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Policy-driven China's Grain to Green Program: Implications for ecosystem services

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ABSTRACT

The policy-driven China's Grain to Green Program (GTGP) is one of the biggest programs in the world because of its massive scales, largest investment and enormous effects. One research concern surrounding the GTGP is how to evaluate its ecological implications for ecosystem services. Taking Yangtze and Yellow river basins as the study area, we provide an overview of the development status and demand for the GTGP, construct the evaluation index system and distributed measurement methods of ecosystem services, and analyze the implications for ecosystem services of the GTGP as rigorously as possible from various sources of combined data. Although there are time lags in ecological implications, but the GTGP also have global implications because it increase vegetative cover and water conservation, enhance soil fertility and carbon sequestration, and atmosphere environmental purification by controlling soil erosion. The future implications for ecosystem services of the GTGP may be even bigger. The main driving factors on the implications changes were the policy and socioeconomic factors, such as the policy governance, the adjustment of economic structure and increased income of peasant households. By contrast, natural environment factors, such as precipitation, terrain slope, and etc., were in a secondary role. The existing problems and challenges for the GTGP were analyzed, and put forward some recommendations to overcome their shortcomings and enhance their potential. The GTGP can provide important experiences for the implementation of similar ecosystem service programs in China and many other parts of the world.

1. Introduction

Forestry plays an important role in dealing with climate change, protecting biodiversity, improving the ecological environment and ensuring human well-being (Woodbury et al., 2007; PGAFESC, 2010; Knoke et al., 2014). The GTGP (Grain to Green Program) is an important program of natural ecological system restoration in China, and it is also the largest forest ecological construction project in the world (SFAPRC, 2014; Deng et al., 2014). The GTGP refers to steps taken to stop soil erosion from farming, desertification and salinization of cultivated land, low grain yield and unstable land, and plant trees and grass and restore vegetation (Cao et al., 2009; Deng et al., 2012; Song et al., 2014), and its ultimate goal is to control soil and water loss, and improve the ecological environment quality. China's GTGP is one of five major ecological projects in the world, and as a new round of the program is implemented in China, huge ecological and environmental effects are expected (Li, 2009; Chen et al., 2009). Moreover, the GTGP has important global implications, although it was initially developed to address pressing environmental problems in China. If implemented adequately and sustainably, it can generate many implications to China and the rest of the world. One research concern surrounding the GTGP is how to evaluate its implications for ecosystem services quantitatively.

The observation and evaluation of the ecosystem services of restored forest resources in developed countries have gone through three stages: wood resources investigation, forest resources investigation, and forest environmental observation (IUFRO, 1994; Baccini et al., 2012). These stages developed as serious global environmental changes were occurring. The initial studies have evaluated the forest ecosystem services from the view of economic value and have focused on the supply of the ecosystem (Costanza et al., 1997; Farley, 2012; Braat and De Groot, 2012). In recent years, the forest ecosystem services studies have

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emphasized on ecological and human social issues (Lakerveld et al., 2015; Xie et al., 2017). Some studies have realized that the forest ecosystem services involved many fields, such as ecological effects (e.g., water conservation, soil conservation, carbon sequestration and oxygen release, etc.), socio-cultural, and economic (De Groot et al., 2012; Cotton et al., 2016; Wei et al., 2017). The UK National Ecosystem Assessment (UK NEA) Technical Report was promulgated in 2011, which is the first analysis of the UK's natural environment in terms of the benefits it provides to society and the nation's continuing prosperity, and it produced an independent and peer-reviewed assessment of the state and value of the UK's natural environment and ecosystem services (Brown et al., 2011). The forest ecosystem services evaluation should be a process that includes supply, delivery, demand, and consumption (Woodall et al., 2011; Uthes and Matzdorf, 2016). These components may be separated by their spatial distributions (e.g., soil conservation or flood regulation, etc.). Therefore, in order to effectively manage forest ecosystem, the forest ecosystem services evaluation should try to integrate such fields and different components, and construct the comprehensive evaluation index system and measurement methods of ecosystem services.

Because of the long-term pursuit of economic interests in the wood industry, forest resources investigations in China were primarily concerned with forest area and accumulation. In 1999, the assessment of "forest health grade" was increased in the supplementary provisions of "the main technical requirements of the National Forest Resources Inventory." Its purpose was to gradually increase the contents of the forest health condition survey in forest resources investigation. In 2004, the State Forestry Administration promulgated "the technical requirements of the National Forest Resources Inventory" (SFAPRC, 2004), and some factors were increased in the "Technical Regulation" reflecting forest ecological status, such as community construction, stands construction, plant construction and vegetation cover degree. The forest ecological function evaluation factors and the classification standard of the type were also increased (Long et al., 2006). Moreover, the State Forestry Administration began to pay more attention to the development of a forest resources inventory system. As of the Seventh National Forest Resources Inventory, the forest ecological service special assessment has been conducted. In 2009, "China's forest ecological service functions assessment" was officially released, and the ecosystem service continuous inventory and assessment was first used in the national forest resources inventory. Particularly since the implementation of the GTGP in China, more and more people focus on this problem, that is, how to evaluate the implications for ecosystem services of the GTGP quantitatively has been an urgent one (Persson et al., 2013). Moreover, Conservation International has been implementing conservation projects in the forest, but in the absence of an estimation of forest ecosystem services for the area to justify greater investment and attention provided towards its protection, this has been challenging (Song et al., 2014; Kibria et al., 2017).

To address the above research gap and to improve management of the area, in this article, taking Yangtze and Yellow river basins as the study area, based on an overview of the development status and demand for the GTGP, we want to achieve the following objectives: (1) to construct the evaluation index system and distributed measurement methods of ecosystem services; (2) to analyze the implications for ecosystem services of the GTGP as rigorously as possible from various sources of integrated and combined data; (3) to discuss the driving factors on the dynamic changes of the implications for ecosystem services of the GTGP, illustrate existing problems and challenges, and put forward recommendations to overcome their shortcomings and enhance their potential. The results can provide important experiences for the development, implementation, and sustainability of similar ecosystem service programs in China and many other parts of the world.

2. Materials and methods

2.1. Implementation situation of the GTGP

To mitigate the impacts of the degraded environment, China has been implementing the GTGP. The GTGP is by far the ecological construction program with the largest investment (354.2 billion yuan), the most extensive distribution range (25 provinces and 2279 counties), and the largest number of people involved. In the Yangtze and Yellow river basins alone, nearly 33.5% of cropland were on slopes of $\geq 25°$. There are 13 provinces in the upper and middle reaches of the Yangtze and Yellow river basins (Table 1). The vegetation recovery types of the GTGP include cropland afforestation, wasteland afforestation and facilitate afforestation; the forest types of the GTGP include ecological forest, economic forest and shrub forest (Wang et al., 2013). Due to the differences among ecological environments between the provinces, the proportion of the three vegetation recovery types to the forest types of the GTGP can vary widely. However, the implementation area of the GTGP in all the provinces has a significant change. From 1999 to 2014, the total implementation area of the GTGP in the

Table 1
Implementation area of GTGP in provincial region in Yangtze and Yellow river basins (1999–2014).

Provincial region	Total Area (10^4 hm^2)	Vegetation recovery type			Forest type		
		Cropland afforestation (10^4 hm^2)	Wasteland afforestation (10^4 hm^2)	Facilitate afforestation (10^4 hm^2)	Ecological forest (10^4 hm^2)	Economic forest (10^4 hm^2)	Shrub forest (10^4 hm^2)
Inner Mongolia	286.09	92.20	171.83	22.06	98.89	1.91	185.29
Ningxia	80.40	31.20	45.12	4.08	14.95	0.48	64.97
Gansu	189.69	66.89	106.76	16.04	99.75	24.06	65.88
Shanxi	156.50	46.27	98.70	11.53	89.63	5.82	61.05
Shaanxi	245.46	101.56	128.11	15.79	132.19	60.35	52.92
Henan	109.34	25.11	71.46	12.77	85.17	22.91	1.26
Sichuan	197.65	88.74	94.63	14.28	156.54	26.16	14.95
Chongqing	127.73	44.12	69.84	13.77	111.26	9.66	6.81
Yunnan	120.32	36.11	69.39	14.82	76.14	29.88	14.30
Guizhou	133.53	43.79	73.23	16.51	118.85	6.96	7.72
Hunan	140.94	50.40	75.77	14.77	137.94	3.00	0.00
Hubei	107.57	33.13	71.87	2.57	88.46	19.11	0.00
Jiangxi	70.94	18.61	40.62	11.71	63.34	5.85	1.75
Total	1966.16	678.13	1117.33	170.70	1273.11	216.15	476.90

GTGP: Grain to Green Program.