

Spatial distribution of nature reserves in China: Driving forces in the past and conservation challenges in the future



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ABSTRACT

Nature reserves are hubs of biodiversity conservation in China, but their spatial distributions are not in line with the priority set based on biological criteria. This raises some fundamental questions: What caused this discrepancy? How was the spatial distribution of nature reserves determined in China? This paper aims to address these questions using a unique nation-wide county-level database. Our results reveal that although ecological factors play a significant role in nature reserve designations, economic considerations appear to be more significant in explaining the spatial distribution of local nature reserves in China. The opportunity cost of land conservation affects both the probability of designation and the amount of land designated for nature reserves in a county, and the effects vary by region, type of nature reserves, and time period of designation. Implications of these results for new nature reserve designations and for sustainable conservation of the existing protected areas are discussed.

1. Introduction

Since the late 1970s, the economic reform and opening-up policies have led to a rapid rural-urban transition and large disparities in economic development across regions in China (Long et al., 2016; Long, 2014). This rapid transition has imposed tremendous pressure on land, water, and air quality and has made natural resource management a requisite component of an overall development strategy in China. Within this context, nature reserve designation has become an important policy vehicle for protecting areas of importance for wildlife, flora, and fauna in China. As of 2016, China had established 2750 nature reserves, covering approximately 1.47 million km² or 14.9% of the country's land area (Ministry of Environmental Protection, 2017). These nature reserves were intended to protect China's 34,984 species of higher plants (ranked the third in the world), 6445 species of vertebrates (13.7% of the world total species), and numerous endemic species (Ministry of Environmental Protection, 2010).

Worldwide, 244 countries had established 217,155 nature reserves as of 2016, covering 19.80 million km² (or 14.7%) of global land (UNEP-WCMC and IUCN et al., 2016). From 2010 to 2016, the total protected area in the world increased by 16% (Bertzky et al., 2012). As more land is designated for nature reserves, issues such as site selection, targeting, conflicts between conservation and development, and reserve management have become common challenges for nature reserve

designations.

China's nature reserves system has been credited for protecting many threatened ecosystems and endangered species of national or international importance. However, it has also been criticized for a lack of systematic planning and an inadequate conceptual base (Wu et al., 2011). One particular criticism focuses on the discrepancy between the spatial distribution of the existing nature reserves and the areas that would be selected based on biological criteria. Some have pointed out that about 18.8% of higher plants, 10.2% of the wild plants, and 10.3% of the wild animals required by laws for special protection are not covered by the existing nature reserves (Tang, 2005; Jiang, 2015; Zhou et al., 2015). Others have found that the selection of protected areas is not correlated with the overall species richness, endemism, or threat (Xu et al., 2008). What has caused the discrepancy between the existing pattern and the ecologically optimal pattern of nature reserves in China? To answer this question, it is necessary to identify key determining factors and their relative importance for nature reserve designation decisions. Having a good understanding of the determining factors also has important implications for the designation of new reserves and the management of the existing nature reserves.

Thus far, the importance of economic, institutional, and political factors for reserve site selection has been extensively studied. A sizable literature has examined how to select reserves to maximize the number of protected species (e.g., Kirkpatrick, 1983; Vane-Wright et al., 1991;

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Fischer and Church, 2003; Onal and Briers, 2003; Nalle et al., 2004). Economists have contributed to the literature by accounting for opportunity costs of land conservation (Ando et al., 1998; Wu et al., 2011; Polasky et al., 2001; Costello and Polasky, 2004; Newburn et al., 2006; Polasky et al., 2008; Lewis et al., 2009). Some scholars have also examined roles of institutional factors (such as land tenure) for reserve selection (Ando and Getzner, 2006) and political forces for the growth of nature reserves (Dobson, 2001). Others have recognized the higher-order importance of economic factors (e.g., budget constraints and funding decisions) than ecological factors for species recovery or wetland conservation (Simon et al., 1995; Metrick and Weitzman, 1998; Getzner, 2002). Although the ecologically optimal pattern of nature reserves depends on optimal land use decisions, both market forces and land use policies shape the regional discrepancy in nature reserve distribution. Nevertheless, there is still a dearth of research on the relative importance of economic and ecological factors for designating different types of nature reserves. In China, research along this line is even more limited.

This paper starts to fill the gap in the literature by focusing on the relative importance of ecological and economic factors in determining the spatial distribution of national, provincial, and local nature reserves in China. We find that economic factors appear to play a more significant and robust role than ecological factors in nature reserve designations in China. In particular, the opportunity cost of land conservation, as approximated by population density, affects both the probability of nature reserve designation and the amount of land designated for nature reserves in a given county. Moreover, significant heterogeneity is observed regarding the relative importance of economic and ecological factors in affecting the probability of designation and the amount of land designated across regions, types of nature reserves, and time periods of designation. For example, economic factors play a significant role in the amount of land designated for nature reserves in eastern or central China but not in western China.

In the next section, we review the spatial distribution of nature reserves in China. This is followed by a discussion of the empirical models in Section 3, and data and variable selections in Section 4. We present the empirical results in Section 5, and identify econometric challenges and approaches for robustness checks in Section 6. We discuss policy implications of the results in the final section.

2. Nature reserves in China

The nature reserve system in China has been evolving for 60 years. Although China established its first nature reserve in 1956, 98.2% of its nature reserves were established after 1980. In Appendix A, we provide a detailed description of the development process of the nature reserve system in China.

There are four types of nature reserves in China: national, provincial, prefectural, and county-level. Although nature reserves at each level are supervised by the corresponding level of government, they are often directly managed by the nature reserve management bureaus affiliated to the local governments (normally county governments). National nature reserves accounted for more than 62% of the total area of all nature reserves, but less than 13% of the total number in 2012. In contrast, county-level nature reserves accounted for more than 38% of the total number, but less than 7% of the total area in 2012. Fig. 1 shows the share of each level of nature reserves by number and land area in 2012.

Below, we first describe the spatial distribution of China's nature reserves and then discuss the decision process of nature reserve designations. Finally, we formulate the hypothesis about county governments' motivations for nature reserve designations.

2.1. Spatial distribution of nature reserves in China

The spatial distribution of nature reserves displays three main

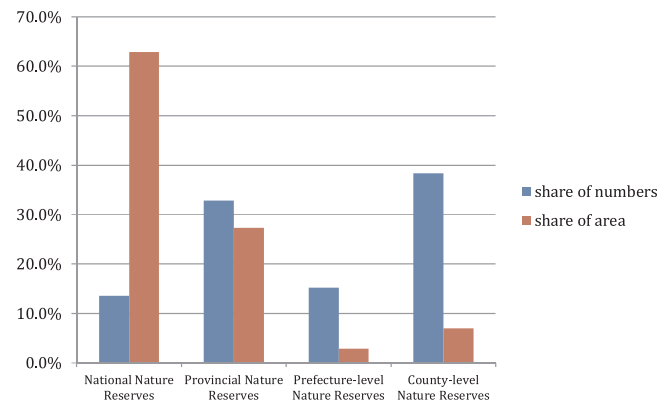


Fig. 1. The composition of different levels of nature reserves in China, by number and area, in 2012.

features. First, most of the land designated for nature reserves lies in northwestern China (see the bottom panel of Fig. 2). Six western provinces, including Tibet, Qinghai, Xinjiang, Inner Mongolia, Sichuan, and Gansu, contain over three-quarters of the designated land for nature reserves and host 16 of 19 nature reserves larger than one million ha of land. In addition, a large amount of land designated for nature reserves is located on the boundaries of Tibet, Sichuan, Xinjiang, and Inner Mongolia.

Second, the number of nature reserves is much more spatially concentrated than the area of nature reserves. Southeastern China has the largest number of nature reserves. In western China, where nature reserves tend to be large, no county hosts more than 5 nature reserves. In contrast, in southeastern China, which hosts numerous small nature reserves, some counties have more than 50 nature reserves.

Third, northwestern China tends to contain relatively large, high-level nature reserves, while southeastern China tends to host relatively small, low-level nature reserves (Fig. 3). The average size of national nature reserves is about 227,948 ha, while the average size of county-level nature reserves is only 10,575 ha. The weighted center of county-level nature reserves is located in the southeast, while the weighted center of national nature reserves is located in the northeastern part of China.

2.2. The decision process for nature reserve designations

The designation process for all levels of nature reserves starts with a county government submitting a proposal for designation. Thus, county governments play a pivotal role in nature reserve designation and their motivations for designating nature reserves can ultimately affect the spatial distribution of nature reserves, although governments at higher levels give final approval on their applications. A national nature reserve can be designated only after the land has been in a provincial nature reserve for at least two years.

To nominate a provincial nature reserve for a national nature reserve, the provincial government must submit an application to the Review Committee of National Nature Reserves in the Ministry of Environmental Protection. The Committee forms a scientific review board to review all applications. Based on the scientific reviews, the Committee makes its decision on the application by a voting system: an application is approved if two-thirds of the Committee members vote "Yes" for it.

The scientific review follows three major criteria with corresponding weights assigned to them: natural conditions (60%), protectability (20%), and protection and management capacity of the local government (20%). Natural conditions include representativeness, fragility, diversity, scarcity, and pristine conditions. Protectability is evaluated based on the appropriateness of scale and the scientific, social, and economic values from protection. Protection and management

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