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Carbon Sequestration Potential of Wetland Parks: A Case Study of Guangzhou Wetland Park

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Abstract As the integration point of urban blue-green spaces, wetland parks play an important role in the construction of urban carbon pools. It is of great significance for achieving carbon neutrality and peak carbon emissions by reasonably evaluating the carbon sequestration capacity of wetland parks and optimizing wetland structure. In this paper, Guangzhou wetland park is taken as the research object. Through field research, the carbon sequestration potential of ecosystems at multiple levels, including forest vegetation, seedlings, and wetland ecosystems is studied, and policy recommendations are put forward for carbon sequestration in wetland systems. The results show that the annual carbon sequestration capacity of the wetland is 1 296.59 t, and the annual net carbon sequestration value is 100 485 yuan. Among the three regions, proportions of annual carbon sequestration of the forest vegetation plate, seedling plate, and wetland ecosystem plate account for 28.4%, 41.3%, and 30.3%, respectively.

Key words Wetland park; Carbon sequestration capacity; Carbon storage; Carbon sink

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Wetlands are one of the important land use types, with significant carbon storage and sequestration functions. Although the global wetland area only accounts for 8% of the land area, its carbon storage accounts for 20% to 30% of the global land carbon storage[1]. At the 75th United Nations General Assembly, China proposed that it will increase its nationally determined contributions, adopt more effective policies and measures, strive to peak carbon dioxide emissions before 2030, and achieve carbon neutrality before 2060[2]. Carbon peak and carbon neutrality targets have become important long-term strategic goals for China, mainly achieved through four technological approaches of "emission reduction, carbon conservation, sink enhancement, and storage". Among them, consolidating the carbon sink function of terrestrial ecosystems and enhancing the carbon sink increment of ecosystems are important ways to achieve the "dual carbon" goals[1].

Wetlands, as an important ecosystem carbon pool second only to forests, play a crucial role in carbon sequestration. In recent years, China has paid high attention to the importance of wetland carbon sink and actively carried out carbon sequestration, sink enhancement and emission reduction work in forest grassland wetland ecosystems, making wetland protection and restoration a top priority. At the same time, the *Measures for the Management of Carbon Emission Trading (Trial)* and the *Interim Regulations on the Management of Carbon Emission Trading* both clearly stipulate that key emission units can use the nationally verified voluntary emission reductions generated by forestry carbon sinks to offset their carbon emission quotas. Forestry carbon sinks have been included in the national carbon emission trading mechanism, and wetland carbon sinks belong to the category of forestry carbon sinks.

Wetlands, as a unique ecosystem formed by the interaction between water and land, play an important role in greenhouse gas regulation due to their unique ecological characteristics. Small fluctuations in wetland carbon storage can directly lead to an increase in atmospheric carbon dioxide and methane concentrations through the emission of greenhouse gases into the atmosphere, thereby affecting global climate change through the greenhouse effect[2]. Therefore, it is of great significance by increasing attention to the carbon sequestration capacity of wetlands, quantifying the spatial-temporal changes of carbon storage in wetland ecosystems, and identifying their influencing factors. It is also one of important ways for China to achieve carbon peak and carbon neutrality goals.

1 Overview of wetland park

This wetland park is located in the northern part of Guangzhou, with the characteristics of high temperature, abundant rainfall, long summer and short winter, and a long frost free period. It is a complex wetland composed of lakes, rivers, streams, ponds, forests, and fields, with high biodiversity and an area of 240.6 hm^2, including 137.1 hm^2 of wetland area and a wetland coverage rate of 56.9%. The area where the park is located is an important water conservation area in Guangzhou, with a complete hierarchy and structure of "wetland species – wetland community – wetland ecosystem", containing rich carbon sink information. The park is divided into five functional areas: ecological protection area, restoration and reconstruction area, science popularization exhibition area, rational utilization area, and administrative service area. By dividing wetland functions, it is ensured that lakes, rivers, floodplains, forests, *etc.* play an important role in the protection and management of protected areas, thereby achieving wetland protection, restoration, and rational uti-

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lization. At the same time, it ensures the naturalness and integrity of river water bodies and wetland ecosystems, achieving overall protection of natural ecosystems. Wetland vegetation and forest and grass vegetation in the river and mudflat area have been well protected, providing habitat for birds and waterfowl, meeting the needs of animals and plants in the wetland park for living space, and promoting the increase of wetland biodiversity. It plays a huge role in the regional ecological environment, and also provides important ecological support for the surrounding farmland, forests and urban ecosystems.

2 Data and research methods

2.1 Data collection and investigation The data required for carbon sequestration calculation comes from the Municipal Planning and Natural Resources Bureau and the Wetland Park Management Center. The main information includes: classified statistical data of park area; main tree species, age, average DBH, average tree height, area, and volume; the main tree species, DBH, and quantity of artificial seedlings and area of wetland plate. The statistical calculation year was 2022.

2.2 Research ideas and methods Carbon sink refers to the process, activity, or mechanism of removing carbon dioxide from the atmosphere. Starting from cost, actual needs, and actual situation of the wetland park, the research is conducted from three aspects: carbon absorption by forest vegetation plate; carbon absorption of artificially configured seedling plate; carbon absorption of wetland ecosystem plate. Using internationally recognized estimation methods and practices such as the *Guidelines for Compilation of Guangdong Provincial Greenhouse Gas Inventory* and the *Technical Guidelines for Gross Domestic Product (GEP) Accounting of Terrestrial Ecosystems*, the carbon sink of wetland parks is calculated.

2.3 Calculation results of carbon sequestration in wetland park

2.3.1 Forest vegetation plate. The total area of forest vegetation plate in the wetland park is 30.07 hm^2, and it is divided into 9 plates with a total storage volume of 2 681 m^3. Using the calculation method of *Guidelines for Compilation of Guangdong Provincial Greenhouse Gas Inventory*, the carbon sequestration of forest vegetation plate in 2022 was determined to be 368 t. In this paper, due to the relatively small annual changes in the area of other suitable forest land and other non-standing forest land, as well as their low carbon sequestration capacity, they can be ignored (Table 1).

Table 1 Carbon sequestration of forest vegetation plate in the wetland park (2022)

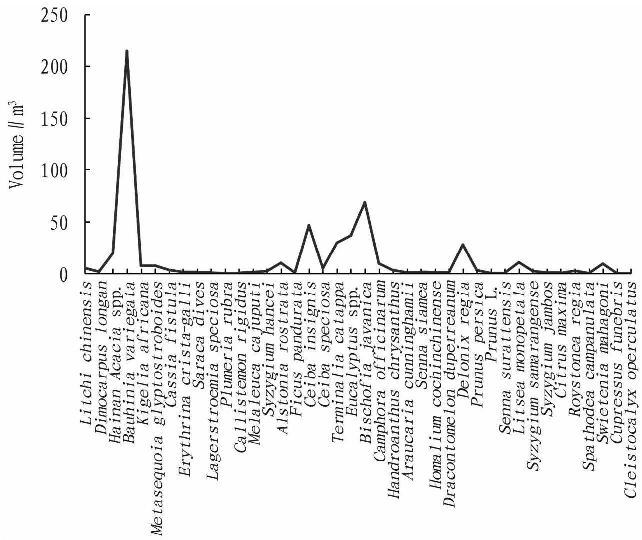
Patch	Land type	Crown density/coverage	Average DBH//cm	Area//hm^2	Total storage volume//m^3	Biomass//t	Annual carbon sequestration//t
1	Arbor forest	0.5	17.9	6.26	617	697	84.68
2	Arbor forest	0.7	17.0	4.40	398	448	54.63
3	Arbor forest	0.6	17.0	6.19	552	619	75.76
4	Arbor forest	0.6	18.0	7.57	766	836	105.13
5	Arbor forest	0.3	19.1	2.66	300	297	41.17
6	Arbor forest	0.3	19.1	0.43	48	48	5.59
7	Other suitable forest land	0	0	1.18	0	6	0
8	Arbor forest	0.6	3.8	0.42	0	5	0
9	Other non-standing forest land	0	0	0.96	0	5	0
Total		–	–	30.07	2 681	2 961	367.97

Note: The data on crown density, DBH, area, volume, and biomass of forest vegetation are sourced from the Municipal Planning and Natural Resources Bureau.

2.3.2 Artificially configured seedling plate. In the wetland park, the total number of artificially planted seedlings is 21 722, with a cumulative accumulation of 3 899.8 m^3. The *Guidelines for Compilation of Guangdong Provincial Greenhouse Gas Inventory* is used, and the annual growth rate (GR) of the stock volume is taken as the provincial average of 8.24%; the basic wood density (SVD) is taken as the provincial average of 0.474; the biomass conversion coefficient is taken as the average value in Guangdong Province, with a BEF of 1.915 3 for the entire forest. Using a carbon content of 0.5 consistent with the IPCC recommendation, the carbon sequestration capacity of artificial seedling plate in 2022 was determined to be 535.25 t (Fig. 1).

2.3.3 Wetland ecosystem plate. The wetland area of the wetland park is 137.1 hm^2. Using the carbon sequestration rate method of the *Technical Guidelines for Gross Domestic Product (GEP) Accounting of Terrestrial Ecosystems*, the carbon sequestration amount of the wetland ecosystem plate in 2022 is calculated to be 393.37 t (Table 2).

2.3.4 Annual carbon sequestration in the park. The total area of the wetland park is 240.6 hm^2, of which the wetland area is 137.1 hm^2 and the wetland rate is 56.9%. According to its different functions, it is divided into three plates: forest vegetation, artificial seedlings, and wetland ecosystem. Based on carbon sink calculation, the carbon sequestration amount in 2022 was 1 296.59 t, with an annual net carbon sequestration value of 100 485 yuan. Among them, the wetland ecosystem plate covers an area of 137.1 hm^2 and has an annual carbon sequestration capacity of 393.37 t, accounting for 30.3% of the total annual carbon sequestration capacity of the wetland park. The area of forest vegetation plate is 30.07 hm^2, and the annual carbon sequestration is 367.97 t, accounting for 28.4%. There are 21 722 artificially planted seedlings, with an annual carbon sequestration of 535.25 t, accounting for 41.3% (Fig. 2).



Note: The data on seedling stock volume comes from the Wetland Park Management Center.

Fig. 1 Volume of artificially configured seedlings in the wetland park

Table 2 Carbon sequestration amount of the wetland ecosystem plate in wetland park (2022)

Type	Area // hm^2	Annual carbon sequestration // t
River surface	55.07	114.53
Lake surface	65.55	136.33
Inland mudflat	16.48	142.50
Total	137.10	393.37

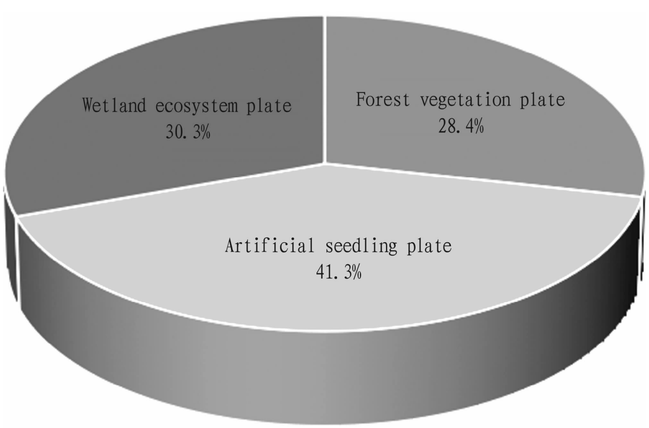


Fig. 2 Composition of carbon sequestration in the wetland park (2022)

3 Conclusions and suggestions

3.1 Emphasizing the improvement of wetland carbon storage in the wetland park The carbon pool of wetlands is mainly influenced by factors such as wetland type, area, vegetation, soil layer thickness, groundwater level, nutrients, and pH[3]. The protection and restoration of wetland ecosystems are the core of achieving a "net carbon sink". The annual carbon sequestration of the wetland park is 1 296.59 t, of which the annual carbon sequestration of the wetland ecosystem is 393.37 t, accounting for 30.3% of the total annual carbon sequestration. Wetland resources of wetland park are divided into river wetland, lake wetland and inland mudflat, which are mainly river and lake water surfaces. The proportion of inland mudflat is relatively low, accounting for only 12% of the wetland area.

Swamp wetlands are important ecosystems in the context of global climate change and a key area for reducing greenhouse gas emissions worldwide. Wetland is an important "sink" or "source", and existing research has shown that rational development, protection, and restoration of wetlands are key to achieving "net carbon sequestration"[4]. Therefore, in order to improve the carbon sequestration capacity of wetland ecosystems, it is recommended to introduce more water-resistant aquatic plants such as mangrove, shrub, and reed, increase biodiversity, ecosystem productivity, and wetland carbon storage.

3.2 Strengthening the utilization of carbon sequestration potential of forest vegetation in the wetland park The forest vegetation in the wetland park is mainly mature forest, with over mature forest accounting for about 60%, near mature forest accounting for 30%, and young forest accounting for 10%. Forest biomass carbon sequestration plays an important role in addressing climate change by sustainably increasing its carbon storage. To enhance the carbon sink capacity of wetland ecosystems, it is necessary to strengthen the management of large-diameter tree species; focus on developing arbor and shrub types and increasing wetland carbon storage; increase replanting work in areas such as forest land and forest gaps. By reducing deforestation, afforestation, protection and restoration, wetland protection and restoration, farmland and grassland management, and other measures, the carbon sink capacity of forests can be improved.

3.3 Fully leveraging the important role of wetland ecosystems Wetlands are an important component of the land – atmosphere – hydrosphere – land – atmosphere – water cycle. In plants, carbon dioxide is converted into organic carbon by photosynthesis. Due to their anaerobic ecological characteristics of over saturated water, wetlands are rich in organic matter and accumulate abundant inorganic and organic carbon. At the same time, wetland plants absorb CO_2 from the atmosphere and release it into the atmosphere through metabolism, respiration, and other processes, forming the wetland carbon cycle. Therefore, by formulating the water quality safety plans of water source, establishing wildlife rescue centers, vegetation restoration projects, biodiversity conservation and restoration projects, and other means, wetland protection can be further strengthened, and the structure and function of wetland ecosystems can be restored. Wetland protection effectiveness can be improved, and sustainable development of wetland can be promoted. Wetland vegetation and soil carbon pools can be increased, and their carbon sink capacity can be enhanced.

3.4 Regularly evaluating the emission reduction and sink enhancement value of wetland ecosystems Wetlands are important "carbon storage reservoirs" and "carbon absorbers", serving as "buffers" for climate change. Wetlands have functions such as resisting extreme weather, buffering and mitigating flood and drought, and absorbing and storing carbon. Currently, people generally advocate the concept of addressing global climate change, while measures driven by carbon finance often focus on " hardware" low-carbon improvements, neglecting the carbon sink functionnecessary to further strengthen data resource sharing, improve ecosystem carbon measurement methods and means, strengthen ecosystem positioning observation and environmental monitoring, and improve the predictive warning and emergency response capabilities in response to climate change. It should regularly evaluate the role of ecosystem activities such as forest vegetation, wetlands, and soil in reducing emissions and increasing carbon sinks, effectively manage ecosystem carbon sinks, and better leverage the role of wetlands in achieving carbon peak goals and carbon neutrality visions.

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3.2 A new method for lightning risk assessment of wind farms being an exploration The comprehensive evaluation of lightning protection status in wind farms based on six indicators (referred to as three regulations, two new, and one effect) including design basis compliance, product compliance, protection method compliance, product innovation, technological innovation, and lightning damage (protection effectiveness), and dividing it into high, medium, and low risk levels, is a new method and exploration.

Unlike the lightning risk assessment method based on the protection angle method, the lightning risk assessment method based on regional lightning protection and semicircular protection defines the sources of risk as direct lightning strike S1, side lightning strike S2, adjacent lightning strike S3, lightning electromagnetic pulse S4, and ground potential counterattack S5 based on the lightning strike point, with high pertinence. It has achieved significant results in application of wind farms[19-20].

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