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Spatiotemporal changes and fragmentation of forest land in Jiangxi Province, China

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ABSTRACT

Habitat loss and fragmentation resulting mainly from increased human impacts related to land use represent considerable threats to biodiversity. When regional ecological security is threatened, governments attempt to regulate unreasonable behavior via policies and laws. China has a dominant forestry industry, and the country is attempting to implement the dual goals of economic development and ecological security; therefore, the Chinese government has formulated a series of policies and regulations to balance these goals. This study presents the main forest policies in China and implements a logistic regression model to analyze the changes in forest land in the study area (Jiangxi Province) and the primary influencing factors for these changes under the forest policies from 1990 to 2010. Subsequently, a forest fragmentation model (non-traditional forest landscape pattern index) was built to analyze the forest fragmentation patterns and interference modes. The results indicated that the total forest land area increased by more than 40,000 ha during the study period; however, the logistic model showed that a large amount of high-quality forest land was replaced by poor-quality forest land because forest land areas that present rich soil organic matter (SOM) content are more easily converted to other land types, whereas areas with poor SOM are more easily converted to forest land. Between 1990 and 2010, forest fragmentation improved because the proportion of interior forests increased and the proportions of patch and perforated forests decreased. The paper concludes by proposing some policy recommendations for the conservation of biodiversity.

Introduction

The most urgent challenge in forest management is conserving biodiversity (Artti, 2008; Thiene et al., 2012). For terrestrial organisms, forest land is the largest habitat and represents a major hot spot of diversity (Selvi et al., 2016). Forests are at the forefront of conservation concerns because harboring extremely rich global terrestrial biodiversity (Ricard et al., 2016), they remain subject to high levels of deforestation, fragmentation, and selective logging, among other impacts (Newbold et al., 2015). In the last 20 years of the last century, human pressures, including habitat conversion, agricultural land reclamation, urban expansion, led to reductions in forest land in China. After 2000, due to the implementation of six key forestry projects and, in particular, the "Grain for Green" Project, forest land increased by 2.37×10^5 hm^2, primarily in the Loess Plateau and the southern hilly areas (Liu et al., 1996; Liu et al., 2014). According to the study of Song and Deng (2017), the ecosystem service values (ESVs) of forest land in China was approximately $26.02 billion; however, during the period 1988–2000, the ESVs of forested areas decreased significantly by $2011 million, but during the period 2000–2008, the ESVs of forested land increased by $642 million. Although China has implemented various policies or projects to restore forest resources, most were originally intended to control soil erosion, land desertification and other environmental issues, whereas there has no specific policy on biodiversity conservation for forest land. Hence, we sought to determine the primary factors influencing forest land use change and forest fragmentation patterns and interference under the forest policies from 1990 to 2010 in China. The findings may provide policy implications for environmental decision-makers about forest biodiversity conservation.

Despite extensive research on the impacts of particular land-use changes on ecosystem services, especially highly contrasting land uses, e.g., forests versus agriculture (Bulte and Horan, 2003;

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Eichner and Pethig, 2006; Hernandez et al., 2014; Xie et al., 2015), very little is known about biodiversity persistence within such heterogeneous landscapes under forest land protection policies (Ricard et al., 2016). Our current understanding of biodiversity responses to forest disturbance change in forests regions is limited by some of the methodological limitations of past studies (Ricard et al., 2016). Stephen et al. (2004) proposed that the conversion of natural habitat in agricultural fields, managed forests or other human-dominated land uses will occur where it is profitable to do so by a simple trade model with a species-area curve. However, these profit-making activities may have a devastating impact on forest biodiversity. Historically, giant pandas were widely distributed throughout China, whereas today, they are divided into more than 20 isolated populations from south to north. Recent human activities, such as the construction of national highways, have further hampered the proliferation and gene flow of giant pandas and exacerbated the risk of extinction of these small populations (Haddock et al., 2007; Wei et al., 2014). Therefore, it is important to know the primary factors influencing changes in land use, especially land attributes and characteristics. Indeed, it is not sufficient to simply study this aspect, as fragmentation is one of the manifestations of landscape pattern change (Xie and Lu, 2017) and the size of habitat determines the diversity and abundance of species (Eichner and Pethig, 2006), landscape structure and spatial configuration also influence the richness of biodiversity. Keken et al. (2016) analyzed the role of spatio-temporal changes in landscape structure between 1950 and 2012 for wildlife-vehicle collisions in the Czech Republic. The evolution of landscape characteristics of forest patches has an effect on many of spatial patterns and ecological processes within a landscape (Gu et al., 2010), Yao and Xie (2016) explored the impact of landscape patterns on the ecological security of land use. Nonetheless, traditional forest landscape pattern indexes have been developed with regard to global change rather than local change. In summary, limited research has been performed to determine the impact of forest policies on biodiversity, and few studies have focused on the impact of changes in the land attributes and characteristics of forests, which can both affect forest land quality. A forest's quality has a significant impact on the recovery of biodiversity (Gren et al., 2014). Using a grid, the effect of land attributes on the quality of forest land can be fully considered and the local fragmentation of forest land can be identified.

This paper attempts to identify the policies that have influenced forest land change in China from 1990–2010. Jiangxi Province is the study area, and a logistic regression analysis model is constructed to explore the direct influencing factors on forest land change. A forest fragmentation analysis model (non-traditional forest landscape pattern index) is then applied to analyze the forest fragmentation pattern and interference mode. Finally, policy recommendations for biodiversity conservation are proposed based on the results of the analysis.

The major objectives of this study were fourfold. Specifically, our goals were to (a) identify the direct influencing factors of forest land change based on the logistic model; (b) use the forest fragmentation analysis model to analyze the forest fragmentation pattern and spatio-temporal variation in Jiangxi Province; (c) quantify the impact of human and natural disturbances on the forest land change process; and (d) provide policy recommendations that favor regional biodiversity.

Policy analysis

After the reform and opening up movement in China, the tremendous pressures of sustained population growth and the intensification of various social and economic activities led to the development of the farming industry and the expansion of farming areas, which resulted in the shrinking of forest land area (Jin et al., 2016; Xu et al., 2004). China's forests are a valuable resource that have changed and developed in tortuous ways. Since the mid-1990s, the sharp decline in forest area has led to an ecological crisis in China. The Chinese government has launched several large or super-large ecological protection projects (EPPs), including the following: the Natural Forest Resources Protection Project, which was implemented to restore the natural forest in the upper reaches of the Yangtze River, the upper reaches of the Yellow River and China's northeastern natural forest; the Grain for Green Program, which was implemented to curb soil erosion and also has wide coverage throughout China and provides long-lasting forest protection; the Wildlife Protection Project and Nature Reserve Construction Project, which were implemented to control the declining trend of biological diversity in nature reserves; and the Fast-Growing and High-Yield Forest Base Construction Project, which was implanted to address the supply of wood and forest products. These projects protect forest land from deforestation or increase the forest area.

The authority to approve land acquisitions (AALA) is an important legal provision that has had important effects on forest land use. In the 1986 version of the "Land Administration Law of the People's Republic of China," forest land acquisition approval authority was granted to the provincial government for expropriations of less than 2000 acres and the county-level government for expropriations of less than 10 acres. When the land acquisition approval process was less strict, forest land could easily be requisitioned. In 1998, the new "Land Administration Law of the People's Republic of China" reclassified the land conversion process, adjusted the rights to examine and approve land requisitions, and eliminated the approval authority of county-level and city-level governments. The provincial government is now responsible for approving expropriations of 70 ha or less (including forest land), and the State Council is responsible for the approval of other land expropriation issues. Moreover, the approval authority for cultivated land is now more stringent than it is for other land types, such as forest land; therefore, forest land is more likely to be expropriated than cultivated land under the same conditions.

Cultivated land balance (CLB) policy was proposed for the first time in 1996; it has been granted legal status and has had a profound impact on changes of forest land. The cultivated land balance policy was implemented to maintain the quantity and quality of cultivated land across China because of the high conversion of cultivated land to construction land. CLB directs that within a given period and administrative unit, any area taken out of cultivation must be offset by putting at least an equal additional area into cultivation (Song and Pijanowski, 2014). Supplementation of existing cultivated land in response to the CLB policy was conducted over the last decade in three ways: land exploitation, land consolidation and land rehabilitation. Land exploitation refers to the conversion of non-farmland (mostly natural areas) to farmland. It is considered the least expensive and easiest form of cultivated land supplementation. However, because of the shortages of cultivated land resources in China, a large amount of forest land was reclaimed for cultivated land while the policy was being implemented.

In 2008, the Communist Party of China's Central Committee and the State Council promulgated the Opinions on Promoting the Reform of Collective Forest Tenure System (RCFTS) (He et al., 2016; Xie et al., 2014). The contractual management rights and forest ownership of collective forest lands were given to farmers, and the policy greatly improved the enthusiasm of farmers for afforestation, forest protection, and silviculture (He et al., 2016). The common role of these policies is to create a spatial and quantitative increase or decrease in forest land and generate a total increase, decrease, or balance in forest land; however, they have caused profound changes to the internal structure, pattern and quality of forest lands. In addition, forest fragmentation, which is a manifestation of

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