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The impact of water level fluctuation on vegetation:An assessment of Zhenjiang Section of Yangtze River

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An assessment of Zhenjiang Section of Yangtze River

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Abstract

Beigu Mount Wetland located in Zhejiang section of Yangtze River, has been suffering from the consequences created by the fluctuation of water. Seasonal flood results in reduction in vegetation growth, lack of diversity in the ecosystem, and poor water quality. In this paper, it first introduces the evolution of the Zhenjiang section of Yangtze River and the formation of the inner river, where the research site is located. Then, it discusses literature review and analysis, the relationship between water level fluctuation and vegetation growth to identify the main cause of the problem by searching hydrological chronicle, plant survey and water level assessment. Finally, the paper identifies future work to do and tries to propose a potential vegetation strategy for Beigu Mount Wetland restoration.

1. Introduction

1.1 Context

Yangtze River is the largest wetland in China, which bears the Yangtze delta, with various natural resources. Zhenjiang section of Yangtze River (Figure 1) was an important intersection for transportation in ancient times. Before the Yangtze River Delta had fully formed, Zhenjiang section was straightly running into the sea (Yuan Gao, 2018). Later, the Yangtze River expanded northwards, and the south began to silt. Sediments piled up in large quantities, gradually forming a freshwater tidal wetland area (Figure 2). Freshwater Tidal Wetlands are marshes and swamps that experience regular lunar tidal or irregular wind tidal flooding with water less salty than brackish. (NCNHP) The freshwater tidal wetlands of the Yangtze Plain are relatively flat, and mostly located on the banks of the river or central island.

Zhenjiang Wetlands belong to intermittent river wetlands, which take up relatively small areas and have low environmental carrying capacity. Water resources of the whole Zhenjiang section in cities are polluted to different degrees. Outer mainstream maintains at the level II standard (slightly polluted) for water quality, but the inner river area can only rate as IV (severely polluted)(Table 1) in normal periods and even worse in dry periods (Hydrological Chronicle of Zhenjiang (1951-1990)). Considering the poor water quality, restoration is needed to mitigate the problem. Besides, over-cutting and over-trample reduce the ecological function of wetland and biodiversity severely.

This research focuses on the Beigu Mount Wetland, a wetland in Zhenjiang inner river. Zhenjiang is located in the southwestern part of Jiangsu Province(31°37' N, 118°58' - 119°58'E), with rich wetlands resources. Zhenjiang inner river sits in the lower section of the Yangtze River near the estuary, Jingkou District in Zhenjiang. Beigu Mount Wetland is located along the south bank of the inner river, at the foot of Beigu Mountain, with the inner river on the outside and the flood control embankment and riverside road on the inside (Figure 3).

The annual average temperature of Zhenjiang is 59.9 °F, the average precipitation is 1027mm, and the annual sunshine hours are 2057.2 hours. Zhenjiang is warm and humid, with rich heat and abundant rainfall, which is suitable for the growth of plants.

1.2 Research question and objectives

Currently, vegetation-based indicators are a common practice for evaluation. Monitoring the distribution of these indicators in restored freshwater wetlands helps examine both the utility of these indicators and the progress of the mitigation wetlands(Matthews et al 2009). Inspired by this approach, I applied it through conducting species identification, height and coverage calculations in my research to access the appraisal for Beigu Mount Wetland. This paper aims to assess the plant condition and water level fluctuation pattern to figure out the relationship between water level and vegetation (including distribution rule, negative effects, seasonal changes, etc) and provide potential solutions to repair the Beigu Mount Wetland ecosystem.

2.Methods or Study Approach

2.1 Historical literature research

To understand the hydrological development of Zhenjiang, I reviewed Zhenjiang chorography and Hydrological Chronicle of Zhenjiang (1951-1990) in Nanjing Library, which cover development of water storage engineering, river engineering, farmland water conservancy, flood and drought control, and water management (Figure 4). From the research, I collected typical water level information from 1951 to 1990 and made comparisons with current data to figure out fluctuation trends.

2.2 Plant Species Survey

Because the dominant species in wetlands are intensive cloned plants that rely on underground tubers for reproduction and hard to count up exact numbers, I investigate the plant through a line transect method. To facilitate locating positions on the digital map and calculating the coverage rate, I created a grid and placed the tape measure along the lines, each with a length of 160 feet (Figure 5). I recorded a catalog of plant species and height of each plant encountered along the sample line (Table 3), plotted the plant community distribution map and estimated the coverage density afterwards (Figure 6). I didn't identify aquatic plants due to the equipment limitation. Then I chose one sample line and marked the starting and ending point. I traced it on the map and obtained elevation of each point from google earth map. These steps allow me to identify the vertical distribution pattern of vegetation which is important to understand plant adaptation to elevation and water levels. Aiming to design a plant strategy for water quality remediation, I made a list of available options through literature investigation on the purification functions of some local plants.

2.3 Water Level Assessment

By overlaying and tracing the topography of the landscape and plant, I am able to see that vegetation species and quantities are closely related to water. And hence I conducted a water level assessment to prove the impact of water level fluctuation on vegetation. I collected the daily water level report from the Zhenjiang water level detection station, which is near the Beigu Mountain (Figure 7), compiled the average water level information and drew a line graph to show the daily and annual water-level fluctuation principles. Daily changes in tidal fluctuation patterns will cause inaccuracy of quantitative analysis on annual water level fluctuations even if the data is detected at the same time everyday. To avoid the abnormal data, I set the monthly water as the average of the water level data on the 5th, 15th and 25th of the month. For further study on the potential influence of flood period on species reduction, I compared water level and the height of vegetation to predict seasonal vegetation performance.

3.Result & Discussion

3.1 Historical research

The historical report demonstrated that, during the year, 60 percent of the rainfall concentrated in summer and autumn (from June to September), which was affected by typhoons and climatic features. Zhenjiang had frequently suffered from floods and droughts throughout history. Through 1951 to 1990, the average water level was 14.44

feet. The highest water level used to appear in the wet season and the lowest water level appeared in January (Table 2). Comparison between past and current data (which I will introduce detailedly in section 3.3) revealed that the trend of water level changes kept the consistency in the past 70 years. If the climate keeps stable, we can safely hypothesize that the water level fluctuation of the Zhenjiang section of the Yangtze River will keep a similar pattern in the near future. But it may not be accurate for unpredictable climate change.

3.2 Plant Species Survey

The wetland in the researched area can be divided into three types according to topography: Low-level wetland(below the water surface), mudflat (flooded in wet season) and high-level wetland. In general, this site has an unpleasant environment (Figure 8) and low vegetation diversity, where Poaceae is the only dominant family.

I drew a section which indicates the general vertical distribution principle (Figure 9). In the low-level wetland, vegetation is dominated by aquatic grass communities. Mudflats consist of aquatic grasses and shrubs. High-level land is composed of arbor, shrub and terrestrial herbs with relatively rich vegetation composition. In terms of the plane distribution, the vegetation is concentrated in the middle of the wetland and decreases with approaching the river bank. The main species in the investigated area are Reeds (Phragmites communis) and Reed canary grass (Phalaris arundinacea) (Figure 10).

Figure 11 indicated that excessive water would affect the health and height of plants. Reeds that lack the support of background plants tend to fall to the side of the water bank. It also showed that the reeds on elevated areas perform better compared to the ones in lower elevation, which is very likely due to the inundation in water.

Plants have the capability to remove harmful chemicals. Many macrophytes, which can survive in this flooded wetland, have a great ability of removing nitrogen, phosphorus, chloride, etc. which are the detect factors for water quality monitoring (Yi et al. 2003). Plants in the family of Gramineae, Cyperaceae and Typhaceae are the optimal choices for purifying the water quality in the site with the consideration of both purification capacity and the existing vegetation environment(Table 4).

3.3 Water Level Assessment

Water level displayed both daily and seasonal changes in the year. There are two high tides and two low tides in each morning and evening (Figure 12). Beigu Mount Wetland entered the wet season in June and finished in October (Table 5). The highest monthly water level occurred in July, which cause floods, and the lowest occured in January. Areas lower than 8 feet suffered from flooding almost all year round.

Through making comparison between water level and the height of reeds, reed canary grass and pale smartweed (Figure 13), during the wet season, emergent vegetation that is shorter than 15 feet will be submerged and die easily. Higher water levels leads to a large species reduction in summer (Valk et al. 1994). Only a few hydrophilic plants such as reeds survive (Table 6).

4.Conclusion

I identified the correlation between vegetation growth and the water level of Beigu Mount Wetland through observation, evaluation and assessment performed. Then I discussed the seasonal adaptability of plants in freshwater tidal wetland to help develop potential strategy for vegetation restoration in Beige Mount Wetland, furtherly, aims to make it applicable to the whole Zhenjiang section of the Yangtze River. Here are some suggestions made:

1. Restoration methods for wetlands should be tailored with the considerations of different elevations. For wetland where the surface elevation is below 8 feet, it is advisable to adopt enhanced restoration methods, such as repairing basal or introducing silt to elevate the wetland base. Elevated space can create a safer safe free of water level fluctuation. In terms of mudflat remediation, it is preferable to select perennial plants which are more water adaptive. High-level wetland which is higher than 15 feet experiences a shorter flood time and shallower flooding depth. In this area, vegetation is less vulnerable to water level fluctuation. We can employ a more complex plant strategy to increase the ecological diversity.

2. We should prioritize local native tree species, which adapt to the local climate and be cost-efficient. Those with biological purification functions would be a plus

to ameliorate the poor water quality. A combination of emergent vegetation, submerged vegetation, and floating vegetation with differentiation in height and seasonal characteristics will contribute to a rich multi-level visual effect and a water-level adaptable environment which minimizes the influence of seasonal fluctuation. Once the available option is established, we need to check carefully to avoid using hostile species with dominant vegetation.

3. There are limitations to field surveys that it is challenging to get an overall big picture of what is going on in the site such as over-water or swamp. There are limitations to field surveys that it is challenging to get an overall big picture of what is going on in the site such as over-water or swamp. However, efficient and accurate vegetation sampling techniques are essential for the assessment of wetland restoration success (Shuman et al. 2003). For sites with limited field access, remote sensing is a potential solution for the protection and rational development and utilization of wetland resources, which can detect environmental indicators and provide quantitative estimates of coastal and estuarine habitat conditions and trends(Lathrop et al. 2000) I will consider applying remote sensing for long-term monitoring of the growth situation and distribution of vegetation as a primary future work.
4. These suggestions provide a better understanding of the actual vegetation and water environment of the site and by using these methods, hopefully it will benefit the outcome of the restoration project.

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Tables

Category	Description for water quality and usage
Class I	Good water quality. Groundwater only needs to be disinfected; surface water only requires simple purification (e.g. filtration) and disinfection is for drinking.
Class II	Slightly polluted. After conventional purification treatment (e.g. flocculation, precipitation, filtration, disinfection, etc.), the water quality is available for drinking
Class III	Moderately polluted. For centralized drinking water source secondary protected areas, general fish protected areas and swimming
Class IV	Deeply polluted. For general industrial protected areas and non-direct contact with the human body of recreational water
Class V	Severely polluted. For agricultural water areas and general landscape required waters.

Table 1. Water Quality Classification in China

(Drawn by author, resource from Chinese environmental quality standards for surface water. GB 3838-2002)

Alerting Level	Highest Level		Lowest level	
	Water Level (ft)	Date	Water Level (ft)	Date
22.31	27.49	1954.8.17	4.07	1959.1.22

Table 2. Water Level Data through 1951-1990

(Drawn by author, resource from Hydrological Chronicle of Zhenjiang (1951-1990))

Type of wetland	Common Name	Scientific Name	Heights (inches)
Mudflat (~6ft - ~12ft)	Reed canary grass	Phalaris arundinacea	32-50
	Reed	Phragmites communis Trin	98-150
	Bermuda grass	Cynodon dactylon	2-3
	Manchurian wild rice	Zizania caduciflora	17-23
	Pennisetum	Pennisetum alopecuroides	11-17
	Yard-grass	Eleusine indica	4-7.5
	Triangular club-rush	Scirpus triqueter	8-12
	Pale smartweed	Polygonum lapathifolium	15-20
	Japanese Dock	Rumex japonicus	24-32
	Toothed dock	Rumex dentatus	15-27
	Chinese violet cress	Orychophragmus violaceus	14-17
	Chinese yellowcress	Rorippa cantoniensis	4-9
	Carolina geranium	Geranium carolinianum	8-14
	Field mouse-ear	Cerastium arvense	5-8
	Stellaria aquatica	Malachium aquaticum	23-32
	Chickweed	Stellaria media	3.5-7
High-level Wetland	Carpet-grass	Axonopus compressus	6-10
	Cobblers pegs	Bidens pilosa	7-15

(~12ft - 28 ft) *Didn't show repetitive plant in both mudflat and high-level wetland	Paper mulberry	Broussonetia papyrifera	Around 400
	Babylon willow	Salix babylonica	Around 275
	Corkscrew Willow	Salix matsudana	Around 350
	Chinese tulip poplar	Liriodendron chinense	Around 650

Table 3. Vegetation Species List

Species	Scientific Name	Purification Function
Submerged plant	Myriophyllum verticillatum	Remove N, P, avoid eutrophication
	Ceratophyllum demersum	Remove N, P, Fe, Mm, reduce O_2 demand
Floating plant	Eichhornia crassipes	Absorb N, P
	Lemna minor	Accelerate Microbial metabolism
	Nelumbo nucifera	Remove N, P, K, absorb floc
Emergent plant	Phragmites australis*	Absorb floc, chloride, nitrate, Hg, etc
	Zizania latifolia*	Remove N, P
	Scirpus triqueter*	Absorb N, P and heavy metal element
	Iris pseudacorus	Reduce O_2 demand

Table 4. A List of Purification Functions of Local Macrophyte (Plants with * indicates it's an existing species in the site)

(Drawn by author, reference from Yunxiao et al.(2003), Howard et al.(2010), nas.er.usgs.gov and https://plants.jstor.org)

Month\Water Level(ft)	5th	15th	25th	Average
January	2.86	5.64	8.30	5.60
February	4.43	4.89	9.58	6.30
March	4.86	6.14	11.09	7.36
April	9.42	8.17	11.15	9.58
May	8.17	5.54	11.78	8.50
June	11.00	11.22	15.65	12.62
July	18.70	20.64	20.54	19.96
August	21.42	17.55	15.52	18.16
September	18.04	14.86	13.91	15.60
October	16.40	15.09	11.15	14.21
November	11.25	10.89	5.51	9.22
December	6.30	7.19		6.75
		Average water level		11.16

Table 5. Water Level of Zhenjiang Station, 2020 (Detected on 11a everyday)

(Drawn by author, resource from Yangtze River Maritime Safety Administration)

Time & Period	Water level (ft)	Prediction of Reed	Prediction of Reed canary grass	Prediction of Pale smartweed
Dec - Feb (Dry Season)	5-7	Wilting stage	Germination stage. Over water	Wilting stage
Mar - May (Normal Season)	7.5-10	Forming stage. Over water	Growth stage. Most over water	Forming stage. Most over water
June - Sept (Wet Season)	12-20	Growth stage. Most over water	Maturation stage. Submerged	Growth - maturation stage. Submerged
Oct - Nov (Normal Season)	9-15	Maturation stage. Most over water	Growth stage. Part over water	Wilting stage

Table 6. All-year Round Performance Prediction of Reed, Reed canary grass and Pale smartweed according to Water Level Fluctuation (Reference from Guoqing 2007)

Figures

Figure 1. The location of Zhenjiang City in the Yangtze River Basin

(Reference by Yuan, 2018)

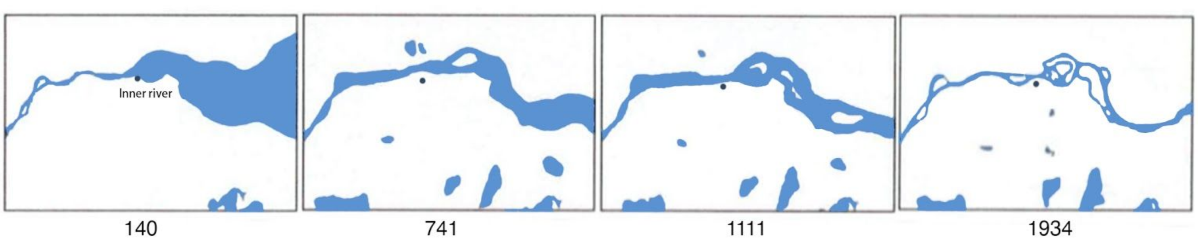

Figure 2. Estuary Pattern Evolution of Zhenjiang Section of Yangtze River

(Resource from the website of China Discovery)

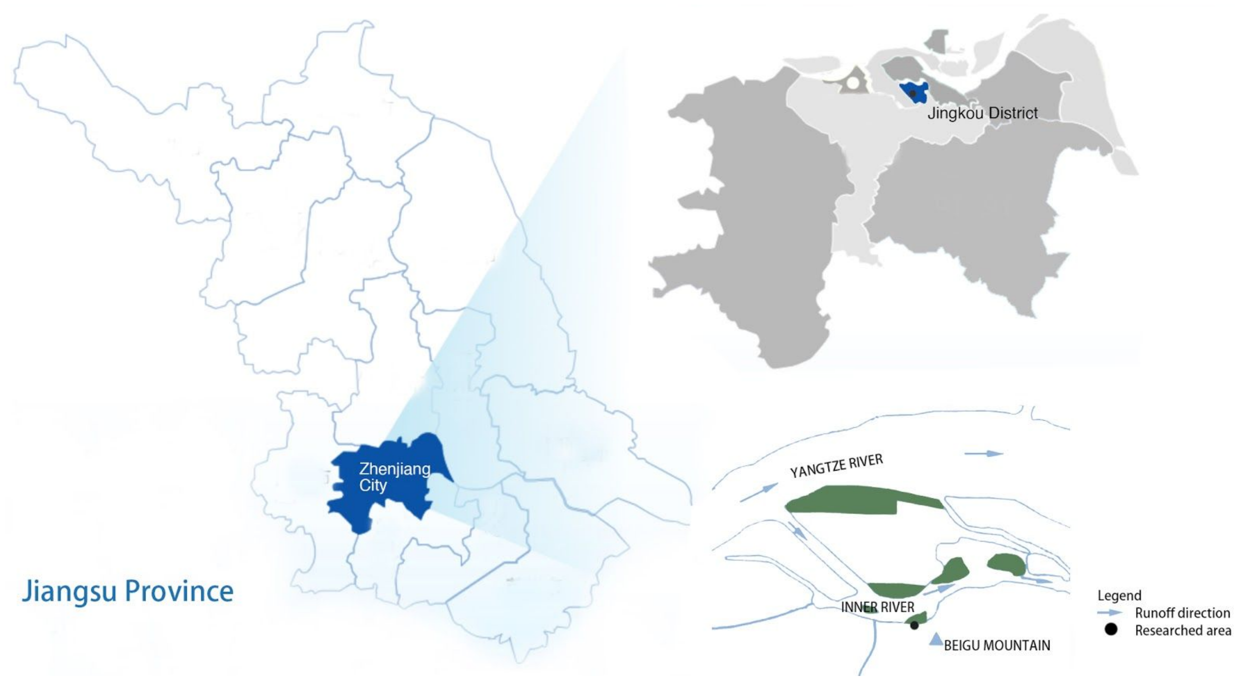

Figure 3. Geographic Map of Research Area

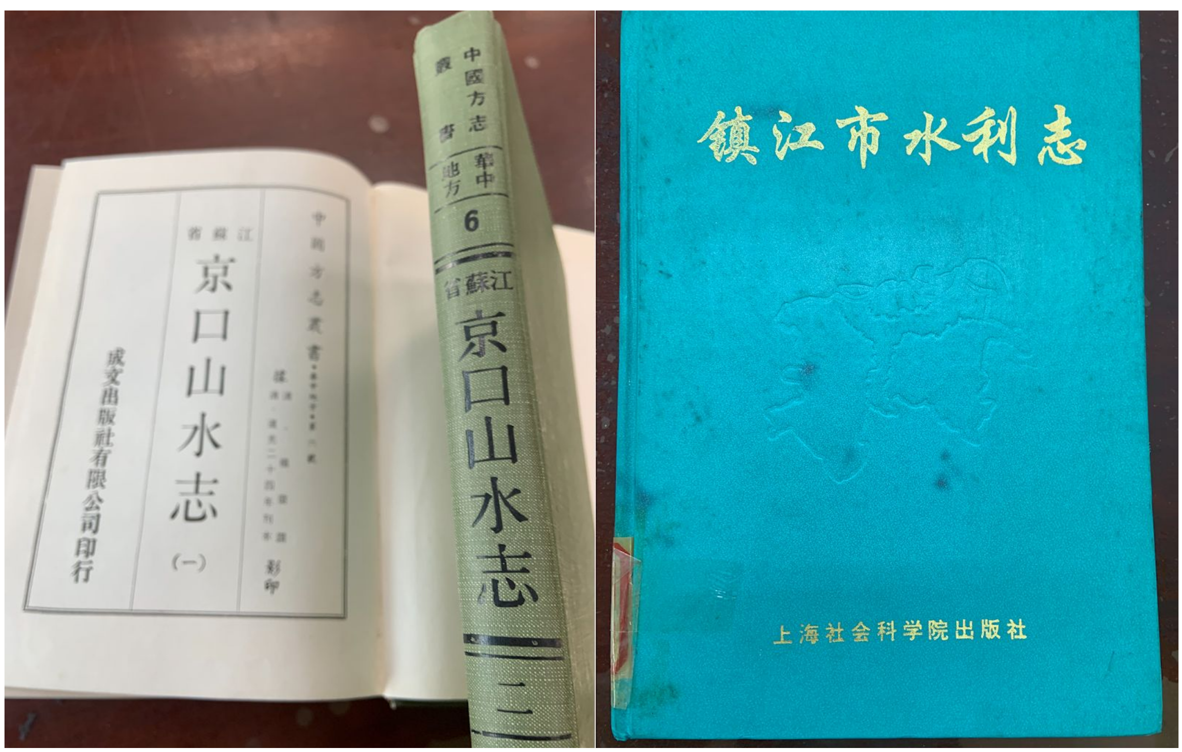

Figure 4. Cover of Zhenjiang chorography and Hydrological Chronicle of Zhenjiang (1951-1990)

Figure 5. Grid of Vegetation Sample Area

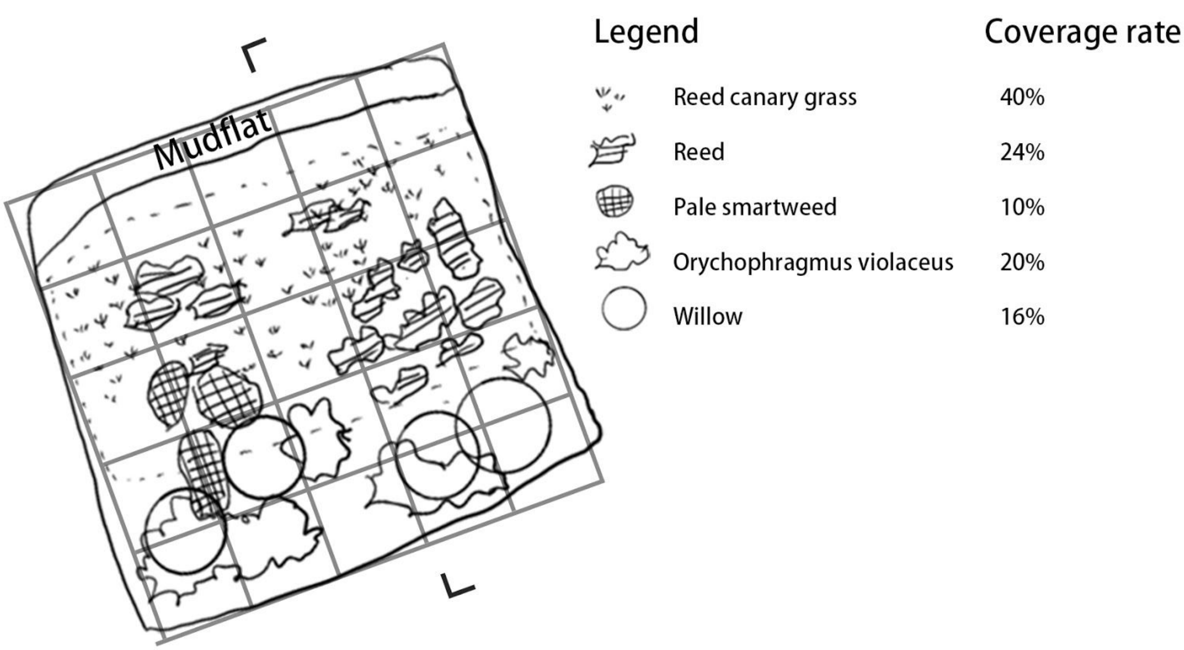

Figure 6. Dominant Plant Distribution Map and Coverage Rate in the Grid Area

Figure 7. Location of the Monitoring Station and Site

Figure 8. Site Photo

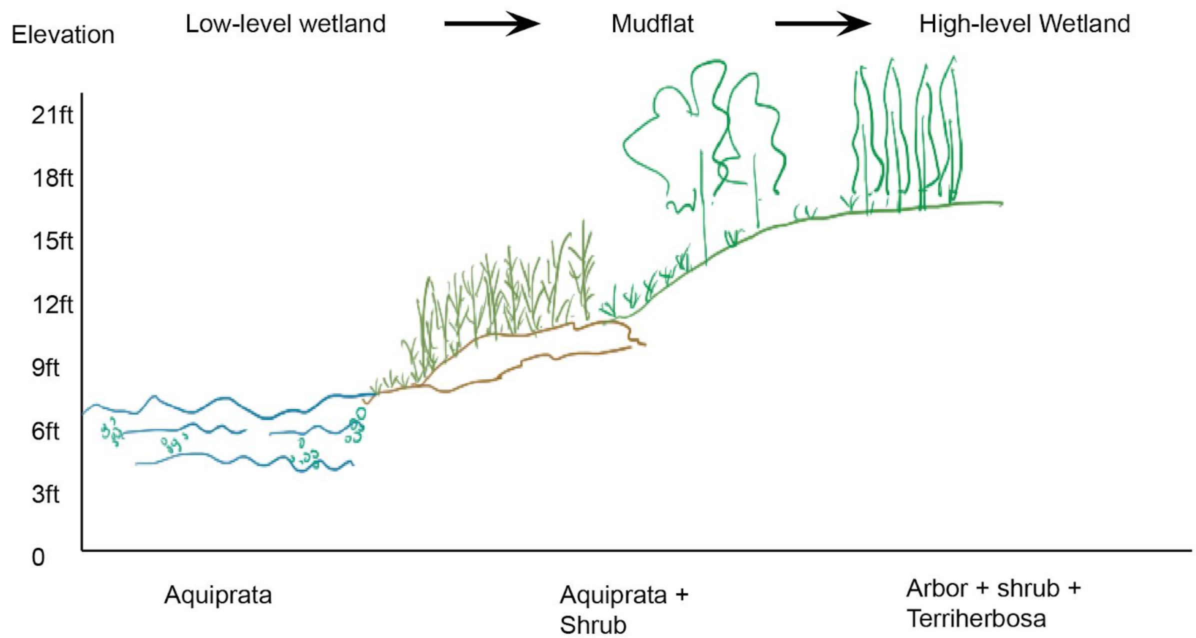

Figure 9. Vertical Plant Distribution Map

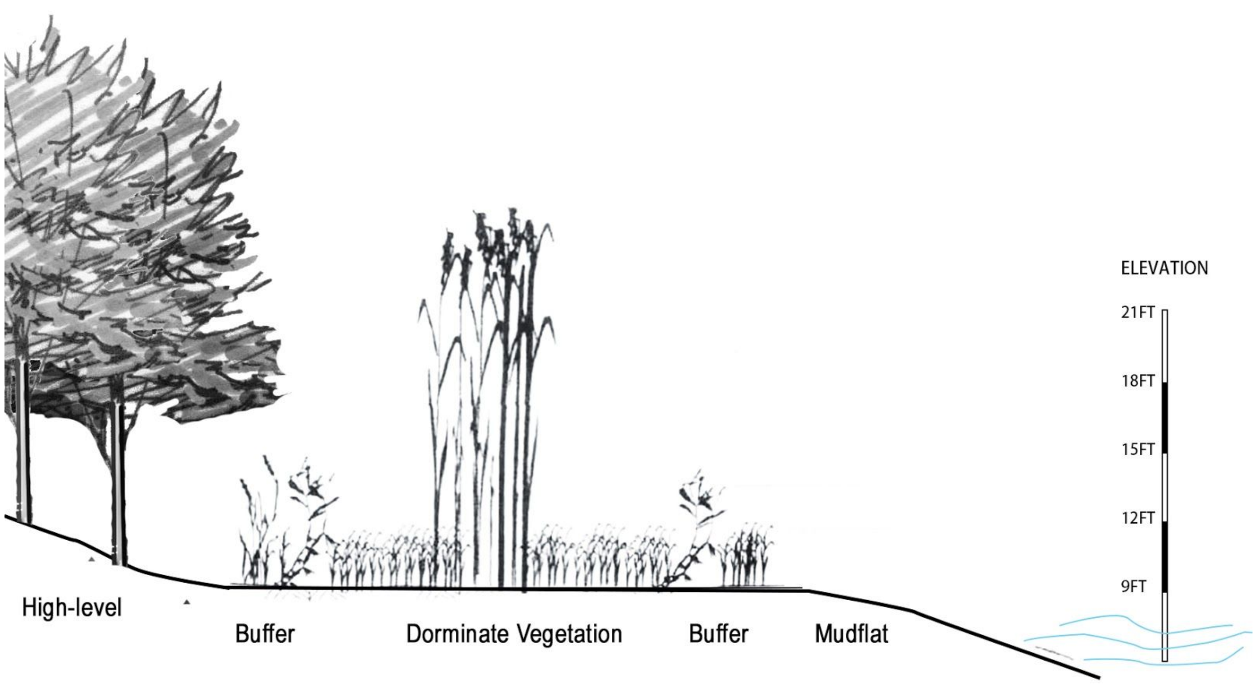

Figure 10. Beigu Mount Wetland Sample Section

Figure 11. Comparison Between Reeds Grown on Different Elevation

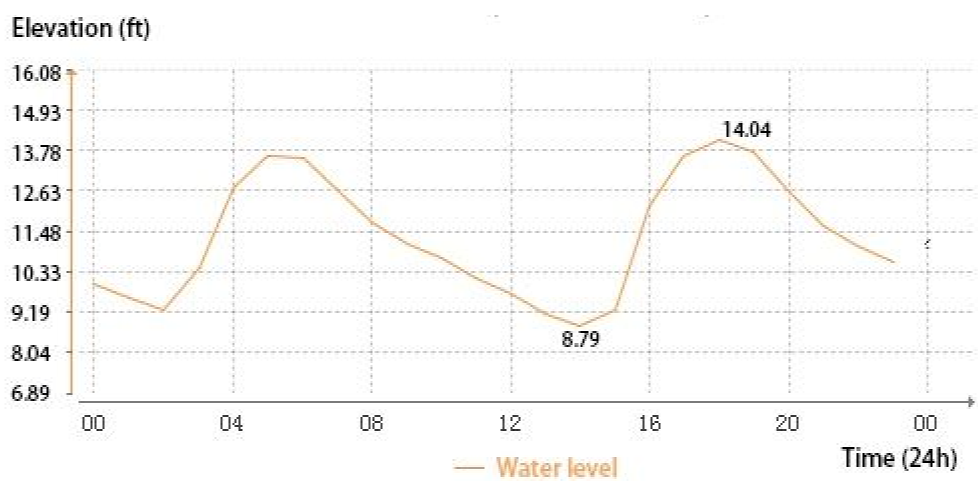

Figure 12. Water Fluctuation Pattern on Dec 13rd

(Resource from Jiangsu Province Hydrology Water Resources Investigation Bureau)

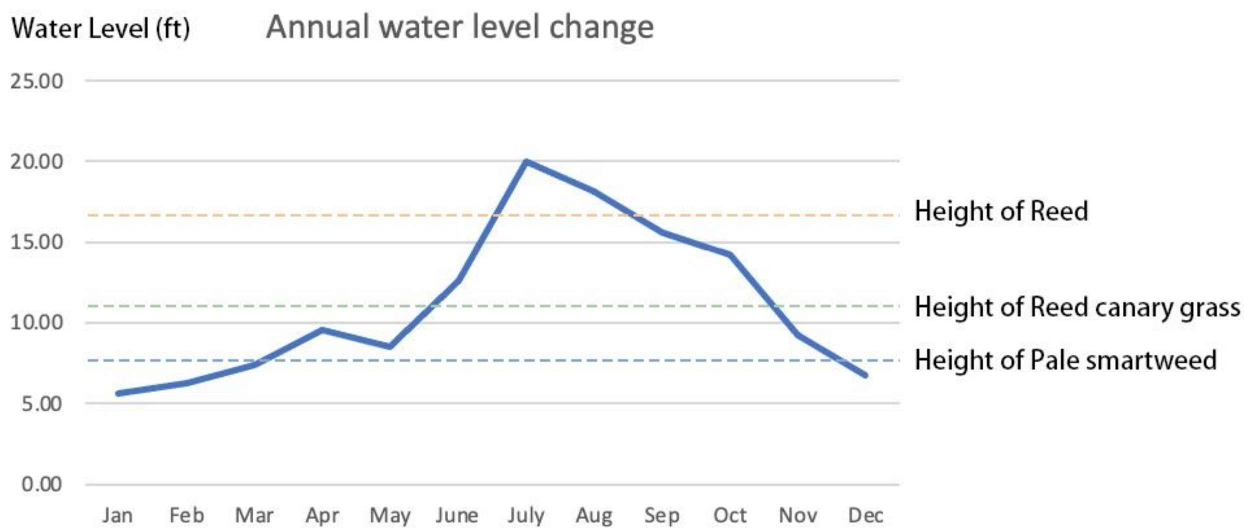

Figure 13. Annual Water Fluctuation Pattern with the Comparison of Vegetation Height

(Base elevation added to the height of vegetation)