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Measuring the socioeconomic impacts of China's Natural Forest Protection Program

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ABSTRACT. China has been implementing one of the world's largest ecological rehabilitation projects, the Natural Forest Protection Program (NFPP), to improve its fragile and precarious environmental conditions. This paper measures the socioeconomic impacts of the NFPP using input–output (I–O) models. We find that the NFPP will expand the annual output of the forest sectors by 5.8 billion Yuan and the whole economy by 8.9 billion Yuan by 2010. Employment will increase by 0.84 million in the forest sectors and by 0.93 million in the whole economy. Associated with the enormous expansion of forest protection and management are huge contributions to mitigating water runoff, soil erosion, flooding, and biodiversity loss. The investments and adjustments are thus worthwhile, if the program is properly implemented. The challenges are to transform loggers into tree planters and forest managers and to ensure that the financial and institutional commitments by the local and national governments will be materialized.

Introduction

China has been implementing one of the world's largest ecological rehabilitation projects, the Natural Forest Protection Program (NFPP), to improve its fragile and precarious ecosystem conditions. Zhang *et al.* (2000) reported on the NFPP and discussed policy measures for its implementation. Loucks *et al.* (2001) argued that the NFPP could strengthen the pandas' future in China's forests by enhancing protection and restoration of corridors among

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remaining forest fragments and increasing habitat preservation. Zhao and Shao (2002) noted the logging restrictions induced by the NFPP and their potential economic and environmental impacts. While the NFPP has drawn broad attention, little has been done to measure its potential environmental and economic impacts. The goal of this paper is to tackle this important issue using an input–output (I–O) analysis based on the recent Chinese national statistics.

Population growth, economic development, and policy failures have resulted in severe environmental problems in China, such as loss of biodiversity, desertification, and soil erosion (World Bank, 1994; Fullen and Mitchell, 1994; Zhang *et al.*, 2000). While the country has made efforts to combat these problems (SFA, 2000), they have not been very effective, and the macro ecological conditions have worsened. In particular, the 1998 floods along the Yangtze River and waterways in the northeast devastated large parts of China, leading to the loss of more than 3,000 human lives and US $12 billion in property damage and output reduction (Liu, 2002; Liang, 1998). It has been accepted that the floods were caused mainly by deforestation and farming on steep slopes (Liu, 2002; Xu *et al.*, 2006). In response, the government has, among other things, initiated the NFPP to protect and expand its forest resources throughout this decade.[1]

While the primary objective of the NFPP is to protect the existing forests, it also aims to expand their coverage through natural regeneration and artificial planting in order to mitigate the occurrence and influence of natural disasters (Zhang *et al.*, 2000). To achieve these objectives, bans of commercial logging are imposed in the southwest, harvests are substantially reduced in the northeast and other regions, and forestation and vegetation activities are carried out.

According to the government plan, the protection and management of over 95 million hectares (ha) of forestland will be greatly strengthened.[2] In addition, 0.5 million ha of bare or degraded land will be afforested every year, and 1.4 million ha of mountains and hillsides will be closed for natural regeneration. Forest cover in the targeted areas will increase from the current 17.5 per cent to 26.8 per cent by 2010 (SFA, 2000). Table 1 summarizes the proposed activities of forest protection, management, and expansion during 1998–2010. The Chinese government hopes that the NFPP and other initiatives will not only greatly improve the domestic ecological conditions but also significantly contribute to the regional and even global environmental protection.

Altogether, the NFPP covers 17 provinces and autonomous regions, including 414 counties or forest bureaus in the upper reaches of the Yangtze River (from the Three Gorges Dam upward) and 358 counties or forest bureaus in the middle and upper reaches of the Yellow River (from

[1] The Sloping Land Conversion, or 'Grain for Green', Program is the other new initiative of ecological rehabilitation. For more details, see Forest and Grassland Taskforce (2003) and Xu *et al.* (2006).

[2] China has a total forestland of 155 million ha (Xu *et al.*, 2006).

Table 1. *Forest regeneration and tree planting under the NFPP*

Area planted or managed	*Unit*	*1998*	*1999*	*2000*	*2005*	*2010*
Total afforestation	1,000 ha	290	478	775	549	549
Artificial regeneration	1,000 ha	289	441	303	344	344
Aerial seeding by airplane	1,000 ha	1	37	152	205	205
Human-facilitated natural regeneration	1,000 ha	139	378	259	259	259
Mountain closure	1,000 ha	2,433	2,207	816	1,463	1,463
Stand tending	1,000 ha	882	1,679	1,281	1,281	1,281

Note:

1. Data sources include the *China Forestry Development Report* (SFA, 2000–2002) and the *China Forestry Statistics Yearbook* (1998–1999).

the Xiaolangdi Dam upward). In addition, it encompasses 84 state forest bureaus, 12 provincial forest enterprises, and one county in the northeast; four provincial forest enterprises and seven county-level forest farms in Hainan; and two state forest bureaus, 25 counties, and four county-level forest farms in Xinjiang (SFA, 2000).

Given the lack of relevant data, this paper does not attempt to assess the environmental impacts of the NFPP. Rather, it will focus on NFPP's socioeconomic impacts on various forest sectors as well as the whole economy. By socioeconomic impacts we mean the concomitant changes in employment, wages and salaries, total output, and value added. In this context, input–output (I–O) analysis is an appropriate technique because it emphasizes inter-sectoral linkages of the economy and can be used to quantify the impacts of either changes in final demands on various economic sectors or changes in the output of one sector on the other sectors and the whole economy. Luckily, we have obtained China's national I–O table for 1997, which is a valuable data source to support our analysis. Of the 124 sectors included in the national I–O table, five are identified as forest sectors: forest management, logging and hauling, sawmilling and panel production, furniture and solid wood products, and pulp and paper making.

The socioeconomic impacts of the NFPP on a specific sector or the whole economy come from two sources – the increased investments in forest protection and management, and the logging bans and harvest reductions. Notably, these changes have distinct features. First, impacts induced by the former should be positive, whereas impacts induced by the latter should be negative. Second, the former are changes in final demand, while the latter are changes in the output of one sector. The objective of this study is to quantify the socioeconomic impacts caused by these different changes. We believe that this study is important and timely for better understanding the potential ramifications of the NFPP and its more effective implementation.

Researchers have extensively applied I–O analysis to forestry, but few have simultaneously considered the impacts of both changes in final

demands and changes in the outputs of certain sectors. For instance, Munn (1998) and Wu (2002) used I–O analysis to assess the importance of the forest products industry in Mississippi and Texas to the state economies. However, they focused only on the economic impacts of final demand changes, with little consideration of the impacts of exogenous output changes in one sector on the other sectors. In the context of the NFPP, both changes in final demands and outputs in the logging and hauling sector are relevant. As to the recent case studies done by Chinese scholars (e.g., Chen *et al.*, 2001; Sheng, 2002) in examining the impacts of the NFPP, they are descriptive and preliminary, and little in-depth analysis was conducted. Also, limited attention was given to the linkages of the economy.

The paper is organized as follows. First, we articulate the specific impacts of the NFPP in section 2 to motivate the development of I–O models in section 3. In section 4, a base case (without the NFPP) is first presented, followed by an analysis of the effects of the policy (with the NFPP). The two scenarios are then combined to determine the impacts of the NFPP on the forest sectors and the whole economy. Finally, conclusions are summarized and suggestions for future work are made in section 5.

Impacts of the NFPP

As noted, the socioeconomic impacts of the NFPP may be induced by the logging bans and harvest reductions, or by the increased investments in forest protection and management. Before we use I–O models to quantify them, it is necessary to define these specific impacts and their sources.

First, the NFPP has significantly reduced timber supply. Roundwood production from natural forests decreased from 32.1 million m^3 in 1997 to 29.3 million m^3 in 1998 and further to 22.8 million m^3 in 1999. Between 2003 and 2010, roundwood production from natural forests will be maintained at 12.1 million m^3 (SFA, 2000), implying that the NFPP will cause a reduction of 20 million m^3/yr in roundwood production throughout this decade. Since the NFPP has mainly reduced the supply of large- and medium-diameter logs (>14 cm), many sawmills have been facing operation difficulty or even shut down. Furthermore, the enlarged gap between timber demand and supply has caused timber prices to rise. For example, it is reported that the log prices in the Beijing area increased by 20–30 per cent in 1998 (Studley, 1999). Partly to fill this gap and partly to meet the growing demand, China has turned increasingly to the international market. Figure 1 shows that the imports for timber products have risen sharply following the implementation of the NFPP.[3]

Because of the logging bans and harvest reductions, the logging, hauling, and processing equipment and facilities owned by the state, worth almost 15 billion Yuan (US$ 1.8 billion), have become obsolete and thus have been abandoned (Li, 2001). Also, an additional one billion Yuan/yr (US$ 120 million) of interest payments for bank loans – an obligation of

[3] As pointed out by a reviewer, in addition to alleviating the pressures on domestic forests, increased timber imports enable the maintenance of a larger share of the wood products processing facilities, which will further swing the balance towards positive net effects of the NFPP.

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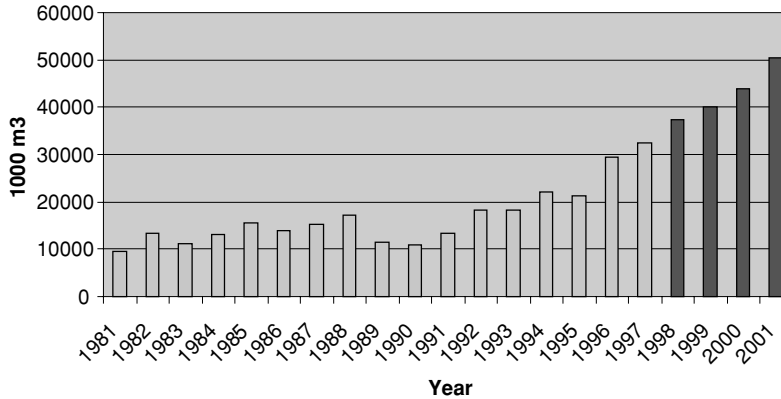

Figure 1. *China's timber imports since 1981*
Notes:
1. Data are from China Customs Statistics (1981–2001).
2. Volumes of different products are converted to roundwood equivalence.

Table 2. *Governmental financial support for implementing the NFPP since 1998 (unit: 1000 Yuan)*

Year	*Total expenditure*	*Infrastructure construction*	*Equipment and facilities for fire control, etc.*	*Afforestation and forest management*	*Compensation to workers*
1998	4,341,260	62,070	57,120	2,158,420	2,063,650
1999	7,605,340	49,360	28,450	4,014,440	3,513,090
2000	9,493,190	61,612*	35,512*	5,010,932*	4,385,133*
2001–2010*	100,000,000*	649,018*	374,079*	52,784,491*	46,192,412*

Notes:
1 Data sources include the *China Forestry Development Report* (SFA, 2000–2002) and the *China Forestry Statistics Yearbook* (1998–1999).
2 An outlay of 100 billion Yuan (US$ 12 billion) has been planned for the period of 2001–2010 (Zhao and Shao, 2002; Xu *et al.*, 2006).
3 *indicates that data are estimated based on the allocation made in 1999.
4 Afforestation and forest management include seedling production, mountain closure, stand tending, artificial and natural regeneration, and pest control.

state forest enterprises – has been accumulated, waiting for write-off by the central government (SFA, 2000; Xu *et al.*, 2006). Meanwhile, the NFPP has laid off a large number of workers in the logging, hauling, and processing sectors, with 0.5 million employees transferred to the forest protection and management activities (SFA, 2000). As a result, the payments for wages and salaries in these sectors have dwindled.

In comparison, forest protection and management activities have been expanded substantially because of the government investments. Table 2

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shows that the total expenses in these activities would reach 121 billion Yuan (US$ 14.6 billion) by 2010 – more than 10 billion Yuan a year. In accordance with these structural adjustments, more permanent as well as temporary employees have been added, and the total payments for wages and salaries in forest protection and management have increased tremendously.

Similarly, the NFPP has affected the other sectors of the economy. On the one hand, logging bans and harvest reductions have reduced the total output, employment, wages and salaries, and value added; on the other, these socioeconomic measures have been expanded due to the increased governmental investments. For instance, in local communities near the natural forests, farmers, who had attached themselves to the logging, hauling, and processing activities through direct employment or indirect services, have been hit hard by the NFPP. Their losses were estimated at 2.3 billion Yuan (US$ 277 million) of sales revenue a year (Yu *et al.*, 2002), and their net income was reduced by 18 per cent (Chen *et al.*, 2001). But farmers have also gained from the new job opportunities of tree planting (and even forest protection) due to the combined effect of its seasonality and large workload. As another example, it was estimated that the NFPP reduced the value-added and employment of railway freight by 223 million Yuan and 14,000 workers, respectively, in 2000 (SFA, 2000).

In short, the forest sectors have extensive interactions with other sectors of the economy. The implementation of the NFPP results in not only intra-sectoral but also inter-sectoral impacts due to their interdependency, and these impacts can be categorized as direct, indirect, and induced effects. The NFPP's direct effects refer to the changes in production, employment, wages and salaries, and value-added caused to the forest sectors. The NFPP's indirect effects refer to the changes in economic activities in other sectors, resulting from the forest sectors' altered purchase of their goods and services. The induced effects of the NFPP come from changes in consumption of goods and services by the employees in the forest sectors. The total socioeconomic impacts of the NFPP on the forest sectors thus include all these effects. Here, the overarching questions are: How will the new forestry program affect the forest sectors and other sectors? What will be the positive impacts induced by the government investments and the negative impacts induced by the logging bans and harvest reductions? By how much will the former be larger than the latter? We address these questions below.

I–O models and data

Socioeconomic impacts can be measured based on the transaction relationships embedded in an I–O table. Referring to table 3, the transactions in an I–O table can be divided into sub-matrices X, Y, and Z. Let $X = \{x_{ij}\}$, where x_{ij} is the amount of sales from sector i to sector j or the amount of purchases from sector j to sector i ($i, j = 1, 2, \ldots, n$); $Y = \{y_i\}$, where y_i is the final demand from sector i; and $Z = \{z_j\}$, where z_j is the total purchase of sector j. By definition, the total output of each sector is equal to the intermediate demand from other industries and the final demand; likewise, the total input of each sector is equal to the intermediate inputs

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Table 3. *A stylistic input–output table*

	Purchasing sector (*j*)					
Producing sector (*i*)	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*Total sales*
(1)	x_{11}	x_{12}	x_{13}	x_{14}	y_1	z_1
(2)	x_{21}	x_{22}	x_{23}	x_{24}	y_2	z_2
(3)	x_{31}	x_{32}	x_{33}	x_{34}	y_3	z_3
(4)	x_{41}	x_{42}	x_{43}	x_{44}	y_4	z_4
Total purchases	z_1	z_2	z_3	z_4		

from other industries and the final payment. So, the sales and purchases of a given sector are equal; that is, $z_i = z_j$ for $i = j$.

Further, let $A = \{a_{ij}\}$, where $a_{ij} = x_{ij}/z_j$ is the portion of total purchases by sector j from sector i. Then, from $X = A \times Z$ and $X + Y = Z$ we know that $Y = (I - A) \times Z$, where I is an $n \times n$ identity matrix. Thus

$$Z = (I - A)^{-1} \times Y \tag{1}$$

The above equation links the level of total economic activity Z to final demand Y by the multiplier matrix$(I - A)^{-1}$ derived from the I–O table (Leontief, 1936). Note that the column sums of the multiplier matrix represent the total effects on the outputs of different sectors of the economy given a unit change in final demand, which are called the output multipliers.

The multiplier matrix reveals the linkage between sectors in the economy and presents two types of multipliers: type I and type II. Type I multipliers sum together direct and indirect impacts, while type II multipliers also include induced effects. In this paper, type I multipliers are adopted. This is because treating household consumption as endogenous will entail forecasting its future values with its identified determinants, which is beyond what our data can accommodate at this point of time. Also, in a developing economy like China's, where a substantial part of the labor force does not participate effectively in the production process, it may not be easy to determine the relation between population size and total output (Hubacek and Sun, 1999). In any case, we expect that the induced effect should be only a small portion of the total effect.

Response to final demand changes

Depending on the sources of exogenous changes, the policy impacts on certain sectors and/or the whole economy may be assessed in different ways. If the vector of final demands changes by ΔY, equation (1) can be written as

$$\Delta Z = (I - A)^{-1} \times \Delta Y \tag{2}$$

thus, a vector of total output changes (ΔZ) can be computed directly. In the current context, changes in final demands are changes in the government investments in forest protection and management.

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Based on the estimated multipliers, it is possible to derive employment changes as well. The formula for the employment change in sector j is

$$\Delta\mu_e = \sum_i (e_i/q_i)^* INV_{ij}\Delta Y \tag{3}$$

where $\Delta\mu_e$ represents employment change due to the final demand change, e_i is the number of employees in sector i, q_i denotes the total output in sector i, and INV_{ij} is an element of multiplier matrix$(I - A)^{-1}$ (Schaffer, 1999).

Similarly, the wages and salaries change can be obtained from the formula

$$\Delta\mu_h = \sum_i (h_i/q_i)^* INV_{ij}\Delta Y \tag{4}$$

where $\Delta\mu_h$ represents wages and salaries change driven by the final demand change, and h_i is the household income of sector i. INV_{ij} and q_i are defined the same as above.

Likewise, the value-added change can be calculated from

$$\Delta\mu_v = \sum_i (v_i/q_i)^* INV_{ij}\Delta Y \tag{5}$$

where $\Delta\mu_v$ represents the value-added change derived from the final demand change, and v_i is the value-added of sector i.

Response to output changes

In many I–O models, only the final demand is considered exogenous. But a mixed type of I–O model may be employed, in which final demands for some sectors and gross outputs for the remaining sectors are specified exogenously (Miller and Blair, 1985). In our case, the output of the logging and hauling sector is determined exogenously. If the output of sector h, $\overline{Z}_h$, is also exogenously determined, equation (1) can be modified as follows

$$\begin{bmatrix} Z_1 \\ \cdot \\ \cdot \\ \cdot \\ Z_{h-1} \\ Z_{h+1} \\ \cdot \\ \cdot \\ \cdot \\ Z_n \end{bmatrix} = (\mathrm{I} - \mathrm{A}^*)^{-1} \begin{bmatrix} Y_1 + a_{1h}\overline{Z}_h \\ \cdot \\ \cdot \\ \cdot \\ Y_{h-1} + a_{h-1,h}\overline{Z}_h \\ Y_{h+1} + a_{h+1,h}\overline{Z}_h \\ \cdot \\ \cdot \\ \cdot \\ Y_n + a_{nh}\overline{Z}_h \end{bmatrix} \tag{6}$$

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where A^* is a new $[(n-1)\times(n-1)]$ input coefficient matrix that differs from A above. Equation (6) can be further modified as

$$\begin{bmatrix} \Delta Z_1 \\ \cdot \\ \cdot \\ \cdot \\ \Delta Z_{h-1} \\ \Delta Z_{h+1} \\ \cdot \\ \cdot \\ \cdot \\ \Delta Z_n \end{bmatrix} = (\mathrm{I} - \mathrm{A}^*)^{-1} \begin{bmatrix} a_{1h}\Delta\overline{Z}_h \\ \cdot \\ \cdot \\ \cdot \\ a_{h-1,h}\Delta\overline{Z}_h \\ a_{h+1,h}\Delta\overline{Z}_h \\ \cdot \\ \cdot \\ \cdot \\ a_{nh}\Delta\overline{Z}_h \end{bmatrix} \tag{7}$$

Combining equations (3)–(5) with equation (7), we can examine the negative impacts of the roundwood output decline caused by the logging bans and harvest reductions on the other forest sectors and the overall economy as well. For example, the impacts of the logging bans and harvest reductions on employment in sector h can be measured by

$$\Delta\mu_e^* = \sum_i (e_i/q_i)^* INV_{ij}^{**} \begin{bmatrix} a_{1h}\Delta\overline{Z_h} \\ \cdot \\ \cdot \\ \cdot \\ a_{h-1,h}\Delta\overline{Z_h} \\ a_{h+1,h}\Delta\overline{Z_h} \\ \cdot \\ \cdot \\ \cdot \\ a_{nh}\Delta\overline{Z_h} \end{bmatrix} \tag{8}$$

where $\Delta\mu_e^*$ represents employment changes due to the output change in the logging and hauling sector, e_h is the number of employees, q_h denotes the total output, and INV_{ij}^* is an element of the multiplier matrix $(I - A^*)^{-1}$.

I–O data

We used China's 1997 national I–O table for our analysis (State Statistics Bureau (SSB), 1998). Since 1981, the SSB has compiled eight national I–O tables. In collaboration with Hong Kong Chinese University, the SSB has recently converted these tables into a uniform format in constant prices. Of the 124 sectors in the national I–O tables, five are identified as forest sectors: forest management, logging and hauling, saw-milling and panel production, furniture and solid wood products, and pulp and paper making. Three other sectors closely related to the forest sectors – coal mining, construction, and railway freight – are also identified.

To focus on the sectors of our primary interest and to reduce the involved workload, an aggregation of other sectors was made. We combined the four agricultural sectors – cropping, fisheries, livestock, and other agricultural

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production – into one, and the three printing and cultural sectors – printing and recording media, cultural goods, and toy production and recreation – into one. Likewise, we combined the ten chemical production-related sectors into one, the six transportation equipment-related sectors into one, the 60 other sectors in secondary industry into one, the ten production sectors in the tertiary industry into one, and the 23 service sectors in the tertiary industry into one. As a result, the final table for analysis contained 15 sectors.

The 1997 data reflect socioeconomic activities just one year before the initiation of the NFPP, and thus matched our base case nicely. All of the estimated monetary values are in 1997 Chinese Yuan. Employment data were taken from China's 1997 *Statistics Yearbook* and *Forestry Statistics Yearbook*. Other data for the forest sectors were obtained from the China Forestry Development Reports (SFA, 2000–2002).

Before proceeding to the presentation of our results, a brief discussion of some data issues is warranted. First, some may question the way we aggregated the 124 economic sectors into 15 for analysis. Our view is that to make our analysis as well as presentation practical, it is necessary to cut down the number of sectors we deal with. There are two approaches to do so. One is to aggregate the 124 sectors first and then create the inverse matrix of the aggregated sectors and do the necessary calculations. The other is to create the inverse matrix of the 124 sectors and do the necessary calculations first and then aggregate the calculated results for presentation. Conceptually, the latter is the better approach. But the former was used for data and computational reasons in this paper.

In addition, China's statistics in general and its GDP in particular are suspected of inconsistency and inaccuracy, due to the changing procedures of data gathering and local officials' 'obsession' with GDP growth rates – the leading criterion for evaluating cadre performance (Rawski, 2001). While we acknowledge these problems and our concern with their influence on data and thus analytic reliability, we think that their potential effect on our study is small. Primarily, given the way the multiplier matrix $(I - A)^{-1}$ is derived, these problems are pretty much offset. Also, even if the base-year (1997) economic activities have been overstated, say, by 2 per cent, the direct impact on our aggregate assessment would be very limited.

Moreover, we may argue that the figures of the initial NFPP impacts, reported by the State Forestry Administration, could be an overestimation of its positive effects and an underestimation of its negative effects. After extensive field visits and discussions with many scholars, our finding is that, while it is quite likely that the official estimates are incomplete, it is less likely that they have been intentionally manipulated. In any case, caution is warranted in interpreting our results and drawing policy implications.

Results

In this section, we first show the direct and total effects of the forest sectors on the economy in 1997 as a base case, which is meant to provide a picture of what roles the forest sectors then played. Next, we present the policy scenario with the NFPP, including its positive and negative impacts on

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Table 4. *The direct effects of the forest sectors on China's economy in 1997*

Sector	*Number of employees*	*Total industry output (1,000 Yuan)*	*Wages and salaries (1,000 Yuan)*	*Value-added (1,000 Yuan)*
Forest management	12,152,000	82,587,000	53,458,412	60,538,329
Logging and hauling	962,858	30,015,155	8,682,428	18,639,838
Sawmilling and panel production	1,215,919	87,119,576	12,112,873	26,576,558
Production of furniture and woodworks	542,720	136,998,635	18,024,779	36,037,235
Paper and paperboard production	2,227,609	243,754,236	40,732,149	71,594,631
Total	17,101,105	580,474,602	133,010,641	213,386,591

Notes:

1 Employment data were taken from the *China Statistics Yearbook* (1997) and the *China Forestry Statistics Yearbook* (1997). Based on available information, the authors estimated employees in the forest sectors. Other data were from the national input–output table (State Statistics Bureau, 1998).
2 All monetary values are in 1997 Yuan.

the forest sectors, and on the whole economy in terms of total output, employment, wages and salaries, and value-added.

The base case

China's forest sectors are important to the whole economy (table 4). In 1997, the country produced 63.9 million m^3 of roundwood, 20.1 million m^3 of lumber, 16.5 million m^3 of wood-based panels, and 44.8 million tons of pulp and paper products (including products made of non-wood fibers). In addition, the forest sectors produced such value-added products as veneers, woodchips, and furniture products. Together, these sectors employed 17.1 million workers, and paid 133.0 billion Yuan in wages and salaries. In addition, they generated outputs worth 580.5 billion Yuan, of which value-added amounted to 213.4 billion Yuan.

In terms of employment, the forest management sector ranked first, the paper and paperboard sector ranked second, and the furniture-making sector ranked the last (figure 2). As for total output, the paper and paperboard sector was the largest, furniture making and solid wood products sector ranked second, whereas the logging and hauling sector was the smallest. For value-added, the paper and paperboard sector was the largest, the forest management sector ranked second, while the logging and hauling sector was the smallest.

Table 5 summarizes the total effects for the forest sectors. The estimated output effects of the forest sector were 1.55 trillion Yuan in 1997. The output

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Figure 2. *Shares of the direct economic impacts of the forest sectors in 1997*
Notes:

1 Employment data were taken from the *China Statistics Yearbook* (1997) and the *China Forestry Statistics Yearbook* (1997). Other data were from *The 1997 National Input–Output Table* (State Statistics Bureau, 1998).
2 All monetary values are in 1997 Yuan.

share of the forest sectors accounted for 8 per cent of gross domestic output, of which the value-added share of the forest sectors was 4 per cent of the national GDP.[4] Also, they provided 45.9 million jobs, and paid 329.4 billion Yuan in wages and salaries.

The policy scenario

The impacts of the NFPP on the forest sectors and on the whole economy are considered over the period 1998–2010.[5] The increased government investments are used to: (1) support construction projects required for forest management and fire control, such as house, road, and fire tower building; (2) purchase equipment and vehicles for fire control and transportation, and (3) increase seed and seedling production, stand tending, artificial regeneration, pest control, and other activities.

In contrast, the logging bans and harvest reductions have resulted in decreases in roundwood production, employee lay-offs, wages and salaries cuts, and a decline of value-added in the logging and hauling sector. The reduced log production has in turn affected the production in the other forest sectors. Because timber production from natural forests would be

[4] Despite the bottleneck nature of the forest sectors to the Chinese economy, the shares of industry output and GDP are much higher compared with those, say, for the United States. In addition to China's stage of economic development, a main reason is that the country takes the gross value of the standing forests into account.

[5] Since we intended to focus on the socioeconomic impacts of the NFPP in this study, we decided not to consider questions related to changes in timber production and forest management outside of the NFPP coverage and the increased imports of forest products. Certainly, they can be addressed in a similar manner.

Table 5. *Total economic impacts of the forest sectors on China's economy in 1997*

Sector	*Number of employees*	*Total industry output (1,000 Yuan)*	*Wages and salaries (1,000 Yuan)*	*Value-added (1,000 Yuan)*
Forest management	14,385,868	134,534,223	66,493,911	72,928,506
Logging and hauling	2,145,001	56,303,064	15,513,229	13,981,045
Sawmilling and Panel production	6,270,840	237,313,725	45,052,224	39,706,736
Production of furniture and woodworks	7,688,145	411,954,895	69,320,103	68,522,741
Paper and paperboard production	15,365,932	711,274,861	133,028,394	138,678,470
Total	45,855,786	1,551,380,768	329,407,861	333,817,499

Notes:
1 Total economic impacts were estimated by multiplying the multipliers with the direct effects of the forest sectors.
2 All monetary values are in 1997 Yuan.

maintained at a constant level after 2003 (SFA, 2000), no more changes should thus be expected in annual logging and hauling ($\Delta \overline{Z_h} = 0$).

Tables 6–9 summarize the impacts of the NFPP on the forest sectors. Compared with the 1997 base case, the total output of the forest sectors was reduced by 1.3 billion Yuan in 1998 due to the logging bans and harvest reductions. However, the government investments led to an output increase in the forest sectors by 2.4 billion Yuan in the same year. The net output in the forest sectors thus gained 1.1 billion Yuan. The annual output of the forest sectors will expand by 5.8 billion Yuan by 2010. In addition, there were 0.04 million laid-off employees, while the government investments added 0.34 million jobs in the forest sectors in 1998. The net increase of employment in the forest sectors was 0.3 million. While the logging and hauling sector has suffered substantial job reductions during the past several years, the employment of the forest management sector has been expanding. Notably, these results are very close to the figures reported in the *China Forestry Statistics Yearbook* (1998, 1999). The total employment of the forest sectors is projected to increase by 0.84 million by 2010.

The reduced log production caused a loss of value-added in the forest sectors by 0.8 billion Yuan in 1998, but the increased investments in forest management resulted in a value-added gain by 1.7 billion Yuan. The annual value-added in the forest sectors will increase by 4.2 billion Yuan in 2010, of which wages and salaries will account for 3.7 billion Yuan. In short, the implementation of the NFPP will greatly benefit the forest sectors from the increased governmental investments, although the benefits come with a significant cost to the logging and hauling sector.

Table 6. *Output changes in the forest sectors and the whole economy induced by the NFPP (unit: 1,000 Yuan)*

Sector		*1998*	*1999*	*2000*	*2005*	*2010*
Forest Management	Increase	2,329,344	4,330,925	5,405,977	5,694,585	5,694,585
	Decrease	155,710	367,775	504,211	0	0
	Net change	2,173,634	3,963,150	4,901,766	5,694,585	5,694,585
Logging and hauling	Increase	6,765	11,600	14,480	15,253	15,253
	Decrease	1,081,212	2,553,741	3,501,122	0	0
	Net change	−1,074,447	−2,542,141	−3,486,642	15,253	15,253
Sawmilling and panel production	Increase	7,502	11,973	14,945	15,743	15,743
	Decrease	3,976	9,391	12,875	0	0
	Net change	3,526	2,582	2,070	15,743	15,743
Production of furniture and woodworks	Increase	4,915	8,047	10,045	10,581	10,581
	Decrease	2,386	5,637	7,728	0	0
	Net change	2,529	2,410	2,317	10,581	10,581
Paper and paperboard production	Increase	22,687	37,352	46,624	49,113	49,113
	Decrease	10,356	24,460	33,533	0	0
	Net change	12,331	12,892	13,091	49,113	49,113
Subtotal net change		1,117,573	1,438,893	1,432,602	5,785,275	5,785,275
Other sectors	Increase	1,495,083	2,369,734	2,957,965	3,115,882	3,115,882
	Decrease	740,516	1,749,044	2,397,900	0	0
	Net change	754,567	620,690	560,065	3,115,882	3,115,882
Total net change		1,872,140	2,059,583	1,992,667	8,901,157	8,901,157

Notes:

1 The increase of industry output is induced by the government investments in forest protection and management, whereas the decrease is induced by the logging bans and harvest reductions.
2 See discussion in the introduction for logging bans and harvest restrictions over time; and see table 2 for investments in forest protection, management, and expansion.
3 The results are reported in annual changes for comparing with the base case.

Table 7. *Annual changes of employees in the forest sectors induced by the NFPP*

Sector		*1998*	*1999*	*2000*	*2005*	*2010*
Forest management	Increase	342,744	637,331	795,551	838,061	838,061
	Decrease	22,945	54,194	74,299	0	0
	Net change	319,799	583,137	721,252	838,061	838,061
Logging and hauling	Increase	217	378	474	502	502
	Decrease	15,909	375,762	515,161	0	0
	Net change	−15,692	−375,384	−514,687	502	502
Sawmilling and panel production	Increase	105	171	214	228	228
	Decrease	56	131	180	0	0
	Net change	49	40	34	228	228
Production of furniture and woodworks	Increase	19	33	42	45	45
	Decrease	9	22	31	0	0
	Net change	10	11	11	45	45
Paper and paperboard production	Increase	207	362	457	492	492
	Decrease	95	224	307	0	0
	Net change	112	138	150	492	492
Subtotal net change		304,278	207,942	206,760	839,328	839,328
Other sectors	Increase	40,544	69,843	88,075	94,718	94,718
	Decrease	18,244	43,090	59,075	0	0
	Net change	22,300	26,753	29,000	94,718	94,718
Total net change		326,578	234,695	235,760	934,046	934,046

Notes:

1 The positive effects are induced by the government investments in forest protection and management, whereas the negative effects are induced by the logging bans and harvest reductions. The positive effects are underestimated due to the lack of consumption data for loggers, who are compensated by the NFPP. After 2003, the negative effects induced by the logging bans and harvest reductions will be zero.

2 See discussion in the introduction for logging bans and harvest restrictions over time; and see table 2 for investments in forest protection, management, and expansion.

3 The results are reported in annual changes for comparing with the base case.

Table 8. *Annual changes of wages and salaries in the forest sectors induced by the NFPP (unit: 1,000 Yuan)*

Sector		*1998*	*1999*	*2000*	*2005*	*2010*
Forest management	Increase	1,507,780	2,803,400	3,499,279	3,686,094	3,686,094
	Decrease	100,938	238,408	326,852	0	0
	Net change	1,406,842	2,564,992	3,172,427	3,686,094	3,686,094
Logging and hauling	Increase	1,957	3,356	4,189	4,412	4,412
	Decrease	253,868	983,267	1,348,037	0	0
	Net change	−251,911	−979,911	−1,343,848	4,412	4,412
Sawmilling and panel production	Increase	1,043	1,665	2,078	2,189	2,189
	Decrease	554	1,308	1,793	0	0
	Net change	489	357	285	2,189	2,189
Production of furniture and woodworks	Increase	647	1,059	1,322	1,392	1,392
	Decrease	314	743	1,018	0	0
	Net change	333	316	304	1,392	1,392
Paper and paperboard production	Increase	3,791	6,242	7,791	8,207	8,207
	Decrease	1,733	4,093	5,612	0	0
	Net change	2,058	2,149	2,179	8,207	8,207
Subtotal net change		1,157,811	1,587,903	1,831,347	3,702,294	3,702,294
Other sectors	Increase	284,282	457,279	570,787	601,260	601,260
	Decrease	133,498	315,312	432,286	0	0
	Net change	150,784	141,967	138,501	601,260	601,260
Total net change		1,308,595	1,729,870	1,969,848	4,303,554	4,303,554

Notes:

1 The positive effects are induced by the government investments in forest protection and management, whereas the negative effects are induced by the logging bans and harvest reductions.
2 See discussion in the introduction for logging bans and harvest restrictions over time; and see table 2 for investments in forest protection, management, and expansion.
3 The results are reported in annual changes for comparing with the base case.
4 All monetary values are in 1997 Yuan.

Table 9. *Changes of value-added in the forest sectors induced by the NFPP (unit: 1,000 Yuan)*

Sector		*1998*	*1999*	*2000*	*2005*	*2010*
Forest management	Increase	1,707,467	3,174,676	3,962,716	4,174,272	4,174,272
	Decrease	114,306	269,982	370,139	0	0
	Net change	1,593,161	2,904,694	3,592,577	4,174,272	4,174,272
Logging and hauling	Increase	4,201	7,204	8,992	9,472	9,472
	Decrease	671,448	1,585,909	2,174,246	0	0
	Net change	−667,247	−1,578,705	−2,165,254	9,472	9,472
Sawmilling and Panel production	Increase	2,289	3,652	4,559	4,803	4,803
	Decrease	1,215	2,869	3,933	0	0
	Net change	1,074	783	626	4,803	4,803
Furniture and solid wood products	Increase	1,293	2,117	2,642	2,783	2,783
	Decrease	629	1,485	2,036	0	0
	Net change	664	632	606	2,783	2,783
Paper and paperboard products	Increase	6,664	10,971	13,694	14,425	14,425
	Decrease	3,046	7,195	9,864	0	0
	Net change	3,618	3,776	3,830	14,425	14,425
Subtotal net change		931,270	1,331,180	1,432,385	4,205,755	4,205,755
Other sectors	Increase	555,697	893,630	1,115,452	1,175,003	1,175,003
	Decrease	273,013	644,836	884,056	0	0
	Net change	282,684	248,794	231,396	1,175,003	1,175,003
Total net change		1,213,954	1,579,974	1,663,781	5,380,758	5,380,758

Notes:

1 The positive effects are induced by the government investments in forest protection and management, whereas the negative effects are induced by the logging bans and harvest reductions.
2 See discussion in the introduction for logging bans and harvest restrictions over time; and see table 2 for investments in forest protection, management, and expansion.
3 The results are reported in annual changes for comparing with the base case.
4 All monetary values are in 1997 Yuan.

Likewise, the NFPP has both positive and negative effects on the whole economy (tables 6–9). Compared with the 1997 base case, the annual industry output of the whole economy will expand by 8.9 billion Yuan, and the annual employment will increase by 0.93 million by 2010. Also, the NFPP will augment the annual value-added by 5.4 billion Yuan, of which wages and salaries will increase by 4.3 billion Yuan. As a result, implementing the NFPP will benefit the whole economy as well. For instance, the annual output of the agricultural sector will expand by 0.3 billion Yuan, and its annual employment will increase by 39,000 by 2010.

Conclusions and discussion

Using an I–O analysis, this paper has assessed the socioeconomic impacts of the NFPP on the forest sectors and the whole Chinese economy. The advantage of this approach is its ability to measure both intra-sectoral and inter-sectoral linkages, and to examine the economic responses to changes in the final demand and/or the output of a certain sector. To sum up, the NFPP will expand the annual output of the five forest sectors – forest management, logging and hauling, sawmilling and panel production, furniture and solid wood products, and paper and paperboard making – by 5.8 billion Yuan and the overall economy by 8.9 billion Yuan by 2010. Employment will increase by 0.84 million in the forest sectors and by 0.93 million in the whole economy.

Therefore, if properly implemented, the positive impacts of the NFPP would much more than offset the negative consequences of the logging bans. It is also clear that potentially tremendous contributions to mitigating the problems of water runoff, soil erosion, flooding, and biodiversity loss are associated with the enormous expansion of forest protection and management. These environmental impacts should be evaluated as soon as possible.

In short, the NFPP can be a great environmental and economic policy. Further, it seems worthwhile to make a trade-off between the short-run revenues and jobs from exploiting the natural forests and the long-run sustainable development. However, the challenges are to truly transform the loggers into tree planters and forest managers, to ensure the financial and institutional commitments made by the central and regional governments to be materialized, and to complete the necessary structural adjustments in an efficient and coherent fashion.

Nevertheless, care should be taken in reaching any definite conclusions from our findings. In addition to the shortcomings of our data – the 1997 national I–O table and forestry statistics may not be as consistent or reliable as we wish, the I–O model used in this study is static and thus restrictive. It assumes fixed input substitution as well as exogenous determination of the final demand. Further, our estimation was based on the routine of aggregating the 124 sectors first and then creating the inverse matrix of the aggregated sectors and carrying out the necessary calculations. We did not pursue the other alternative – creating the inverse matrix of the 124 sectors and conducting the involved calculations first and then aggregating the results to a smaller number of sectors for presentation. Therefore, the assessed policy impacts may not be very accurate.

There are other approaches, such as the computable general equilibrium (CGE) and dynamic I–O (D/I–O) models, which can be used to mitigate some of the concerns or relax some of the assumptions. However, adopting those approaches is not cost free, either. For instance, while a D/I–O model can explicitly distinguish between investment and consumption demands and make either or both of them endogenously determined (Leontief, 1936; Schaffer, 1999), it requires more data and time to develop. Also, it may not be easy to forecast the future values of these variables. As to the CGE model, its advantage of capturing the general equilibrium (rather than only the partial equilibrium) effects must be weighed against its assumptions of the existence of such an equilibrium and fixed functional forms and price elasticities, as well as its added needs for data and analytic work (Kaimowitz and Angelson, 1998). It was based on these considerations that we decided to undertake a static I–O analysis in this study. On balance, we believe that our work has provided some interesting estimates of the NFPP impacts, which should significantly advance understanding of the long-term policy-induced changes in the forest sectors and the economy.

Finally, it should be pointed out that our I–O model can be extended in other meaningful directions as well. For one, it can be expanded into an environmental I–O (EIO) analysis by augmenting the transaction matrix with additional rows and columns to represent the material flows or status changes for soil erosion and water runoff. Then, it will be practical to assess the environmental effects induced by the NFPP in a unified framework. Additionally, if regional I–O tables are available, an I–O analysis can be done at the regional level so that close attention can be given to those regions most affected by the NFPP. Fortunately, we have obtained China's first regional I–O table, which was compiled by the SSB in 2003. It will be exciting to enhance and expand our current assessment by taking its advantage.

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