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Economical assessment of forest ecosystem services in China: Characteristics and implications

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ABSTRACT

China is an important country in the world in terms of forestry and the function of its forest ecosystem. It is an essential issue to account the value of the forest ecosystem services (FESs) of China in both ecological economy and environmental policy making. However, a big challenge exists because of the variety in climate types, forest vegetation, and silvicultural measures. In the current study, the monetary value of some important China's FESs, such as water conservation, soil conservation, carbon sequestration and oxygen release, nutrient accumulation, atmosphere environment purification, and biodiversity conservation, was estimated to be about 10.01 trillion RMB/year (1.48 trillion US dollars/year) in 2008, wherein the largest fraction was water conservation (40.51%). A four-fold variation used to exist in the FESs per unit area by the provinces which are geographically used as assessing units. This value of FESs was about 33% of the gross domestic product (GDP) of China in 2008. The values of FESs are unevenly distributed across the country, decoupling from GDP among different provinces. The value of China's FESs will continue to have a fast increasing trend due to massive forestation in the future decades. Beyond that, it is clear that how much ecological benefits human obtained from forest, what kind of ecological benefits offered by forest, and which are predominant or potential FESs types in province under different natural and social conditions according to ecological location quotient (ELQ). Compared with the Engel's coefficient (EC) of individual and the willingness to pay index (WTP) of governmental to FESs, we can conclude that insofar as we have a thorough understanding of the value and functions of FESs, and bring the government WTP and individual EC into full play, and promote the high environmental protection consciousness, it will have large potential WTP for improving the environment quality based on the low level WTP of the government in reality. Moreover, these results show important implications in making a policy for ecological complementary on the national scale in China and in assessing FESs in other countries, and will be useful to scientists, managers, policy makers and people who are concerned with relationship between human and natural systems.

1. Introduction

Coupled human and natural systems (CHANS) are systems in which human and natural components interact (Liu et al., 2007). According to Mooney and Ehrlich (1997), the idea that humans depend on natural systems dates back as far as Plato, but the first modern publication that addresses this issue is Man and Nature by George Perkins Marsh in 1864. Today, interactions between human and natural systems have emerged as special concerns because human activities are globally connected. At the same time human societies and globally interconnected economies rely on ecosystems services and support (Millennium Ecosystem Assessment (MA), 2005). Ecosystem services are the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life (Daily, 1997), which include provision services, regulation services, cultural services and support services. It is now clear that patterns of production, consumption and wellbeing not only develop from economic and social relations within and between regions but also depend on the capacity of other regions' ecosystems to sustain them (Arrow et al., 1995; Folke et al., 1998).

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Valuation of ecosystem continued throughout the next few decades (De Groot et al., 2002), but research and attention have expanded greatly since the estimation on the value of the ecosystem services and natural capital of the world (Costanza et al., 1997). The development of science-based policy has been increasingly recognized as an effective way for protecting and managing the environment in the context of global change (Sun and Chen, 2006; Daily and Matson, 2008; Fisher et al., 2008; Mäler et al., 2008; Carpenter et al., 2009). The more recent Millennium Ecosystem Assessment has provided a new general conceptual framework for estimating the value of ecosystem services at the regional, national, and global scales (MA, 2005). In April 2011, a report for the UK national ecosystem assessment (UK NEA) was published. It was the first and relatively complete assessment of ecosystem services at a national scale (UK NEA, 2011). The UK NEA included four recognized services, namely the supporting, regulating, provisioning, and cultural services, provided by all main ecosystems.

Among all ecosystems on earth, this paper focuses on valuing the China's forest ecosystems services (FESs). Forests not only provide timber but they also critically represent important habitats for the ecosystem services they supply (e.g., Miller and Tangley, 1991; Mendelsohn and Balick, 1995; Pearce, 1998, 1999). The FESs are diverse and difficult to quantify accurately at a national level. In the last two decades, the estimation of the value of FESs at the national or regional scale has been the focus in ecosystem services studies. For instance, the economic techniques for estimating the total economic value (TEV) of forests in Mexico was put forward (Adger et al., 1995), however, only a proportion of this value can feasibly be 'captured' within Mexico: much of the benefit of Mexico's forests falls outside the country's borders, and is therefore not considered by forest users or national policy makers. The benefits include maintaining water quality, reducing storm water run-off and erosion, improving air quality, regulating climate and carbon sequestration, providing habitat for wildlife, maintaining biodiversity, and providing a destination for recreation and tourism in addition to providing timber and non-timber resources, which were estimated in America (Krieger, 2001). The economic value of Mediterranean forests, which brought together forest valuations at the national level from eighteen Mediterranean countries, based on extensive local data collection, and also explores the research findings in the context of the institutions and policies that affect Mediterranean forests and proposes new policy approaches for improving forest policies and management at the national, regional and local levels (Merlo and Croitoru, 2005). The study on the total economic value of Amazonian deforestation during the period of 1978–1993 also suggested the value of FESs from different points of view (Torras, 2000), and scientists combined the green income accounting and total economic value approaches and applies the new framework to Brazil in order to assess the foregone economic benefits resulting from Amazonian deforestation. Canada also assesses the real value of Canada's boreal ecosystems (Anielski and Wilson, 2005). The assessment work was carried out three times in 1972, 1991, 2000 in Japan (Wang, 2005), and more recently research on UK (UK NEA, 2011). All these studies showed the high value of FESs, which has important implications in the development of a policy to protect and manage forests using the so-called ecological compensation.

In the last 30 years, the forest resources of China have rapidly increasing along with the growth of its economy. In 2008, the total area of forests was 195 million ha with a growing stock of more than 13 billion cubic meters (State Forestry Administration, SFA, 2009a). Forested areas covered 20.36% of the land base of China in 2008, a value that has tripled from 8% 60 years ago. China is an important country in the world in terms of the importance of forests. Without a doubt, the benefits of afforestation and reforestation make an important contribution to the environment improvement and economic development. The value of China's FESs in both forest ecology and forestry economy is an essential issue to consider. Based on the latest national forest resources survey (the seventh) and socioeconomic data, the current study aims to show the monetary value of China's FESs in national scale in 2008, and to display the characteristics and implications of these assessments in an international context. Meanwhile, this paper showed ecological location quotient (ELQ) in each province, which mainly distinguish predominant and potential FESs. In addition, it also illustrated the relation between the individual Engel's coefficient (EC) and the governmental willingness to pay index (WTP) to FESs.

The research is committed to supporting policy action towards a sustainable use of forest resources nationwide, and the forest economic evaluation challenge has gradually reached the national policy agenda. The methodology and approaches for assessing FESs and the application of the results are currently being developed in China and in other countries, but there still exist uncertainty factors during assessing FESs. Therefore, sharing research methods and results among scientists, forest managers, policy-makers, and the public in different countries is important. While Chinese scientists and policy-makers desire to learn from the works done in other countries, the diverse conditions of China favor the development of a methodology that is applicable to other countries with different climatic, geographical, and hydrological conditions. Thus, China should also play an important role in the development of environmental and forestry management.

2. Data and method

This section introduces the data source all used and establishes a framework for the evaluation of FESs in China.

2.1. Data source

The data used in this assessment were from three kinds of sources. Firstly, the field measurement data, which mainly consist of ecological properties (e.g., net primary productivity (NPP), water and soil conservation, etc.) and characteristic parameters were obtained based on 50 long-term research stations (consisting of 286 supplement stations) of China Forest Ecosystem Research Network (CFERN). This network covers almost the forest ecosystems of all dominant trees in the country. Secondly, the forest inventory dataset. Although China's State Forestry Administration are available from 1973 to 2008, that means seven periods national forest resources inventory (NFI) (1973–1976 (1th NFI), 1977–1981 (2th NFI), 1984–1988 (3th NFI), 1989–1993 (4th NFI), 1994–1998 (5th NFI), 1999–2003 (6th NFI), 2004–2008 (7th NFI)), only the period of 2004–2008 (7th NFI) are complete and report both the forest area and timber volume and some ecological parameters. The data recorded included the forest group (planted and natural forests), dominant tree species and age class. In the present study, we used the 7th NFI data. Thirdly, the social-economical public data released by authorities is referred as well.

2.2. Established a framework for the ecological valuation of FESs in China

We evaluated the valuation of FESs based on the framework. As Fig. 1 shows, the framework consists four steps: (1) selection the indicators of the FESs assessment; (2) identification the units of assessing FESs; (3) calculation process; and (4) synthesis the results of FESs.

2.2.1. Selection the items of the FESs assessment

Ecosystems generate numerous benefits or "ecosystem services" to the various biological, including provisioning, regulating,