Chapter 4
Forest Landscape Restoration in China

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4.1 Introduction

In the past two decades, China has made considerable effort in solving growing environmental problems. Increasingly programs and policies have addressed protection of existing natural forests and restoration of lands degraded by unsound exploitation, severe natural disasters and various forest threats, including wildfires, pests and diseases (Li 2004; Yin 2009). Since the late 1980s, the Chinese central government has declared a national policy of encouraging tree-planting, protecting natural forests and improving environmental quality. As a result of this basic national policy accompanied with increased investment from the central government, China's total forest coverage increased from 13.9% of the national land area in the late 1980s to 16.6% in the late 1990s (The State Forestry Administration – SFA 2009; Zhang and Song 2006; Song and Zhang 2010). However, conserving and restoring China's severely degraded forests remains a great challenge; China is one of the world's most populated (ca. 1.33 billion) and least forested with only 0.11 ha of forest per person, compared with a world average of 0.6 ha (FAO 2010). Deforestation in China is among the most severe of the major countries; in the late 1990s, China's forests covered an area of 130 million ha with a timber volume of 9,000 million m^3. This is only about 3–4% of the total forest area of the world (Li 2004).

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Entering the new millennium, China's economic growth and social development are under increasing pressure of population growth and environmental crises. The conflict among people's basic livelihoods, economic growth, protection of natural resources, and restoration of the degraded forests still is an unsolved issue (SFA 2009). China's long history of forest exploitation and unsound land use policy in 1950s and 1960s led to disastrous ecological consequences, including degradation of forests, soil erosion, loss of biodiversity, and catastrophic natural disasters (Liu et al. 2003). In populated areas, the situation is deteriorating (Liu and Diamond 2005; Shen 2003). Major natural disasters have become more common; in recent years, China suffered several successive major natural disasters, including the 1997 severe drought in the Yellow River basin and the massive 1998 floods along the Yangtze River, and the 2000 large-scale sandstorms in northern China.

The serious natural disasters have triggered new efforts to protect the country's fragile and fragmented environment. The central government launched several nationwide ecological restoration programs and put forth unprecedented effort to protect and restore forests lands in the late 1990s and early 2000s (Xu et al. 2006; SFA 2009; Yin and Yin 2010). Progress has been remarkable in achieving program goals nationally. Total forest cover increased from 16.6% in the late 1990, to roughly 20.4% in 2008 (SFA 2009; FAO 2010) and carbon storage in living forest biomass has increased significantly since the 1980s (Fang et al. 2001; Chen et al. 2007; Xu and Li 2010). In addition, those programs have had profound positive impacts on local economy and society; in particular, the programs increased the income for many poor farmers and improved their livelihoods in program areas (Liu et al. 2008; SFA 2009; Xu et al. 2007; Yin and Yin 2010).

However, the benefits of the programs vary greatly by region and programs need to be carefully evaluated for effectiveness and long-term effects in light of pending policy and technical issues (Yin and Yin 2010). In this chapter, we provide a synthesis of China's recent forest restoration efforts and progress based on government statistics and published literature. We provide an overview on six nationwide major forest protection and restoration programs. We identify key scientific issues for forest restoration and describe ecological and social challenges that China faces in improving the effectiveness of implementation. We also examine how China's evolving forestry strategy and improved policy may benefit both forest protection and restoration activities. Overall, to be effective and sustainable in conserving natural forests and restoring degraded lands, we suggest that the Chinese central government should take a more balanced and comprehensive approach, which should include: promoting sustainable forestry; adopting an integrated ecosystem management approach; increasing effectiveness of forest protection and restoration through land ownership reform; collaborating among the central government, state and local people; expanding research to improve forestry understanding; and enhancing technical support, training and forest restoration-related education.

4.2 The Ecological and Socioeconomic Challenges

4.2.1 Increasing Land Degradation and Desertification

The major ecological challenge in China is land degradation and desertification, which increasingly threatens national economic development and environmental security (Zhang et al. 2007). Historically, among all forms of land degradation in China, soil erosion has long been the greatest ecological problem. Even during the 1990s, as total forest coverage increased, eroded lands continued to increase by more than 10,000 km^2 annually (Zhang et al. 2000; Li 2004). At the end of 2000, the total area of soil erosion estimated from remote sensing was 3.56 million km^2; at roughly 37.42% of China territory, this is one of the highest figures for any major country (Xu et al. 2002).

Land degradation is largely related to the complex physical environment of China, which is a vast country (ca. 9.6 million km^2) with a long geological history. Most of the landscape was formed as early as the end of the Mesozoic era (Li 2004; National Bureau of Statistics of China 2007) and China's landforms provide enormous variety: notable among these are the world's largest and highest plateau (Tibetan plateau), the highest mountain (Mt. Everest), two of the largest deserts (Taklimakan and Gobi), and two of the world's longest rivers (the Yangtze and Yellow). Other landforms include eroded loess plateaus, rolling grasslands, and a long coastline and large continental shelf (Fig. 4.1). China's climate is as complex as its landforms. Temperatures characteristically vary only slightly in summer between north and south but greatly in winter. Annual precipitation varies greatly among the regions: rainfall is heavy in the southeast, causing frequent floods in south China in the summer. Rainfall decreases to the northwest and becomes increasingly unreliable; severe drought in northwestern China seriously influences both industry and agriculture.

Soil erosion is increasing at an alarming rate with severe consequences. Every year the area of soil and surface water loss caused by human activities reaches 10,000 km^2. Annual soil loss amounts to 5 billion tonnes (3.3 billion tonnes from agricultural land), equal to 19.2% of the world total. Soil loss includes loss of organic matter and nutrients, which directly decrease soil fertility and land area for farming, hence lowering the productivity of land, increasing the occurrence of drought and water shortages, and lowering agricultural production.

Soil erosion statistics include not only surface erosion from water, wind and freeze-thaw erosion but also mass movements such as landslides, mud flows and avalanches. While the occurrence of accelerated soil erosion is mainly attributed to unfavorable natural conditions, in particular drought and warm climate, the causes of soil erosion in China vary greatly by region. Some forms of irrational development and exploitation of natural resources have accelerated soil erosion including mining and construction. Other factors include deforestation and overgrazing (Fig. 4.2).

Erosion is especially devastating in the Loess Plateau in the middle reaches of the Yellow River (Li and Shao 2006), where about 70% of the land is eroded. Average soil erosion is 3,720 tonnes km^{-2} and the sediment concentration of the

Fig. 4.1 The GLC 2000 land cover map of China. Global Land Cover 2000 database. European Commission, Joint Research Centre, 2003. http://bioval.jrc.ec.europa.eu/products/glc2000/glc2000.php

Yellow River is 37.6 kg m^{-3}. By comparison, this is 38 times that of the Mississippi River, and 49 times that of the Nile River. Although this is a typical soil erosion area in China, another example is the increasingly eroded area along the Yangtze River, whose sediment discharge exceeds the combined discharges of the Nile and Amazon, the world's two longest rivers.

Desertification in China is severe and the total area affected by desertification has being expanding. The entire desertification area is 2.62 million km^2, about 28% of the national territory (SFA 2009). Over the past 20 years, China's desertification problem has not been effectively controlled, leading to a sharp decrease in usable land, increased deterioration of the ecological environment, worsening poverty of the people living in the region, and causing substantial economic losses to the country. The desertified lands are scattered mainly over the north and northwest, comprising 18 provinces (autonomous regions or municipalities) and their 470 counties (banners or cities). The size of desertified areas has surpassed that of arable land in some locales, and nearly 400 million people are threatened by desertification. Direct annual economic losses caused by desertification were estimated at 54 billion Chinese yuan (RMB) (ca. $ 6.5 billion) (SFA 2009).

The area of low-degree desertification is 0.95 million km^2, medium-degree desertification of 0.64 km^2, and the high-degree desertification is 1.03 million km^2.

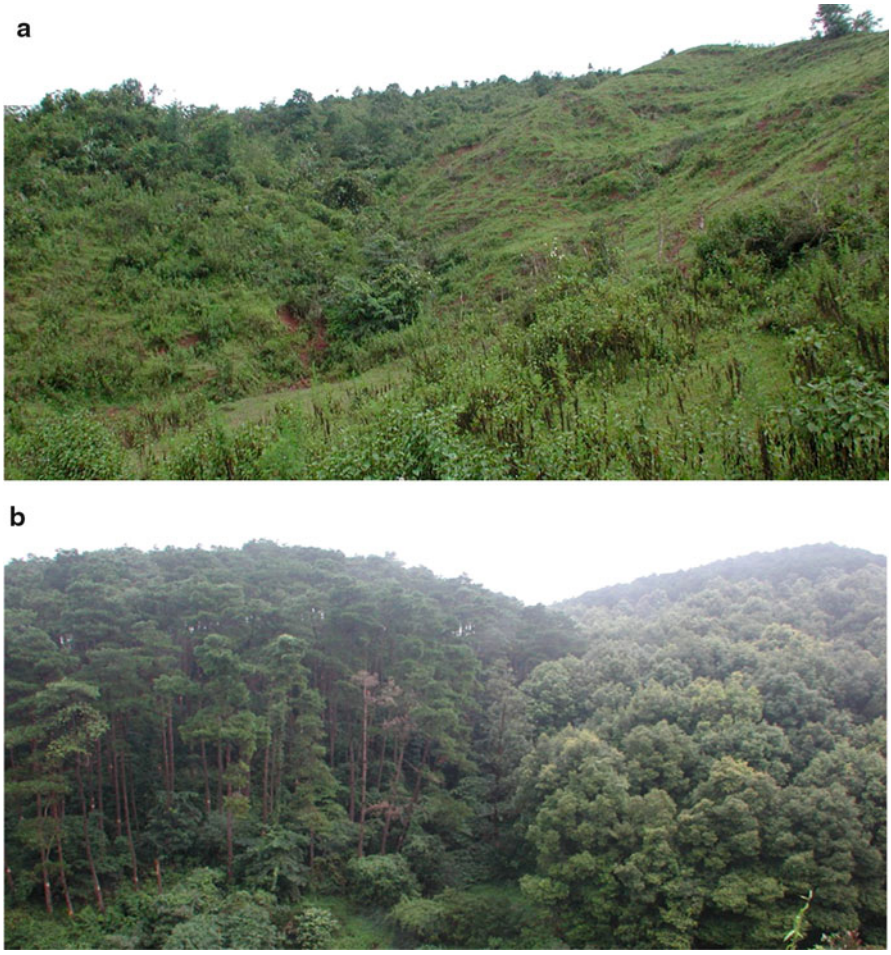

Fig. 4.2 (**a** and **b**) Restoration of degraded ecosystems in the southwest mountainous area: *Top*: Soil erosion has led to eco-environmental degradation; *Bottom*: The landscape of the mountain area after restoration treatment. These are typical ecologically fragile areas that pose many challenges such as accelerated soil erosion, land desertification, and drought. Restoration measures require multiple disciplines, integrated assessment of ecological and economic benefits, and sustainable development

Compared to Africa where the high-degree desertification is among the highest in the world, high degree desertification in China is about 30% higher (SFA 2009). Not only is China's desertification large in area, but increases at a high annual rate. Based on satellite remote sensing surveys, degraded grassland has enlarged by approximately 100% from 1983 to 1995 with the net enlarged area of 174,000 km^2. The accelerated rate of desertification has been increasing from 1,560 km^2 per year in the 1950s to 2,100 km^2 per year in the 1970s and to the current 2,460 km^2 (SFA 2009).

Low rainfall and periodic drought, vegetation degradation and frequent wind/sand storms leading to accelerated soil erosion are the most common causes of desertification. Moreover, irrational human activities such as rampant cultivation and destruction of natural vegetation contribute to the rapid expansion of deserts in northwestern China (Wang et al. 2007a, b). The area of wind erosion-caused desertification is 1.6 million km^2, water erosion-caused desertification 205,000 km^2, frozen and melting process-caused desertification is about 363,000 km^2, and salinization-caused desertification is about 233,000 km^2.

Distribution of forests in China is very uneven. The diverse environment, complex climate and long geological history provide favorable conditions for large number of plants (ca. 27,000 species of higher plants, of which 7,000 species are woody plants) and diverse vegetation; with a few exceptions, China contains the main forest types of the northern hemisphere (Wu 1980; Li 2004) Nevertheless more than half of China's forests occur in the northeastern and southwestern regions, where the land area accounts for only one-fifth of the national total. In contrast, the northwestern region comprises 30% of the total territory but only 2.55% of the national forest estate (SFA 2009).

Decline in both quantity and quality of natural (old-growth) forest is a direct indicator of China's degrading ecological conditions. Natural forest, defined in the national forest inventory as closed forests with at least 20% stocking, declined over the period 1950 to 1998 by 30% of the total forest area; unit-stocking of natural forests declined by 32% (Zhang et al. 2000; Li 2004). In 1998, China had 106.97 million ha of natural forests, which accounts for 69.62% of the total forest land. But 62.89% of the natural forests are immature, which was a result of the old forest policy in 1950s to the middle of 1970s that focused mainly on timber production.

Within China's diverse landscapes lie fragile areas that account for about 28% of the national territory. Major natural disasters include droughts, floods, typhoons as well as forest and grassland fires and forest environmental threats, including insects. Southern China is wet, but heavy rainstorms cause erosion on slopes. Conversely, northwestern China's variable rainfall, winds and droughts expose its high-altitude grasslands to dust storms and soil erosion. In addition, geological hazards such as landslides occur frequently in mountainous areas. Natural disasters are major factors limiting forest landscape restoration, as well as economic and social development in China (Table 4.1).

4.2.2 Policy Issues, Financial and Technological Constraints

China's deforestation and land degradation, to a large extent, is a combined result of long land-exploitation history and unsound forestry policies from 1950s to 1970s. Before 1949, China had few remaining forests and consequently a poor base for forestry. In 1949, deforestation was the legacy of agricultural and pastoral expansion, over-cutting for construction and fuel wood, and repeated wars (Shen et al. 2006). In the early 1950s, wood production was the priority of the Ministry of

Table 4.1 Ecological restoration zones in China

Code	Ecological restoration zones	Ecological restoration sub-zones	Annual precipitation (mm)	Aridity index	Climate zone
I	Chang Bai Mountains and Southeastern China Humid Zone	Chang Bai Mountainous Zone Northern Yangtze River Mountainous Zone Southern Yangtze River Red Soil Zone	>800	<1.0	Humid zone
II	North China-Northeast China-eastern Qinghai-Tibet Plateau Semi-Humid Zone	Jing-Ha Black Soil Zone Northern Mountainous Zone Southern Tai-Lan Loess Plateau Southwest China Mountains	500–600	1.5	Semi-humid
III	Inner Mongolia Plateau-Loess Plateau-Qinghai-Tibet Plateau Semi-arid Zone	Inner Mongolia Plateau Northern Tai-Lan Loess Plateau Qinghai-Tibet Plateau	<400	2.0	Semi-arid
IV	Xinjiang-Inner Mongolia, Northwestern desert arid land of Tibetan Plateau Zone	Inland Plain Zone Grassland Zone Desert Zone	<200	>2.0	Arid

Forestry and protection and restoration were limited with little or no funding support. At that time, China's top administration believed that humans could conquer nature (Liu and Diamond 2005). The Great Leap Forward in 1958–1960 caused more deforestation due to reliance on fuel wood for inefficient backyard steel production. During 1960–1976, unsound nationwide forest policies resulted in uncontrolled forest logging in many of the remaining forested areas.

Such thinking began to change by the mid-1970s as China reformed national policies and transitioned from a planned economy to a market economy (Liu and Diamond 2005). China declared environmental protection to be a basic national policy in 1983 and by the late 1980s, had begun a series of national and regional programs to accelerate forest restoration (mainly tree planting) and control soil erosion. These initiatives included the Integrated Small Watershed Management program and the Mountain Closure for Facilitating Afforestation program. In the early 1990s, additional nationwide programs were initiated with funding assistance from the World Bank, including the Shelterbelt Project in the Three-North (i.e., the Northwest, North, and Northeast) region of China (World Bank 2001). A milestone was in the late 1990s when China adopted a sustainable development framework as a basic national policy (Yin 1998; SFA 2009); a 5-year plan of natural resource and environmental protection soon followed. All of these changes resulted in encouraging fundamental progress in China's effort for environmental protection and forest restoration (Liu 2001). At the same time, local, private-sector and international efforts have increased, bringing fresh mechanisms to forest protection and restoration efforts (Zhang et al. 2000; Lu et al. 2002; Yin et al. 2003; Carle and Ma 2005; SFA 2009).

However, despite a 20-year-old national policy of achieving sustainable development, tough policy challenges remain (Zhang et al. 2006; Liu et al. 2008). First, the existing regional and local forest management policies still lag behind national policy. Second, the unclear forestland ownership and land tenure rights discourage local farmers from making improvements and urgently need to be reformed. Third, there is a strong need for establishing a legal system to regulate all forestry and restoration activities.

Financial instability has long been a limiting factor for implementing forest protection and restoration projects. Although the central government began to increase the national forestry budget prior to the 1990s, the overall increase was much less than the pace of development and growth of the national economy in the same period (Zhuang 2001; Li 2004). Since the late 1990s, the central government has realized the importance of forest protection and restoration, and largely increased the total capital input for these programs. As forest protection and restoration recently has become a focus of China's national forestry investment, the rate of annual budget increases has been higher than growth of the national economy and total investment in forestry from 2003 to 2010 was 839.8 billion RMB (SFA 2009). Despite increased government funding for forestry in recent years, a significant gap remains for forest restoration. From 2011 to 2050, the projected need is 1.45 trillion RMB (National Forestry Key Ecological Projects Socio-economic Forecast Center 2005a, b).

In addition to fiscal constraints, inadequacy of scientific research and technical support limit China's capacity for sustainable forestry development and forest

restoration efforts. China's basic forestry research capability, in particular those involving original innovation, is still insufficient (Li 2004; SFA 2009). According to 2001 statistics, China's forestry technology contributes about 30% to economic growth, lower than the national level of around 40%. Compared to the developed forestry level of 70–80% in the world, the gap was even greater.

The current knowledge of forest protection and restoration is still not able to fully meet China's forestry development, especially the restoration needs in western forests. In spite of notable success in promoting forest protection and restoration, many scientific and technical issues remain. First, China still lacks advanced forestry knowledge and techniques for many restoration needs. Second, China's infrastructure (e.g., field monitoring facilities and data collection techniques) is still insufficient. Third, China lacks standard scientific criteria and indicators for assessing success of forest restoration. The applied technologies that can be used for forest restoration (e.g., site preparation, control of desertification, and damaged landscape reconstruction) are still the 'bottleneck' that limits forest restoration efforts in China. Moreover, applications of the existing technologies are ineffective, at least to some degree. In addition, regulatory mechanisms for reducing soil erosion, optimal methods for controlling desertification, and protection strategies for managing forest diseases and pests have not been effectively addressed. These limitations have impeded China's forest restoration efforts.

4.3 Recent Major Forest Restoration Programs

In this section, we briefly provide information of contents, implementation and preliminary outcomes from six recent nationwide programs. We also look into some issues in implementation of these programs. Moreover, to provide a more balanced view of forest restoration efforts in China, we provide a brief overview of some examples of on-going projects that have been conducted by the international and non-governmental organizations (NGOs).

4.3.1 Key National Forest Restoration Programs

4.3.1.1 The Scope and Goals

In response to successive natural disasters in the late 1990s, the central government launched several national ecological restoration programs aimed at improving China's deteriorated ecological conditions and reducing poverty in the poorest and most ecologically fragile regions. The central government set a 10-year goal of increasing forest cover from 16.55% in 1998 to roughly 19% by 2010; long-term goals were to increase forest cover to 23% by 2020 and 26% by 2050 (SFA 2009).

To meet these goals, the SFA initiated the Natural Forest Protection Program (NFPP) in 1998 and the Sloping Land Conversion Program (SLCP) in 2002. In addition, the SFA consolidated some previous or on-going forestry programs and began four 'new' large-scale ecological restoration programs, including the Desertification Combating Program around Beijing and Tianjin (DCBT), the Shelterbelt Network Development Program (SNDP), the Wildlife Conservation and Nature Reserve Protection Program (WCNR), and the Industrial Timberland Plantation Program (ITPP).

These six national priority forestry programs are significant both in the large geographical areas they plan to cover and in the large amount of money to be invested. The programs vary significantly in terms of mission, duration, and financial commitments, with the SLCP by far the largest. These programs cover over 97% of counties of the country and 76 million ha of plantations are planned to be established, which makes the programs unprecedented in terms of their wide range, large scale, and the size of investments. As mentioned above, except for the SLCP and the NFPP, none of the programs is brand-new or even recently initiated. Rather, various predecessors were in existence much earlier; they were consolidated either for more effective administration or more focused targeting (SFA 2009). For example, the Shelterbelt Network Development Project was begun in 2001 by combining under a single SNDP umbrella several regional projects launched during the 1970s and the 1980s. Another example is DCBT; it is an outgrowth of different initiatives to counteract desertification that was undertaken in response to frequent dust storms affecting Beijing, Tianjin, and other cities in the Northern Plains (SFA 2009). Efforts to stop desertification in other areas now overlap with and even have become part of the SLCP (Yin and Yin 2010).

Below we briefly describe the scope and the program goals of the six major national programs. More information about the six programs can be found in Xu et al. (2004, 2006) and Yin (2009).

The Natural Forest Protection Program (NFPP)

The NFPP was officially launched in 1998 and mandates protection of the remaining natural forests, mainly national and state-owned natural forests. The program covers 17 provinces, 734 counties and 167 national and state-owned state forests in the upper reaches of the Yangtze River, the upper and middle reaches of the Yellow River, and the Northeast and Inner Mongolia areas (Shen et al. 2006; Yin and Yin 2010). Accordingly, as a first objective, major commercial logging was completely banned in the upper reaches of the Yangtze River and the upper and middle reaches of the Yellow River to conserve over 61.08 million ha of forests (Zhao and Shao 2002; Xu et al. 2006). The second objective of the program was to accelerate afforestation and forest regeneration. An additional 14.66 million ha of forest and grassland, including 8.66 million ha of forest, are established in the program areas to raise the forest cover by 3.72% (Fig. 4.3). From 2001 to 2010, China has invested 96.4 billion RMB (US $ 11.63 billion) in the NFPP (SFA 2009).

Fig. 4.3 *Top*: Soil and water conservation project in the upper and middle reaches of the Yangtze River; *Bottom*: Protecting soil resources in the limestone mountainous area of the upper reaches of the Wu River. The area is characterized by steep slopes, rocky and droughty soils, and a shortage of agricultural land. Restoration treatments focused on halting soil erosion and protecting land resources by constructing terraces and converting farmland to forest

The NFPP included transfer of about 740,000 forest workers displaced as a result of the ban on logging and harvest reduction, to new forestation and forest management jobs; some would be retired or lost by attrition. All existing and newly retired employees would be incorporated into the provincial pension and social security

Fig. 4.4 Reversing environmental degradation in the dry and hot valley of the Jinsha River. The restoration model consisted of developing an information system, classifying and mapping the types of ecological degradation, and implementing treatments

system. In addition, the central government planned to write-off a large amount of business debt due to the dramatic disruption in logging activities and have shared the burden of increased financial pressure on the provinces and county governments (Lei 2002a; Xu et al. 2006; Yin and Yin 2010).

The Sloping Land Conversion Program (SLCP)

The SLCP was officially launched in 2000 to convert sloping croplands and desertified fields back to forest, grassland or wetland in order to control soil erosion and contain desertification in China's key fragile areas. The program covers 24 provinces, autonomous regions and municipalities (Fig. 4.4). The SLCP planned to retire or convert 14.66 million ha of fragile sloping farmlands by 2010, including 4.4 million ha on slopes steeper than 25º and desertified fields. The retired farmland may be converted into ecological forests and commercial forests. Meanwhile, the program was designed to afforest 13 million ha in the sparsely vegetated mountainous, hilly and sandy lands. Upon completion of the program, it was expected that the forest and grass cover of the program areas will rise by 5%, ultimately resulting in erosion control of over 86.67 million ha and desertification containment of over 102.67 million ha. The total investment was projected to be 225 billion RMB (SFA 2009; Xu et al. 2010; Yin and Yin 2010).

The program provides compensation to farmers who participate in the program for their labor costs and for buying tree seedlings. The compensation scheme includes annual grain and cash subsidies as well as free seeds or seedlings at the beginning of the conversion. The subsidies last for 8 years if ecological forests are established, 5 years if economic forests are established, and 2 years if grass cover is established (Xu and Cao 2002). The annual cash subsidy is 300 RMB ha^{-1} for eligible land. Additionally, the converted lands are exempted from agricultural taxes (Yin 2009).

The Desertification Combating Program Around Beijing and Tianjin (DCBT)

The DCBT program targets the sandstorm problem in the areas surrounding the capital Beijing by treating about 10 million ha of desertified lands, of which 5.21 million ha is to be vegetated or re-vegetated. The program covers 75 counties, with a total area of 460,000 km^2, in five provinces, including Beijing, Tianjin, Hebei, Shanxi and Inner Mongolia. The estimated total investment is 57.7 billion RMB (SFA 2009).

To fulfill these tasks, the DCBT plans to use multiple measures that include the conversion of cropland to forests, grassland rehabilitation, selective banning of open grazing, integrated watershed management, and ecological restoration. In addition to cropland retirement, which receives a subsidy similar to that under the SLCP, compensations for other activities include: afforestation at 4,500 RMB ha^{-1}, forest regeneration via aerial seeding at 3,000 RMB ha^{-1}, mountain closure at 1,050 RMB ha^{-1}, grassland establishment via artificial planting and aerial seeding at 1,800 RMB ha^{-1} and 1,500 RMB ha^{-1}, grassland fencing at 1,050 RMB ha^{-1}, livestock per building at 200 RMB m^{-3}, integrated watershed management at 200,000 RMB km^{-2}, and ecological resettlement at 5,000 RMB per person (Yin and Yin 2010). In certain places, the carrying capacity of the degraded farmland and grassland ecosystems has become so abysmal that farmers and herders have no choice but to resettle to other, more viable locations. Upon completion of the program, the ecological environment in the vicinity of Beijing should be remarkably improved, with the forest cover reaching over 19%, an increase of over 8%.

The Shelterbelt Network Development Program (SNDP)

The goal of the SNDP is to mitigate wind-induced erosion, landslides, and flooding and to protect grasslands, riverbanks, and coastlines (SFA 2009). The program aims to combat desertification in the Three-North regions of China and the ecological problems in the middle and lower Plain of the Yangtze River (Liu et al. 2004). The initial investment from the central government was about 70 billion RMB from 2001 to 2010 (Yin and Yin 2010).

The SNDP includes two major sub-programs: (1) the Three-North Shelterbelt Program (TNSP), which was an existing project that focused on controlling desertification in 13 provinces in the Three-North region of China. Under the

TNSP, 9.46 million ha of degraded lands will be afforested and 1.3 million ha of desertified lands controlled. Upon completion of the program the forest cover in the program area will be raised by a net 1.84%, nearly 11.33 million ha of farmland will be protected, and 12.66 million ha of desertified, salinized or degraded grassland will be protected or rehabilitated. (2) The Key Shelterbelt Development Program in the middle and lower reaches of the Yangtze River encompasses land in 31 provinces, autonomous regions or municipalities. It is expected that 18 million ha of land will be afforested, 7.33 million ha of low-efficiency shelterbelt improved and 37.33 million ha of existing forests properly managed and protected. The program also supports the adoption of appropriate silvicultural techniques and the integration of shelterbelts with farming and grazing through agroforestry practices (Yin 2009).

The Wildlife Conservation and Nature Reserve Protection Program (WCNR)

The WCNR targets issues of species, nature and wetland protection, and strives to expand the number of nature reserves and enhance the protection of wildlife. The total planned investment is 135.65 billion RMB over a period of 30 years starting in 2001; roughly half of the investment (66.5 billion RMB) is from the central government. The program aims that the total number of reserves reaches 1,800 by 2010 and 2,000 by 2030 (SFA 2009). The program also seeks the active participation of non-governmental domestic and international entities, including the broad involvement of the private sector (Yin and Yin 2010). In addition, included in the WCNR are measures for wetland restoration, ecotourism development, wildlife breeding, and the role of science and technology, particularly regarding the monitoring and evaluation of reserves and biodiversity.

Program priorities, between 2001 and 2010, has been given to the three sub-project areas: (1) set up 15 wild flora and fauna reserves (including the Giant Panda, Golden Monkey, Tibetan Antelope and plants in the orchid family); (2) established 200 nature reserve projects in the types of forest, desertified land and wetland ecosystems, 32 wetland conservation and wise use demonstration projects, and 50,000 nature reserve areas; and (3) completed germplasm pools for conservation of wild fauna and flora. In addition, the program made progress in establishing the national research system of wild fauna and flora and a monitoring network. By 2010, the number of nature reserves reached 1,800 including 220 national nature reserves with a total area in nature reserves comprising 16.14% of the national land area.

The Industrial Timberland Plantation Program (ITPP)

The ITPP represents a major market-driven effort to increase the domestic timber supply (SFA 2009; Yin and Yin 2010). The main objectives of the ITPP are to ensure a supply of timber and at the same time, mitigate the pressure of timber demand on forest resources. The program covers 886 counties of 18 provinces and autonomous regions. Over the period 2001–2015, it calls for establishing 13.33 million ha

of fast-growing and high-yielding plantations in three phases. The cumulative area targets are 4.7 million ha by 2005, 9.2 million ha by 2010, and 13.3 million ha by 2015.

The projected total investment by the Chinese government is 71.8 billion yuan (Yin 2009). To encourage private initiatives, as much as 70% of investments may come from loans subsidized by the National Development Bank; tax incentives are also prescribed. This program urges active involvement by various types of business entities, including state or collectively-owned firms, shareholder-based organizations, or fully private businesses. The program will provide 130 million m^3 of timber annually upon completion, accounting for 40% of China's commercial timber consumption, thus keeping an initial balance between timber supply and demand (Yin 2009).

4.3.1.2 Implementation, Outcomes and Pending Issues

At national level, the six key national ecological restoration programs have made promising progress in achieving project goals. Over the last decade, China has invested about 500 billion RMB or roughly US $70 billion for implementing these nationwide programs (Ren and Peng 2003; Liu et al. 2008; Wang et al. 2007a, b; Yin and Yin 2010). According to government reports, the condition of natural forest resource has been much improved. A large amount of degraded farmland and grassland has been converted and rehabilitated to forests and grassland, and their cover expanded substantially (SFA 2009). China's total forest cover increased from 16.6% in the late 1990, to roughly 20.4% in 2008 (SFA 2009; FAO 2010). In addition, those programs raised awareness of the need for conservation and restoration of the natural forests throughout China and have profound positive impacts on China's economy, environment and society.

During the period from 1999 to 2006, forest area increased by 8.1 million ha and stocking volume grew by 466 million m^3 in areas covered by the NFPP (Yin and Yin 2010). In the areas targeted by the NFPP, 92.66 million ha of forests have been protected and appropriately managed. About 60% of the total forest area in China, 6.33 million ha, has been newly established and 186 million m^3 of net stock volume was increased (Wu et al. 2002a, b). A complete logging ban was placed on commercial harvesting in the natural forests in 13 provinces and autonomous regions along the upper reaches of the Yangtze River and the upper and middle reaches of the Yellow River. The timber output in such state-owned forest areas as the Northeast and Inner Mongolia has been significantly adjusted and reduced by 7.63 million m^3.

In the SLCP, 2.16 million ha of barren mountains and wasteland and cropland have been afforested and converted into forests or grassland. A survey made by the State Forestry Administration in 2000 showed that over 97% of plantation areas were verified and more than 87% qualified according to plantation criteria.

The progress of the DCBT is also impressive. As of 2006, afforestation had expanded to 2.8 million ha through artificial planting and aerial seeding and to 1.3 million ha through mountain closure. In addition, about 1.5 million ha of grassland

have been rehabilitated, 0.5 million ha of small watersheds treated, and over 101,000 poverty-stricken people resettled to places where a basic livelihood can be sustained (SFA 2009). The total investment in the program reached 13.6 billion RMB between 2000 and 2006; most of the investment has been used for subsidized conversions of cropland into forests and grassland and 900,000 ha covered with trees and grasses in the DCBT program area.

Likewise, the WCNR has made tremendous advances. The amount of nature reserves has increased steadily, and the conservation of wild plants and animals greatly enhanced. Under the WCNR, 167 new nature reserves were established, taking the number of nature reserves in forest and wild fauna and flora types to a total of 1,740; the total area reached 116 million ha, which accounted for 12.6% of the country's land area. Of these new reserves, 198 are national, 583 provincial, 289 municipal, and 670 county-level (SFA 2009). As a result, 90% of the terrestrial eco-zones, 85% of the wild animal species, 65% of the plant communities, and 45% of the wetlands are now under protection (SFA 2009). Species included are over 300 rare and endangered animal species, such as pandas, tigers, elephants, monkeys, and cranes, as well as more than 130 rare and endangered plant and tree species (SFA 2009).

Similarly, during from 2001 to 2006, afforestation, reforestation, and other land rehabilitation schemes were widely implemented under the SNDP, which expanded by 3.25 million ha in the Three-North region and 3.05 million ha in the Yangtze River basin (SFA 2009). The Three-North Shelterbelt Development Program has brought 1.58 million ha of desertified land under control. In comparison, less than 0.4 million ha of industrial timber plantations were established during the same period under the ITPP (SFA 2009), suggesting the very slow development of the ITPP.

The result of these programs has been an improvement in the overall ecological conditions in China (Fig. 4.5). This is reflected in a decline in the severity of soil erosion and water runoffs, an expansion of wildlife habits and species abundance, and a reduction in sandstorm and flood occurrences. At the same time, the economic structure has been fundamentally adjusted, as indicated by the growth of non-timber forest products, the increase in ecotourism and recreation, diversification of local economies, the acceleration of labor transfer, an increase in income and living standards, and a reduction in poverty (SFA 2009).

Although these statements are generally true, still poorly understood are the where, how, and to what extent these programs have changed ecological and socio-economic conditions. In part this is because some government statistics are unavailable or unreliable. Independently performed and comprehensive assessments of program impacts by the science community are not yet available and the government has paid inadequate attention to monitoring and evaluating efforts.

Some recent local-level (i.e., county, town or village) surveys that carefully examined restoration effects on the NNPP and SCLP programs provide some insight into what has happened on the ground. Various studies have suggested that at the local level, implementation of these government programs has been far from perfect and the ecological and socioeconomic effects were mixed. In terms of ecological effects, the programs were generally effective in increasing forest or

Fig. 4.5 Ecological communities on the banks of the Yangtze River. Afforestation around the Three Gorges Reservoir, along with protection of natural forests, has improved water quality by reducing soil erosion and sedimentation

vegetation cover, reducing soil erosion, and to some extent, enhancing ecosystem services. For example, in a study of landscape vulnerability in northern Shaanxi Province, Cao and others (2009) found that that total vegetation cover increased from 29.7% in 1998 to 42.2% in 2005 in the SCLP program area. On the other hand, Jiao and others (2012) found that afforestation in the loess plateau offered few additional advantages when compared with natural recovery sites and had significant negative effects on soil desiccation, questioning the long-term sustainability of the afforested systems.

Local surveys also have shown mixed results for the socio-economic impacts of the programs. For example, in a county and township level study, Wang and others (2007a, b) found that the SLCP program in many cases gave inadequate consideration to land productivity and environmental heterogeneity when selecting plots; with more than half of the afforestation plots on flat cropland (slopes of less than 5°). In five of the eight townships, net incomes on afforested land were substantially above or below previous crop incomes, raising questions about the equity of the allocation of compensation to farmers participating in the program.

More recently, Wang and others (2010) found that that the effectiveness of the Three-North Forest Shelterbelt program in combating desertification and controlling dust storms in arid and semiarid region may be overstated, although

the SFA claims that the past three decades of the program have achieved dramatic rehabilitation of the ecological environment of arid and semiarid China. They argued that there are two primary reasons why the Three-North program may have failed to meet its goals. First, the decreased desertification and frequency of dust storms in arid and semiarid China in the post-project period may have been caused mainly by climatic variation, not by human activity such as the program. Second, a relatively low proportion of the region has been affected by the program, the survival of the planted trees and shrubs has been low, and the afforestation has not targeted the areas responsible for the majority of dust production or the areas most at risk of desertification in the Three-North region.

Chinese ecologists have debated whether the government's rigid policies may be causing new ecological problems in some regions. For example, Cao and others (2010) argued that trees not adapted to the local environment in arid and semi-arid regions but used in large-scale afforestation and tree-planting programs may actually damage local ecological conditions. They found evidence that large-scale afforestation could increase the severity of water shortages, decrease vegetation cover in afforestation plots, and adversely affect the number of species present. The scientific community in China has set up a monitoring network to re-evaluate ecological impacts based on longer-term data and scientific approaches and has called for more attention paid to the quality of afforestation programs rather than just their scale (Yin and Yin 2010).

4.3.2 International Collaboration and Non-government Efforts

In addition to the six large-scale, top-down government restoration programs, numerous international and non-governmental organizations, including the Food and Agriculture Organization of the United Nations (FAO), the International Union for Conservation of Nature (IUCN), World Wildlife Fund (WWF), World Agroforestry Centre (ICRAF), and the Nature Conservancy (TNC) have made great strides in assisting China to develop the capacity of sustainable forestry and conservation. Although the scales of the projects are smaller than the major government projects, the impacts of those projects are profound; in general these projects are more comprehensive and better planned. For example, non-government programs usually include species improvement, assessments and breeding, protected area management, environmental law and environmental economics. Their activities are often based on thematic principles such as resources and technology and information; capacity development and training, education and facilitation; governance and administration policy.

FAO has been working for 20 years with the SFA and the Belgium Development Cooperation on various forest restoration projects. One of the major projects was Afforestation, Forestry Research, Planning and Development in the Three North Region that targeted the Korqin Sandy Lands. This project included five integrated components: tree improvement and breeding, afforestation research,

mechanized afforestation, project coordination and management, and training (Carle and Ma 2005).

Through its forest programs, IUCN China has made efforts to conserve forest biodiversity, reduce illegal logging and promote the sustainable use of forest products for the benefit of the rural poor. IUCN China has implemented a program called Livelihoods and Landscapes Strategy (LLS). By using a forest landscape restoration framework and measures, LLS demonstrated approaches that would optimize the biodiversity and productivity of forest landscapes and deliver livelihood benefits to the rural poor. For example the Beijing Miyun watershed forest landscape restoration and livelihood improvement project was an initiative of forest landscape restoration among IUCN China, Beijing Forestry Society and local government (IUCN China 2009).

WWF has been working in China with a wide range of stakeholders to develop an approach to conservation that balances the ecological, social, and economic needs of the landscape. In the Upper Yangtze, WWF identified the Minshan mountain range in Sichuan and Gansu as a particularly outstanding landscape because of unique and endangered wildlife, with important populations of giant panda, clouded leopard, golden monkey and the world's richest variety of pheasants. The Minshan covers parts of six counties and 19 nature reserves and is populated by close to one million Han, Tibetan, Qiang, and Baima people. The project contributes to the conservation of the forests of the Upper Yangtze. The objective is to increase the extent and quality of the forests in the Minshan Mountains landscape, for the benefit of key species, in particular the giant panda, while enhancing the livelihood security of local communities (Du et al. 2005).

The logging ban, while addressing wildlife conservation concerns, led to the loss of several thousand jobs in the Minshan logging sector. Increases in illegal logging and poaching may be attributable to the ban as local people attempt to fill the financial gap left by their lost jobs. WWF is working with local partners to improve management of the region's forests through greater community involvement and by helping local people to develop livelihoods which are both environmentally and economically sustainable. WWF also has been conducting a biological assessment of the Minshan landscape to determine priority areas for conservation intervention. The assessment will produce a map of current land uses such as protected areas, farmland, and state forest enterprises and indicate the potential for ecotourism and development of environmentally friendly livelihoods such as beekeeping. WWF will then work with stakeholders, ranging from provincial officials to community representatives, to develop and reach agreement on a conservation strategy for the landscape which ensures sustainable economic growth (Du et al. 2005).

The efforts from the World Agroforestry Centre (ICRAF) have largely focused on the mountains of Southwest China (Yunnan and Sichuan Provinces). ICRAF's current work in China focuses on the Three Parallel Rivers area of northwest Yunnan, where the Yangtze, Salween, and Mekong Rivers flow within 85 km of each other. The ICRAF China Project includes field research, farmer and forester training, capability building and outreach. Charting a new course for the mountains

of Southwest China involves expanding the current emphasis on high-input, high-yield grain production and livestock rearing to include new options, such as on-farm trees, non-timber forest products and payments for environmental services. Incorporating these new options requires short-, medium-, and long-term investments to overcome both cyclical and structural constraints.

A long history of failures of government programs in Southwest China has left the region's farmers increasingly reactive and risk averse. As a result, farmers and government agencies often lack the knowledge, skills, or resources to re-orient farm production toward more profitable and sustainable forms. Structurally, there remain few mechanisms for policy feedback; many of the failures of the SLCP and NFPP, for instance, were characteristic of previous policies. ICRAF's work in Southwest China seeks to strengthen communities' confidence to break this cycle of risk aversion by introducing farmers and agency staff to new ideas and methods, and to institutionalize mechanisms for policy feedback to improve provincial and national decision-making (ICRAF China 2009).

4.4 The Key Scientific and Technical Issues in Forest Restoration

4.4.1 The Effectiveness of Forest Restoration and Its Driving Factors

The impacts of forest landscape restoration on the environment are profound and wide-spread. To a certain extent, those effects are still less clear and need to be carefully evaluated. Therefore, more research on post-restoration effects may improve effectiveness. Impacts may include effects of restoration practices on watershed-level eco-hydrology processes including regulatory mechanisms, water flow under different restoration scenarios and material movements; nutrient cycling, soil quality, and site productivity; forest succession and changes in species diversity; cumulative effects on natural resources and the consequences of climate change. These related issues need to be clarified and further addressed (Weyerhaeuser et al. 2005).

One of the key scientific issues for forest restoration is to understand China's restoration potential (i.e., the original vegetation or the reference conditions) and the driving factors that have influenced past restoration efforts. In particular, restoration potential or reference conditions of a given area provide the upper-level limits on human's restoration efforts and therefore serve as useful guide for forest restoration practices. The research on potential vegetation or historical vegetation in China is still rare but needed for establishing baselines and realistic goals for forest landscape restoration.

To understand the restoration potential of a specific area, drivers and level of degradation of an impacted forest area need to be examined in detail. The diagnostic

process may include understanding the past vegetation conditions and descriptions of the degraded forests by using comparative diagnostic methods. At present, many studies of degradation in China use qualitative (and possibly subjective) approaches. For example, some studies divide the landscape into slightly degraded (reversible) and severely degraded forest (nonreversible) (e.g., Du et al. 2003; He et al. 2007). Obviously, more detailed work in this aspect is urgently needed.

China's natural and socio-economic conditions vary considerably according to region. In order to use suitable restoration measures in different regions, research on classifying ecological restoration zones is essential. Several past studies provide promising progress in this direction. Four ecological restoration zones have been identified based on their internal similarity of the key limiting factors (e.g., soil water availability, annual precipitation) for growth of plants; and 13 sub-zones was identified based on soil erosion and landforms (Table 4.1, Cai et al. 2004).

More detailed zoning work helps to identify key areas and prioritize the restoration planning and assessment efforts. Certain key areas have been identified for conducting forest restoration, for example the Beijing and Tianjin vicinity for ecological restoration to combat soil erosion; the Northwest Loess Plateau for water erosion ecological restoration area, and the middle reaches of the Yangtze River ecological restoration area (Liu 1999; Chen et al. 2003; Peng et al. 2005).

4.4.2 Transferring Science and Technology into Practice

Whereas progress has been made in China's forest restoration in the past 20 years, the effectiveness of forest restoration practice and the uncertainty of the restoration results are still yet not fully addressed (Xu et al. 2006; Yin and Yin 2010). In many cases, the impacts of forest restoration practices on the forest areas are unclear. Rarely is an environmental impact assessment conducted before implementing a restoration project (McVicar et al. 2007). In fact in many cases, no such technical protocols or assessment standards exist (Liu et al. 2005).

Generally, forest restoration practices need to comprehensively consider all key ecological, economic and social factors. However, the complexity of degraded forest conditions in time and space makes restoration planning and implementation difficult, especially under continuously increased human disturbances. Because of this complexity, it is difficult to clearly describe the degree of degradation using a single index or factor. In order to accelerate China's forest restoration projects, there is a need for both short-term and longer-term monitoring for evaluating restoration success. Establishing such standards is a critically important issue that needs further consideration and research. Ecological zoning work helps to identify key areas and prioritize the restoration planning and assessment efforts.

Tree species improvement and breeding is important for the success of forest restoration. A successful example was a 10-year project of improving poplars in the Three-North region of China with assistance from FAO (Carle and Ma 2005). The project developed a long-term breeding plan for poplars based on a medium-sized

provenance collection of *Populus simonii* and other related species. The project also developed clonal banks that incorporated many of the existing poplar varieties of northern China together with some imported varieties. After a series of comparative studies, a large collection of poplar clonal material was made and planted out. Superior clones were screened for their adaptation to different site types. Stand with new clones were established in the field to evaluate these valuable genetic material and to test long-term performance. Developing site-adapted clones improved establishment success.

4.4.3 The Assessment of Forest Ecosystem Health and Services

Forest ecosystem health has become an increasingly important scientific issue related to forest restoration. Both the Chinese forestry authority and forest researchers have been working on this area, with some success (Liu et al. 2008). Forest ecosystem health addresses the ecological relationships among human activities, social factors, and human health. Ecosystem health refers to ecosystems that can self-maintain their structure and function under various level of environmental threats (e.g., hurricanes, invasive species).

A healthy ecosystem generally has the following characteristics: no major maladjusted phenomena, strong capability of recovery, self-sustainable, no harm to neighbor ecosystems or to economic development and human health. Establishing standards for assessing ecosystem health is a key issue in the ecological restoration arena (Ren et al. 2000). This is especially important in China, where forest types are diverse and human impacts are pervasive.

4.5 Toward Sustainability and Scientifically Based Restoration

While China has made world-class achievements in recent large-scale forest restoration programs, ecological restoration has been goal-oriented with a top-down approach and heavy reliance on central government financing. The benefit of this approach was of course the large-scale of activities achieved in a short time. However, the disadvantages of this approach were also obvious: largely dependent on central government funding, policies were too rigid, often without consideration of local conditions and therefore not sustainable. Those shortcomings plus at times inconsistent policies and technical constraints continue to pose great challenges to further restoring degraded forest lands in China.

Yin and Yin (2010) have pointed out the shortcomings that needed to improve: inadequacies in monitoring and assessment, heavy reliance on state financing, rigidity and inconsistency regarding certain policy measures, lack of inter-agency cooperation and careful planning, insufficient consideration of local interests, and neglect of appropriate technical practices. Among these issues, certain forest

strategies and policies need to be reformed or evolve to enhance the sustainability of forest restoration efforts (Xu et al. 2000; Wang et al. 2004). We concur with their concerns and in the following section, we provide some suggestions for more effectively implementing forest protection and restoration practices.

4.5.1 Promoting Sustainable Forestry Policies

The success of China's on-going restoration efforts depend largely on government policies as mostly they have been national, top-down government projects. How then can we improve policies and the resulting practices? Certain pending policies and the forestry legal (governance) system needs to be improved.

First, more work needs to be done to transform the past top-down approach into bottom-up efforts. For this, motivating local farmers is the key. In most on-going forest restoration projects, local farmers have little say; they have no input into restoration issues such as what types of forests should be restored and they usually have no option but to stand back while local government staff makes the decisions. For example, frequently local famers would like to increase native tree species with economic value but the national-level protocol only allows for <20% of forests as economic forests. Moreover, local communities should be given greater say in program design and implementation. The local government should communicate with local people through demonstration projects or showcases and they should be promoting local (village)-level self-sustainable project designs. This is an area where the international community, in particular non-governmental organizations could provide assistance and have great influence in improving China's ecological conditions. Forest landscape restoration should move toward more comprehensive and sustainable forestry and agricultural policies that consider both the environment and local farmer livelihoods.

Sustainability of forest protection and restoration projects is essential for the ultimate success of restoring China's degraded forests. China has been promoting sustainable development in forestry since the 1990s, and will continue to do so (SFA 2009). At the national level, forest restoration sustainability should include a national research program for better understanding the causes of land degradation, the movement of air and water, nutrient cycles, and the relationships among natural vegetation, forest succession, and climate change that are critical for guiding forest restoration. More importantly, regional or landscape planning are crucial as the impacts of different factors typically vary according to regions, and have different regional implications (Xu and Cao 2002). For example, the direct causes of forest degradation in China's western region are due to the serious water shortage and severely damaged natural vegetation. Such land degradation further decreases vegetation cover, which is already exacerbated by severe drought, desertification, and other natural disasters such as sand storms (Economy 2002).

The present situation and that faced in the future have generated the need to establish a legal system to regulate forestry. Therefore, it is necessary to accelerate

legislation for sustainable forestry development and to effectively enforce the current laws and regulations. The goal is to establish a legal framework with the Forestry Law and the Desertification Control Law as central components and administrative regulations and local by-laws as auxiliary components. The framework can be effectively enforced and readily monitored, so that sustainable forestry development shall be secure. The major actions planned should include: (1) initiating legislation for sustainable development of forestry and improving the forestry legal framework; (2) strengthening research and education of forestry-related legal sciences and promoting development of legislative theories; (3) increasing public awareness and education of forestry legislation; (4) improving the forestry law-enforcement system, strengthening organizations and stabilizing a task force for enforcement, and establishing and improving enforcement procedures and rules; and (5) establishing and developing a supervisory system for forestry law enforcement and promoting professional standards.

4.5.2 Land Tenure Reform

Forest land tenure reform is a major issue in China and has profound implication for forest protection and restoration (Liu and Yin 2004; Lei 2002b). In China, many forestry policies in China were adopted as early as several decades ago, and are still in force (Wang et al. 2001). Recently, unclear land tenure rights have been identified as both a driver of deforestation and a prerequisite for effective forest protection and restoration. With the implementation of the six key forestry programs described above, China's forestry sector has entered a new developmental stage. Forestry in this stage will give priority to ecological values and take into account ecological, social and economic benefits to speed up development (Horst et al. 2006; Xu et al. 2006). Nationally the comprehensive development of forestry and forest landscape restoration can only be advanced with the impetus of land tenure reform.

4.5.3 Increasing Collaboration

Forest landscape restoration does not exist in a vacuum. At the national level, preventing land degradation and promoting forest restoration involves multiple interests and many government departments including agriculture, forestry, environmental protection, water, land and natural resources. In the operational and local levels, land degradation and restoration involves all aspects of society. Therefore, to restore degraded forest land, it is necessary for society as a whole to be involved and

engaged (Liu 2004). In China, a national forestry project should be collaboration among all departments with a stake in land management to avoid duplication and benefit from synergy.

4.6 Conclusions

China's forest restoration activities have accumulated successful experiences and learned valuable lessons (Richardson 1990; Hill 1994; Uchida et al. 2007). The Chinese people, including its leaders, recognize that restoring China's degraded forests is an important but challenging task and increasingly they are aware of the complexity of this task. Over the past 20 years, China has supported efforts to restore its degraded forests by adopting a national sustainable forestry strategy, adjusting forest policies, reforming forest ownership rights, and increasing investments. The results are significant (Jiang 2005; Liu et al. 2008). However various problems and issues exist when carrying out the restoration projects that need to be resolved. Despite regional improvements, China's total forest resources are still inadequate to meet domestic needs. Deforestation continues due to population growth, increasing living standards, and the pressure placed on natural resources and the environment by economic development.

For China, forest restoration is a long-term task. The Chinese government has set ambitious goals both for economic growth and forest landscape restoration. To implement these goals in a balanced fashion, China should continue its current national strategy of sustainable development and conduct forest restoration activities under this framework. Preserving the remaining natural forests is particularly important; China needs to develop sound scientific knowledge and technology, and transfer them into practice, in order to increase the effectiveness of forest restoration. Moreover, China needs to improve regulations and policies and enhance both pre-project planning and post-project assessments in order to improve restoration practices. Long-term financial investment, scientific and technological support, coordination and silvicultural management, effective advocacy and education are needed to further strengthen these efforts. In this regard, an integrated approach that incorporates both natural and social sciences is needed.

The Chinese central government and people are working to address the major challenges to provide a sound enabling environment for investment and collaboration. China's recent large-scale forest protection and restoration programs provide valuable case studies for world restoration efforts. At the same time, great opportunities exist for the international community to contribute by providing needed scientific and technical support to China's effort to improve its ecological conditions.

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