地理学报(英文版) 2002年第12卷第2期

On models for landscape connectivity: a case study of the new-born wetland of the Yellow River Delta

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The models for landscape connectivity are distinguished into models for line connectivity, vertex connectivity, network connectivity and patch connectivity separately. Because the models for line connectivity, for vertex connectivity, and for network connectivity have long been studied and have become ripe, the model for patch connectivity is paid special attention in this paper. The patch connectivity is defined as the average movement efficiency (minimizing movement distance) of animal migrants or plant propagules in patches of a region under consideration. According to this definition, a model for landscape connectivity is mathematically deduced to apply to GIS data. The application of model for patch connectivity in the new-born wetland of the Yellow River Delta shows patch connectivity has a negative interrelation with human impact intensity and landscape diversity.?

On models for landscape connectivity: a case study of the new-born wetland of the Yellow River Delta YUE Tian-xiang 1, YE Qing-hua1, LIU Qing-sheng1, GONG Zheng-hui2 (1. Institute of Geographic Sciences and Natural Resources Research, CAS, Beijing 100101, China; 2. Gudao Monitoring Station of Shengli Oil Field Administration, Dongying 257231, China) 1 Introduction Since Menger´s Theorem came into being in 1927, connectivity has become one of the most important aspects of graph theory. Since the early 1960s, connectivity has evolved into many research fields as a mathematical tool and solved a wide variety of problems. In the early 1980s, the term, connectivity, was first applied into studies of landscape ecology (Merriam, 1984; Risser et al., 1984). 1.1 Conception of connectivity Haber and his institute have adopted connectivity as an important research step in their holistic approach of land planning (Haber, 1984, 1986, 1987, 1988, 1990; Haber and Burhardt, 1986, 1988). Merriam (1984) regarded connectivity as a parameter of landscape function that measures the process by which sub-populations of a landscape are interconnected into a demographic function unit (Baudry and Merriam, 1988; Mcdonnell and Pickett, 1988). Risser et al. (1984) stated that movement of migrants or propagules among elements of the land mosaic could be expressed in graph theoretic measures of connectivity. Forman and Godron (1986) defined it as a measure of how connected or spatially continuous a corridor is, in terms of the mathematical concept of connectivity in topology, which is the concept of network connectivity. A high level of connectivity in a landscape element type has three consequences (Forman and Godron, 1986): 1) the element may function as a physical barrier separating the other elements; 2) when the connectivity takes the form of an intersecting of thin, elongated strips, the element may function as a series of corridors facilitating both migration and gene exchange among species; and 3) the element may encircle other landscape elements to create isolated biological islands. Schreiber (1988) stated that connectivity in landscape ecology includes the entire complex of relationships in and between ecological systems, i.e. not only the interrelationships in communities and between organisms but also the network of interactions and flows between the biotic and abiotic compartments of the ecosystem. Janssens and Gulinck (1988) believed that connectivity in landscape is a combination of contiguity and proximity. Haber (1990) stated that connectivity is an assessment of spatial interrelations among all ecotope types or ecotope assemblages of a regional natural unit, with special emphasis on connectedness and mutual dependence. Taylor et al. (1993) defined landscape connectivity as the degree to which the landscape facilitates or impedes movement among resource patches. Forman (1995) defined connectivity as a measure of how connected or spatially continuous a corridor, network, or matrix is. With et al. (1997) described landscape connectivity as the functional relationship among habitat patches, owing to the spatial contagion of habitat and the movement responses of organisms to landscape structure. Connectivity in landscape ecol

ogy in terms of the above studies can be distinguished into line connectivity, vertex connectivity, network connectivity and patch connectivity. 1.2 Existing models for connectivity Many models for landscape connectivity have been developed in the research field of landscape ecology, such as the model based on the Law of Universal Gravitation (Mladenoff et al., 1997), the model based on dispersal success (Malanson et al., 1999), the model based on search time (Ruckelshaus et al., 1997), the model based on cell immigration (Tischendorf and Fahrig, 2000) and the model based on movement frequencies (Pither and Talor, 1998). In fact, except model for patch connectivity, models for line connectivity, for vertex connectivity and for network connectivity have long been studied and become ripe in other research fields such as mathematics and human geography. 1.2.1 Models for line connectivity One of the most important concepts in graph theory is the connectivity. In 1927, Menger showed that connectivity of a graph is related to the number of disjoint paths joining distinct points in the graph. The Menger´s result stated the minimum number of points separating two nonadjacent points s and t is the maximum number of disjoint s-t paths. In other words, a graph is n-line-connected if and only if every pair of points is joined by at least n line-disjoint paths. The connectivity includes point-connectivity and line-connectivity (Harary, 1969). The point-connectivity k=k(G) of a graph G is the minimum number of points whose removal results in a disconnected or trivial graph. The complete graph Kp cannot be disconnected by removing any number of points, but the trivial graph results by removing p-1 points. In other words, the point-connectivity can be formulated as where p is the number of points of the graph G (p,q); q is the number of lines of the G (p,q); V1 is the cut-vertex set of the graph G (p,q); Kp means that G (p,q) is a complete graph. The line-connectivity (=((G) of a graph G (p,q) is the minimum number of lines whose removal results in a disconnected or trivial graph. The point-connectivity, line connectivity and minimum degree follow the inequality (Whitney, 1932), k (G) (((G)(((G). According to Chartrand (1966), if G has p points and where is the greatest integer not exceeding the real number , then . It is proven that among all graphs with p points and q lines, the maximum connectivity is 0 when q < p - 1 and is when . Combining with Chartrand´s results, the maximum line-connectivity equals the maximum point-connectivity, i.e. 1.2.2 Models for vertex connectivity Accessibility or vertex connectivity is defined as the ease with which a specific location can be reached from a given point (Lowe and Moryadas, 1975). The methods evaluating the vertex connectivity include 5 models (Lowe and Moryadas, 1975; Taaffe and Gauthier, Jr., 1973; Garrison, 1960): (a) K?nig index of vertex connectivity where Ki is the maximum of the distances dij from vertex i to each of the other vertices j. (b) Accessibility index where Ai is the accessibility of vertex i; dij is the distance between vertex i and vertex j. The value of the accessibility index is inversely related to the accessibility of the vertex i to the network as a whole. (c) Model for direct connectivity of a vertex This model for direct connectivity is based on a connectivity matrix, C = (cij)n(n in which when there is a route between vertex i and vertex j, cij equals one and when there is no route between vertex i and vertex j, Cij equals zero. (d) Model for indirect connectivity of a vertex where cijk is the element at ith low and jth column of matrix Ck that is the kth power of the matrix C = (cij)n(n. (e) Model for vertex accessibility where tij is the element at ith low and jth column of matrix T; and the matrix T is formulated as where s is a scalar with a value between 0 and 1(0

关键词： landscape connectivity; mathematical model; human impact; landscape diversity

