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China's ambitious ecological red lines

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ABSTRACT

China has initiated a new environmental strategy for delimiting "ecological red lines (ERL)" to balance economic growth and ecological and environmental protection in the country. This study uses the Yangtze River Economic Belt as a case study to illustrate the strategy and address the challenges of the implementation of this strategy. The paper identifies three knowledge gaps that urgently need research: key indicators to measure ERL, methods and criteria for spatial analysis and classification of ERL, and effective integration with other ecological protection policies. The study suggests four adaptive countermeasures to improve the scientific and practical implementation of the Chinese ERL policy.

1. Introduction

"Ecological red lines (ERL)" is the Chinese government's newest strategy for building the nation's ecological civilization that seeks a harmonious equilibrium between ecological protection and development of human society (Lü et al., 2017; Sang and Jan, 2016). The ERL, initiated by the State Council of China (2011) in 2011, is of vital importance to enhance integrated ecosystems management and ecological (environmental) protection in the country. The ERL, as conceptualised by the Chinese Ministry of Environmental Protection (Ministry of Environmental Protection of the People's Republic of China (MEP), 2015), refers to the ecological bottom line to safeguard national and regional ecological security. It can be defined as the minimum space that needs the strictest protection to improve ecological functions to ensure the sustainable supply of ecological goods and services (Lü et al., 2013; Bai et al., 2016; Wang and Pan, 2017). Standard technical guidelines, released by the Ministry of Environmental Protection of the People's Republic of China (MEP) (2015), provided a clear definition, types, principles, technical processes and methodology in the delineation of ERL. Protecting the ERL areas is part of China's newly revised Environmental Protection Law (Bai et al., 2016) and is listed as one of the priority actions to build ecological civilization (Lü et al., 2017). The Chinese central government has committed ERL as a vital policy for ecological protection, implying that policy is seen as a key determinant of the Chinese ecological civilisation process. The Chinese ERL policy has potential not only to produce substantial positive effects on environmental protection and ecological rehabilitation in China, but also to be an example for other nations to devise practical environmental policies to achieve the United Nations' Sustainable Development Goals (Sutherland et al., 2016).

The Yangtze River Economic Belt (hereafter the Belt), the Coordinated Development of the Beijing-Tianjin-Hebei Region (BTHR) and the 'One Belt and One Road' initiative have been established as China's threefold strategies in regional economic development since 2015 (Fig. 1). The Belt and the BTHR account for 21.3% and 2.3% of China's land area, 43% and 8.1% of its population, and 44% and 10.2% of its GDP, respectively. Thirty years of rapid economic and population growth in these two regions have caused significant environmental consequences, including water quality deterioration, biodiversity degradation, soil erosion, siltation and flooding (Yang et al., 2009; Chen et al., 2017). The Yangtze River Economic Belt Development Plan Outline (National Development and Reform Commission (DNRC), 2016) and the Outline of the Beijing-Tianjin-Hebei Coordinated Development Plan (Xinhuanet, 2015) reinforced that the processes of urbanisation and industrialisation will continue to gain momentum in the coming years. Hence, to preserve essential ecological functions and to seek an equilibrium between ecological protection and economic development are of fundamental national and regional importance. The Belt and the BTHR have been prioritised for the implementation of ERL, while the implementation in the other provinces will go ahead by the end of 2020. The ERL for 15 provinces (including Ningxia and all 14 provinces/municipalities in the BTHR and the Belt) has been preliminarily delineated by the state (Xinhuanet, 2018).

However, the framework and methodology for defining ERL still

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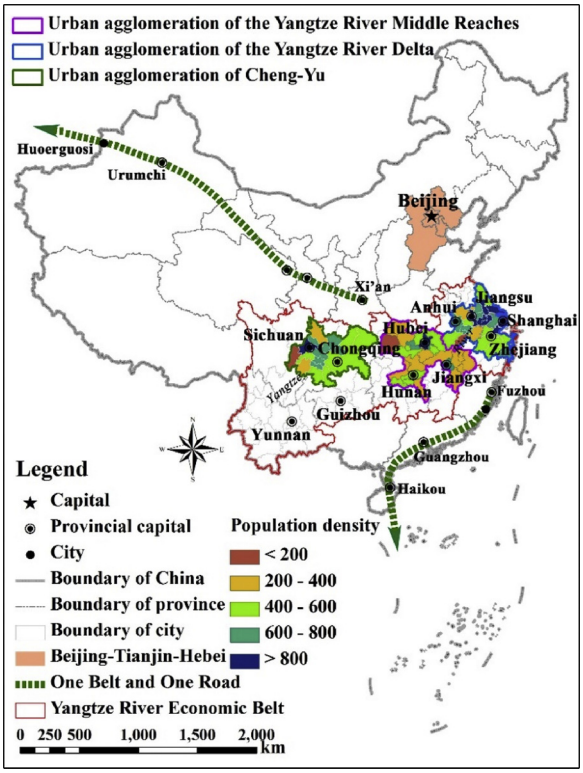

Fig. 1. The Yangtze River Economic Belt.

face several major challenges: the lack of science-informed criteria for the selection of key indicators, unclear methods for classification of various ERLs, spatial mismatch of ERLs in cross-border regions, and ineffective coordination between the ERL policy and existing other ecological protection policies. This paper seeks to use the Belt as an example to discuss these gaps limiting the successful implementation of the ERL, and suggest adaptive countermeasures.

2. Existing policies

Several existing policies on land-use zoning and ecological protection in China include: the Nature Reserves (NR), National Ecological Function Zones (NEFZ) and Major Function Oriented Zoning (MFOZ) (Bai et al., 2016; Lü et al., 2013). The NR were zoned for the protection and management of natural areas with abundant pristine ecosystems, rare and endangered wildlife species, and natural heritage on land or in water (Wu et al., 2011). The NEFZ sought to partition ecological function zones at a national scale based on comprehensive analysis of the status and spatial differentiation of ecosystem types, ecological problems, ecological sensitivity and vulnerability, and ecosystem services (Wan, 2011). The MFOZ aimed to optimise the spatial pattern of regional economic development and environmental conservation, by demarcating four types of development zones (optimised, major, prohibited and restricted) (Fan and Li, 2009). Due to remarkable inconsistencies between these policies in the conservation targets, scales and management, there is a low level of spatial overlap between biodiversity targets and ecosystem services, and between NR and NEFZ. The protected areas are not well delineated to protect either biodiversity or key ecosystem services due to a lack of a clear framework for defining conservation targets and maximising the efficiency of ecological management and restoration (Xu et al., 2017). There were 98 national NR and 691 local NR distributed in the Belt by the end of 2014 (Fig. 2(b)).

We used spatial analysis methods (e.g., classification, spatial overlay) under the ArcGIS 10.0 environment to reveal the discrepancy of the patterns of the existing ecological protection zones. The results show that there are significant spatial mismatches between existing conservation areas (NR and NEFZ) and development zones (MFOZ), accounting for 14.2% of the total land area in the Belt (Fig. 2(d)). Such spatial mismatches can be as extreme as up to 152,652 km^2 in the main strategies for soil retention, water conservation (93,487 km^2), biodiversity conservation (33,454 km^2), and flood regulation (9701 km^2) implemented in the region. The significant mismatches between different land-use zonings were also reported by other researchers (Lü et al., 2013; Bai et al., 2016; Wang and Pan, 2017; Xu et al., 2017).

The ERL is designated by the Chinese government to safeguard fundamental ecological services, natural resources, human health and well-being. Compared with existing ecological policies, the novelty of the ERL approach is that the government advances ecosystem services as a way to sustain the country's long-term development goals and gives environmental policy redline status. Three main objectives of the ERL are to protect important eco-function areas (e.g. ecosystem service hotspots) and ecologically fragile areas (eco-sensitive zones), to protect habitats for important species, and to maintain biodiversity hotspots on a national and global scale. Hence, the ERL attempts to build a holistic understanding about where the ecosystem biodiversity hotspots are, who provides ecosystem services, and how to solve current management conflicts, in addition to identifying the target population that these policies are meant to benefit in meeting their current and future needs (Bai et al., 2016). The central objectives of the ERL practised in China are similar to those of protected natural areas in the United States and Australia (Bai et al., 2016; Saura et al., 2017) and ecological networks which are designed in Canada, for example, to maintain biodiversity and ecological processes by protecting habitats and their linkages (Théau et al., 2015; Hausner et al., 2017). Globally, protected areas focus on a minimum area required to maintain species richness and functional diversity; ecological networks seek to maintain ecosystem integrity, stability and flexibility. In China, the ERL policy is characterised by not only its sheer large scale but also its complexity and cohesion.

3. Challenges to a coherent ERL

3.1. Key indicators for ERL

According to the Guidelines for the ERL delineation released by the Chinese Ministry of Environmental Protection (Ministry of Environmental Protection of the People's Republic of China (MEP), 2015), key criteria can be grouped into two categories: ecosystem services (water conservation, biodiversity conservation, soil retention, windbreak and sand fixation) and ecological sensitivity (soil erosion, land desertification, rocky desertification). Existing key ERL criteria have clear uncertainties when applied to the Belt and thus need to be extended by incorporating more indicators to measure important ecosystem services (water purification, flood regulation, and carbon sequestration) and ecological sensitivity (e.g. geological hazards).

Industrialisation and population growth along the Yangtze River have given rise to eutrophication and extensive encroachment into flood prone areas. Eutrophication of lakes and reservoirs has progressively worsened and become a major problem over the last decade (Yangtze River Water Resources Commission (YRWRC), 2016). Mega-hydropower projects such as the Three Gorges Dam and an increasing number of cascade dams in the upper Yangtze have altered hydrological regimes, reducing sedimentation and impeding river-lake flood connectivity throughout the Yangtze River basin (Yang et al., 2016). The surface areas of the lakes adjacent to the Yangtze have shrunk by 61.6% from the 1950s (17,198 km^2) to the present, and the size of wetlands decreased by 19.3% from 1978 to 2008 (Niu et al., 2012). These changes have led to aggressive predator-prey relationships and food scarcity amongst aquatic species and birds (Xie et al., 2015), and reduced lake storage and flood control capacity (Yang et al., 2016). Furthermore, carbon sequestration services in the Belt accounts for