Evaluation of wetland ecosystem services in green core of Changzhutan urban agglomeration, Hunan

Jia Luo 1,2, Xiaoling Zhou 1,2, Zhihao Zhang 3, Yuxin Tian 1,2, Xian Tang 4,*

1 Hunan Academy of Forestry, Changsha, Hunan 410004, China
2 Cili Forest Ecosystem Research Station, Cili, Hunan,410004, China
3 Changsha Environmental Protection College, Changsha, Hunan 410004, China
4 Sanya Academy of Forestry, Sanya, Hainan 572023, China

*Corresponding author e-mail: tangxian@sanyau.edu.cn

Abstract: Wetland in Changzhutan green core area of Hunan Province provides a number of ecosystem services for local urban construction and economic development. The evaluation of wetland ecosystem services may provide the wetland value data for the construction of Changzhutan urban agglomeration, and provide the basis for the creation of ecological compensation for wetland ecological protection. In this study, 8 service functions: water conservation, pollution degradation, carbon fixation & oxygen release, soil fixation & fertilizer preservation, nutrient accumulation, microclimate improvement, habitat provision provision, and scientific research & culture recreation were selected to evaluate the ecological service functions of wetlands in the green core area. The results showed that: (1) The total value of wetland ecological services in the green core area was 748 million yuan/a, among which the water conservation function was the dominant service function, with the highest value (319 million yuan), followed by the carbon fixation & oxygen release function and the pollution degradation function (156 million yuan and 125 million yuan, respectively). (2) From the perspective of the three prefecture-level cities, the total annual ecological value of Changsha wetland (353,007,600 yuan/a) was the highest, followed by Xiangtan (268,140,900 yuan/a), and Zhuzhou (126,749,900 yuan/a) was the lowest. (3) From the perspective of each district and county, both the total value and individual value of wetland service functions are the highest in Yuetang District, followed by Yuhua District and Tianxin District, and the lowest in Xiangtan County. The research results may provide a reference for the construction of wetland ecosystem service evaluation index system, strengthen the protection and utilization of wetland resources, and provide data support for the improvement of ecological civilization in Changzhutan urban agglomeration.

Keywords: Changzhutan green core area; Wetland ecosystem; Wetland services; Service Function evaluation.

1. Introduction

Ecosystem services refer to the ecological products necessary for human life and the ecological functions that ensure the quality of human life provided by ecosystems (Costanza, 1997). Since 1997, studies on...
ecosystem services evaluation have emerged (Dail, 1997; Millennium Ecosystem Assessment, 2005; Zhang et al., 2008). Wetlands, as a special ecosystem, have been gradually recognized by people for their unique environmental and social values. Evaluation of wetland ecosystem services has become the cross frontier field of wetland ecology and economics at home and abroad now. (European Environment Agency, 2010; Zhang et al., 2015; Jiang et al., 2015).

In recent years, with the rapid development of industry, agriculture and the accelerating of urbanization, the contradictions between wetland resources utilization and protection has intensified (Millennium Ecosystem Assessment, 2005; Zhang et al., 2008). The coordination between ecosystem security and economic development has become an important standard to measure regional health and sustainable development (Wang et al., 2011). The researches on ecosystem services in China were relatively late, but has developed rapidly in recent years. Evaluation methods of wetland ecosystem services experienced a development process from qualitative assessment of a function in the early stage to quantitative evaluation of multiple functions, and the latter (the value evaluation method of ecosystem services presented in the form of currency) is more popular because its results are easy to be incorporated into the national economic accounting system. At present, common evaluation methods include equivalent factor method, hypothesis evaluation method, travel cost method, market value method, carbon tax law, shadow engineering method and benefit transfer method, etc. (Zhang et al., 2019; Yang et al., 2018), diversified assessment methods. Domestic scholars have not only studied and explored the theories and methods of ecosystem service value assessment, but also started large-scale practice. In 1997, Cui and Song (1997) conducted a comprehensive evaluation and study on the value of wetlands in China. After that, domestic scholars have conducted a series of studies on evaluation of river and lake wetlands (Shao, 2008; Guo, 2019), coastal wetlands (Cheng et al., 2016), wetlands in arid and semi-arid areas (Li, 2017) and constructed wetlands (Li, 2020). The research areas were all over the country, especially in the eastern and southeastern regions. At present, the evaluation of wetland ecosystem service content mainly includes supply function, regulation function, cultural function and support function, etc. (Hao et al., 2017). These research results quantify the value of wetlands in the form of monetization, directly reflect the ecological function of wetlands, and provide a powerful theoretical reference for wetland managers, and aiming to quantify and correctly understand the value of wetlands, strengthen the development and utilization of wetland resources, and promote the orderly development of ecological economy.

Green core area is an ecological barrier, “two-oriented society” ecological service demonstration area and ecological civilization construction pilot area of Changzhutan urban agglomeration. The aim of construction of this region is to build an ecological urban agglomeration with overall improvement of ecological environment quality, safer ecological pattern, more complete ecological functions, more efficient ecological services, and harmonious coexistence between man and nature. As an ecological barrier of urban agglomeration, the wetland in the green core has certain ecological value, and it is of great significance in promoting ecological civilization construction, promoting urban-rural integration, driving industrial innovation and promoting rural revitalization. Therefore, the study of wetland service function assessment is an important part of study of the green core area value.

2. Survey of research site and research method

2.1. Research Site Overview

Ecological green core area is located in the intersection of Changsha, Zhuzhou and Xiangtan, reaching Changsha Raocheng expressway and Liuyang River in the north, Changtan expressway in the west, Zhentou Liuyang in the east and Yisuhe Xiangtan County in the south, with a total area of about 528.32 square kilometers. It covers 306.00 square kilometers of Changsha (57.92%); 83.87 square kilometers of Zhuzhou (15.87%) and 138.45 square kilometers of Xiangtan (26.21%). The wetlands in the green core area are mainly river-lake wetlands, including Xiangjiang River and its tributary Liuyang River, as well as Yunfeng Lake, Tongsheng Lake, Yangtian Lake, Shiyan Lake, Xianren Reservoir and other water bodies. The wetland area is large.
2.2. Evaluation Index System

On the basis of meeting the principle of being measurable, quantifiable and describable, through summarizing the work and research experience in recent years, and referring to the research of Wang Bing et al. (2020), this evaluation selects four categories of services: support service, regulation service, supply service and cultural service. The monitoring and evaluation index system mainly includes 8 functions: water conservation, pollution degradation, carbon fixation & oxygen release, soil fixation & fertilizer preservation, nutrient accumulation, microclimate improvement, habitat provision provision and scientific research & culture recreation.

2.3. Evaluation Formula

The calculation formula of wetland ecosystem services in this study is shown in Table 1.

| Service type              | Functional indicator                          | Calculation formula                                      | Parameter meaning                                                                 |
|---------------------------|-----------------------------------------------|----------------------------------------------------------|-----------------------------------------------------------------------------------|
| Regulating services       | Water conservation function                   | \( U_{bc} = C_u P + R_u K \)                              | \( U_{bc} \) = Water conservation value of wetland ecosystem (yuan/a)             |
|                           |                                               |                                                          | \( C_u \) = Total water resources of wetland ecosystem (m³)                       |
|                           |                                               |                                                          | \( P \) = Domestic water price (yuan/m³)                                        |
|                           |                                               |                                                          | \( R_u \) = Overland runoff volume (m³)                                         |
|                           |                                               |                                                          | \( K \) = Water purification costs (yuan/m³)                                    |
|                           | Pollution degradation                         | \( U_{cd} = C_{cd} AR \)                                 | \( U_{cd} \) = Pollution degradation value of wetland ecosystem (yuan/a)          |
|                           |                                               |                                                          | \( C_{cd} \) = Value of wetland degradation pollution per unit area              |
|                           |                                               |                                                          | \( A \) = Wetland area in green core area (ha)                                 |
|                           |                                               |                                                          | \( R \) = Exchange rate between USD and RMB                                      |
|                           | Carbon fixation & oxygen release              | \( U_{co} = [1.63 R_c (L + Q) C_c + 1.2 (L + Q) C_o] \times 2 \) | \( U_{co} \) = Value of carbon fixation & oxygen release (yuan/a)                |
|                           |                                               |                                                          | \( L \) = Phragmites communis yield (t/a)                                      |
|                           |                                               |                                                          | \( Q \) = Other aquatic plants yield (t/a)                                      |
|                           |                                               |                                                          | \( R_c \) = Carbon content in carbon dioxide (%)                               |
|                           |                                               |                                                          | \( C_c \) = Carbon fixation price (yuan/t)                                     |
|                           |                                               |                                                          | \( C_o \) = Oxygen price (yuan/t)                                             |
|                           | Microclimate improvement                      | \( U_{mi} = AP_1 \times 24 \)                            | \( U_{mi} \) = Improve microclimate value of wetland ecosystem (yuan/a)           |
|                           |                                               |                                                          | \( P_1 \) = Price of electricity (yuan/kw)                                     |
|                           |                                               |                                                          | \( A \) = Wetland area in green core area (ha)                                 |
| Support services          | Soil fixation and fertilizer preservation     | \( U_{sf} = 0.025 A CV_1 + 0.025 A (N + P + K) V_1 \)    | \( U_{sf} \) = Value of soil fixation and fertilizer preservation (yuan/a)       |
|                           |                                               |                                                          | \( N \) = Average percentage of nitrogen content of soil in green core area (%)|
|                           |                                               |                                                          | \( P \) = Average percentage of phosphorus content of soil in green core area (%)|
|                           |                                               |                                                          | \( K \) = Average percentage of potassium content of soil in green core area (%)|
|                           |                                               |                                                          | \( C \) = Average volume weight of soil in green core area (g/m³)               |
|                           |                                               |                                                          | \( V_1 \) = Cost of excavating and transporting earthwork per unit volume       |
|                           |                                               |                                                          | (yuan/m³)                                                                       |
|                           |                                               |                                                          | \( V_y \) = Fertilizer price (yuan/t)                                         |
|                           |                                               |                                                          | \( A \) = Wetland area in green core area (ha)                                 |
|                           | Nutrients accumulation                        | \( U_{na} = A(N + P + K) V_f/1000 \)                    | \( U_{na} \) = Nutrients accumulation value of wetland ecosystem (yuan/a)       |
|                           |                                               |                                                          | \( N \) = Average nitrogen content of soil in wetland ecosystem (kg/ha)         |
|                           |                                               |                                                          | \( P \) = Average phosphorus content of soil in wetland ecosystem (kg/ha)      |
|                           |                                               |                                                          | \( K \) = Average potassium content of soil in wetland ecosystem (kg/ha)       |
|                           |                                               |                                                          | \( V_f \) = Fertilizer price (yuan/t)                                         |
|                           |                                               |                                                          | \( A \) = Wetland area in green core area (ha)                                 |
| Supply service            | Habitat provision                             | \( U_{hp} = S_{hp} AR \)                                 | \( U_{hp} \) = Habitat provision value in wetland ecosystem (yuan/a)            |
|                           |                                               |                                                          | \( S_{hp} \) = Habitat value of per unit area wetland (Costanza, 1997) [USD/(ha/year)] |
|                           |                                               |                                                          | \( R \) = Exchange rate between USD and RMB                                     |
|                           |                                               |                                                          | \( A \) = Wetland area in green core area (ha)                                 |
| Cultural services         | Scientific research & cultural recreation     | \( U_{sc} = P_{sc} AR \)                                 | \( U_{sc} \) = Scientific research & cultural recreation value of wetland ecosystem (yuan/a) |
|                           |                                               |                                                          | \( P_{sc} \) = Research and cultural recreation value of per unit area wetland (Costanza, 1997) [USD/(ha/year)] |
|                           |                                               |                                                          | \( R \) = Exchange rate between USD and RMB                                     |
|                           |                                               |                                                          | \( A \) = Wetland area in green core area (ha)                                 |
2.4 The Data Source

The data of wetland area used are all from the "two-oriented society office" in the green core.

3. Results

3.1 Total value of wetland ecosystem services

As shown in Table 2, the total value of wetland ecological service functions is 748 million yuan/a. The rank order of 8 service functions was water conservation > carbon fixation & oxygen release > pollution degradation > habitat provision > scientific research & culture recreation > microclimate improvement > soil fixation & fertilizer preservation > nutrient accumulation. The wetland had the largest functional value of water conservation, accounting for 42.71%, indicating that the wetland ecosystem played an important role in maintaining water safety in the green core area; followed by carbon fixation, oxygen release and pollutant degradation, indicating that the wetland acted as "natural oxygen bar" and "sewage treatment plant".

| Service function          | Value (million yuan) | Proportion (%) |
|---------------------------|----------------------|----------------|
| Water conservation        | 319.69               | 42.71          |
| Pollution degradation     | 124.71               | 16.66          |
| Carbon fixation & oxygen release | 156.28       | 20.88          |
| Soil fixation & fertilizer preservation | 2.52        | 0.34           |
| Nutrient accumulation     | 2.50                 | 0.33           |
| Microclimate improvement  | 10.78                | 1.44           |
| Habitat provision         | 103.47               | 13.82          |
| Scientific research & culture recreation | 28.57        | 3.82           |
| Sum                       | 748.53               | 100.00         |

3.2 Evaluation results of wetland ecosystem services in cities, districts (counties)

As shown in Table 2 and Figure 1, from the perspective of the total annual ecological value of wetland, Changsha (353,007,600 yuan) > Xiangtan (268,140,900 yuan) > Zhuzhou (126,749,900 yuan), Changsha had the largest contribution to the value of wetland service functions. As shown in Figure 1, the rank order of 8 service functions’ value was Changsha > Xiangtan > Zhuzhou. The annual value of water conservation in wetland of cities ranged from 54.13 million yuan/a to 150.77 million yuan/a, which was the highest among the 8 ecological service functions. The value of carbon fixation & oxygen release ranged from 26.46 million yuan/a to 73.70 million yuan/a. The value of pollution degradation ranged from 21.12 million yuan/a to 58.82 million yuan/a. The value of soil fixation and fertilizer preservation ranged from 427,500 yuan/a to 1,190,400 yuan/a. The value of nutrient accumulation ranged from 423,100 to 1,178,300 yuan/a. The value of Microclimate improvement was in the range of 1825.70 ~ 5085.00 thousand yuan/a. Habitat provision was in the range of 17.52 ~ 48.80 million yuan/a. The value of scientific research & cultural recreation was in the range of 4.84 ~ 13.47 million yuan/a.
As shown in Table 1, the total value of wetland ecosystem service functions in prefecture-level cities was 747.90 million yuan/a, and Changsha was the largest one, which was 353.01 million yuan/a, accounting for 47.20%. The second was Xiangtan, the value was 268.14 million yuan/a, accounting for 35.85%, and Zhuzhou was the smallest with 126.75 million yuan/a, accounting for 16.95%. The rank order of total wetland service value of each district (county) was: Yuetang District > Yuhua District > Tianxin District > Yuhu District > Liuyang > Yuelu District > Xiangtan County. The wetland service functions value of Yuetang District was the highest with 168.95 million yuan/a, accounting for 27.20% of the total value. The second was the Yuhua District, the value of wetland service functions was 144.86 million yuan/a, accounting for 23.32%. Xiangtan County was the smallest (30.07 million yuan/a), accounting for 4.84%.

![Figure.1 Value of wetland service functions in cities of green core area](image)

As shown in Table 1, the total value of wetland ecosystem service functions in prefecture-level cities was 747.90 million yuan/a, and Changsha was the largest one, which was 353.01 million yuan/a, accounting for 47.20%. The second was Xiangtan, the value was 268.14 million yuan/a, accounting for 35.85%, and Zhuzhou was the smallest with 126.75 million yuan/a, accounting for 16.95%. The rank order of total wetland service value of each district (county) was: Yuetang District > Yuhua District > Tianxin District > Yuhu District > Liuyang > Yuelu District > Xiangtan County. The wetland service functions value of Yuetang District was the highest with 168.95 million yuan/a, accounting for 27.20% of the total value. The second was the Yuhua District, the value of wetland service functions was 144.86 million yuan/a, accounting for 23.32%. Xiangtan County was the smallest (30.07 million yuan/a), accounting for 4.84%.

**Table 3. Evaluation results of wetland ecosystem service functions value in each city**  
| Prefecture level city | District (county) | Water conservation | Pollution degradation | Carbon fixation & oxygen release | Soil fixation & fertilizer preservation | Nutrient accumulation | Microclimate improvement | Habitat provision | Scientific research & culture recreation | Sum |
|-----------------------|-------------------|--------------------|----------------------|-------------------------------|---------------------------------------|----------------------|-------------------------|-----------------|-----------------------------------------|-----|
| Changsha              | Tianxin District  | 4801.41            | 1873.08              | 2347.22                       | 37.91                                 | 57.53                | 164.94                  | 1553.96         | 429.03                                   | 11242.08 |
|                       | Yuhua District    | 6186.68            | 2413.50              | 3024.43                       | 48.85                                 | 48.35                | 208.66                  | 2002.31         | 552.82                                   | 14485.59 |
|                       | Yuelu District    | 1977.05            | 771.27               | 966.50                        | 15.61                                 | 15.45                | 66.68                   | 639.87          | 176.66                                   | 4629.09  |
|                       | Liuyang District  | 2111.54            | 823.74               | 1032.25                       | 16.67                                 | 16.50                | 71.22                   | 683.40          | 188.68                                   | 4944.00  |
|                       | Zhuzhou           | 15076.68           | 5881.59              | 7370.40                       | 119.04                                | 117.83               | 508.50                  | 4879.54         | 1347.19                                   | 53500.76 |
|                       | Zhuzhou City      | 5413.35            | 2111.81              | 2646.37                       | 42.75                                 | 42.31                | 182.57                  | 1752.02         | 483.71                                   | 12674.89 |
|                       | Proportion (%)     | 47.20              | 47.20                | 47.20                         | 47.20                                 | 47.20                | 47.20                   | 47.20            | 47.20                                    | 47.20    |
|                       | Xiangtan          | 5413.35            | 2111.81              | 2646.37                       | 42.75                                 | 42.31                | 182.57                  | 1752.02         | 483.71                                   | 12674.89 |
|                       | Xiangtan County   | 1284.41            | 501.06               | 627.90                        | 10.14                                 | 10.04                | 43.32                   | 415.70          | 114.77                                   | 3007.33  |
|                       | Xiangtan          | 7215.56            | 2814.77              | 3527.40                       | 56.98                                 | 56.39                | 243.36                  | 2335.30         | 644.75                                   | 16894.61 |
|                       | Proportion (%)     | 16.95              | 16.95                | 16.95                         | 16.95                                 | 16.95                | 16.95                   | 16.95            | 16.95                                    | 16.95    |
|                       | Yuhu District      | 2952.12            | 1151.66              | 1443.18                       | 23.31                                 | 23.07                | 99.57                   | 955.45          | 263.79                                   | 6912.15  |
|                       | Xiangtan County   | 1284.41            | 501.06               | 627.90                        | 10.14                                 | 10.04                | 43.32                   | 415.70          | 114.77                                   | 3007.33  |
|                       | Proportion (%)     | 35.85              | 35.85                | 35.85                         | 35.85                                 | 35.85                | 35.85                   | 35.85            | 35.85                                    | 35.85    |
|                       | Sum               | 31942.12           | 12460.99             | 15615.25                      | 252.22                                | 249.64               | 1077.32                 | 10383.01        | 2854.21                                   | 74789.74 |

Water conservation: as shown in Table 2, Yuetang District, Yuhua District and Tianxin District ranked the top 3 in terms of water conservation values with 72.16 million yuan/a, 61.87 million yuan/a and 48.01 million yuan/a, respectively, accounting for 68.62% of the total water conservation value of each district (county) in green core area. The value of wetland water conservation in Xiangtan County
was the smallest, which was 1.84 million yuan/a, accounting for 4.84% in the whole area. The rank order of wetland water conservation value by district (county) was: Yuetang District > Yuhua District > Tianxin District > Yuhu District > Liuyang City > Yuelu District > Xiangtan County.

Pollution degradation: wetlands are known as the "kidney of the earth", because of their efficient absorption of N, P, K and heavy metals and the effect of settling particulate matter. According to Table 2, the values of pollution degradation in Yuetang District, Yuhua District, Tianxin District and Yuhu District all exceeded 10 million yuan/a, which were 28.15 million yuan/a, 24.14 million yuan/a, 18.73 million yuan/a and 11.52 million yuan/a, respectively. The value of degraded pollutants in Yuelu District and Liuyang Wetland was in the range of 7.71 ~ 8.24 million yuan per year. The value of in Xiangtan County wetland was the lowest(5,010,600 yuan/a). The rank order of pollution degradation value in wetland in district (county) was: Yuetang District > Yuhua District > Tianxin District > Yuhu District > Liuyang City > Yuelu District > Xiangtan County.

Carbon fixation & oxygen release: wetland ecosystem is called "green carbon pool" because of its function of carbon sequestration and oxygen release. As is shown in Table 2, the annual carbon fixation & oxygen release values of Yuetang District, Yuhua District, Tianxin District, Yuhu District and Liuyang Wetland were all more than 10 million yuan, which are 35.27 million yuan/a, 30.2443 million yuan/a and 23.47 million yuan/a, respectively. Xiangtan County wetland carbon fixation & oxygen release value was the smallest, which was 6.28 million yuan/a. The rank order of carbon fixation and oxygen release value of each district (county) was: Yuetang District > Yuhua District > Tianxin District > Yuhu District > Liuyang City > Yuelu District > Xiangtan County.

Table 2 shows that the values of soil fixation & fertilizer conservation in Yuetang District, Yuhua District, Tianxin District and Yuhu District were more than 230,000 yuan/a, which were 569,800 yuan/a, 488,500 yuan/a, 379,100 yuan/a and 233,100 yuan/a, respectively. The value of soil fixation & fertilizer conservation of Yuelu District and Liuyang City wetland was between 156,100 yuan and 166,700 yuan per year. Xiangtan County wetland soil fixation & fertilizer preservation value was the smallest, which was 101,400 yuan/a. The order of the value of soil fixation & fertilizer preservation by each district (county) was: Yuetang District > Yuhua District > Tianxin District > Yuhu District > Liuyang City > Yuelu District > Xiangtan County.

Nutrients accumulation: Table 2 shows that the values of nutrients in Yuetang District, Yuhua District, Tianxin District and Yuhu District were more than 230,000 yuan, which were 563,900 yuan, 483,500 yuan, 375,300 yuan and 230,700 yuan per year, respectively. The value of nutrients accumulation of Yuelu District and Liuyang City wetland was in the range of 154,500~165,000 yuan per year. Xiangtan County wetland nutrients accumulation value was the smallest, which was 100,400 yuan/a. The order of accumulation value of wetland nutrients in each district (county) was: Yuetang District > Yuhua District > Tianxin District > Yuhu District > Liuyang City > Yuelu District > Xiangtan County.

Microclimate improvement: As is shown in Table 2, the value of wetland improvement of microclimate in Yuetang District, Yuhua District and Tianxin District were more than 1 million yuan, which were 2.43 million yuan, 2.69 million yuan and 1.62 million yuan per year, respectively. The value of wetland in Yuhu District, Liuyang City and Yuelu District in improving microclimate ranged from 666,800 yuan to 995,700 yuan per year. The value of microclimate improvement in Xiangtan County was the least, which was 433,200 yuan/a. The rank order of microclimate improvement value of each district (county) was: Yuetang District > Yuhua District > Tianxin District > Yuhu District > Liuyang City > Yuelu District > Xiangtan County.

Habitat provision: as shown in Table 2, the value of habitat provision by the wetland in Yuetang District and Yuhua District exceeded 20 million yuan, which were 23.35 million yuan and 2.02 million yuan/a respectively. The value of habitat provision by Tianxin District, Yuhu District, Liuyang City and Yuelu District ranged from 6.3987 million yuan to 15.5396 million yuan per year. The wetland in Xiangtan County provided the smallest amount of habitat value, which was 4.16 million yuan/a. The rank order of habitat provision value of each district (county) was: Yuetang District > Yuhua District > Tianxin District > Yuhu District > Liuyang City > Yuelu District > Xiangtan County.
Scientific research & cultural recreation: Table 2 shows that the values of scientific research & cultural recreation in Yuetang District and Yuhua District were more than 5.5 million yuan, which were 6.44 million yuan and 5.53 million yuan per year respectively. The value of wetland scientific research & cultural recreation in Tianxin District, Yuhu District, Liuyang City and Yuelu District were between 1.77 million yuan and 4.29 million yuan per year. The value of wetland scientific research & cultural recreation in Xiangtan County was the smallest, which was 1.15 million yuan/a. The rank order of wetland scientific research & cultural recreation value of each district (county) was: Yuetang District > Yuhua District > Tianxin District > Yuhu District > Liuyang City > Yuelu District > Xiangtan County.

4. Discussion
The total value of wetland service function in Changzhutan green core area was equal to 0.06% of the total GDP of Changsha in 2020. The evaluation results showed that the wetlands in the green core area have brought obvious ecological benefits to Changzhutan area, revealing the importance of protecting the wetlands in this area. The evaluation results may not only improve the ecological protection awareness of the public and management decision makers, but also provide a reference for the establishment of ecological compensation and other economic driving mechanisms. The evaluation parameters and methods may provide a basis for dynamic monitoring of wetland ecology in the green core area.

The evaluation results showed that the wetland in the green core area provided the highest proportion of value in water conservation, carbon fixation & oxygen release and pollution degradation, accounting for 85% of the total value of the wetland. Water conservation was dominated, it provides the economic value of up to 319 million yuan/a. Green core area wetlands in flood period can accumulate flood, ease the loss caused by flood, and reserve water during the dry season to provide water for production and living. It plays an important role in the supply and regulation of water resources, thus providing higher benefits for Changzhutan urban agglomeration. The value of the wetland providing carbon fixation and oxygen release function in this area is second only to the value of water conservation function, which reached 156 million yuan/a, indicating that the wetland and its affiliated products have produced great benefits in the process of absorbing CO2 and releasing O3, and the wetland in the green core area had made an important contribution to the optimization of atmospheric composition in this region. Secondly, wetland is known as “kidney of the earth”. Wetlands have high efficiency in absorbing organic pollutants and heavy metals, and have good water purification function (Xie, 2018), and can effectively reduce the pollutant concentration, especially for nitrogen, phosphorus and other nutrients and heavy metals in the water. Wetland can promote the degradation of particulate matter by slowing the flow down, which would conduce to toxic material removal from the water. This nature of wetland makes the investment of artificial degradation pollution decrease relatively and achieves economic benefits. As an ecological barrier for the Changzhutan area, green core area has the vast wetland, which is an important place for pollution settlement, has irreplaceable value to the environment and society of the region. Wetland can affect the microclimate. The water in the wetland evaporates into steam, and then drops to the surrounding areas in the form of precipitation, keeping the local humidity and rainfall, and affecting the local people's life and industrial and agricultural production. According to the measurement, 1 ha of wetland vegetation can absorb 81.8 MJ of heat from the environment in summer, which is equivalent to the refrigeration of 189 1 kW power air conditioners working all day. In the wetland ecosystem, the nutrients are mainly stored in the soil. In the geological cycle, the nutrients in the ecosystem are continuously leached downwards, while in the biological cycle, a series of essential nutrient elements are preserved and accumulated from the geological cycle. As the biological growth, prosperity and biomass accumulated ceaselessly, a lot of nutrition element in soil parent material was released for biological growth needs. Living things, therefore, is the dominant factor in soil formation and soil fertility. When a plant's life cycle is complete, a large amount of nutrients are transferred to other parts of the plant before leaves turns yellow and falls off, and some are returned to the soil through litter such as dead branches and leaves. Wetland is a complex ecosystem. Large areas of reed, marshes, tidal flats, rivers and lakes provide good habitats for wild animals and plants. The high heterogeneity of wetland
landscape provides a base for many wild animals and plants to inhabit and multiply, so wetland is of great importance in the protection of biodiversity. Green core area wetland ecology, biology, geography, hydrology, climatology and wetlands and birds research of natural background and base, as the foundation of many research provides the ideal place of scientific experiments. Wetland natural scenery is beautiful, and lots of birds and aquatic animals and plants live breeding grounds, will attract a large number of tourists to travel. However, green core area of wetland research & cultural recreation function value accounted for only 3.82%, to a certain extent, natural protection and social development is complementary, and pay more attention to the construction to ecological sustainability. But in recent years, green core area of wetland ecological effect of science, the research value and ecological culture tourism are gradually increasing.

In terms of the total annual ecological value of wetlands, Changsha was the highest, accounting for 47.20%, while Zhuzhou was the lowest, accounting for 16.95%. From the point of view of various functions, were also shown as: Changsha > Xiangtan > Zhuzhou. Because Changsha has the largest area of green core area, accounting for 57.92%, while Zhuzhou only accounts for 15.87%. The wetland area in Changsha is also relatively large, so it has more value. Yuetang District has the highest value of wetland ecological service functions, followed by Yuhua District and Tianxin District. Yuetang District belongs to Xiangtan and is located at the confluence of Xiangjiang River and Lianshui River in the northeast of the urban, and is rich in wetland resources. Yuhua District and Tianxin District are both part of Changsha, while Xiangtan County has the same area as Yuelu District, but smaller wetland area.

5. Conclusion
The total value of wetland ecological service function in green core area was 748 million yuan/a, among which the value of water conservation function was the highest, which was 319 million yuan, followed by the function of carbon fixation & oxygen release and pollution degradation (156 million yuan and 125 million yuan).

The total annual ecological value of Changsha wetland (353.01 million yuan/a) was higher than that of Xiangtan (268.14 million yuan/a), and the lowest value was that of Zhuzhou (126.75 yuan/a), which was the same result for the 8 service function values respectively.

From the perspective of each district and county, the total value of wetland service function and the value of each service function are the highest in Yuetang District, followed by Yuhua District and Tianxin District, and the lowest in Xiangtan County. The value of wetland service function in Yuetang District is 168.95 million yuan/a, while the value of wetland service function in Xiangtan County is only 30.07 million yuan/a.

Acknowledgments
This work was financially supported by Hunan forestry science and Technology Innovation Fund Project (XLK202103-1, HNGYL-2020-1), Forestry Science and Technology Plan Project in Hunan (Construction and monitoring of large sample plot of natural forest), Natural Science Foundation of Hunan Province(2019JU70012), National Science and Technology Plan for Twelfth Five-Year in the Countryside(2015BAD07B04), National Key R & D Program of China (2017YFC0505506).

References
[1] Costanza R, d’Arge R, de Groot R, et al. The value of the world’s ecosystem services and natural capital [J]. Nature, 1997,387:253-260.
[2] Daily G C. Nature’s Services: Societal Dependence on Natural Ecosystems [M]. Washington DC: Island Press, 1997.
[3] Millennium Ecosystem Assessment (MEA). 2005. Ecosystems and Human Well-Being: Wetlands and Water Synthesis [M]. Washington, DC: Island Press.
[4] Zhang H., Wu J, Sun C Z. Evaluation on wetland ecosystem service in Liaoning[J].Resources Science,2008, 30(2):267-272.
[5] Zhang H, Wu J, Sun C X. Evaluation of wetland ecosystem service value in Liaoning Province.
[6] Jiang B, Zhang L, Ouyang Z Y. Ecosystem services valuation of Qinghai Lake[J]. Chinese Journal of Applied Ecology, 26(10): 3137-3144.

[7] European Environment Agency (EEA). 2010. Scaling up ecosystem benefits- A contribution to the economics of ecosystems and biodiversity (TEEB) study//European Environment Agency Report No 4/2010, Kongeriget Danmark: EEA, 2010.

[8] Wang Z B, Fang C L, Wang J. Evaluation on the coordination of ecological and economic systems and associated spatial evolution patterns in the rapid urbanized Yangtze delta region since 1991[J]. Acta Geographica Sinica, 66(12):1657-1668.

[9] Zhang Y R, Zhou D M, Liu M. Ecosystem service valuation research of Chinese inland wetlands based on case study[J]. Acta Ecologica Sinica, 2015, 35(13):4279-4286.

[10] Cheng M, Zhang L Y, Cui L J, et al. Progress in ecosystem services value valuation of coastal wetlands[J]. Acta Ecologica Sinica, 2016,36(23):7509-7518.

[11] Cui L J, Song Y X. Study on social and economic evaluation index system of Wetland [J]. Scientia Geographica Sinica, 1997, 17(Supp): 446—450.

[12] Shao N P, Liu X P, Qu X Y. Valuation of lake wetland ecosystem services of Yinchuan City[J]. Chinese Journal of Ecology, 2008(09):1625-1630.

[13] Guo Y H, Zhou Y D, Liu W B, et al. Evaluation on the ecosystem services values of urban river wetlands in the city of Haikou[J]. Journal of Green Science and Technology, 2019(12):22-26.

[14] Li X, Ye Y H, Fu L. Valuation of wetland ecosystem services in Arid and Semi-arid Area——a case study in Etuokeqianqi[J]. China Forestry Economics, 2017(4): 11-15.

[15] Li X D. Ecosystem service evaluation of constructed wetland based on AHP—taking Yong Wen River wetland as an example[J]. Journal of Agricultural Catastrophyology, 2020, 10(9): 128-129.

[16] Hao Y J, Bai X, Zhang J A, et al. Value Assessment of Wetland Ecosystem Service in Beidaihe District[J]. Journal of North University of China(Natural Science Edition), 2017,38(4):487-492.

[17] Zhang S F, Zhang J L, Cheng L L, et al. Protection of protective development: A case study of assessing the net ecosystem service value of Xixi national wetland park in Hangzhou[J]. Modern Urban Research,2019(10):75-83.

[18] Yang R, Wu X H, Yang H W, et al. Ecosystem service valuation of the Yellow River wetland in Baotou[J]. Journal of Inner Mongolia Forestry Science and Technology, 2018, 44(4):43-49.

[19] Xie H Y, Guo C X. Evaluation of Haizhu wetland ecosystem service value in Guangzhou[J]. Tropical Geomorphology, 2018,39(1):26-33.

[20] Wang B, Chi G D, Dong Z S, et al. Evaluation of forest, wetland and grassland ecosystem service in Liaoning Province [M].Beijing: China Forestry Publishing House,2020.