Valuation of forest ecosystem goods and services and forest natural capital of the Beijing municipality, China

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An attempt to estimate the full market and non-market values of Beijing's forests, as well as the sectoral and spatial distribution of the forest benefits.

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Landscape forest around the Great Wall: forests, both natural and planted, have a critical role in Beijing's ecology, aesthetics and socio-economic development

Forest ecosystem goods and services, and the natural capital stocks that produce them, make significant direct and indirect contributions to national economies and human welfare. There have been many attempts to value these contributions. In the past two decades a good deal of progress has been achieved in developing valuation methods for forest ecosystem services and promoting their inclusion in national economic accounts.

In China the valuation of forest ecosystem goods and services has been one of the most researched topics over the past decade, with a rising number of studies at national, provincial and local management unit levels (Yang, Wen and Song, 2008). Many of these have focused on Beijing, carried out with different scales, perspectives and purposes and using different valuation concepts and methods; they have come up with widely varying results.

As the capital of China, Beijing is governed as a municipality under the direct administration of the central government. The municipality is divided into 16 urban and suburban districts and two rural counties extending over approximately 16 800 km^2, of which about 62 percent is mountainous. The municipality has been experiencing rapid economic growth and urban population expansion; at the end of 2007 its resident population was 16.3 million, and per capita gross domestic product (GDP) was 56 000 yuan (around US$7 370).[1]

[1] Conversions in this article use the average annual exchange rate for 2007, US$1 = 7.598 yuan.

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Forests, both natural and planted, and including trees spread across the terrain, have a critical role in the ecology, aesthetics and socio-economic development of the municipality. Beijing's forest resources have been increasing significantly since the 1950s as a result of active planting and management. At the end of 2007, the municipality's forest area reached almost 1.1 million hectares (Figure 1), with a total standing timber volume of 13.7 million cubic metres. The dominant tree species include *Quercus mongolica*, *Platycladus orientalis*, *Pinus tabulaeformis*, *Populus davidiana*, *Betula platyphylla*, *Robinia pseudoacacia* and *Larix principis-rupprechtii*. The forests are rich in biodiversity, hosting a variety of fauna and flora.

This article reports an attempt to estimate the full market and non-market values of these forests, using the latest survey data on Beijing's forest resources. Unlike most other valuation studies, it also includes an analysis of the distribution of the benefits from forest goods and services among economic sectors and among local, regional and global beneficiaries.

There are naturally many limitations to both the current and previous studies, many of which are pointed out in the article, and it is recognized that experts are unlikely to reach consensus on non-market values. Such efforts are nevertheless important to help raise awareness of the multifunctional roles of forest ecosystems, and can ultimately contribute to the conservation and sustainability of forest resources.

STUDY FRAMEWORK

The study applied an updated framework for valuation of forest ecosystems proposed by Hou and Wu (2008) with reference to authoritative international documents in the field (Eurostat, 2002a, 2002b; United Nations *et al.*, 2003; Millennium Ecosystem Assessment, 2003; FAO, 2004) (Figure 2).

The framework distinguishes between assets (natural capital stocks) and production (the flow value of forest goods and services), which have generally been mixed together in other valuation studies in China. Change in the former indicates whether forest management is sustainable or not. The latter is what should be counted in GDP or green GDP.

In this framework, the benefits people obtain from forests are classified into three categories: forest goods, environmental services and sociocultural benefits. Forest environmental services have been included in most studies in China, but the new framework includes an additional and innovative category, forest environmental assets. This concept differentiates, for example, forest carbon storage (as an asset) from forest carbon sequestration flow (as a service).

The valuation method in this study involved quantification of all forest ecosystem services and goods. The main methods used to value these amounts were the market value, direct revealed preference (replacement costs, productivity loss, cost of illness, etc.) and benefit transfer methods.

Data on forest area, growing stock, net increment, age classes and species were from a survey conducted by the Beijing Forestry Survey and Design Institute in 2007 applying 3S technology (integrating remote sensing, geographic information systems and global positioning systems) and field investigations. Where value data were taken from earlier studies, they were converted to 2007 values using the consumer price index for Beijing.

VALUATION CATEGORIES

Forest natural capital

Forest land assets. Forest land, one of the most important economic assets, is generally valued on the basis of market transactions, either directly (e.g. using market prices for bare forest land) or as a ratio of the value of exchanged forest property. In this study, forest land was categorized into five types (forested land, open forest land, shrub land, nursery land and bare forest land) and valued according to the prices of each type. Zhou and Li (2000) applied a stratified sampling method to investigate the transaction

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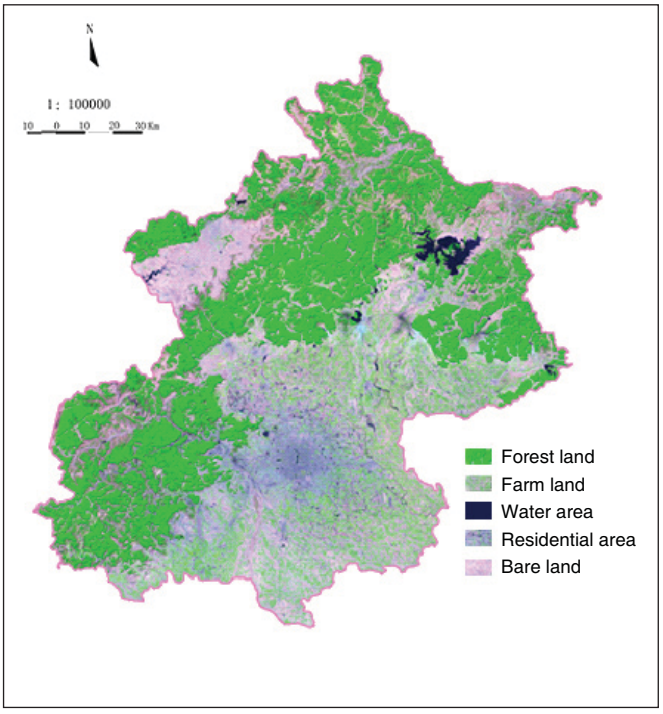
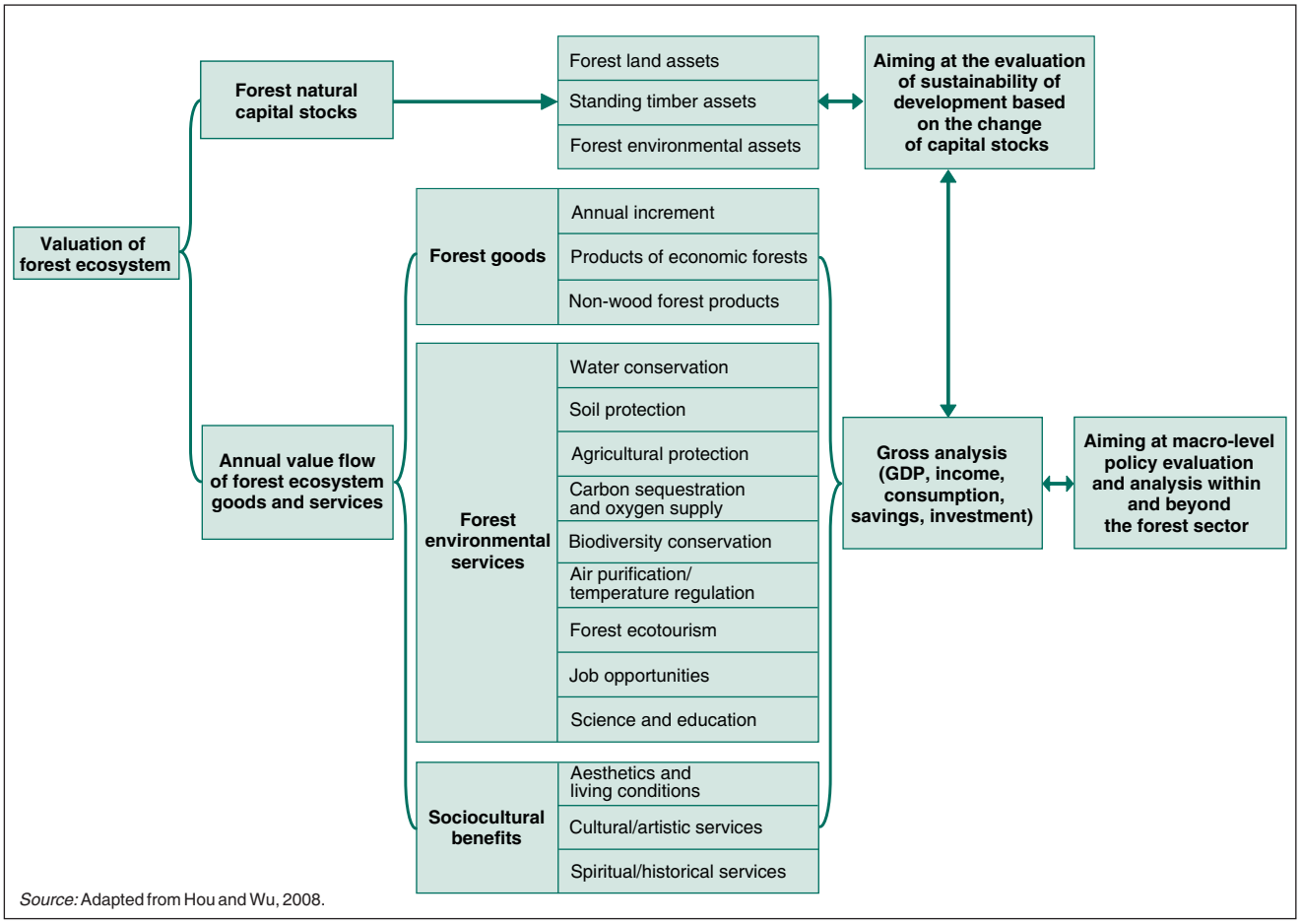
Distribution of forest ecosystems and other land use in Beijing





2
Framework for valuation of forest ecosystem services and natural capital

prices for different types of forest land in the Beijing area. Their results were converted to 2007 values.

Standing timber assets. A simple stumpage value method was used for the valuation of standing timber. Stumpage prices by species and diameter were taken from existing transactions in the study area and in southern China. In the latter case, the prices were adjusted using the ratio of consumer price index for the area of origin to that of Beijing (and other conversion factors as needed). These prices were applied to the stock according to its species and diameter composition.

Forest environmental assets. The environmental assets considered in the study were forest carbon stock and forest wildlife.

Estimates of forest carbon stock and stock changes were calculated based on growing stock and net increment using the biomass expansion factors (BEFs) of the Intergovernmental Panel on Climate Change (IPCC, 2004). The value of forest carbon stock assets was calculated by multiplying forest carbon stock by the carbon price derived from the Badaling forest farm carbon project in Beijing (178 yuan or US$23 per tonne CO_2).

For Beijing's rich wildlife resources, the study adopted the value estimated by Zhou and Li (2000) based on a valuation of wildlife for the whole country (State Environmental Protection Administration of China, 1998) and data on China's and Beijing's wildlife resources, with conversion to the 2007 value.

Forest goods

Annual increment of standing timber. The value of the annual increment of the forest stand was estimated by the stumpage value method using the annual increment by species and age classes and the corresponding stumpage prices per cubic metre by species.

Products of economic forests. The market value method was used to estimate the value of fresh fruits, nuts and flower products from economic forests, i.e. forests of economic value including those that have been specifically planted for these products. The production data were taken from the *China Forestry Statistical Yearbook 2007* (State Forestry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"Green reservoir" services of forests include the capture, storage and purification of water

Administration, 2007), and the prices came from market surveys and direct observations.

Non-wood forest products (NWFPs). The value of the main non-wood forest products (wild medicinal materials, mushrooms, wild vegetables, bee products and hunting, as well as tree breeding and planting, which are listed as NWFPs in Chinese forestry statistics) was calculated using the market value method. Production data for these products were from a survey conducted by the Beijing Municipal Bureau of Landscape and Forestry in 2007.

Forest ecosystem services

Water conservation. "Green reservoir" services of forested watersheds include the capture and storage of water (contributing to the quantity of water available during the dry season) and the purification of water through the filtering of contaminants and the stabilization of soils. The total value of water conservation services was estimated based on the water regulating capacity and the cost of supplying water for the city (which includes the sewage treatment fee).

Water quantity was estimated by the water balance method, using the forest area and rainfall data to get the total water input into the catchments and subtracting evapotranspiration and surface runoff for each forest type. The maximum water quantity regulating capacity was seen as equal to the total storage capacity of the catchment forests, and its value was estimated using the replacement cost method (using the cost of establishing a conventional water reservoir in Beijing, taken from Yu and Wang [1999] and Zhang *et al*. [2008] and converted to the 2007 value).

Soil protection. Forest vegetation helps stabilize soils, reduce surface erosion and sedimentation and maintain soil fertility. The estimated value of soil stabilization primarily reflects the costs associated with sediment clearance, calculated with the replacement cost or avoided cost method, using the average cost for sediment dredging in the Beijing area and the finding of Yu and Wang (1999) that the soil erosion on non-forested lands is 3.7 tonnes per hectare per year higher than that on forested lands in Beijing. The value of soil fertility protection was estimated by applying the market value method, assuming that the forested soil around Beijing contains on average around 2 percent compound fertilizer (Yu and Wang, 1999) and using the observed market price of compound fertilizer in 2007.

Agricultural protection. The study focused on the increased crop production benefits provided by forest shelterbelts. The market value method was adopted to estimate this value based on the increase in crop production, the area of cropland with forest shelter and the price of the crop.

Air purification and temperature regulation. Air pollution is the greatest of Beijing's environmental problems, and the municipal government has proposed tree planting as a measure to alleviate it (Yang *et al*, 2005). This study valued the services of forests in the removal of sulphur dioxide (SO_2), nitrogen oxide (NO_x) and fluoride and the suppression of dust, based on the average removal rates for these pollutants by broadleaves and conifers as


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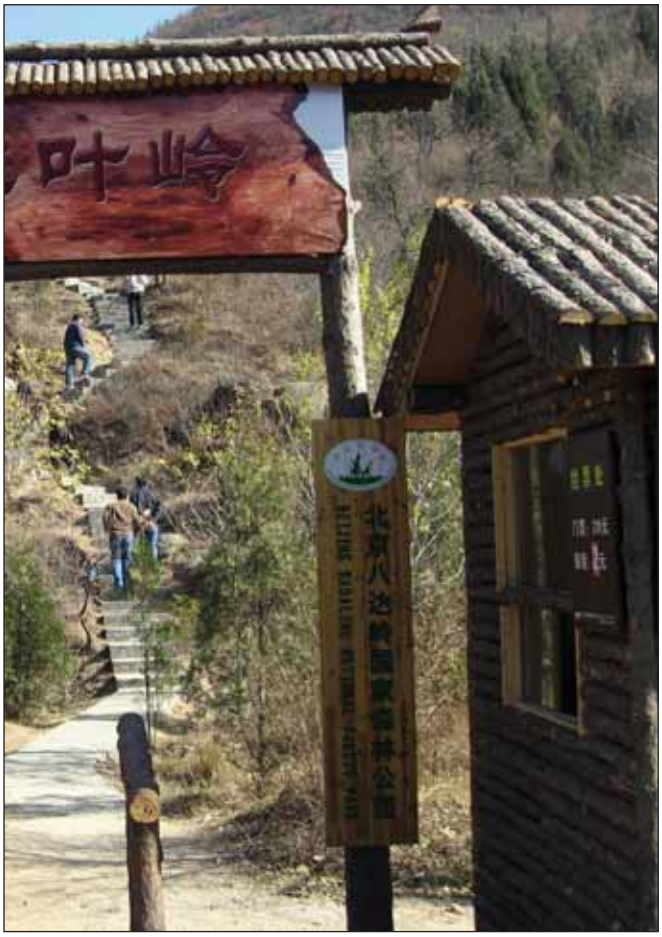
Xiangshan (Fragrant Hills) Park, a popular scenic spot for Beijing residents and visitors of all ages, has important value for outdoor recreation as well as air quality and temperature regulation – and also raises the value of the surrounding houses



FAO/J. CARLE

Forest ecotourism – a marketable environmental service (collection of entrance fees, Badaling National Forest Park)

reported in the *State report on biodiversity of China* (State Environmental Protection Administration of China, 1998). The costs of removing these pollutants were calculated based on air pollution charges in China.

The study also included the value of noise reduction by the so-called "four sides" tree belt (comprising trees on non-forested lands beside villages, houses, roads and watercourses), estimated based on the length of the tree belt, its capacity to reduce noise, and the market price of using soundproof materials. Based on Leng *et al.* (2004), it was assumed that a 4 to 5 m wide tree belt can reduce noise by 5 decibels if trees are distributed appropriately. The "four sides" belt comprises 51.9 million trees, i.e. 103.9 million metres of a double-line tree belt 8 m wide.

The study's analysis of remote sensing, field investigation and meteorological data showed that in areas of Beijing with forest vegetation, temperature was decreased by an average of 3℃ in summer (May to September). Forests also conserved heat in winter (December to February), although the effect was less pronounced. Other studies (e.g. Li *et al.*, 2002; Jiang, Chen and Li, 2006; Wu, Wang and Zhang, 2009) have indicated similar findings in this regard. The value of temperature regulation by forests was calculated based on the electricity saving achieved through reduced use of air conditioning in summer, applying the direct market method.

Carbon sequestration and oxygen supply. Annual carbon sequestration was estimated using the net primary production of forest stands and the soil carbon sequestration by type of forest stand, derived from the literature (Fang, Liu and Xu, 1996). Again, the carbon price was derived from the forest carbon project in Badaling forest farm of Beijing. The oxygen price was the observed price of industrial oxygen.

Forest ecotourism. The travel cost method has often been used to estimate the value of forest ecotourism. Because of limited time and funding, the present study applied the results from other research: the ecotourism value estimated by Zhou and Li (2000) for the 11 forest parks of Beijing, converted to the 2007 value. This value was multiplied by the total forest area used for ecotourism to estimate the total value of forest ecotourism.

Biodiversity conservation. The study adopted the average per-hectare value of forest biodiversity conservation for the Beijing area estimated by Zhang (2002) using the opportunity cost method, multiplied by the forest area of Beijing.

Forest sociocultural benefits

Job opportunities. Employment creation was considered as a social rather than an economic benefit because the capacity of forests to provide traditional employment in remote communities was seen as more important than the strictly economic benefits of employment creation, since employment opportunities are abundant in Beijing. The analysis covered direct and indirect employment, using data on personnel and wages from the *Beijing Statistics Yearbook 2007* (Beijing Statistics Bureau, 2007).

Science and education. Under sociocultural benefits the study focused on scientific research and education, while ecotourism benefits were valued separately (above). The study adopted as unit price the average value of science and education estimated by Zhang (2004) in

TABLE 1. Different types of output from Beijing's forests

Output	Marketable		Non-marketable		Total	
	Billion yuan	Billion US$	Billion yuan	Billion US$	Billion yuan	Billion US$
Forest goods	6.77	0.89	–	–	6.77	0.89
Forest ecosystem services[a]	1.12	0.15	39.96	5.26	41.08	5.41
Forest environmental services	0.38	0.05	39.66	5.22	40.03	5.27
Forest sociocultural benefits	0.74	0.10	0.30	0.04	1.04	0.14
Total	**7.89**	**1.04**	**39.96**	**5.26**	**47.85**	**6.30**

[a] Includes forest environmental services and sociocultural benefits.
Note: The ratio of services to goods is 6.07. The ratio of non-marketable to marketable goods and services is 5.06.

the Beijing Songshan National Natural Reserve using the expenditure method. The total value was estimated by multiplying this unit price by the total area of forest parks and nature reserves in Beijing.

RESULTS

Stock value of forest natural capital

The value of the capital stock of the forest resources of Beijing reached 19.5 billion yuan (US$2.6 billion) at the end of 2007, of which forest environmental assets accounted for 44.8 percent, standing timber 39.2 percent and forest land 16.0 percent. The per capita stock of forest natural capital was 1 192 yuan (US$157).

Annual flow value of forest goods and services

The flow value of annual output of forest ecosystem goods and services of Beijing was 47.9 billion yuan (US$6.3 billion), of which forest environmental services accounted for 83.7 percent, forest goods 14.2 percent and forest sociocultural benefits 2.2 percent. In other words, the value of intangible forest environmental services and sociocultural benefits was six times that of the forest material goods. The forest goods were all marketable. Of the forest environmental services, only forest ecotourism was marketable. As for the sociocultural benefits, job opportunities were marketable while the scientific and educational benefits were not. Therefore, most of the value of the annual output of forest ecosystem goods and services of Beijing, 39.7 billion yuan (US$5.3 billion), was not realized through the existing market system. Non-marketable outputs had 5.1 times the value of marketable outputs (Table 1).

Among the forest environmental services, water conservation and air purification had the most important role (Figure 3). This finding accords with the real situation in Beijing: Forest inventory data indicate that the city has scant water resources, obtaining 80 percent of its drinking-water from the Miyun Reservoir of Beijing. Protection forests account for 62.1 percent of the forest area, and watershed forests account for 86.6 percent of these protection forests. Beijing is listed among the world's ten most polluted cities (World Bank, 2000), but its forests are making a notable contribution to improving environmental and air quality.

GDP and annual output of forest goods and services

The flow value of the annual output of forest ecosystem goods and services in Beijing amounted to 5.3 percent of its GDP in 2007. Broken down further, the value of forest goods amounted to 0.8 percent of GDP and forest environmental services and sociocultural benefits amounted to 4.6 percent. The value of marketable forest outputs amounted to 0.9 percent of Beijing's GDP, and non-marketable output 4.5 percent.

However, the share of forest goods and services included in Beijing's official GDP in 2007, in accordance with the current national accounting system, was only 0.2 percent.

DISTRIBUTION OF FOREST BENEFITS

Among different economic sectors

The current system of national accounting records the direct economic outputs from forests such as timber and timber-related products, part of the non-wood forest products and forest ecotourism. However, part of these outputs are counted in the forestry sector, and part

3 Forest environmental services in the Beijing municipality

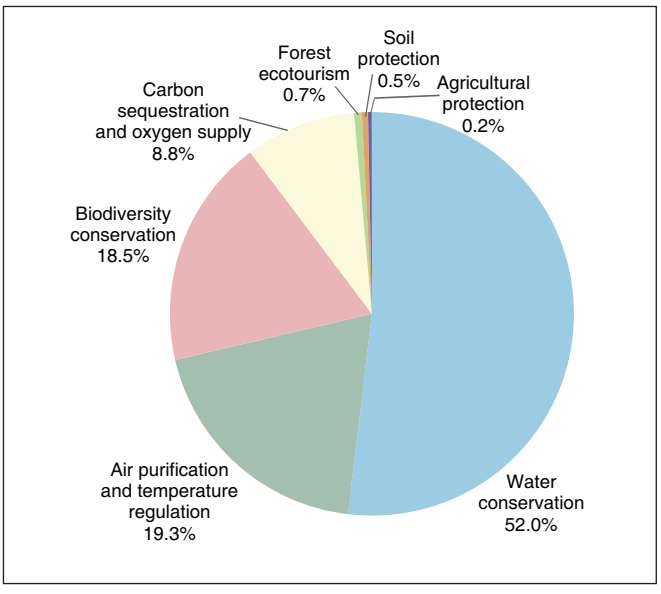


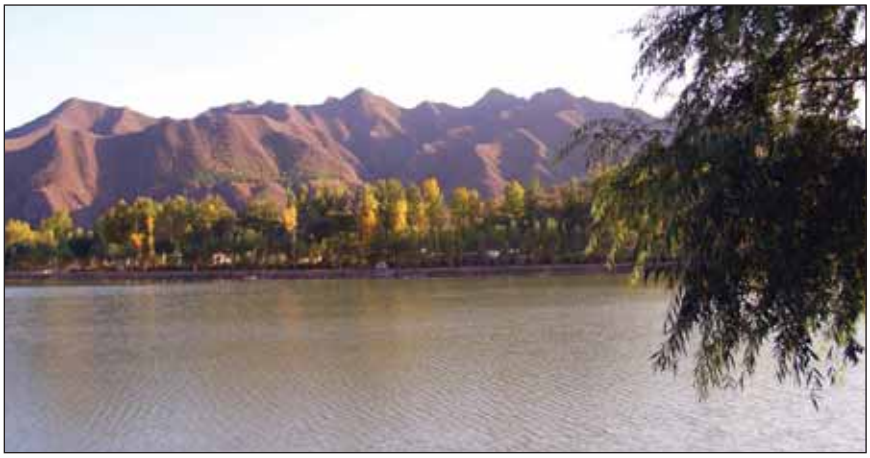
TABLE 2. Distribution of forest benefits among different economic sectors

Output	Forestry		Other sectors											
			Subtotal		Environment		Water		Agriculture		Tourism		Science, education and culture	
	Billion yuan	Billion US$	Billion yuan	Billion US$	Billion yuan	Billion US$	Billion yuan	Billion US$	Billion yuan	Billion US$	Billion yuan	Billion US$	Billion yuan	Billion US$
Forest goods	4.48	0.59	2.29	0.30	–	–	–	–	2.29	0.30	–	–	–	–
Forest environmental services	0.21	0.03	39.82	5.24	25.14	3.31	14.19	1.87	0.11	0.01	0.38	0.05	–	–
Forest sociocultural benefits	0.74	0.10	0.30	0.04	–	–	–	–	–	–	–	–	0.30	0.04
Subtotal	5.44	0.72	42.41	5.58	25.14	3.31	14.19	1.87	2.41	0.32	0.38	0.05	0.30	0.04
Share of total flows (%)	**11.4**		**88.6**		**52.5**		**29.7**		**5.0**		**0.8**		**0.6**	

in the agriculture and tourism sectors. Forest ecosystem services besides forest ecotourism are not included at all in national economic accounts but are partly indirectly reflected in the outputs of related sectors or industries.

The analysis indicated that the value of forest goods and services to non-forestry sectors of the economy accounted for 88.6 percent of the total flows, of which the environment sector accounted for 52.5 percent and the water sector 29.7 percent (Table 2). The importance of the forests of Beijing to these sectors of the economy is thus clear.

Catchment forests around the Miyun Reservoir, which provides 80 percent of Beijing's water



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Among different groups in society

The analysis showed that communities living just outside the Beijing municipality and those residing elsewhere in China were the largest receivers of benefits from Beijing's forests, receiving 47.3 percent of the total flow value of forest ecosystem goods and services (Table 3). Such non-local communities benefit directly from recreation and indirectly from environmental services such as watershed protection, even though they may not be fully aware of the value of the indirect benefits they receive.

Local beneficiaries, living in close proximity to the forest, received 31.2 percent of the benefits. These beneficiaries are usually aware of the direct benefits they receive from the forest.

Global beneficiaries received 21.5 percent of the benefits, through services such as carbon storage, biodiversity conservation and international tourism.

CONCLUSIONS: POLICY IMPLICATIONS

Unless most forest values are recognized through institutionalized valuation methods, forests as a land use will not get the societal attention needed to make them an integral part of a sustainable global economy. Many attempts in this direction have been made in China, as in many other parts of the world, but because of the wide differences in concepts and methods, the many estimates of forest ecosystem goods and services made in the past have been inconsistent and not amenable to meaningful comparison across services and periods.

As natural capital and ecosystem services become more stressed in the future, on account of both greater demand and reduced supplies (in part due to changing climate), their value can be expected to increase. Given the huge uncertainties involved, it may never be possible to have a precise estimate of the value of ecosystem services. Nevertheless, even crude estimates provide a useful starting point (Costanza *et al.*, 1997), with implications for decision- and policy-making. What this study makes clear is

TABLE 3. Distribution of forest benefits among different groups in society

Output	Local beneficiaries		Regional beneficiaries		Global beneficiaries	
	Billion yuan	Billion US$	Billion yuan	Billion US$	Billion yuan	Billion US$
Forest goods	6.77	0.89	–	–	–	–
Forest environmental services	7.4	0.97	22.35	2.94	10.28	1.35
Forest sociocultural benefits	0.74	0.10	0.30	0.04	–	–
Subtotal	14.92	1.96	22.65	2.98	10.28	1.35
Share of total flows (%)	**31.2**		**47.3**		**21.5**	

that forest ecosystem services provide an important part of the total contribution to economic development and social welfare of Beijing. The forest natural capital stock that produces these services must thus be given adequate weight in the decision-making process.

In recent years, the importance of forest ecosystems to Beijing has been well recognized, and the forest sector has been getting an increasing share of the public budget for forest protection and management. The institutionalization of payment for forest ecosystem services has become a prominent policy issue. A special fund has been allocated to local communities for tending of protection forests in the mountainous areas since 2004.

The share of forest goods and services actually included in Beijing's GDP accounting, however, is a small fraction of the flow value of the annual output of forest ecosystem goods and services shown in this study. This finding could support requests for a larger share of the national budget for forest management and investment, which are often woefully underfunded in many developing countries.

The demonstrated importance of forest ecosystem services to other sectors, especially water and environment, could contribute to the design of economic instruments such as water resources fees and environmental taxes which could be used to promote sustainable forest use or to compensate local communities. This finding could also be helpful in building cross-sectoral alliances based on mutual benefits.

The analysis of distribution of forest benefits among different groups in society is useful in identifying obstacles to sustainable forestry. Local communities in mountainous areas of Beijing, for example, have had to forego some forest uses in order to maintain a sustainable flow of forest protection services, and these foregone benefits need to be compensated adequately. The incentive for sustainable forestry declines when local communities do not receive appropriate benefits. The identification of stakeholders provides a good basis for negotiations over payments for forest ecosystem services.

Estimation of the full range of values from forests is helpful in designing forest management strategies. Forests have multifunctional uses to society, and by quantifying the relative values and identifying the economic trade-offs among competing uses of forests, it should be possible to determine optimal and secondary targets for forest management, use and investment, and to take appropriate measures to achieve them.

Forest valuation can also demonstrate the impacts of non-forestry policies on forest use. It can help identify potential conflicts between the development objectives of forestry and those of other sectors, as well as within the forest sector, for the design of a forest strategy that takes into account all stakeholders.

Finally, these findings can be used to raise public awareness of the multiple values of forests to society.

The absence of a real market for most of the forest ecosystem services discussed in this article implies a certain degree of subjectivity in the valuation process, and it is likely that many experts would hesitate to concur with the actual values assigned to these services, even if they agree with the methodology in general. However, the central purpose of this study will have been achieved if it helps to further robust debate on the valuation process. ◆

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