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A complex adaptive systems perspective of forest policy in China

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ABSTRACT

The world's forests have historically been managed as systems in which environmental health is compromised for the sake of economic efficiency and growth. China's forest policy framework has generally followed this paradigm as large-scale deforestation over the 20th century led to landscapes that, while economically productive, were made vulnerable to natural disturbances. However, in recent decades China has experienced substantial forest reforms that aim to protect important forested lands while simultaneously increasing timber outputs from plantations. Multiple green growth oriented programs have been in place to attain these objectives with the anticipation that rural poverty can be alleviated and the vulnerability towards natural disasters can be avoided. A growing body of research demonstrates the success of these reforms for improving the lives of landowners while also increasing the country's forest cover. However, these reforms have brought upon substantial change to the relationship within and between social, economic and ecological properties of the nation's forest system, and consequentially its ability to respond and adapt to change in the future. The objective of this paper is to describe the relationship between forest policy and environmental change in China during the last century using a complex adaptive systems framework. This approach demonstrates the coupled nature of policies and forest dynamics that need to be considered in future policy development. China's green growth directed policies and practices must embrace a perspective of constant change and the inevitability of perturbations and disturbances. In this way, China can begin to consider how to build resilience into its policies and management strategies so that the overall system maintains a level of flexibility that allows it to adapt to unforeseen economic and ecological change.

1. Introduction

The management of natural resources has drastically altered landscapes around the world (Steffen et al., 2006). For decades, the prevailing paradigm of natural resources policies has focused on optimization of outputs by simplifying natural ecosystems and enforcing policies with narrow objectives across diverse landscapes (Folke et al., 2004). This paradigm treats the growth of natural resources as a stable process, where inputs are controlled and outcomes are predictable (Drever et al., 2006). While this mode of governance has produced substantial social and economic wealth, there is growing evidence that the paradigm is leading to the production of social and ecological systems that are more vulnerable to economic and natural disturbances (Folke et al., 2002).

A predominant example of this paradigm has been China's forest policies over the 20th century that have exploited the countries forests for timber production in order to satisfy the country's increasing desire for wood and wood products and for supplying export market demands (Démurger et al., 2009). China has a long record of large-scale deforestation, which in recent decades helped facilitate the rise of the globalized Chinese economy and mass population growth during the second half of the 20th century (Wang et al., 2004). However, this period of exploitation has led to widespread land use change (Zhang and Song, 2006), loss of habitat for thousands of native species and created social and economic disparities between landowner farmers and those selling timber in domestic and international markets (Li et al., 2007).

While pressure for more sustainable forest policies was mounting from environmental groups in China in the late 20th century, the most significant reform to the country's forestry practices were precipitated by the 1998 floods of several major rivers including the Yangtze and Yellow Rivers (Ji et al., 2011). The flooding of the Yangtze reportedly caused 1320 deaths, affected 223 million people, and destroyed over 150,000 homes (Xu et al., 2006). While numerous causes of this flood have been reported, deforestation is often cited as the most prominent driver (Démurger et al., 2009). The direct link between deforestation and these floods prompted significant forest policy reforms at the national level that aimed to curb deforestation in key areas in order to decrease soil erosion and sandificaiton of deforested lands. At the same time, new reforestation and afforestation programs were put into place to increase China's forest cover to further assist with soil erosion problems as well as improve the livelihoods of rural farmers.

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China set forth to dramatically reform its forest policies to increase its forests across the country, but at the same time it also focused efforts on enhancing its ability to produce sufficient timber for domestic and international markets (Wang et al., 2004). This was accomplished through multiple programs that distributed land tenure and resource extractions rights to local governments and landowners, and provided subsides to farmers for transferring agricultural land to forests from which timber could be sold. Additionally, the government set aside large areas for plantations where the primary purpose is to grow fast, high-yielding species (Yin et al., 2003). This time period can be seen as one in which China invested considerably in a green growth approach to managing its forests as engaged in a more sustainable use of natural resources for assisting economic growth.

Previous studies have revealed numerous positive outcomes from these reforms, including decreased biodiversity loss (Xu et al., 2009), increase in overall household income (Li et al., 2011), increase in carbon sequestration (Huang et al., 2012), diversification of industries (Zhang, 2006) and an increase in soil carbon stocks (Deng et al., 2014). Moreover, overall forest cover has increased in recent decades due to reforestation and afforestation efforts (see current forest land cover in Fig. 1). However, these benefits are contrasted against some of the adverse consequences of the reform programs that include a decrease in household income in some areas and in some specific parts of the forest industry (Wang and Maclaren, 2012), inappropriate site selection for specific tree species – mostly involving selecting the wrong species to be used in plantation (Trac et al., 2013) and afforestation sites (Cao et al., 2011), and continued soil erosion in managed areas (Fu et al., 2011). Several problems with administering these programs have also been noted, such as a lack of interagency cooperation and long term planning as well as the use of inappropriate technical practices in specific areas resulting from an overemphasis on a top-down administration of the programs (Xu et al., 2006).

These studies together provide an understanding of how successful the sustainable reforms have been to date. However, less attention is paid to how the management of China's forests as a dynamic natural resource system in which social and ecological processes interact over time to produce uncertain and at times adverse outcomes, such as the 1998 floods in which ecological degradation affected hundreds of millions of people. Existing critiques are largely based on quantitative metrics the measure improvements (or lack thereof) of social (e.g. income) or ecological (e.g. forest cover, carbon stocks) dimensions of the sustainable forest programs (Yin et al., 2003). While some of this work has focused around the quantification of ecosystem services (Lü et al., 2012) in which both ecological and social dimensions are collectively considered for evaluating the programs, a theoretical modeling framework is still needed that can conceptualize the forest reforms as a dynamic, interrelated system built upon the complex relationships between policies, landowners, land managers, landscapes and forests. Rarely are the programs evaluated as interacting systems in which ecological and social processes become intertwined and at times inseparable because of how income dependencies often drive management decisions that impact forest ecosystems and their connected landscapes, and likewise how specific ecological consequences of management force changes in human behavior.

The goal of this paper is to provide an alternative perspective of China's forest reforms over the last century by examining the coupled nature of economic and ecological change. This paper seeks to utilize a complex adaptive systems (CAS) framework to describe China's recent history with its forests, and to frame its current policy paradigm in order to provide a means to forecast how socioeconomic and ecological

Fig. 1. Forest cover across China.