Measurement of Protection Equality for Wetland Park in Pearl River Delta

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Abstract: Protection equality metric was applied to measure the ecological representation of wetland parks at both time scale and city scale in the Pearl River Delta region, China. Results show that at time scale, the protection equality values were relatively low, but it displayed a trend of increased values during 2012-2015. At city scale, fine cities had high protection equality values with more than 0.5, the other four cities were less than 0.4. Protection equality metric revealed different results of ecological representation of wetland parks at different scales, which will be of important significance for conservation strategies making of wetland habitat in the process of establishing wetland protected area network for decision makers.

1. Introduction

Wetlands are a valuable natural resource in need of increased protection or restoration, especially in the face of current and future global change. With their fragility and sensitivity to hydrologic shifts and land-use changes, wetlands are among the most vulnerable of such ecosystems. Wetlands in China are facing with area shrinking, habitat degradation and fragmentation, biodiversity reduction and other issues. Protected areas are one of the cornerstones for conserving the world's remaining biodiversity and an important tool to maintain the integrity of wetland habitat and species diversity. Due to the conservation and management efforts on wetlands, the wetland protected areas system has been established in China. Wetland Park as one of wetland protected areas has played an important role in protecting wetland habitat. However, although thousands of wetland parks have been established, then it is still unclear whether the current wetland protection network can ensure effective conservation of wetland biodiversity.

Margules et al realized that conservation goals require strategies for managing whole landscapes, but the practice of conservation planning has generally not been systematic and new reserves have often been located in places that do not contribute to the representation of biodiversity. Convention on Biological Diversity (CBD) not only aims to achieve the targeted percentage of protected areas, but also emphasizes on the requirements of ecological representation, effectiveness and connectivity. Ecological representation is a pivotal component of systematic conservation planning. How to measure the representation put forward by Aichi target 11 has been a problem due to a lack of sufficient indicators. While at present, there is no clear definition of what desirable ecological representation looks like, or guidelines of how to standardize its assessment as the protected area estate grows. Barr et al identified that current reporting metrics of the total area protected did not account for the bias toward areas that are unattractive for other human uses, then they proposed protection equality (PE) metric from the Gini coefficient to evaluate the distribution of protected areas and to quantify the ecological representation of a protected areas network. Base on this, Chauvenet et al presented a refined measure of PE metric and proposed to measure ecological representation in protected area networks using PE metric. Now the PE metric has been applied to evaluate the representation of many ecological features including protected areas or protected areas network, biodiversity, ecoregions and habitats.

Pearl River Delta region is located on the migratory routes of migratory birds in northeast Asia and is an ideal habitat for fish, waterfowl and other wildlife. Till to 2015, the number of WPs established in Pearl River Delta region was 68. With a sharp increase number of wetland parks, especially during 2013-2015, requirements that more than one state-level and two province-level wetland parks are required to be established in the prefecture-level city were made by Guangdong

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province. Is it scientific or sufficient to protect the wetland habitat? To what degree the ecological representation of wetland parks has achieved? The measurements of ecological representation and protection equality of wetland parks in Pearl River Delta region are of important significance for the construct of wetland conservation network.

2. Methods

2.1 Study region

Pearl River Delta region is located in the middle south of Guangdong province, and belongs to the lower part of Pearl River in China, including 9 cities, such as Dongguan, Foshan, Guangzhou, Huizhou, Jiangmen, Shenzhen, Shiuhing, Zhongshan, and Zhuhai. Meanwhile, it is located on the migratory routes of migratory birds in northeast Asia and is an ideal habitat for fish, waterfowl and other wildlife. In the light of great importance attached by Guangdong province to the ecological construction of the Pearl River Delta region, the nine cities are focusing on establishing the wetland parks. Till to 2015, 68 wetland parks have been established, including state-level, province-level, city-level and county-level. In order to give full efficacy of wetland in Pearl River Delta region, Guangdong province put forward a systematic planning in 2015 for the nine cities included in Pearl River Delta region which are required to build more than one state-level wetland parks and more than two province-level wetland parks. At present study, the list of 68 wetland parks was compiled and the area of each wetland park was collected.

2.2 Protection Equality

Due to that as the most common used reporting index, the percentage of a particular protected area concealed the deficiency of the protection of unprotected biodiversity, Barr et al proposed proportional PE metric to measure the world's protected area coverage in 2011. Then Chauvenet et al extended their work and proposed the fixed area PE to calculate PE and introduced a correction factor for PE. At present study, in light of the big difference between the area of wetland park and the area of the city, fixed area PE was chosen to calculate the PE.

2.2.1 Mathematical formulation

According to the theoretical principle of Gini coefficient, . And the mathematical formulation of PE metric is as follows. Chauvenet et al illustrated the calculation of protection equality (Fig. 1).

Where N is the number of wetland parks, and is the area of wetland park i (i=1,2,…N).

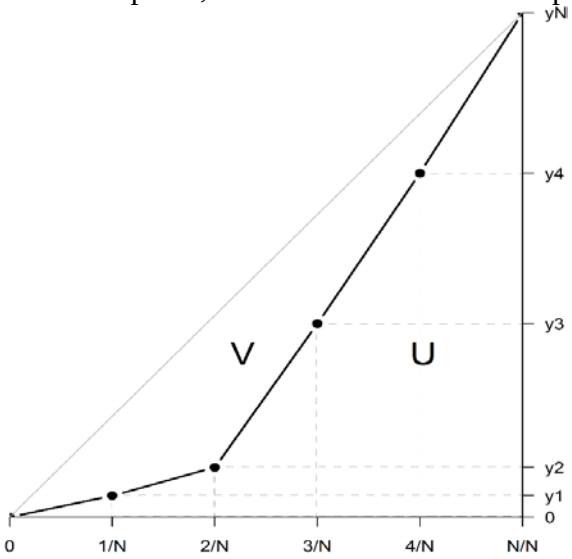

Fig.1 Illustration of how Protection Equality is calculated (Chauvenet et al, 2018)

Fixed area PE was applied to calculate the PE in this study. Then in combination with Fig.1, the calculation formulations of V and U are as follows.

And the sum of the areas of U and V is equal to the area of the triangle, so the calculation can be

carried out as follows.

2.2.2 Corrected protection equality metric

For the calculation of PE, as N increases, PE tends to be 0. In order to avoid the presence of this kind of problem, Chauvenet et al created a correction factor that can rescale the PE value between 0 and 1 when N is small. The calculation formulation is as follows.

3. Results and Discussion

3.1 Statistical characteristics of wetland parks

Till to 2015, 68 wetland parks had been established in the Pearl River Delta region. Figure 2 shows that from 2001 to 2012 there was a sTable development of wetland park, with one wetland park being established at one year. During these years, most of the wetland parks are the county-level. Then the development of wetland parks has entered a stage of rapid growth since 2013, among which national and provincial wetland parks have been established. Figure 3 shows that there are great differences in the number, level and areas of wetland parks established in different cities, and there is no obvious quantitative relationship between the number and areas of wetland parks, which cannot directly indicate the protected difference of wetlands among cities. In terms of quantity, Dongguan wetland park has the largest number and Jiangmen the smallest. In terms of areas, the area of wetland park has the largest total protected area in Guangzhou and Zhongshan the smallest.

3.2 Representation of the wetland park protection in the Pearl River Delta

At the spatial scale, the PE values for the wetland parks were relatively low. All of them were less than 0.4(Table 1), indicating unequal ecological representation of wetland parks. The very small value can be explained by the small amount of wetland parks established in 2012. But it is worth noting that there is also another very small value in 2013 with three times number of wetland parks as in 2012, which can be explained by the , ranged from 25 to 935.4ha. It is indicative of uneven distribution of wetland parks across the region. On the other hand, there is an obvious increase of values which indicate the improvement of ecological representation for the wetland park in the Pearl River Delta region during 2012-2015.

Table 1 Protection equality of wetland parks during 2012-2015

Year			Mean	Median	Min	Max	N
2012	0.046	0.031	55.675	52	28	90.7	4
2013	0.072	0.057	203.134	68.5	25	935.4	12
2014	0.188	0.175	186.497	80.35	5.8	935.4	30
2015	0.381	0.372	140.506	52.91	4	935.4	68

At the city scale, there is also an obvious difference of values among the nine cities (Table 2). values of fine cities are more than 0.5 and the other 4 cities are less than 0.4. The highest value is in Huizhou with the highest median value and the lowest in Dongguan with the largest number of wetland parks. This shows that the highest equal ecological representation of wetland parks is in Huizhou and the lowest in Dongguan. Guangzhou and Zhongshan had similar values in despite of having large difference in the number of wetland parks. This shows that cities with fewer wetland parks can score similar PE to those with more wetland parks. Similarly for Foshan and Shenzhen, which had similar values, the latter shows a much higher mean value than the former but they have the similar number of wetland parks. This implies that Foshan is doing good or Shenzhen is doing worse in terms of the total protected areas of wetland parks. Surprisingly, the value of Jiangmen was ranked in the number two, but with the lowest mean, median and max values, and the lowest number and areas of wetland parks which were much lower than that of Huizhou. This could be explained by a small variance in values. Indeed, the coefficient of variance (CV) of values is 0.581 for Jiangmen and is 0.34 for Huizhou, while for others, it is more than 0.7 and most is more than 1.

Table 2 Protection equality of wetland parks in the Pearl River Delta region

City			Mean	Median	Min	Max	Total	N
Dongguan	0.165	0.101	105.68	76.70	5.8	351.97	1479.57	14
Foshan	0.639	0.548	68.58	36.00	23.5	133.4	342.9	5
Guangzhou	0.272	0.206	130.08	18.93	9	869	1560.96	12
Huizhou	0.845	0.806	236.8	225.00	153	370	1184	5
Jiangmen	0.742	0.657	25.53	20.37	14.7	46.67	102.1	4
Shenzhen	0.592	0.523	197.26	128.74	38	440	1380.8	7
Shiuhing	0.398	0.248	307.85	30.70	24	935.4	1539.24	5
Zhongshan	0.237	0.110	103.643	21	4	625.6	725.5	7
Zhuhai	0.495	0.432	137.71	70	12	460	1239.35	9

Above all, the results indicate that there is a big difference of reporting metrics between the total protected areas and the protection equality. Protection equality metric can reveal the difference of ecological representation at both the time scale and the city scale. The values for wetland parks were relatively low during 2012-2015, indicating an unequal representation or not performing well in the protection equality of wetland habitat protection in the Pearl River Delta region. However, it was worth noticing that there was an increase of value along with the increased number of wetland parks. At the city scale, values of fine cities were more than 0.4, implying that an average level of protection equality occurs for the nine cities.

In order to make a further understanding of the relationship among PE metric and other statistics, Spearman correlation analysis was carried out at both the time scale and the city scale (Table 3). Results show that at the time scale, there was a significant correlation between PE values and the min values, total values and number of wetland parks, and at the city scale, there was a significant correlation between PE values and min values, CV and amount of wetland parks. In contrast, PE values at different scales reveal different performance of protection equality and are correlated with different variables with different degree of significance. Barr et al proposed that measures of protection equality are not used in isolation, but rather in combination with one of the existing protection metrics. For the conservation strategies of wetlands, it calls for decision makers to make overall consideration to implement the target-driven planning in the process of establishing the wetland protected areas network.

Table 3 Correlation analysis between PE values and other statistics

PE	Mean	Median	Min	Max	Total	CV	N
Time-scale	0.200	0.400	-1.000**	0.775	1.000**	0.800	1.000**
City-scale	0.932	0.283	0.783*	-0.500	0.433	-0.733*	-0.766*

Annotation: ** means a significant correlation occurs at the 0.01 level (Double-tailed).
* means a significant correlation occurs at the 0.05 level (Double-tailed).

4. Conclusion

Of the 68 wetland parks analyzed, at time scale, the protection equality values of wetland parks were relatively low, but there was an increase of protection equality values in the Pearl River Delta region during 2012-2015, indicating an unequal ecological representation of wetland habitat. And at city scale, Foshan, Huizhou, Jiangmen, Shenzhen and Zhuhai had protection equality with more than 0.5, indicating a good performance in protection equality of wetland habitat. While the other cities need to take efforts to improve the ecological representation of wetland habitat. Results revealed by protection equality metric are significantly different at different scales.

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