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Effects of conservation policies on forest cover change in giant panda habitat regions, China

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ABSTRACT

After long periods of deforestation, forest transition has occurred globally, but the causes of forest transition in different countries are highly variable. Conservation policies may play important roles in facilitating forest transition around the world, including China. To restore forests and protect the remaining natural forests, the Chinese government initiated two nationwide conservation policies in the late 1990s – the Natural Forest Conservation Program (NFCP) and the Grain-To-Green Program (GTGP). While some studies have discussed the environmental and socioeconomic effects of each of these policies independently and others have attributed forest recovery to both policies without rigorous and quantitative analysis, it is necessary to quantify the outcomes of these two conservation policies simultaneously because the two policies have been implemented at the same time. To fill this knowledge gap, this study quantitatively evaluated the effects of the two conservation policies on forest cover change between 2001 and 2008 in 108 townships located in two important giant panda habitat regions – the Qinling Mountains region in Shaanxi Province and the Sichuan Giant Panda Sanctuary in Sichuan Province. Annual forest cover change rate was evaluated using a land-cover product (MCD12Q1) derived from the Moderate Resolution Imaging Spectroradiometer (MODIS). This product proved to be highly accurate in the study region (overall accuracy was ca. 87%, using 425 ground truth points collected in the field), thus suitable for the forest change analysis performed. Results showed that within the timeframe evaluated, 94% of townships (i.e., 101 out of 108) in both regions exhibited either increases or no changes in forest cover. After accounting for a variety of socioeconomic and biophysical attributes, a linear regression model suggests that the GTGP had a positive and significant effect on the annual forest cover change rate after seven years of implementation. Our results also suggest that elevation has a significant positive effect on forest cover change, while the percentage of agricultural population, initial forest cover in 2001, and the interaction term of elevation and slope had negative significant effects. Findings from this study will be useful for evaluating the implementation of current conservation policies, designing future conservation policies, developing future giant panda habitat conservation projects, and achieving forest sustainability in China and elsewhere.

Introduction

Unprecedented rates of human population growth and other factors (e.g., timber harvest, cropland cultivation, infrastructure construction) have caused the conversion of natural forests to other land cover types across the world (Myers, 1990; Pahari and Murai, 1999; Carr, 2004, 2005). However, while the overall amount of forest cover has been declining worldwide, an opposite trend – forest expansion – started to occur in France in the late 18th century (Mather, 1992), and then spread to other European, North American and Asian countries (Totman, 1986; Foster et al., 1998). With the spread of industrialization and urbanization, the trend of increase in forest cover also appeared later in many developing countries across the world. For instance, four major developing countries in Asia – China, India, Vietnam, and Bangladesh – have been experiencing forest regeneration since the 1980s (Rudel, 2005; Mather, 2007). During recent decades, a similar trend of positive forest cover change has also been identified in Latin American countries, such

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as Mexico, Ecuador, and Brazil (Klooster, 2003; Baptista and Rudel, 2006; Farley, 2007). This turning point of forest cover change from negative to positive was termed 'forest transition' (Mather, 1992, 2004; Mather et al., 1998, 1999; Mather and Fairbairn, 2000).

Forest transition has therefore been reported for many places around the world, and has been documented at length (Mather, 1992, 2007; Grainger, 1995; Mather and Needle, 1998; Rudel, 1998; Rudel et al., 2005, 2010; Barbier et al., 2010). In addition, an extensive body of literature exists on the many factors that play important roles as determinants of forest transition across the world (Kaimowitz, 1997; Foster and Rosenzweig, 2003; Klooster, 2003; Perz and Skole, 2003; Nagendra et al., 2005; Pan and Bilsborrow, 2005; Lambin and Meyfroidt, 2010). But two arguments have been suggested to generalize the observed patterns (Rudel, 1998; Rudel et al., 2005). The first one establishes that deforestation raises the price of wood and wood products, which not only induces people to harvest the remaining primary forests but also encourages them to plant more trees (Prunty, 1956; Hart, 1968, 1980; Sedjo and Clawson, 1983; Royer, 1987; Rush, 1991; Haeuber, 1993; Fairhead and Leach, 1995; Hardie and Parks, 1996; Walters, 1997). The second one states that industrialization creates many off-farm job opportunities that attract laborers to shift from farm to off-farm economic activities, leading to the abandonment of marginal farmland and its re-conversion to forests (Hart, 1968; Bentley, 1989). However, this binary rationale (i.e., wood scarcity and economic development) does not explain all forest-transition phenomena. A variety of causal factors (driving forces) that operate under different environmental, socioeconomic, and political contexts are also important (Mather, 2007; Trac, 2011), since neither development nor forest plantation alone can guarantee the emergence of a forest transition (Klooster, 2003; Perz and Skole, 2003; Perz, 2007). Therefore, it is important to develop a thorough understanding of the driving forces behind forest transitions under different contexts.

Governments play important roles in facilitating forest transition by establishing different mechanisms (e.g., policies) that try to preserve and/or restore forest cover (Grainger, 1995; Mather, 2007; Nagendra, 2007). Therefore, the role of government policies should not be overlooked in forest transition theory (Viña et al., 2011), particularly in developing countries (Jack et al., 2008). As a part of government activities, Payments for Environmental (or Ecosystem) Services (PES) have emerged globally during the past few decades (Ferraro and Kiss, 2002). These programs provide direct (e.g., land purchases, leases, and easements) or indirect (i.e., alternative economic and social benefits) incentives to individuals or communities for mitigating the overexploitation of natural resources and stopping the degradation of natural systems associated with them (Ferraro and Kiss, 2002). However, many externalities (e.g., natural disasters and economic recession) may lower the cost-effectiveness of indirect approaches (Ferraro, 2001; Ferraro and Kiss, 2002; Ferraro and Simpson, 2002). Therefore, direct incentives have become prevalent, and more direct conservation payment programs have been initiated by governments and international non-governmental organizations around the world (Milne and Niesten, 2009). These programs not only reward local communities for conservation activities, but also help them develop alternative income opportunities (James et al., 1999; Ferraro, 2001).

The demands of its large population and booming economy have caused deforestation and many other environmental problems in China, particularly during the last 60 years (Liu, 2010). Excessive timber harvest of natural forests and reclaiming farmland on hillsides of the upper reaches of the Yangtze and Yellow Rivers are considered the main reasons for the frequent droughts and floods during the 1990s in the Yangtze and Yellow rivers floodplain areas (World Wildlife Fund, 2003; Liu and Diamond, 2005; Hu et al., 2006), which have demonstrated the urgency of stopping deforestation and expanding the areas under forest cover (World Wildlife Fund, 2003). But it was only after suffering severe droughts in 1997 and huge floods in 1998 (Weyerhaeuser et al., 2005; Liu et al., 2008) that the Chinese government initiated two nationwide PES programs [the Natural Forest Conservation Program (NFCP) and the Grain-to-Green Program (GTGP, also called Sloping Land Conversion Program, or Grain for Green Program) in 1998 and 1999, respectively] to restore the degraded forest ecosystems.

The main goals of the NFCP and GTGP are to conserve (through logging bans with regular patrolling, and payments for ecosystem services schemes) and restore (through afforestation and reforestation) forests in ecologically sensitive areas (e.g., areas with steep slopes). Besides regular patrolling by forest bureaus at county level and in very few places (e.g., Wolong Nature Reserve for giant pandas) decentralized household monitoring, provincial and local governments also set timber checking stations along main roads to control illegal logging. While in China, forests are managed at three organizational levels: state, collective, and household, NFCP targets the state-owned and collective-owned forests. The forest bureau in each county allows petitions of certain amount of timber extraction in collective-owned through applying permits. Local households also can collect fuelwood and timber in forest parcels where they have use rights. Details of these programs have been summarized in previous studies (Zhang et al., 2000; Xu et al., 2006; Liu et al., 2008; Chen et al., 2009). Government reports declare that both conservation policies have achieved the established goals. For instance, it has been reported that by the end of 2008, the NFCP had protected around 108 million ha of natural forests and planted about 5.7 million ha with trees (State Forestry Administration, 2009a). It has also been reported that by the end of 2008, about 9.1 million ha of cropland in steep areas and 13.6 million ha of barren land have been planted with trees through the GTGP (State Forestry Administration, 2010a). In addition, results of the 7th national forest resources survey (2004 through 2008) showed that forest cover in China grew steadily since the previous survey, from 18.2% of the country's area by the end of 2003 to 20.4% by the end of 2008 (State Forestry Administration, 2010b).

These two conservation programs have drawn worldwide attention due to their operating scales, amount of public investments, and environmental implications (Xu et al., 2000, 2004, 2007; Zhao et al., 2000; Ye et al., 2003; Shen et al., 2006; Uchida et al., 2007; Wang et al., 2007; Liu et al., 2008; Uchida et al., 2009; Cao et al., 2010). However, most published studies have focused on the evaluation of social, economic, and ecological effects of each of these programs independently, and acting at either the national level or the household level (Uchida et al., 2007; Xu et al., 2007; Liu et al., 2008), while very few studies have been conducted at township and county levels (Trac et al., 2007; Zhou et al., 2007). The township level, in particular, is highly relevant because townships constitute the basic implementation unit of the NFCP and GTGP (Zhu and Feng, 2003). In addition, township is the basic stratum of the overall 5-level planning system (i.e., National-Provincial-City-County-Township) for land use in China (Ou et al., 2002). As a basic administrative level, township-level statistical data are often collected each year, which are not only an important data source for higher administrative levels (e.g., county, province), but also provide relatively sufficient, proximate and accurate socioeconomic indicators that can be used for identifying driving forces of land-cover change. Township governments are in charge of making specific annual plans based on socioeconomic and biophysical conditions of the township, as well as tasks directly assigned by higher level governments (Zhu and Feng, 2003). In addition, very few studies have evaluated the simultaneous environmental effects of these two programs (Viña et al., 2011). This is important since conservation policies, such as the NFCP and GTGP, together with other driving forces (e.g., demographic, economic, technological, cultural and biophysical) may be some of the most important determinants