed bank > substrate, and the light condition was more prominent than the other two indexes.

Results: Comprehensive analysis

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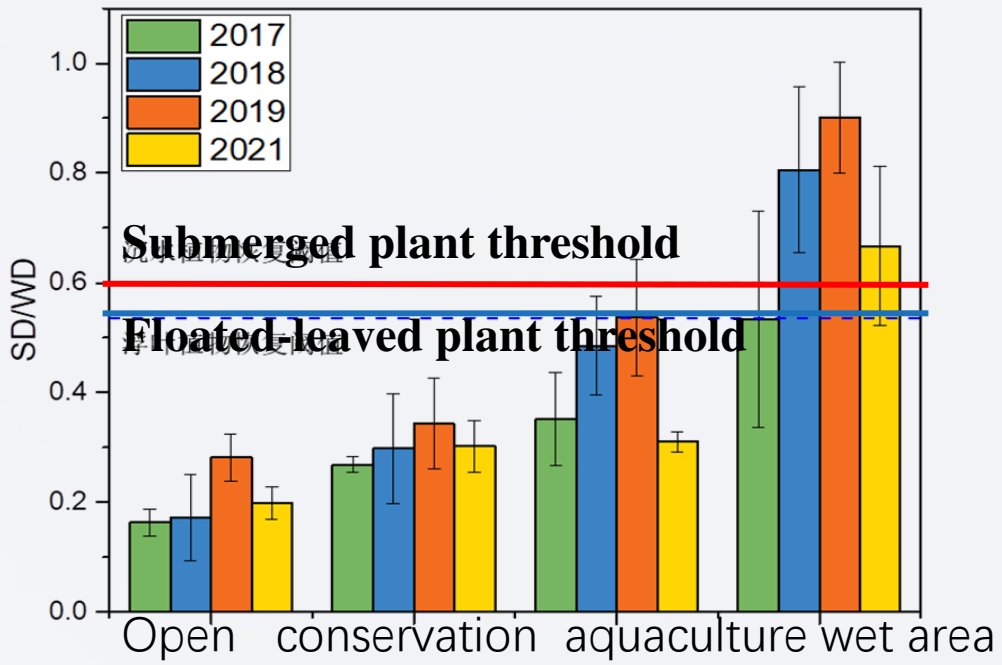
SD/WD in spring of each functional area in the past five years



Underwater light availability in the spring of 2021 Unit: m

Functional area	Month	Water depth	Transparency	SD/WD
Open area	3	1.45	0.36	0.25
	4	1.7	0.32	0.19
	5	1.75	0.29	0.17
	6	1.8	0.365	0.20
Conservation area	3	1.25	0.32	0.26
	4	1.1	0.4	0.36
	5	1.05	0.36	0.34
	6	1.4	0.37	0.26

- SD/WD ratio, the aquiculture area is close to threshold, the nearshore wet area basically exceeds the threshold value in each month, and the open water area and conservation area are significantly lower than the threshold value
- The failure of the conservation area to reach threshold may be the inability of the existing plant communities to expand

Wet areas and culture areas have the basis of natural recovery. The light conditions of open water area and conservation area can not meet the restoration needs, and some additional artificial means are needed to assist.

Conclusion

- In the East Taihu Lake region, the seed bank stock was significantly lower than the historical data, and the functional regions were different, and the early species should be paid more attention to.
- The physical and chemical properties of substrate in East Taihu Lake gradually tend to the natural state, and the current sediment properties are conducive to the natural recovery of aquatic plants
- The reference thresholds of water level and transparency required for natural restoration of characteristic aquatic plants in the in-situ water environment of East Taihu Lake were obtained through laboratory simulation experiments
- To sum up, the East Taihu Lake has a certain potential of aquatic plant restoration, and it is necessary to integrate natural restoration and artificial restoration methods to formulate restoration strategies.

Policy recommendations

1. Continue to monitor the germination and growth of aquatic plant to collecting data of vegetation in East Taihu Lake;

2. Based these results, considering the recovery of aquatic plant and security of drinking water, during the spring germination period, the water level should be appropriately lowered to ensure that the light availability of aquatic plants reaches the threshold to meet the conditions for germination and growth.

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THANKS!

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