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Regional differences in gully network connectivity based on graph theory: a case study on the Loess Plateau, China

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Gullies are some of the areas with the most frequent material exchanges in loess landforms. By studying the influence of the spatial structure of gully networks on material transport and describing the difficulty of material transport from sources to sinks, it is of great significance to understand the development and evolution of loess landforms. This study is based on graph theory and digital terrain analysis and describes the relationship between gully networks and terrain feature elements via a gully network graph model. The adjacency matrix of the gully network graph model is constructed to quantify the connectivity. Taking six typical small watershed sample areas of the Loess Plateau as the research objects, the changes in the gully network connectivity characteristics in different loess geomorphic areas are analyzed from the aspects of overall network connectivity and node connectivity. The results show that (1) From Shenmu to Chunhua (the sample areas from north to south), the average values of the gully network edge weights first decrease and then increase. The maximum value is 0.253 in the Shenmu sample area, and the minimum value is 0.093 in the Yanchuan sample area. These values show that as the gully development increases, the greater the capacity of the gully network to transport materials is, and the less resistance the material receives during the transfer process. (2) The average node strength reaches the minimum in the Yanchuan sample area, and from Yanchuan to the north and south sides, it gradually increases. It can be concluded that the overall connectivity of the gully network shows a gradually weakening trend from the Yanchuan sample area to the north and south sides. (3) The potential flow (Fi) and network structural connectivity index (NSC) show similar characteristic changes; from north to south, the connectivity of nodes from the Shenmu to Yanchuan sample areas gradually increases, and from the Yanchuan to Chunhua sample areas, it gradually weakens. The accessibility from source to sink (Shi) shows the opposite trend. At the same time, the connectivity index values of the gully network nodes in the six typical areas all show clustered spatial distribution characteristics. (4) By comparing the results of the connectivity indicators calculated by the Euclidian distance used in the previous study and the sediment transport capacity index used in this study and by comparing the variation in the gully network quantitative indicators and the gully network connectivity indicators, this comparison result indicates the rationality of connectivity indicators in this paper. The connectivity

of the gully network contains abundant and important information on the development and evolution of loess gullies. Research on the connectivity of the gully network will help deepen the understanding of the evolution process and mechanism of loess gullies.