The Selection of Distance Threshold of Wetland Landscape Connectivity in Tianjin Binhai New Area

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Abstract. When applying the landscape connectivity method to study landscape pattern changes, choosing the appropriate distance threshold is the key. By using the Landsat 8-OLI remote sensing image interpretation data of wetland in Tianjin Binhai New Area in 2017, this paper aims to screen the most proper connection threshold of wetland landscape in the study area. Based on habitat availability, 11 distance thresholds (100, 200, 400, 600, 800, 1000, 1500, 2000, 3000, 5000, 8000m) were selected to compute the Number of Links (NL), Number of Components (NC), Equivalent Connectivity Area (ECA) and Landscape Coincidence Probability (LCP), and the computed values were used for analysing and screening the distance threshold. The results show that the suitable range of the distance threshold for the connectivity of wetland landscape in Tianjin Binhai New Area is 400-800m, of which 400m is the best value, and the research results can provide reference for the study of wetland landscape in this area.

1. Introduction
The effectiveness of the ecological restoration action on biodiversity conservation often depends on the limitation of restoring the landscape of the area, and the parameters related to landscape connectivity will affect the ecological restoration effect [1]. Earlier research on landscape connectivity focused on structural connectivity and neglected functional connectivity based on species-diffusion actions, which was meaningless [2]. The setting of the distance threshold will affect the analysis of landscape connectivity in the study area. If the distance threshold is set too low, the patches in the area will not communicate with each other and the fragmentation will be severe. If the distance threshold is set too high, the patches in the area are interconnected and belong to the same component, neither of which can truly reflect the real situation of the landscape in the study area.

The distance threshold refers to the maximum reachable distance of ecological flow, which is usually used to judge whether the ecological flow exists and strength between the habitat patches in the study area [3]. At present, the research methods of the optimal distance threshold are various, including target species analysis [4-7], distance threshold gradient method [8,9], relation curve method [10,11] and so on. Szabó (2012) used the ground beetle (Pterostichus melas) as a target species and studied the importance of habitat patch by using the maximum moving distance of the target species as the distance threshold [5]. Laita (2010) set different gradients of distance thresholds to calculate the importance and network center of patch in the study area [8]. Neel (2008) established the ‘landscape
connectivity index-distance value’ curve to study the relationship between the two and the mutation point to determine the regional distance threshold [9]. Determining the appropriate distance threshold for the study area is conducive to the identification of key patches and the connection of relatively weak areas, which can provide reference for the ecological restoration process.

Located in the southeast of Tianjin, Tianjin Binhai New Area is a necessary place for migratory birds to migrate from East Asia to Australia and has a rich habitat. In recent years, due to expansion of urban construction and rapid industrial development, the wetland system has undergone significant changes, which are manifested by an increase in the number of landscape patches and an increase in fragmentation. In this paper we took Binhai New Area as the research object and drew the curve of ‘the index of landscape connectivity-distance threshold’, and finally chose the most appropriate distance threshold.

2. Date and methods

2.1. Study area

Tianjin Binhai New Area is located in the southeast of Tianjin City, close to the Bohai Sea, geographical coordinates are 38°40' -39°00' N, 117°20' -118°00' E. The area is a coastal impact plain, showing high in the northwest and low in the southeast, with an elevation of 1-3m and the slope of the ground is less than 1/10000. The land area is 2270km², the sea area is 3000km², and the coastline is 153km [12]. The vast wetland area of the Binhai New Area provides a migratory habitat for birds. In the spring and autumn of each year, many birds stay here to carry out activities such as inhabiting, feeding and supplementing energy, which is important for protecting bird diversity.

2.2. Date source

The remote sensing data comes from the Geographical Spatial Data Cloud Platform of the Computer Network Information Center of the Chinese Academy of Sciences (http://www.gscloud.cn). The 2017-4-14 Landsat-8 OLI image was selected, and the cloud amount was less than 5%, remote sensing images of this period can meet the analysis requirements. Other supporting data include the Tianjin Binhai New Area border vector, Tianjin vegetation distribution map and Tianjin city overall plan and other related maps.

2.3. Distance threshold setting

Different species have different spreading ranges and there is an important relationship between the connectivity of the patch and the migration and diffusion characteristics of the organism. The average diffusion range of birds is 30-32000m, and the average diffusion range of small and medium mammals and amphibians and reptiles is 50-1000m [13]. Preliminary studies have shown that when the diffusion distance threshold reaches 3000m, the number of wetland landscape components in the study area is close to 1, and basically no longer changes, indicating that all the patches in the landscape are interconnected and belong to the same component, so the analysis will be meaningless. In summary, this paper set 11 diffusion distance thresholds of 100, 200, 400, 600, 800, 1000, 1500, 2000, 3000, 5000, and 8000m.

2.4. Landscape connectivity index selection

This paper chose the Number of Links(NL) [14,15], Number of Components(NC) [16,17], Equivalent Connectivity of Integral Index of Connectivity(EC(IIC)) [18-20], Equivalent Connectivity of Probability of Connectivity (EC(PC)) [18-20], Landscape Coincidence Probability(LCP) [21,22] as the screening index.

(1) Number of Links (NL) refers to the number of connections between habitat nodes in a landscape. In other words, if the distance between any two patches is less than the set distance threshold, the number of links between these two patches is considered to exist [14,15]. The better the landscape connectivity, the greater the total number of links.
(2) Number of Components (NC) refers to a whole consisting of functionally or structurally interconnected patch [12]. An isolated node or patch will form a component, and there is no functional relationship between the different components. Therefore, the closer together the patches within the landscape, the smaller the number of components [16].

(3) The equivalent connection area (ECA) refers to the size of a single patch (maximum connection) that provides the same probability of connection as the actual habitat pattern in the landscape. When the attributes of the patch correspond to other habitat characteristics (habitat quality, population size, etc.) in the area, the equivalent connection area index (ECA) can be equivalent to the equivalent connectivity index (EC). The equivalent connectivity index used in this paper includes the equivalent connectivity area index (EC(IIC)) of the overall connectivity and the equivalent connectivity area index (EC(PC)) of the possible connectivity [17]. EC(IIC) and EC(PC) have all the ideal attributes and prioritization capabilities of IIC and PC indices, and have the same advantages as node attributes, facilitating the quantification of landscape connectivity changes [18,19].

(4) Landscape Coincidence Probability (LCP) refers to the probability that two random nodes located in a landscape are located in the same habitat. Usually, the degree of coherence of the landscape is reflected by studying the set of connected patches. In general, the value of LCP increases with the increase of connectivity [20,21].

2.5. data processing
This paper used ArcGIS 10.2, ENVI 5.3 software to process the remote sensing image, and used Conefor Sensinode 2.6 software to calculate the connectivity index, and finally used the Origin 8.5 software to draw the chart.

Conefor Sensinode 2.6 was developed by Santiago Saura and Josep Torné and is the development of the previous 2.2 version [22]. The software can quantify the importance of habitat patches through the graphical structure and habitat availability index. Conefor Sensinode 2.6 can calculate several different connectivity indices. The most commonly used are the overall connectivity index (IIC) and the possible connectivity index (PC). The input file can be converted by the Conefor expansion module in ArcGIS.

3. Result and discussion

3.1. The effect of distance threshold on NL and NC
From the Figure 1, it can be seen that as the distance threshold increases, the NL value shows an increasing trend, and the NC value shows a decreasing trend and eventually tends to be 1. According to the result, the threshold can be divided into 4 intervals.

(1) When the distance threshold is 100-400m, the NC value decreases rapidly, indicating that the distance threshold in the interval is not suitable for describing the connection status of the landscape in the study area.

(2) When the distance threshold is 400-800m, the NC value decreases slowly and NL also increases slowly, indicating the degree of landscape connectivity in this interval is relatively stable, and is less affected by the change of the threshold of the diffusion distance, which is conducive to the analysis of landscape connectivity.

(3) When the distance threshold is 800-2000m, the change rate of NC value is small, but the rate of change of NL value is still relatively large. The results show that the landscape stability is still poor in this threshold range, so it is not suitable for the analysis of landscape pattern and process.

(4) When the distance threshold is greater than 2000m, the number of components decreases smoothly to 1, that is, all the ecological patches in the focal landscape belong to one component and the patches are connected to each other, which is obviously inconsistent with the actual habitat conditions in the study area. In summary, 400-800m is a suitable range.
3.2. The effect of distance threshold on Equivalent Linking Index

From the Figure 2, the EC(IIC) and EC(PC) index values increase with increasing distance thresholds. According to the result, the threshold can also be divided into four intervals.

1) When the distance threshold is 0-400m, the EC(IIC) and EC(PC) values increase rapidly. The reason may be that many broken small patches in the study area are considered connected when the distance threshold increases, so the connectivity index increases rapidly. However, this threshold interval cannot be used as the threshold selection range, in which the landscape is unstable and is easily affected by the threshold.

2) When the distance threshold is 400-800m, EC(IIC) and EC(PC) values increase slowly, at this time, the landscape connectivity changes in the study area do not fluctuate, and the landscape stability is better.

3) When the distance threshold is 800-2000m, the growth of the EC(PC) index value is still relatively slow, but the growth of the EC(IIC) index value increases rapidly. Because the EC(IIC) index has the same indication as the IIC index, it represents overall connectivity. When the distance threshold increases again, larger areas of landscape patches are also considered to be connected, so the index increases. The increase in EC(PC) index values but the slower growth may be due to the contribution of some intermediate patches when considering the possibility of connectivity between patches.

4) The distance threshold is greater than 2000m, EC(IIC), EC(PC) index values are growing slowly and gradually tend to stabilize, at this time the entire habitat can be considered to belong to the same component.

In summary, based on EC(IIC), EC(PC) index, 400-800 meters is the most suitable distance threshold range, and the results are the same as the results of NL and NC.

3.3. Optimal distance threshold selection

In order to further determine the specific distance threshold, the index dLCP, dIIC, and dPC that reflect the importance of the patches were selected for analysis. Analysis of the data revealed that the change trend of dLCP, dIIC, and dPC remained basically consistent within a suitable threshold range. Six patches that have a large influence on the overall area of the landscape were selected, and three distance thresholds of 400m, 600m, and 800m were set up to study changes in dLCP, dIIC, and dPC. The results of the study are shown in Figure 3.
The analysis results show that when the distance threshold is 400 m, the change trends of $d_{LCP}$, $d_{IIC}$, and $d_{PC}$ are basically the same. Under this threshold, the reasonable connectivity of landscape patches within the study area can be truly reflected. Therefore, the optimal distance threshold for the study area is 400 m.

4. Conclusion
Based on the principle of landscape connectivity, this paper set 11 different distance thresholds, and chose different landscape connectivity indices for the selection of the optimal distance threshold for the connectivity of wetland landscapes in the Tianjin Binhai New Area, and finally drew the following conclusions.

(1) By analysing the influence of different distance threshold conditions on the number of links (NL), number of components (NC), and equivalent attachment index (EC, including EC(IIC), EC(PC)), 400-800 m can be considered suitable. In this interval, the connectivity of the habitat patch in the study area is relatively stable, which can clearly show the distribution of the patches and help to identify the important patches in the landscape.

(2) By further calculating the importance of habitat patches in the study area, it was found that the $d_{LCP}$, $d_{IIC}$, $d_{PC}$ trends were consistent when the distance threshold was 400 m, and 400 m was finally selected as the optimal distance threshold for the connectivity of the wetland ecosystem in Tianjin Binhai New Area. The research results can provide reference for the study of wetland landscape in...
Tianjin Binhai New Area. However, in the actual research process, the choice of distance threshold can be adjusted according to the purpose of research and the level of study.

In the analysis of landscape connectivity, suitable distance thresholds need to be determined in order to find the weak links of landscape connectivity and identify small patches that have important contributions to the overall landscape connectivity. If the distance between habitat patches within the study area is large, it is difficult to find the weak links of landscape connectivity with a small distance threshold; if the distance between individual habitat patches is small or coverage is high, a smaller distance must be used, large distance thresholds often will be the default for each patch is interconnected, thus affecting the analysis of the importance of small areas. In this paper, the optimal distance threshold for landscape connectivity analysis in the study area was selected based on the landscape connectivity index such as IIC and PC. The interaction mechanism between the optimal distance threshold and the landscape pattern in the study area needs further study.

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