Quantitative Evaluation of Plant Priority Protection in Liangzi Lake Wetland Nature Reserve

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Abstract. Based on the field survey data and relevant literatures, the evaluation index system of plant priority protection, which consists of threatened coefficient, genetic coefficient and species coefficient was established. Quantitative study and comprehensive evaluation of plant resources in Liangzi Lake Nature Reserve were carried out, and protection levels were classified. The results showed that there were 254 plant species in nature reserve, including 18 endangered species, 46 vulnerable species, 76 lower risk species and 114 safety species. The coefficients of threatened, genetic and species were analyzed and calculated by the indexes and proportion weights. The priority protection order of plants was determined, including 12 species of the first class conservation, 18 species of the second class conservation, 33 species of the third class conservation and 191 species of the delayed conservation. The corresponding protection suggestions were put forward. The purpose is to provide theoretical guidance for plant protection work and to help protect biodiversity of Liangzi Lake Nature Reserve.

1 Preface

With the rapid increase of modern population and the rapid development of global economy, the increasing of people's demand for nature is out of control. The earth's resources and environment are deteriorating. Species and biodiversity are sharply decreasing. In the face of the disappearance of these biological species, the efforts of the human society seem insignificant. The endangered species were analyzed and evaluated to determine the priority protection level. Only in this way, can we put forward scientific and reasonable suggestions for protection and utilization.

The world's first convention on the protection of wild fauna and flora was born in 1993. People's awareness of protection on nature, ecology and rare species has been awakened. Various natural environment related agencies followed. Such as IUCN, TNC, WWF, GEF, etc. In 1980s, China joined the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). In May 1987, China's first document on natural resources and natural environment protection, China's Natural Protection Measures, was officially published. In the following years, the List of Rare and Endangered Plants in China, the List of Endangered Plants in China and the Red Book of Chinese Plants were published, which laid the foundation for the protection of rare and endangered plants in China. In recent years, more and more experts and scholars have done a lot of work on the quantitative study of plant priority protection [1-4].

Liangzi Lake Wetland Nature Reserve is located at the junction of Wuhan and Ezhou in Hubei province, belonging to the provincial nature reserve. In recent years, many scholars had studied wild animal and plant resources, biodiversity information system, ecosystem services and other aspects of the nature reserve [5-8], but lack of quantitative research on plant priority protection. From April to October 2017, the research team visited the Liangzi Lake Wetland Nature Reserve many times to investigate the plant resources. And the assessment system of plant priority protection was also established. For the first time, a quantitative evaluation of plant priority protection in protected areas was conducted. It had made up for the blank of research in this area. The purpose is to provide theoretical guidance for plant protection work and clarify the problems in the current work of Liangzi Lake Wetland Nature Reserve.

2 Research area and method

2.1 General situation of research area

Liangzi Lake Wetland Nature Reserve is located in the south bank of the middle reaches of the Yangtze River, with a total area of 37946.3 hectares, ranging from 114°31′19″~114°42′52″E and 30°04′55″~ 30°20′26″N. The core area is 4000 hectares, the buffer area is 12438 hectares, and the experimentation area is 21508.3 hectares. It consists Liangzi Lake, Yaer Lake, Sanshan Lake and Baoan Lake. The total rainfall area is 3265 square kilometres. The climate of the protected area is a subtropical humid monsoon climate zone. The monsoon climate is obvious. The rainfall is abundant. The frost free period is long. The average annual temperature is 17℃ [9-10].

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2.2 Field investigation method

From April to October, 2017, the plant resources in the nature reserve were investigated by means of route survey and typical sample-plot survey. The survey line was all over the entire protected area. The main survey sites were Wangdiancun, Chenmujiang, Liujiabao, Xinguohuang, Zhongxiaowan, Dashanchen, Dingluo, Dongbianfang, Qiaotouxu, Xiaoxu, Dajiang, Kuangshuai, Xiamincun, Zhangjiacun and other places. According to the geographical conditions of protected areas and the distribution of vegetation, 4 sample areas were set up. Each sample area was equipped with 6~10 plots. There were 32 sample plots. Each sample plot was randomly allocated to 3~5 quadrats. There were 143 quadrats. Each sample plot recorded the plant species name, longitude and latitude, altitude, soil condition and human disturbance. Each quadrat recorded the coverage of herbage layer, height and coverage of shrub layer, tree per tree scale, canopy density and other characteristics.

2.3 Priority protection evaluation system

The quantitative evaluation system of plant priority in Liangzi Lake Wetland Nature Reserve was constructed from three aspects: threatened coefficient, genetic coefficient and species coefficient.

2.3.1 Threatened coefficient

Threatened coefficient refers to the degree of endangerment of a plant under natural distribution. Quantitative evaluation is made according to the frequency distribution in China, Hubei and sample plot (Table 1).

Table 1. Index of plant threatened coefficient

Index subdivision	Qualitative description	Score
Frequency distribution in China (FC)	1 province	5
	2 to 3 provinces	4
	4 to 6 provinces	3
	7 to 10provinces	2
	≥11 provinces	1
Frequency distribution in Hubei (FH)	1 county	5
	2~3 counties	4
	4~6 counties	3
	7~10 counties	2
	≥11 counties	1
Frequency distribution in sample plot (FS)	1 plot	5
	2 to 3 plots	4
	4 to 7 plots	3
	8 to 15 plots	2
	≥16 plots	1

The above indexes were used to grade the plants in nature reserve. The threatened coefficient (Ct) of plant species was calculated by the equation (1). According to the calculated values, the plant threatened grading was classified (Table 2).

$$Ct = \sum_{i=1}^{3} X_i / \sum_{i=1}^{3} X_{i\max} \quad (1)$$

In the equation, X_i is the actual score of index i, and X_{imax} is the highest score of index i, (i = 1, 2, 3).

Table 2. Standards of plant threatened grading

Score of threatened coefficient	Threatened grading
Ct ≥ 0.8	endangered species
0.6 < Ct < 0.8	vulnerable species
0.5 < Ct ≤ 0.6	lower risk species
Ct ≤ 0.5	safety species

2.3.2 Genetic coefficient

The genetic coefficient refers to the potential genetic value of plants. The quantitative evaluation was made according to the species type and endemic distribution (Table 3).

Table 3. Index of plant genetic coefficient

Index subdivision	Qualitative description	Score
Species type (ST)	only 1 species in family	5
	2 to 3 species in family	4
	only 1 species in genus	3
	2 to 3 species in genus	2
	≥ 4 species in genus	1
Endemic distribution (ED)	only in here	5
	only in Hubei	4
	in region specific	3
	only in China	2
	in China and other countries	1

The above indexes were used to grade the plants in nature reserve. The genetic coefficient (Cg) of plant species was calculated by the equation (2).

$$Cg = \sum_{i=1}^{2} X_i / \sum_{i=1}^{2} X_{i\max} \quad (2)$$

In the equation, X_i is the actual score of index i, and X_{imax} is the highest score of index i, (i = 1, 2).

2.3.3 Species coefficient

The species coefficient refers to the size of plants in terms of economy, society, ecology and scientific research value. Quantitative evaluation is made according to the ecological value, medicinal value and other values (Table 4).

Table 4. Index of plant species coefficient

Index subdivision	Qualitative description	Score
Ecological value (EV)	Edificators	5
	Co-species of a community	4
	Dominant species other than edificators	3
	Subdominant	2
	Others	1
Medicinal value (MV)	Included in the Chinese Pharmacopoeia	4
	Included in the New Chinese Medicine Chronicles	3
	General folk medicinal plants	2
	Others	1
Other values: Ornamental, timber, food, feed, industrial raw materials, etc. (OV)	Having 3 kinds and above	4
	Having 2 kinds	3
	Having only 1 kind	2
	None	1

The above indexes were used to grade the plants in nature reserve. The species coefficient (Cs) of plant species was calculated by the equation (3).

$$Cs = \sum_{i=1}^{3} X_i / \sum_{i=1}^{3} X_{i\max} \quad (3)$$

In the equation, X_i is the actual score of index i, and X_{imax} is the highest score of index i, (i = 1, 2, 3).

2.3.4 Priority protection grading

According to the actual situation and relevant research literature of Liangzi Lake Wetland Reserve, the weights of threatened coefficient (Ct), genetic coefficient (Cg) and species coefficient (Cs) were set [11-13]. The synthetic value (Vs) of plant species was calculated by the equation (4).

$$Vs = Ct \times 60\% + Cg \times 20\% + Cs \times 20\% \quad (4)$$

According to the score of synthetic value (Vs), the standards of plant priority protection grading were developed (Table 5).

Table 5. Standards of plant priority protection grading

Score of synthetic value	Protection grading
Vs ⩾ 0.6000	The first class conservation
0.5500 ⩽ Vs < 0.6000	The second class conservation
0.5000 ⩽ Vs < 0.5500	The third class conservation
Vs < 0.5000	The delayed conservation

3 Results and analysis

According to the results of field investigation, 254 species of plants belonging to 64 families and 189 genera were recorded in 32 sample plots of Liangzi Lake Wetland Nature Reserve. Herbaceous plants were the dominant species, and dicotyledonous plants accounted for a large proportion. Shrubs and trees were relatively scarce.

3.1 Threatened coefficient evaluation

According to the index of plant threatened coefficient, the plant species of nature reserve were quantitatively evaluated. Combined with the standards of plant threatened grading, the threatened situation of plants in nature reserve was obtained.

Most of the plants with high threatened coefficient in the reserve were less distributed throughout the country. They existed only in some provinces in China. There were also a small number of plants which were widely distributed in China, but rare in Hubei, with low frequency in the sample plots (Tables 6).

There were 18 endangered species in reserve, accounting for 7.09% of the total (Table 7). Each of endangered species of distribution was scattered and the number of individuals was scarce. There were 46 vulnerable species in reserce, accounting for 18.11% of the total. Each of vulnerable species of distribution range was small, and the growth environment was special, and the number of individuals was small. There were 76 lower risk species, accounting for 29.92% of the total. Each of lower risk species of distribution was scattered or banded, but the number of individuals was large. There were 114 safety species, accounting for 44.88% of the total. Timely monitoring and protection of the endangered species and vulnerable species, so that their survival environment and population can be more stable.

Table 6. Evaluation of plant threatened coefficient*

Latin name of species	FC	FH	FS	Ct
Carex unisexualis	4	5	5	0.9333
Wisteria villosa	3	5	5	0.8667
Phragmites karka	3	5	5	0.8667
Alnus cremastogyne	3	5	5	0.8667
Cyperus haspan	3	5	5	0.8667
Ipomoea cairica	3	5	5	0.8667
Ipomoea triloba	4	5	4	0.8667
Ajuga ciliata	2	5	5	0.8
Medicago minima	3	4	5	0.8
Triarrhena sacchariflora	2	5	5	0.8
Elymus dahuricus	2	5	5	0.8
Viola patrinii	3	4	5	0.8
Sonchus brachyotus	2	5	5	0.8
Sonchus asper	2	5	5	0.8
Chenopodium ambrosioides	2	5	5	0.8
Stauntonia chinensis	2	5	5	0.8
Parthenocissus quinquefolia	2	5	5	0.8
Physalis peruviana	4	5	3	0.8

*Ct ⩾ 0.8 are listed.

Table 7. Evaluation of plant threatened grading

Threatened grading	Number of species
Endangered species	18
Vulnerable species	46
Lower risk species	76
Safety species	114

3.2 Genetic coefficient evaluation

According to the index of plant genetic coefficient, the plant species of nature reserve were quantitatively evaluated. There were 22 plant species of genetic coefficient score above 0.4 in the reserve (Table 8). Among them, *houttuynia cordata* is the highest (Cg = 0.5). There were no old relic plants in the reserve, so that the scores were not high.

Table 8. Evaluation of plant genetic coefficient*

Latin name of species	ST	ED	Cg
Houttuynia cordata	4	1	0.5
Poncirus trifoliata	2	2	0.4
Phyla nodiflora	3	1	0.4
Eichhornia crassipes	3	1	0.4
Pueraria lobata	3	1	0.4
Cardiospermum halicacabum	3	1	0.4
Lagedium sibiricum	3	1	0.4
Pericampylus glaucus	3	1	0.4
Orychophragmus violaceus	3	1	0.4
Semiaquilegia adoxoides	3	1	0.4
Synurus deltoides	3	1	0.4
Hemistepta lyrata	3	1	0.4
Aeschynomene indica	3	1	0.4
Nelumbo nucifera	3	1	0.4
Melochia corchorifolia	3	1	0.4

Perilla frutescens	3	1	0.4
Arachis hypogaea	3	1	0.4
Foeniculum vulgare	3	1	0.4
Wahlenbergia marginata	3	1	0.4
Capsella bursa-pastoris	3	1	0.4
Verbena officinalis	3	1	0.4
Eclipta prostrata	3	1	0.4

*Cg ⩾ 0.4 are listed.

3.3 Species coefficient evaluation

According to the index of plant species coefficient, the plant species of nature reserve were quantitatively evaluated. There were 17 plant species of species coefficient score above 0.6 in the reserve (Table 9). Some were important species or dominant species in the reserve, such as *cynodon dactylon, broussonetia papyrifera, melia azedarach,* etc. There were also some traditional Chinese medicines and widely used plants, such as *eclipta prostrata*, *cyperus rotundus, morus alba,* etc.

Table 9. Evaluation of plant species coefficient*

Latin name of species	EV	MV	OV	Cs
Morus alba	3	3	4	0.7692
Cynodon dactylon	5	2	3	0.7692
Broussonetia papyrifera	5	3	2	0.7692
Eclipta prostrata	4	4	1	0.6923
Kummerowia striata	5	2	2	0.6923
Glycine soja	3	2	4	0.6923
Rubus coreanus	3	4	2	0.6923
Nelumbo nucifera	1	4	3	0.6154
Perilla frutescens	1	4	3	0.6154
Daucus carota	4	3	1	0.6154
Cocculus orbiculatus	2	4	2	0.6154
Xanthium sibiricum	2	3	3	0.6154
Melia azedarach	4	1	3	0.6154
Scirpus yagara	1	4	3	0.6154
Sophora japonica	1	3	4	0.6154
Cyperus rotundus	2	4	2	0.6154
Solanum nigrum	3	4	1	0.6154

*Cs ⩾ 0.6 are listed.

3.4 Priority protection evaluation

According to the priority protection evaluation system, the plant synthetic value of reserve was quantitatively evaluated. There were 12 plant species of synthetic value score above 0.6 in the reserve (Table 10).

Table 10. Evaluation of plant synthetic value *

Latin name of species	Ct	Cg	Cs	Vs
Carex unisexualis	0.9333	0.3	0.2308	0.6662
Wisteria villosa	0.8667	0.3	0.3077	0.6415
Alnus cremastogyne	0.8667	0.3	0.3077	0.6415
Ipomoea cairica	0.8667	0.2	0.3846	0.6369
Phragmites karka	0.8667	0.3	0.2308	0.6262
Poncirus trifoliata	0.7333	0.4	0.4615	0.6123
Chenopodium ambrosioides	0.8	0.2	0.4615	0.6123
Arundo donax	0.7333	0.3	0.5385	0.6077
Cyperus haspan	0.8667	0.2	0.2308	0.6062
Ipomoea triloba	0.8667	0.2	0.2308	0.6062
Ajuga ciliata	0.8	0.3	0.3077	0.6015
Stauntonia chinensis	0.8	0.3	0.3077	0.6015

*Vs ⩾ 0.6 are listed.

Among them, *Carex unisexualis* is the highest (Vs=0.6662). Plants with high threatened coefficient generally have higher synthetic value, such as *Alnus cremastogyne, Ipomoea cairica, Wisteria villosa,* etc. Although the weight ratio of genetic coefficient and species coefficient is not high, it also plays a key role in plant evaluation system. For example, *Semiaquilegia adoxoides* and *Aeschynomene indica* had high genetic coefficient, *Lysimachia christinae, Vicia hirsute* and *Pueraria lobate* had high species coefficient, their threatened coefficients were not high, but their synthetic values were also above 0.5.

Combined with the standards of plant priority protection grading, the plant priority protection grading in nature reserve was obtained (Table 11). There were 63 plant species of synthetic value score above 0.5 in the reserve.

Table 11. Evaluation of plant priority protection grading

Protection grading	Number of species
The first class conservation	12
The second class conservation	18
The third class conservation	33
The delayed conservation	191

There were 12 plants of the first class conservation in reserve, accounting for 4.72% of the total. In the reserve, their quantity was scarce, and the anti-interference ability was weak. Therefore, they were urgent to strengthen the number of stable population. There were 18 plants of the second class conservation in reserve, accounting for 7.09% of the total. It is necessary to monitor the population status in time, maintain and feel the living environment of the population, and prevent the occurrence of extremely small population. There were 33 plants of the third class conservation in reserve, accounting for 12.99% of the total. Most of them were dominant or sub-dominant species in the reserve, which can be reasonably utilized without special protection measures to maintain a stable population. There were 191 plants of the delayed conservation in reserve, accounting for 75.20% of the total. Most of them were constructive species in reserve, and the self-recovery ability of the population was stronger after being disturbed.

4 Conclusion and discussion

Through the quantitative evaluation of the plant priority protection in Liangzi Lake Wetland Nature Reserve, the following conclusions were drawn. Of the 254 species investigated in Liangzi Lake Wetland Nature Reserve, 18 plants were endangered, 46 were vulnerable, 76 were lower risk and 114 were safety. There were 12 species of the first class conservation, 18 species of the second class conservation, 33 species of the third class conservation and 191 species of the delayed conservation. Compared with the national list of endangered plants, the priority of conservation determined according to local conditions is more

conducive to the establishment of more targeted conservation plans in the nature reserves.

The protection of plants depends on the overall natural environment and reasonable human intervention. Corresponding protection measures should be taken according to different plant protection levels.

For the first class conservation plants, artificial reproduction can be adopted to increase the population to ensure safe survival in reserve. They should be monitored plant population ecology in real time to find problems and solve problems. For the second class conservation plants, human destruction should be avoided. In general, no special protection measures are needed for them. In the case of continuous population decline, timely measures should be taken. For the third class conservation plants, the development and utilization can be carried out in the reserve. Attention should be paid to preventing the irreversible consequences of over exploitation. We should strengthen management and strictly control the intensity of development so as to maintain a relatively stable population level. For the delayed conservation plants, there was no need to pay too much attention.

The rationality of plant protection grading is the premise of effective plant protection. Different regions should adjust measures to local conditions. According to the actual situation, a reasonable local plant protection grade evaluation index should be worked out. Regional plant protection is an important basis for plant protection of China. The priority of regional plant protection must be combined with national endangered plant protection. Only in this way, can we improve the efficiency of plant protection more comprehensively, and protect the biodiversity of China effectively.

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References

1. Q. Q. Peng, Z. X. Wang, Y. Tang, Y. Chen, X. Han, FRM, 2, 143-150 (2017)
2. E. Zhang, Z.X.Wang, Z. Li, K. Tian, JWFS, **44**, 6, 100-105 (2015)
3. Y. J. He, G. F. Cui, Z.W. Feng, J. Zheng, J. S. Dong, Y. B. Li, CJAE, 8,1307-1312 (2004)
4. S. Jin, T. H. Hu, C. L. Zhao, D. Y. Lin, Z. G. Li, G.F. Cui, JBFU, **32**,2,113-117 (2010)
5. J. W. Ge, Q. H. Cai, H. X. Hu, J. K. Liu, G. B. Cao, Z. Q. Zhu, S. X. Liu, D. L. Shi, JNR, 3, 285-292 (2004)
6. J. W. Ge, Q. H. Cai, J. K. Liu, S. X. Liu, Y. H. Pu, W. J. Mei, CES, 5, 4-9 (2003)
7. Y. X. Peng, H. Liu, H. F. Xiong, WS, **9**, 4, 382-386 (2011)
8. C. F. Xie, T. Shu, Y. Liu, W. B. Ren, J. H. Jiang, S. Yang, REYB, **24**, 8, 1387-1394 (2015)
9. Y. Qin, Y. Q. Li, L. X. Wu, H. B. Chen, Z. H. Li, Y. X. Huang, JLS, **28**, 5, 994-1003 (2016)
10. S. Q. Zhang, L. Y. Kong, X. W. Deng, Z. X. Wang, H. B. Li, Z. Q. Li, ASC, **37**, 9, 3613-3620 (2017)
11. R. B. Chen, G. F. Zhang, J. Liu, S. Li, JERE, **31**, 2, 174-179 (2015)
12. Q. Q. Peng, Z. X. Wang, T. T. Li, B. M. Xiong, Q. C. Yang, GUI, **37**, 7, 859-867 (2017)
13. G. F. Cui, K. W. Cheng, D. Z. Lu, J. Z. Wang, J. Q. Li, JBFU, 4, 8-13 (2000)