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# China's Primary Programs of Terrestrial Ecosystem Restoration: Initiation, Implementation, and Challenges

Runsheng Yin · Guiping Yin

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**Abstract** China has undertaken several major programs of terrestrial ecosystem restoration (ERPs) in recent years, including the Natural Forest Protection Program (NFPP) and the Sloping Land Conversion Program (SLCP). There have been reports on the implementation of these programs, their preliminary impacts, and the problems encountered in carrying them out; a great deal has been learned from these studies. Nonetheless, China's ERPs are not limited to the NFPP and the SLCP. Because a complete documentation and a timely update of these major efforts are still missing from the literature, it is difficult to gauge the scope of these programs and the scale of their impacts. In addition, a more thorough and critical analysis of both the general ERP policy and the specific technical measures used in implementing the ERPs remains urgently needed. The purpose of this article is to tackle these tasks. Overall, with the huge government investments in the ERPs, tremendous progress has been made in implementing them. To complete them successfully and to fundamentally improve the targeted ecosystems, however, it is essential for China to have a more balanced and comprehensive approach to ecological restoration. This approach must include: adopting better planning and management practices; strengthening the governance of program implementation; emphasizing the active engagement of local

people; establishing an independent, competent monitoring network; and conducting adequate assessments of program effectiveness and impact.

**Keywords** Land conversion · Forest protection · Soil erosion · Desertification · Program effectiveness and impact · Policy improvement

## Introduction

Due to population pressures, economic growth, and historic exploitation, a large portion of China's primary forests and wetland has been depleted, and a high percentage of its farmland and grassland has been degraded (WWF 2003; Yin and others 2005). These ecosystem disturbances have caused extensive desertification, flooding, soil erosion, dust storms, elevated levels of greenhouse gas emissions, and severe damage to wildlife habitats (Liu and Diamond 2005; Xu and others 2006). To address these concerns and improve its environmental conditions, China has undertaken several major ecological restoration programs (ERPs), including the Natural Forest Protection Program (NFPP), the Sloping Land Conversion Program (SLCP), and the Desertification Combating Program around Beijing and Tianjin (DCBT). These ERPs represent large-scale programs aimed at transformational changes and, as such, should have profound environmental and socioeconomic impacts both domestically and internationally (Forest and Grassland Taskforce of China 2003; Wang and others 2007b).

A few studies have investigated the early implementation of these programs, their preliminary impacts, and the problems encountered in carrying them out. For instance, Xu and others's (2006) study was one of the earliest

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attempts to summarize the essentials, progress, and effects of the NFPP and SLCP. These authors also discussed challenges facing the programs. Similarly, Liu and others (2008) reported the implementation of these two programs, reviewed the patchy evidence regarding their effects, and suggested steps for improving their effectiveness, including systematic planning, diversified funding, effective compensation, integrated research, and comprehensive monitoring. In addition, Wang and others (2007b) presented a synopsis of these and other programs and then related them to the latest forest tenure reforms and other policies of the Chinese government. An expanded version of Wang and others (2007b) later appeared in another journal (Wang and others 2008). Undoubtedly, China's experiences on ecological restoration are of broad interest, and much has been learned about the NFPP and the SLCP from these and other studies.

Nonetheless, China's ERPs are not limited to the NFPP and the SLCP (Wang and others 2008; Liu and others 2008). Moreover, because a complete documentation and a timely update of these major programs are still missing in the literature, it is difficult to gauge the scope of these programs and the scale of their impacts. In addition, a more thorough and critical deliberation of both the ERP policy and the specific technical measures used to implement these programs remains urgently needed. The purpose of this article is to tackle these tasks in order to both facilitate China's implementation of the ERPs as well as to advance international understanding of these programs. Before proceeding, note that, due to space limitation and subject distinction, we have decided not to review the literature that has assessed the socioeconomic and ecological impacts of the ERPs here. Readers interested in this literature can refer to Yin and others (2009) for a comprehensive review. Rather, since our task is to narrate the basic contents of the programs and their progress as well as to discuss the major issues encountered in their execution and we have to do with the lack of well-conducted and comprehensive assessments of the program impacts, various statistics have been drawn from government sources in order to present a largely descriptive analysis.

The article is organized as follows. In the remainder of this section, we provide the historic context in which China's ERPs were launched. Then, we present key elements of the ERPs as well as the ways in which they have been implemented in the next two sections. Finally, we address the critical issues that China faces in successfully completing these programs and fundamentally improving its ecosystem.

After the People's Republic of China was established in 1949, large tracts of primary natural forests remained in the northeast, southwest, and a few other places. Most of these forests were later nationalized, and 136 state-owned forest

bureaus were gradually set up to produce timber to spur the country's economy (SFA 2001). Along with this strategy of resource exploitation, the Socialist governance system came into existence, under which the state enterprises lacked incentive and autonomy to manage and utilize resources efficiently (Yin 1998). Logging was the main, or at times even the sole, revenue source for many of these areas, and the forest bureaus had to assume the heavy burden of providing almost all social services to their workforce. As a result, over-cutting became prevalent, and regeneration and other types of forest management were neglected. At the same time, population growth and increased demand for employment in these forest regions led to more fuelwood consumption, housing construction, and land clearing. Consequently, China's natural forests were quickly depleted (Liu 2002). This over-cutting and under-management also resulted in the structural deterioration of the forests, as reflected in reduced stocking volume, an imbalanced age structure, an altered species composition, and a low growth rate (Yin 1998).

Unfortunately, the ecological environment in the rural parts of China is even worse. The collectivization of the 1950s discouraged people from tree-planting and forest management. Soon after, as part of the attempt to industrialize, a campaign to increase steel production took place during the Great Leap Forward initiatives. In many places, even backyard furnaces fueled by wood charcoal were deployed to produce steel (Yin 1994). Throughout the 1960s and 1970s, forest and grassland was converted to farmland due to the chronic crises of grain shortages, on the one hand, and the national policy of food self-sufficiency, on the other. These malpractices resulted in the severe destruction of vegetation as well as deforestation. In addition, farming on steep slopes became common due to the demographic explosion and lapses in regulation (Du 2001). Coupled with uneven rainfalls and rugged terrains, this led to a substantial reduction in the ecosystem's capacity to regulate water flows and to contain soil erosion (Lu and others 2002). These factors were deemed the primary reasons for the record dry-up of the Yellow River in 1997 and the widespread flooding in the Yangtze basin in 1998 (Xu and Cao 2001). Another disaster has been the loss of grass cover and desertification in the Northwest, which has been driven by uncontrolled grazing, poor maintenance of rangeland, and the human-induced decline of water tables (Yin and others 2005).

To be sure, the Chinese government has made attempts to combat the growing environmental problems, but the record of their effectiveness is utterly disappointing. Since 1978, for instance, a number of afforestation projects have been launched (Xu and others 2006). Despite their broad geographic reach and remarkable planting efforts, public investments were limited, and so the efforts were rarely

followed through to completion (Smil 1993). Often, sites were poorly prepared, seeds and/or seedlings were not properly planted, and saplings were not well tended. Therefore, these forestry projects have failed miserably in delivering their expected environmental benefits. Similar problems have hindered efforts to curb farming on slopes (Xu and Cao 2001). In addition, having gained economic independence from the rural reforms, many farmers have aggressively sought new croplands, and herders have hastily increased their livestock (Du 2001). Oftentimes, this has meant that a large number of the more sensitive patches on steeper slopes were claimed, and a great amount of the grassland in the arid and semi-arid regions became overgrazed.

By the late 1990s, several successive ecological disasters had indicated that China's historic efforts to protect its ecosystems had not improved its overall ecological conditions, and more decisive and forceful measures were thus necessary to bring these problems under control. It was against this backdrop that new the ERPs were launched and the existing ones were consolidated. Prompted by the ecological disasters as well as the State Council, the State Forestry Administration (SFA) proposed the NFPP in 1998 as a large-scale scheme to protect most of China's natural forests. The SFA then developed the SCLP in 1999 to convert croplands on slopes and desertified fields back into forestland, grassland, and wetland on an even larger scale. The SLCP is also known as the "Grain for Green" program (WWF 2003; Xu and others 2006).

In addition, China has carried out four other ERPs: the DCBT, the Shelterbelt Network Development Program, the Wildlife Conservation and Nature Reserves Protection Program, and the Industrial Timberland Plantation Program (SFA 2002). Together, these projects were designated by the SFA as the "Six Priority Forestry Programs" of ecological restoration and resource expansion; moreover, they have been incorporated into national economic development and environmental protection plans (SFA 2007; Wang and others 2007b). They are called forestry programs, not because they all have a clear forest orientation but because they are managed by the State Forestry Administration (SFA), who believes that this naming will give it, not another agency, a heightened mandate and thus relevance, which will guarantee its funding and publicity. Notably, there have been other ecological restoration programs, such as the water and soil conservation initiatives undertaken by the Ministry of Water Resources and the farmland and grassland protection initiatives administered by the Ministry of Agriculture. However, the geographic coverage and public investments in these programs are generally much smaller than those of the SFA.

The Chinese government hopes that these programs will not only greatly improve domestic resources, ecological

conditions, and rural livelihoods but also significantly contribute to regional and global environmental causes (Yin and others 2005; Liu and others 2008). The total investment in these programs over this decade will easily top 500 billion yuan, or roughly US\$70 billion, given the current exchange rate of US\$1 for 6.85 yuan (Wang and others 2008).

## Program Contents

### The NFPP

Because a substantial portion of China's natural forests is comprised of national forests managed by state forest enterprises (Yin 1998), the NFPP is geared toward national forests and state forest enterprises. After 2 years of trial, it was formally launched in 2000. The specific goals of the NFPP are to (1) reduce timber harvests from natural forests from 32 million m<sup>3</sup> in 1997 to 12 million m<sup>3</sup> by 2003; (2) conserve nearly 90 million ha of natural forests; and (3) afforest and re-vegetate an additional 8.7 million ha by 2010 by means of mountain closure, aerial seeding, and artificial planting (Liu 2002).

As a result of the bans on logging and harvest reductions, 740,000 loggers and other workers downstream of the timber supply chain may be displaced. So, the NFPP also stipulates whether those displaced employees should be transferred to forestation and forest management activities, retired, or laid off, depending on each employee's years of service, preferences, and reemployment opportunities, among other things. In addition, all existing and newly retired employees would be incorporated into the provincial pension and social security systems; for the laid-off workers, a minimum living expenditure would be assured. This could have created a great budgetary burden for the provincial and county governments in which forestry was a main sector. To alleviate this problem as well as explore new business opportunities, the financial burden has been partly shared by the central government.

The widespread defaults of the state forest enterprises on their financial obligations due to the drastic disruptions in business mean that the government must write off a large amount of business debt. In addition, in order to protect existing resources, expand resource coverage, and improve resource quality, the government has allocated a large sum of funds for forestation, re-vegetation, and land management activities. Subsidies for various activities are set as follows: mountain closure receives a subsidy of 1,050 yuan/ha; aerial seeding receives 750 yuan/ha; artificial planting receives 3,000 yuan/ha in the Yangtze River basin and 4,500 yuan/ha in the Yellow River basin; and forest protection receives 10,000 yuan per worker for 340 ha. The

original budget of the program was 96.4 billion yuan until 2010. Of that total, 85% would be covered by the central government and 15% by governments of the provinces involved (SFA 2001).

### The SLCP

The land conversion pilot program began in 1999 in Sichuan, Shaanxi, and Gansu, which are provinces located in the middle and upper reaches of the Yellow River and the upper reaches of the Yangtze River. The SLCP was originally planned for 2001–2010 in two phases. The first phase, from 2001 to 2005, was aimed at gaining preliminary control of the fragile ecological situation in the program areas. One main task was to retire and convert 11.33 million ha of sloping farmlands, including 4.4 million ha on slopes steeper than 25°, and desertified fields. Meanwhile, another 13.33 million ha of sparsely vegetated mountainous, hilly, and sandy lands was included for forestation or re-vegetation. It was envisioned that these steps would lead not only to a significant increase in vegetation cover but also to erosion control and desertification curtailment on a large scale. During the second phase, from 2006 to 2010, the SLCP was designed to retire and convert an additional 3.3 million ha of farmlands and afforest and re-vegetate 4.0 million ha more of the sparsely vegetated hilly and sandy fields. It is expected that by 2010, the vegetation cover will be further expanded, ultimately resulting in erosion control of over 86.67 million ha and desertification containment of over 102.67 million ha (SFA 2002).

The SLCP mandates that farmers who participate in the land retirement and conversion projects be compensated. The retired farmland may be converted into ecological forests (i.e., forests primarily providing ecological functions and services), commercial forests (i.e., forests producing timber, fruits, nuts, medical goods, and other commodities), or grass cover. 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 2001). To account for regional variations in crop yields and population densities, the grain subsidy is set at 2,250 kg/ha in the Yangtze River basin and 1,500 kg/ha in the Yellow River basin. The cash subsidy is 300 yuan/ha for eligible land each year. Finally, agricultural taxes on the converted lands are exempted, and the loss of local revenues due to reduced agricultural output and a shrunken tax base are shared by the central and provincial governments. The total investment is projected to be 225 billion yuan during 2001–2010 (Tang 2007).

### The DCBT

In the spring of 2000, sandstorms struck northern China twelve times. The high frequency, broad coverage, and large damage of these events had seldom been seen over the past half century. Shocked by these events, the central government quickly drew up a blueprint to inhibit the encroachment of desertification and to improve the natural environment for Beijing, the capital of China, and its adjacent areas, thus leading to the DCBT commission (SFA 2002). This program is also targeted at the 2001–2010 period. The main objective of the DCBT is to treat 10.13 million ha of desertified lands, of which 5.21 million ha is to be vegetated or re-vegetated. To fulfill these tasks, measures include the conversion of cropland to forests, grassland rehabilitation, selective banning of open grazing, integrated watershed management, and ecological resettlement.

The area of cropland that would be converted to forest and grass coverage is roughly 2.63 million ha. Meanwhile, over 4.94 million ha of degraded and sandy fields will be afforested or reforested, 10.63 million ha of grassland rehabilitated, 23,445 km<sup>2</sup> of small watersheds protected, and 180,000 villagers resettled. 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. Understandably, the degraded lands are rehabilitated in this case. Questions remain, however, regarding how to guarantee that farmlands and grasslands around newly resettled sites are not degraded in the future. Farmers and herders involved in these activities are compensated as well. In addition to cropland retirement, which receives a subsidy similar to that under the SLCP, compensations for other activities include: afforestation at 4,500 yuan/ha, forest regeneration via aerial seeding at 3,000 yuan/ha, mountain closure at 1,050 yuan/ha, grassland establishment via artificial planting and aerial seeding at 1,800 yuan/ha and 1,500 yuan/ha, grassland fencing at 1,050 yuan/ha, livestock pen building at 200 yuan/m<sup>2</sup>, integrated watershed management at 200,000/km<sup>2</sup>, and ecological resettlement at 5,000 yuan/person. The program covers 75 counties in Beijing, Tianjing, Hebei, Shanxi, and Inner Mongolia. The estimated total investment is 57.7 billion yuan (SFA 2003).

### Other Programs

In this section, we discuss the other three ERPs, namely, the Wildlife Conservation and Nature Reserves Protection Program (WCNR), the Shelterbelt Network Development Program (SNDP), and the Industrial Timberland Plantation Program (ITPP).



The WCNR strives to expand the number of nature reserves and enhance the protection of wildlife. It proposes that the total number of reserves reach 1,800 by 2010 and 2,000 by 2030; moreover, it stipulates that the primary protected areas be administered by central and provincial governments, while smaller, less critical areas be managed by municipal and county governments (SFA 2002). 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. The total planned investment is 135.65 billion yuan over a period of 30 years starting in 2001; roughly half of the investment (66.5 billion) is from the central government. The program also seeks the active participation of non-governmental domestic and international entities, including the broad involvement of the private sector.

Covering the vast “Three Norths” (i.e., the Northwest, North, and Northeast) the Yangtze River basin, the Zhujiang River basin, and the Taihang Mountain Range, the SNDP intends to mobilize public agencies, civil society, and everyday individuals to engage in shelterbelt development and maintenance as well as extensive tree planting. Once the shelterbelt network in the Three Norths is fully developed, it will constitute a belt 400–700 km wide and 4,500 km long that parallels the Great Wall. Thus, it is often called the “Green Great Wall” by the government and the media (SFA 2002). The goal of the SNDP is to mitigate wind-induced erosion, landslides, and flooding and to protect grasslands, riverbanks, and coastal lines (SFA 2002). Because of limited investment by the central government (namely, 70 billion yuan from 2001 to 2010), the program is aggressively seeking regional investments and local labor contributions. Additionally, it supports the adoption of appropriate silvicultural techniques and the integration of shelterbelts with farming and grazing through agroforestry practices.

The ITPP represents a major market-driven effort to increase the domestic timber supply (SFA 2002). 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 also urges active involvement through various types of business entities, including state or collectively owned firms, shareholder-based organizations, or fully private businesses. The target area is 4.7 million ha from 2001 to 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.

These six programs are summarized in Table 1. Obviously, these ERPs vary significantly in terms of their mission, their duration, and their financial commitments, among other things. Nonetheless, the SLCP is by far the

largest. Notably, except for the SLCP and the NFPP, none of these programs are brand-new or even recently initiated, as some authors have suggested. Rather, various predecessors have been in existence much earlier; they were consolidated a few years ago either for more effective administration or for more focused targeting (SFA 2002). For example, shelterbelt expansions were originally launched in various regions during the 1970s and 1980s. It was only in 2001 that they were combined under a single SNDP umbrella. Another example is initiatives to counteract desertification, which were and still are carried out on a vast geographic scale. The DCBT was an outgrowth of these undertakings in response to the frequent invasion of dust storms to Beijing, Tianjin, and other cities in the Northern Plains (SFA 2002). Efforts to stop desertification in other areas now overlap with and even have become part of the SLCP.

## Implementation and Outcomes

Since the initiation of these ambitious ERPs, farmers, herders, state employees, and other stakeholders as well as communities and public agencies have enthusiastically participated. With the help of unprecedented levels of government financing, remarkable progress has been made in the implementation of these programs (Xu and others 2006; Wang and others 2007b; Liu and others 2008). Therefore, the government claims that the conditions both of the ecosystems and people’s livelihoods have been significantly improved (SFA 2007).

### Implementation

The areas involved in the NFPP include Yunnan, Sichuan, Guizhou, Chongqing, Hubei, and Tibet in the upper the Yangtze River basin; Shaanxi, Gansu, Qinghai, Ningxia, Inner Mongolia, Henan, and Shanxi in the upper and middle reaches of the Yellow River; and the national forests in Heilongjiang, Jilin, Inner Mongolia, Hainan, and Xinjiang. In total, it covers 17 provinces, 734 counties, and 167 forest enterprises. Of the targeted 19.9 million m<sup>3</sup> reduction in annual production of commercial timber, 12.4 million m<sup>3</sup> will occur in the upper reaches of Yangtze River and upper and middle reaches of Yellow River, and 7.5 million m<sup>3</sup> will occur in the Northeast. In 1997, China’s total production of commercial roundwood was 56.1 million m<sup>3</sup>, of which 61% came from natural forests. As much as 98% of the 18.8 million m<sup>3</sup> produced by the state-owned forest bureaus was from natural forests (Xu and others 2006).

In carrying out the NFPP, the targets regarding logging bans, commercial harvest reductions, resource protections,

**Table 1** Key policy measures of the six priority forestry programs

Program	Key policies
Sloping Land Conversion Program (SLCP), covering 25 provinces from 2001 to 2010	<ul style="list-style-type: none"> <li>• Sloping or desertified cropland is converted into ecological or economic forest, and grassland; ecological forest should account for 80% of the converted land.</li> <li>• The central government subsidizes farmers with seeds or seedlings, grain, and cash.</li> <li>• Subsidies last 8 years for ecological forest, 5 years for economic forest, and 2 years for grassland. The annual cash subsidy is 300 yuan/ha, and the annual grain subsidy is 1,500 kg/ha in the Yellow River basin and 2,250 kg in the Yangtze River basin.</li> <li>• The central government also makes fiscal transfers to compensate subsequent losses to local fiscal revenues.</li> <li>• The original estimate of total investment is 225 billion yuan.</li> </ul>
Natural Forest Protection Program (NFPP), covering 17 provinces from 2000 to 2010	<ul style="list-style-type: none"> <li>• It establishes a complete ban on commercial logging in the upper Yangtze and upper and middle Yellow River basins and sharp reductions in commercial harvests in other regions.</li> <li>• Other measures include shutting down certain processing facilities, compensating logging firms, and dealing with displaced workers and equipment.</li> <li>• Afforestation and forest management is promoted where necessary.</li> <li>• Administration and law enforcement is strengthened, including forest protection.</li> <li>• The forest industry is restructured, and the efficiency of timber utilization is improved.</li> <li>• The initial investment commitment was 96.4 billion yuan.</li> </ul>
Wildlife Conservation & Nature Reserve Development Program (WCNR), scattered all over the country during 2001–2050	<ul style="list-style-type: none"> <li>• Priority protected areas are administrated by the central government, while smaller and less critical areas are managed by the regional governments.</li> <li>• The number of established reserves will reach 1,800 by 2010, 2,000 by 2030, and 2,500 by 2050.</li> <li>• Also included are wetland protection and restoration measures, ecotourism development, and wildlife breeding initiatives.</li> <li>• Encouraging domestic and international participation and contributions, including broad involvement of the private sector.</li> <li>• Strengthening the role of science and technology, particularly regarding the monitoring and evaluation of nature reserves and biodiversity.</li> <li>• Projected total investment is 135.65 billion yuan over the first 30 years; roughly a half of this investment is covered by the central government.</li> </ul>
Shelterbelt Development Program (SBDP), covering all 31 provinces from 2001 to 2010	<ul style="list-style-type: none"> <li>• This program includes the ‘Three Norths’ (i.e., the Northwest, North, and Northeast), the Yangtze River basin, the Zhujiang River basin, and the Taihang Mountain Range.</li> <li>• Public agencies, civil society, and individuals are mobilized to participate in shelterbelt development and tree planting.</li> <li>• Regional government investment, local labor contributions, and the adoption of new silvicultural techniques are encouraged.</li> <li>• Projected total investment is 70 billion yuan.</li> </ul>
Desertification Combating around Beijing and Tianjing (DCBT), including Inner Mongolia, Hebei, Shanxi, Beijing, and Tianjin from 2001 to 2010	<ul style="list-style-type: none"> <li>• Desertified land is converted into forestland and grassland through flexible, diversified measures based on the local conditions.</li> <li>• Herding and animal husbandry practices are changed to control overgrazing and rehabilitate degraded grassland.</li> <li>• Irrigation projects are developed, and people are resettled away from fragile areas.</li> <li>• The provision of technology and energy is included.</li> <li>• Desertification monitoring systems and dust storm forecasting systems are implemented.</li> <li>• Projected total investment is 57.7 billion yuan.</li> </ul>

**Table 1** continued

Program	Key policies
Industrial Timber Plantation Development Program (ITPP), covering 18 provinces from 2001 to 2015	<ul style="list-style-type: none"> <li>• Market-driven and profit-orientated efforts are developed for increasing domestic timber supply.</li> <li>• As much as 70% of the investment may come from loans subsidized by the National Development Bank.</li> <li>• Tax incentives are provided.</li> <li>• Active participation is encouraged from various enterprises, including state and collectively owned firms, shareholder-based organizations, and fully private businesses.</li> <li>• The planned area of establishment is 4.69 million ha by 2005, 9.2 million ha by 2010, and 13.33 million ha by 2015.</li> <li>• Projected total investment is 71.8 billion yuan.</li> </ul>

and levels of reforestation and afforestation have been well met. Timber production has been restricted to a quota determined by the State Council. In 2006, for instance, the total production of commercial roundwood was 13.5 million m<sup>3</sup> across the entire program area. Over 90 million ha of natural forests have been protected, and reforestation via artificial planting, aerial seeding, and mountain closure has reached 15 million ha. Regional and local authorities have made concerted efforts to develop alternative business opportunities and transform the forest-based economy. Ecotourism and other related farming activities have gained broad recognition. In addition, more and more of these activities have been undertaken by private enterprises.

Meanwhile, 665,000 state employees in logging, hauling, and wood product processing have been terminated, with over 200,000 transferred to forest protection and management and 353,600 laid off or retired (SFA 2007). A social safety net, including employee pensions and medical and unemployment insurance, has been put in place to cover 99% of the employed and retired personnel. Statistics suggest that the bulk of investments (68% prior to 2004) in state forest bureaus has been spent on employee settlements and benefits rather than on actual forest protection, management, and tree planting (SFA 2006). Thus far, a total of 57.5 billion yuan has been invested, of which 53.9 billion yuan (or 93.69%) has been contributed by the central government. Implementing the NFPP has also caused a large amount of logging, hauling, and processing assets in state forest enterprises to become obsolete. To dispose of these assets and write off both the principals and the interest on loans acquired by these firms, the central government has added 24.5 billion yuan to its budget (Tang 2007). Hence, the actual investment is expected to be no less than 120.7 billion yuan by 2010. And there have been indications that the central government will extend the program well into the next decade (SFA 2008).

In March 2000, the SLCP enrolled 174 counties in Yunnan, Guizhou, Sichuan, Hubei, Shanxi, Henan, Shaanxi, Gansu, Ningxia, Qinghai, Xinjiang, and Chongqing. Then, in 2001, it was expanded to 20 provinces, 400 counties, and 27,000 villages. Participation grew to 120 million farmers in 32.5 million households of 2,291 counties, concentrated in the West (SFA 2006). In the first 3 years, 1.2 million ha was converted into forest and grassland, with an expenditure of 3.65 billion yuan (Xu and Cao 2001). In 2002 and 2003, however, converted cropland increased to 2.9 million ha and then to 3.3 million ha, respectively (SFA 2004). By the end of 2004, a total of about 9 million ha of cropland had been converted, including 4 million ha on slopes steeper than 25°. But thereafter, the government abruptly scaled back the conversion of cropland amid a dwindling grain surplus and



concerns for food security and restricted annual enrollment to 0.67 million ha (Xu and others 2006). These unexpected ups and downs in addition to issues regarding set-aside enrollments and site and seedling preparations have made the smooth execution of the program difficult. Meanwhile, the subsidies now take the form of both seedlings and cash payments, with grain valued at a fixed rate of 1.4 yuan per kilogram (Tang 2007).

From the onset of the SLCP, the central government promised that the availability of grain and cash subsidies would be extended if, after review, there were more qualified lands (Du 2001). Nevertheless, there have been general concerns regarding whether the government will honor its promise. In 2007, the State Council announced that the program would be extended until 2021, since many participating farmers were still facing poverty and had difficulty finding alternative income after having converted their farmland (Tang 2007). However, the new scheme has included a major adjustment. In addition to keeping the original cash subsidy of 300 yuan per ha per year, the amount of subsidized grain has been halved. Consequently, the total subsidy is now 1,875 yuan per ha per year in the Yangtze River basin and 1,350 yuan per ha per year in the Yellow River basin. Again, the subsidies last 8 years if ecological forests are planted, 5 years if economic forests are planted, and 2 years if grass cover is established.

With 206.6 billion yuan added as per the adjusted policy, the total investment of the SLCP will amount to 431.1 billion yuan by 2021 (Tang 2007). In addition, a special fund has been proposed by the Ministry of Finance in order to promote the long-term development of the livelihoods of farmers and environmental recovery. This means that there will be continued investment in poverty alleviation, infrastructure expansion, ecological resettlement, alternative energy, and maintenance of forests and grassland (Tang 2007).

The progress of the DCBT is also impressive. As of 2006, afforestation had expanded to 2.8 million ha through artificial plantation and aerial seeding and to 1.3 million ha through mountain closure. In addition, about 1.5 million ha of grassland has been rehabilitated, 0.5 million ha of small watersheds has been treated, and over 101,000 poverty-stricken people have been resettled to places where a basic livelihood can be sustained (SFA 2007). The total investment in the program reached 13.6 billion yuan from 2000 to 2006. Surveys show that most of the investment has been used for subsidized conversions of cropland into forests and grassland.

Likewise, the WCNR and the SNDP have made tremendous advances. The amount of nature reserves has increased steadily, and the conservation of wild plants and animals has also been greatly enhanced. By the end of 2006, there were already 1,740 nature reserves, accounting

for 12.6% of the country's land base. Of the 1,740 nature reserves, 198 are national, 583 provincial, 289 municipal, and 670 county-level (SFA 2006). Due to these reserves, 90% of the terrestrial eco-zones, 85% of the wild animal species, 65% of the plant communities, and 45% of the wetland have been put under protection (SFA 2007). 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 2006).

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 Norths and 3.05 million ha in the Yangtze River basin (SFA 2007). In comparison, less than 0.4 million ha of industrial timber plantations were established during the same period under the ITPP (SFA 2007), suggesting the very slow development of the ITPP.

### Preliminary Outcomes

According to government reports, the condition of natural resource has been much improved due to the ERPs. During from 1999 to 2006, forest area increased by 8.1 million ha, and stocking volume grew by 466 million m<sup>3</sup> in areas covered by the NFPP (Tang 2007). Similarly, a large amount of degraded farmland and grassland has been converted and rehabilitated, and the forest and grassland coverage expanded substantially through the implementation of other programs (SFA 2007). As a result, ecological conditions have been improved as well, as is broadly reflected in the decline of soil erosion and water runoffs, the 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, the diversification of local economies, the acceleration of labor transfer, an increase in income and living standards, and a reduction in poverty (SFA 2007).

While these statements are generally true, where, how, and to what extent these programs have changed the ecological and socioeconomic conditions is still poorly understood. Of course, in part this is because certain government statistics may not be available or are not reliable. In another part, it is because independently performed and comprehensive assessments of the program impacts by the science community are yet available and the government has not given adequate attention to the monitoring and evaluating efforts. For instance, the SFA (2006) reported that desertified land decreased 6,416 km<sup>2</sup> from 1999 to 2004; as such, the intensity of wind erosion has weakened, and sandstorms as well as days of strong winds have been

reduced in Beijing and its vicinity. However, these findings were not independently derived or even verified by the scientific community. Furthermore, several analyses of selected sites in Hebei, Inner Mongolia, Gansu, and Qinghai suggest that the DCBT and other similar programs rarely showed a significant positive effect until 2005 (Zan and Wang 2006; Wei and others 2006; Yin 2007). In another study, the government asserts that the marked decline in erosion and sediment in the upper Yangtze basin reflected in the records of certain hydrologic stations is largely due to the combined effects of the SLCP and the NFPP. In the Sichuan province alone, implementing these programs has led to a sediment reduction of 53 million tons and an increase in ecosystem water retention by 684 million tons a year (SFA 2006). Studies show that so many dams and reservoirs have been built in the region over the past two decades that their holding capacity has increased steadily (Yin 2007). It is far from clear whether and how much the reduction of erosion and sediment is due to ecological restoration efforts or hydro-engineering projects. Therefore, much more effort must be made to monitor and assess these programs.

Notably, Xu and others (2006), Uchida and others (2007), and Liu and others (2008) are among the few studies in the international literature that have corroborated some of the official claims regarding the impacts of these programs. Still, their evidence is preliminary as well as sketchy; in fact, some of it came from second-hand sources. Because the literature on impact assessment has been reviewed separately (Yin and others 2009) and several studies evaluating the specific ecological and/or socioeconomic effects of China's ERPs are included in this Special Issue, in this article it suffices to highlight the knowledge gaps between the government's claims and the assessed outcomes.

## Main Challenges

Despite admirable intentions, huge investments, and seemingly tremendous achievements, China's ERPs have faced great challenges. Indeed, we have alluded to the fact that most, if not all, of them suffer from 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. Understandably, these challenges are intertwined. Below, we elaborate them in detail and suggest ways to overcome them. Interested readers can also refer to Xu and others (2006) and Liu and others (2008) for early discussions of some of these challenges.

## A More Balanced and Adequate Approach to Ecological Restoration

First, in contrast to its enthusiasm to plant trees, the SFA has shown less interest in other measures aimed at ecological restoration, such as grassland recovery and check-dam formation, even if such measures are better suited in certain circumstances. Back in 2003, the Forest and Grassland Taskforce already noted that "implementation has not been tailored to local conditions, and there has been an overemphasis on tree planting rather than restoring original vegetation cover" (Forest and Grassland Taskforce 2003, p. 3). More recently, several commentators have voiced their concern that planting tall trees in semiarid and arid northwestern regions may not work well in that environment (Normile 2007; Wang and others 2007a; Cao 2008). They argue that planting poplars as a major species for afforestation in those regions is problematic given the limited precipitation. In many cases, it is difficult to establish the trees, and wherever they are established, their deep root system can hemorrhage ground water through transpiration, lowering the water table and making it harder for native grass and shrubs to survive (Normile 2007; Wang and others 2007c). The time has come for the SFA to carefully evaluate its methods of species and site selection.

One might add that even forest management activities ensuring tree planting and regeneration, such as tending and thinning, have not been well incorporated into the programs; furthermore, this issue has been confounded by the high initial planting densities driven by requirements for high survival rates (Wang and others 2007a; Yin and others 2005). As a result, the growth rate tends to be low after canopy closure, and thus, forest quality, let alone ecosystem functionality, has not been very satisfactory. This, in turn, makes the forests vulnerable to fire and pest attacks in the long term. More attention should thus be paid to the quality of both forest establishment and management. The past record shows that while China's attempts of afforestation were ambitious and massive, the final outcome of these attempts was far from impressive in terms of stand growth, yield, and productivity. This is due primarily to the deficiency of active and adequate management efforts as well as the poor practices of site and species selection (Yin 1998). These historical lessons must not be forgotten.

To strengthen forest management, better technical work and broader support are necessary. Regarding the former, improvements can be made in site preparation, planting density, species selection, competition control, thinning, and other activities. To that end, lagging public investment in capacity building and technical training must be reversed (Cao 2008; Yin and others 2005). Regarding the latter, it is unrealistic to rely on central government investments

alone; local governmental and private entities must play a role throughout the process of ecological restoration (Xu and others 2006). Of course, as discussed below, this can happen only if governance is effective and if incentives are sufficiently attractive. In addition, it is essential to adopt an ecosystem management approach with an emphasis on sustainability, system functionality, and system integrity (Millennium Ecosystem Assessment 2003). Also, it is necessary to better integrate conservation needs into development policies (Loucks and others 2001).

#### Strengthening the Governance of Program Implementation

The SFA has the responsibility of administering the NFPP, the SLCP, and other ERPs. However, other agencies responsible for agriculture and livestock production, water and soil conservation, poverty alleviation, and environmental protection have not been actively involved (Yin and others 2005). Inter-agency cooperation and coordinated implementation is weak at all levels of the government. In addition, the central government has not granted regional authorities and local communities much flexibility in implementing restoration efforts (Bennett 2008). One may wonder whether this type of top-down, campaign-style push for ecological restoration can be truly effective and long-lasting, even with huge financial commitments.

In addition, the SFA has assumed both program implementation and monitoring. Without a clear separation of monitoring and implementation, the effective implementation of the ERPs is questionable, and the efficiency of public investments can be compromised (Xu and Cao 2001). Given the political structure in China and the bureaucratic tendency toward reporting, or even exaggerating, good news while concealing or disregarding bad news, this is an especially worrisome situation. To promote effective implementation, an integrated and authoritative program monitoring system must be established with its own budget and staff. The protocols by which samples are selected, data are collected, and statistics are compiled and released must be scientifically sound. Likewise, the transparency and openness of monitoring efforts must be upheld (Liu 2007).

Currently, the monitoring of socioeconomic and environmental impacts of the ERPs is fragmented and incomplete. The SFA's Forest Economics and Development Research Center is in charge of monitoring the socioeconomic impacts of the ERPs. Another SFA center assumes the duty of monitoring trends in desertification and sandification. Monitoring the short-term changes in land use and resource conditions in the program areas is the responsibility of the SFA's regional forest inventory apparatuses. Finally, monitoring long-term ecological conditions is

largely carried out by the Chinese Academy of Forestry in conjunction with regional universities and research institutes. The lack of independence, transparency, and adequate procedures is a major hurdle to the SFA's efforts, whereas the lack of coordination, collaboration, and funding is an impediment facing the scientific community (Liu 2007). In addition, the lack of scientific advisory and/or stakeholder representation is a common problem across all of these monitoring activities. Obviously, a systematic assessment of the program effectiveness becomes difficult given these monitoring problems.

#### Better Planning and Management

Inadequate planning, targets in excess of the capabilities of local entities, rushed implementations, and a failure to follow through are just some of the issues that hinder progress (Bennett 2008; Liu 2002). More specifically, the logging bans, harvest reductions and massive employee layoffs under the NFPP could have been gradually executed, which would have alleviated much of the loss and trauma inflicted on local economies and stakeholders (Yin and others 2005). Meanwhile, numerous other challenges have arisen due to the logging bans and harvest reductions, including the introduction of invasive species as well as environmental damage to exporting countries that have increased timber imports. Also, rural communities, which depended on the forests covered by the NFPP for seasonal jobs and service opportunities, have been devastated (Xu and others 2006).

Importantly, in addition to the national forests covered under the NFPP, the program has also spread to community forests in several provinces, including Sichuan, Guizhou, and Yunnan (Yu and others 2002). In some cases, not only secondary natural forests but also timber plantations have been put under the purview of the NFPP. Because of its orientation toward national forests and state forest enterprises, however, the regulation of collective forestry activities as well as compensation to community entities were not initially detailed in the program. Accordingly, while the logging and management operations of farmers were denied or disrupted, their losses and expenditures on forest protection and management were not compensated (Yin and others 2005). These situations have caused a large uproar, and only much later have the logging restrictions been relaxed and selective protection and management operations been incorporated into the government's funding protocols. Still, farmers wonder why their commercial forestry activities cannot be allowed and why these activities cannot benefit the environment.

For the SLCP, neither the 2002–2004 expansion nor the drastic contractions thereafter have been constituted effective implementation. The government should have

foreseen and taken into account the induced burdens of program coordination, activity inspection, and compensation delivery (Xu and others 2004). Because of poor administrative budgeting and capacity, many of the millions of plots enrolled in the SLCP have yet to be inspected (Bennett 2008). Only since 2002 has the central government allocated any administrative fees to provincial agencies for implementing the SLCP. These fees, however, have been insufficient and are often in large part diverted by lower levels of government before reaching their constituents (Bennett 2008). Of course, this is partially a result of the fast expansion of the program, which has created even greater administrative needs and, thus, shortages in administrative funds and staff, which in turn has led to problems in implementation and subsidy delivery. Consequently, supervision has been weakened, the delivery of food subsidies to farmers has been delayed, and the quality of project tasks has deteriorated (Xu and Cao 2001). As part of the DCBT, some farming and herding families have been resettled to places with less degraded land and thus greater carrying capacity. However, questions remain regarding how to guarantee that the farmlands and grasslands near newly-resettled sites are not degraded in the future, while the livelihoods of those farmers and/or herders can be enhanced. Clearly, in addition to careful upfront planning and piloting, it is also crucial to make timely and careful adjustments to planned targets according to changed circumstances (Wang and others 2007c).

#### An Emphasis on the Active Engagement of Local People

Without adequate consultation and bottom-up initiatives, local people tend to not plant or properly maintain trees and grass. As a result, survival and growth rates can be meager. More broadly, central authorities have relied too much on administrative campaigns and failed to realize the role of incentives as well as the importance of contracting, open bidding, and other market-based mechanisms for implementing specific activities (FAO 2004; Yin and others 2005). Coupled with the uniform standards of subsidies and weak monitoring, the lack of attention to incentives is troublesome, because it may compromise effectiveness, sacrifice efficiency, and even cause misappropriation (Xu and others 2004). In addition, without clear responsibilities and rewards, forest enterprises, state employees, and rural households cannot participate in forest, grassland, and wetland protection and management as actively as might be assumed (Du 2001; Agrawal and others 2008). In addition, the adaptive capability and capacity of farmers and herders must be enhanced so that they can move out of their dependency on traditional forests and/or government subsidies.

Furthermore, private participation and investment must be aggressively sought. Without strong and lasting private engagement, sustainable forestry and ecosystem management cannot be accomplished, no matter what the government does. China's experience has proven that farmers are interested in and can contribute to an array of forestry and natural resource management activities as long as an incentive structure is properly arranged (Yin and others 2003). To a large extent, the slow progress of the ITTP indicates that the incentive structure is such that forest production companies and rural farmers remain unwilling to engage in commercial forestry (Xu and others 2006). Naturally, one wonders why the government makes great financial and programmatic commitments to ecological restoration but does not embrace effective policies or incentive structures in order to attract private interest and action.

A key component of this incentive structure is the realization of property rights. While China has made breakthroughs in terms of defining property rights, it still has a long way to go in terms of their realization (Wang and others 2007b). Therefore, the current forest tenure reform in the southern forest region and the state forest enterprise reform in the northeast should be cohesively integrated and implemented with ecological restoration efforts. Related to this, the notion that commercial forestry and other activities of private interest cannot benefit environmental protection efforts must be refuted (Yin and others 2003). The fact is that the improved conditions of resources as well as productivity driven by the private sector can both alleviate the government's burdens in providing timber, fuel, fodder, and other products as well as generate a whole host of ecosystem services, such as erosion control, watershed regulation, and carbon storage (FAO 2004).

#### Concluding Remarks

In this article, we have provided a comprehensive description of China's ERPs and their implementation. China has not only made unprecedented commitments but also impressive progress in implementing some of the world's largest ecological restoration programs. We also have discussed several critical issues that the Chinese government must address in order both to implement these ERPs more effectively and to fundamentally improve the country's ecosystems.

We argue that it is crucial for China to embrace a more balanced and adequate approach to ecological restoration by adopting better planning and management practices, strengthening the governance of program implementation, emphasizing the active engagement of local people,



establishing an independent and competent monitoring network, and conducting timely, high-quality assessments of the effectiveness and impacts of the ERPs. And it is our view that in each of these areas, well-organized and effective scientific research and policy changes must be pursued; the international community can and should provide a wide range of assistance.

Finally, it should be reiterated that, considering the limited space here and the sparse empirical evidence, we were unable to gather many findings regarding the assessed impacts of the ERPs. To a large degree, our narrative has been based on government statistics. As more independent monitoring reports and scientific studies appear in the literature, it will become feasible to review and synthesize them in order to depict a clear and complete picture of the effectiveness and impacts of China's ERPs. Doing so will benefit China and many other countries as they pursue ecological restoration and sustainable development.

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