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Research article

Ecological control line: A decade of exploration and an innovative path of ecological land management for megacities in China

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ABSTRACT

Ecological control line is a system innovation in the field of ecological environment protection in China and it has become as an important strategy of national ecological protection. Ten years have passed since the first ecological control line in Shenzhen was delimited in 2005. This study examines the connotations of ecological control line and the current study status in China and abroad, and then takes a brief description about the delimitation background and existing problems of the ecological control line in Shenzhen. The problem-solving strategy is gradually transforming from extensive management to refined management. This study proposes a differential ecological space management model that merges the space system, management system, and support system. The implementation paths include the following five aspects: delimiting ecological bottom lines to protect core ecological resources; formulating access systems for new construction projects to strictly control new construction; implementing construction land inventory reclamation assisted by market means; regulating boundary adjusting procedures and processes; and constructing ecological equity products by using multiple means to implement rights relief. Finally, this study illustrates the progress of the implementation and discusses the rigorousness and flexibility problems of ecological control line and calls for the promotion of the legislation. The management model and implementation paths proposed in this study have referential significance for developing countries and megacities to achieve ecological protection and sustainable development.

1. Introduction

In the past 30 years, with high-speed economic development and a rapid population increase in China, the original land use configuration has changed significantly (Chen et al., 2015; Seto and Fragkias, 2005). Natural resources have been depleted and the area of natural ecosystems has decreased. In addition, the landscape has fragmented and gradually leads to soil degradation and severe degradation of ecosystem functions (Blanchard et al., 2015; Boluwade and Madramootoo, 2015; Rege et al., 2015). Shenzhen is the most typical representative of the rapid urbanization process in China. It also faces the dilemmas of limited space, scarce resources, a highly concentrated population, and environmental carrying capacity overdraft. Urgent environmental issues are testing the limits of current management approaches and pushing demand for innovative approaches (Virapongse et al., 2016). In recent years, China has greatly promoted ecological civilization construction. China has proposed the “five in one” national development strategy that consists of ecological civilization construction, economic construction, political construction, cultural construction, and social construction in an attempt to solve the overall urbanization problem.

Urban ecological management has always been a core issue in urban planning (Allen, 2003; Pickett et al., 2008). Ecological control line plays the “bottom line” role in the process of preventing urban sprawl and ecological civilization construction. It refers to the boundaries of important ecological protection factors that are delimited according to relevant laws and regulations. Its boundary

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is defined under the premise of respecting urban natural ecosystems and reasonable environmental carrying capacities to protect basic urban ecological safety, maintain the scientific nature, integrity, and continuity of ecosystems, and prevent urban construction sprawl (Sheng, 2010). As the first real "ecological control line" in China, the ecological control line in Shenzhen started the exploration of urban ecological land protection and management in China. Shenzhen became the pioneer of practicing ecological control lines in China. In the last decade, nearly 30 Chinese cities began planning and management practices and academic research regarding ecological control lines. Among these cities, Wuxi, Dongguan, Wuhan, and Xiamen have already formally implemented ecological control lines and are representative cities (Zhou, 2015). In 2006, Wuxi delimited an ecological control zone of approximately 530 km^2. In 2008, the Dongguan government compiled the "Dongguan Ecological Control Line Plan" and established an ecological control zone of approximately 1103 km^2. In 2013, Wuhan identified the ecological protection range area in the urban development zone surrounded by a basic ecological control line to be 1814 km^2. In 2014, Xiamen delineated an ecological control range of 981 km^2 and an urban development zone of 640 km^2 simultaneously. These cities have undoubtedly borrowed from the practical experience of Shenzhen in the aspects of denomination, positioning, regulation content, and control policy.

An ecological control line is a system innovation in environmental protection in China. The structures abroad that are similar to this protective system mainly include urban boundaries based on sprawl control (including a Green Belt and Urban Growth Boundary) and land protection zones based on urban development limits (including protection zones, greenways, and ecological networks). Through the corroboration of the two opposite sides of urban boundary control and land protection models, cities can maintain the integrity, stability, and flexibility of ecosystems that are consistent with the protection objectives of ecological control line. In 1938, London, UK, enacted the "Green Belt Law" to protect and construct urban green lands and green belts to limit urban sprawl (Thomas, 1963). Later, numerous cities consecutively established green belts that separate urban and rural areas. The widths are mostly between 5 and 15 km (Kühn, 2003). The United States of America passed the "Urban Growth Boundary" regulation in 1958 to delimit boundaries between urban and suburban areas and to control and guide urban sprawl and regional planning (Nelson and Moore, 1993; Turnbull, 2004).

Urban land protection areas are regions with ecological protection values or urban development limits. Protection areas receive protection because of their recognized natural, ecological and/or cultural values. The practice is to delimit the space ranges of special ecological significance and special species and ecotypes to achieve the long-term conservation of nature (Borgström et al., 2010; Trzyna, 2014). Currently, there are approximately 209,000 protected areas globally (as of August 2014) (Juffe-Bignoli et al., 2014). Cartographic analysis and engineering geology maps are useful tools for the planning and management of protected natural area (Martínez-Graña et al., 2012, 2013, 2014). Little proposed the concept of a Greenline Park and suggested protecting landscapes with high values and delimiting regions with mixed ownership (including public and private) of land and resource values. The concept of a green line gradually changed to greenway and then developed to protection belts with multiple functions of protecting wild animals, reducing soil erosion and floods, and maintaining water quality, education, and urban landscape entertainment (Belcher and Wellman, 1991; Zube, 1995). Ecological networks comprise core areas, corridors, and buffer zones (Ignatieva et al., 2010). Ecological corridors connect isolated, important habitats so that ecological networks become an integrated system, which benefits species migration. The typical case is the Pan European Ecological Network which aims to conserve the full range of ecosystems, habitats, species and landscapes of European importance (Jongman et al., 2011).

Overall, the ecological control line is a complex system that merges nature, economy, society, humanity, and environmental features. Chinese cities have established the construction of an ecological environment as a strategic objective. Cities abroad use urban boundary controls and land protection models to specify non-construction zones; the two strategies are the same in terms of objectives and approaches. But there still are some problems to be worth thinking. Ambiguities in the conceptual framework, type division, and management system cause ecological controls to lack rigorousness and to be overly flexible; technical control and public governance are not closely combined (Jiang et al., 2015; Lin et al., 2016). We suggest that urban ecological space control research should have more specific objectives and that management models should provide general ideas and specific paths to implement the rigorous protection and rational use of ecological space. Therefore, this study used Shenzhen, a highly urbanized region in China, as the study subject. Based on the practice and exploration of the ecological control line in Shenzhen in the past decade, we summarize and systematically discuss the management model that merges a space system, management system, and support system. Also we propose specific implementation paths to provide theoretical and practical references for other cities and related studies.

2. Background of ecological control line

At a longitude of 113° 46′ to 114° 37′ and latitude of 22° 27′ to 22° 52′, Shenzhen is located in the southern part of Guangdong Province, China. It is on the east coast of the Pearl River Delta adjacent to Hong Kong (Fig. 1). The terrain declines from southeast to northwest. In the past 30 years, Shenzhen has experienced large-scale, high-density urban population migration and agglomeration, which created a remarkable "Shenzhen speed". It became the first city without rural institution in China and achieved an urbanization rate of up to 100%. Shenzhen's GDP has increased from \$40.68 million in 1980 to \$26.36 $\times$ 10^4 million in 2014, and the resident population grew from 0.3 million in 1980 to 10.62 million in 2014.

While Shenzhen achieved rapid social and economic development, the total urban natural ecological space decreased annually, and urban ecological resources faced tremendous pressure. On November 1, 2005, the Shenzhen Municipal People's Government delineated 974 km^2 of land as an ecological control range (Fig. 1). The component elements of the ecological control line included first-class water source protection zones, scenic zones, natural protection zones, basic farmland protection zones, forest and country parks, mountains with slopes steeper than 25°, highlands with elevations higher than 50 m, water reservoirs and wetlands, ecological corridors, etc.

Based on relevant data provided by government ministries, the status quo of land use is mainly ecological land use (including farmlands, park lands, woodlands, grasslands, park green lands, and water areas). The area is 845 km^2 and constitutes 87% of the total area. Approximately 300 communities (equivalent to administrative villages) are located inside the line. The number of communities with more than 1000 people is 67 and there were 45.9 thousand buildings of different types inside the line in 2014. A total population of approximately 300,000 was estimated within the line with approximately 308– population density.