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Review

China's Key Forestry Ecological Development Programs: Implementation, Environmental Impact and Challenges

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Abstract: Forest ecosystems are in serious trouble globally, largely due to the over-exploitation. To alleviate environmental problems caused by deforestation, China has undertaken a series of key forestry ecological development programs, including the Natural Forest Protection Program (NFPP), the Conversion of Cropland into Forests Program (CCFP), the Desertification Combating Program around Beijing and Tianjing (DCBT), the Key Shelterbelt Development Programs in the Three-North Region and in the Middle and Lower Reaches of the Yangtze River (KSDP) and the Nature Reserve Development Program in Forestry Sector (WCNR). This article aims to make a documentation of the specific contents (duration, major aims, geographic coverage and investment), and environmental impacts of these programs from peer-reviewed literature, official reports and journals. Environmental impact is measured with land area afforested (except the WCNR) and the consequent changes in ecosystem function. Overall, with the huge investment and long-term efforts, these programs have made tremendous progress in increasing vegetative coverage, enhancing carbon sequestration, controlling soil erosion, conservation of biodiversity, etc. For proper implementation and remarkable achievement, a more balanced approach with flexible planning, suitable measures and proper management should be adopted. Meanwhile, the scientific communities need to be more actively involved in execution and assessment of these programs. The environmental impact of the DCBT, the KSDP, and the WCNR deserve more research concern.

Keywords: China; ecological restoration; forest protection; afforestation; desertification; biodiversity; program impact; sustainability

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1. Introduction

China is one of the largest countries in the world. The forest area of China ranks the fifth around the world, encompassing a wide range of forest ecosystems, climate types, landform and soil content [1]. The forest ecosystems in China support a wide variety of plant species (33,000 vascular plants) and vegetation types (four vegetation-type groups, 24 vegetation types), covering the main forest vegetation types of the Northern hemisphere [2–4]. However, a large portion of China's forest areas are subject to severe deforestation and degradation [5,6]. The disturbances on forest ecosystems have caused severe environmental problems, such as desertification, sand storm, flooding, soil erosion, increased emission of greenhouse gas, loss of wildlife habitats [7,8].

Since the 1970s, China has launched a series of key forestry ecological development programs, including the Natural Forest Protection Program (NFPP, also known as the

Natural Forest Conservation Program), the Conversion of Cropland into Forests Program (CCFP, also known as the Sloping Land Conversion Program and the Grain to Green Program), the Desertification Combating Program around Beijing and Tianjing (DCBT, also called Sandification Control Program for the Areas in the Vicinity of Beijing and Tianjin), the Key Shelterbelt Development Programs in the Three-North (the Northeast, Northwest and North China) Region and in the Middle and Lower Reaches of the Yangtze River (KSDP, also known as the Shelterbelt Network Development Program) and the Wildlife Conservation and Nature Reserve Development Program in Forestry Sector (WCNR) [9]. Assessment of restoration success is critical for improving restoration approaches and facilitating priority setting [10,11]. In spite of the major accomplishment of afforestation and poverty alleviation, there had not been a major attempt to review the ecological impacts of these programs. Ecological impact is not immediate as socioeconomic effects. Some domestic and international research projects have been conducted to assess the environmental impact of these programs. As the studies differed in spatial scale, environmental indicator and the terrain condition and land-use pattern of study sites, they may draw antagonistic conclusions. A timely updated documentation of major effects is still missing. This article aimed to review the specific contents and environmental impacts of key forestry ecological development programs of China, as well as the major challenges in their implementation. The sources used included international peer-reviewed literatures, official reports and journals.

2. Historic Perspective

In early history, China was rich in forest resource. According to textual research, the percentage of forest cover was over 60% before the Xia Dynasty (2070–1600 BC) [12,13]. Since then, the forest area decreased gradually along with population growth, agricultural intensification and productivity development. The greatest loss of forest occurred in the subtropics and Yellow River Basin [14]. The rapid damage of forest resource occurred in Ming Dynasty (1368–1644), late Qing Dynasty (1840–1911) and the Republic of China (1911–1949) [13]. The forest cover dropped to 8.6% in 1949 [15]. In ancient China, forest exploitation was predominant in the Pre-Qin Period (before 221 BC). In the Qin and Han dynasties (221 BC-220 AD), forest cultivation was promoted, and the plantation of fruit trees, roadside forest, garden and mausoleums forest and military defense forest was expanded. Since the Wei Jin Southern and Northern dynasties (220–581), forest conservation was emphasized in order to enhance the resource utilization and prohibit deforestation. As the economic and environmental value of forest was realized, subsequent rulers adopted more strict forestry policies for utilization and conservation of the diminishing forest resources [16].

Since the establishment of People's Republic of China in 1949, most of the primary natural forests were nationalized [17]. A strategy of resource exploitation was conducted to accommodate the increased demand of fuelwood consumption, housing construction, and land clearing for population growth, employment and economy development [17,18]. Consequently, over-cutting and neglect of forest management resulted in depletion of natural forests, reflected in reduced forest cover, low growth and yield, imbalanced age structure and worsened species composition [19]. According to early forest surveys, the forest cover was 12.0%–12.7%, the forest area was 115.27–121.86 million ha, and the stocking volume was 8.63–9.03 billion m^3 during 1973–1981 [4]. From 1949 to 1990, small-range forest restoration was conducted in China; by contrast, the forest exploitation was predominant. During 1991–2000, environmental disruption and disasters caused by forest deterioration enhanced the efforts of ecological restoration. Afforestation, forest management and logging restrictions are expanded nationwide, and large-scale ecological restoration programs were initiated. From 2000 to now, forestry policy was adjusted, and forest restoration programs were integrated, with huge financial support and local participation [18,20].

Chinese forest initiatives have been supported from forest and environmental policies, and it is important for the future of Chinese forest heritage. Ecosystem Function Conservation Areas (EFCAs) was settled for the improvement of ecosystem services at a national level, covering 49.4% of China's land area (4.74 million km^2) [21]. The 18th National Congress of Communist Party of China emphasized the basic state policy of resource conservation and environmental protection, to protect natural ecosystem, restrain environment deterioration and contribute to the global ecological security [22]. Ecological Redline Policy (EPR) aimed to the conservation of important wildlife habitats, flood mitigation areas, water resource supplies and sandstorm prevention areas [23]. These forest and environmental policies raised nationwide concern of forest protection and promoted awareness of local government and people. Chinese forest initiatives conformed to international environmental agreements, for instance the Rio de Janeiro Environmental International Agreements, Kyoto Protocol and the Paris Agreement. These agreements promoted the transition to a green and sustainable development model, in order to protect natural ecosystem and restrain global climate change and environment deterioration [1,24]

3. Specific Contents of Programs

3.1. National Forest Protection Program (NFPP)

The NFPP, initiated in 1998, is one of the largest environmental rehabilitation efforts in the world, in terms of spatial scale and governmental investments [25]. The NFPP aimed to protect most of the natural forests in China and improve ecological environment and livelihood in forest region. The restoration measures included commercial logging bans from natural forests, afforestation, relocation of forest employees and restructure of forest industry [9]. The NFPP includes 18 provinces and autonomous regions (Table 1) [9]; however, the protection was geographically concentrated within the boundaries of natural forests in the northeast and southwest, where China's natural forests are mainly distributed [18]. From 1998 to 2018, the total investment to the NFPP reach CNY 531.3 billion (USD 80.9 billion), of which 90.9% was from central government (Table 2) [9].

Table 1. Duration, main aims and geographic coverage of China's key forestry ecological development programs.

Program	Duration	Main Aims	Geographic Coverage
Natural Forest Protection Program (NFPP)	Initialed in 1998	Protecting natural forests in China and improving ecological environment in forest region. (1) Ban on commercial logging and timber harvests reduction from natural forests. (2) Afforestation, re-vegetation and forest management in natural forest regions, by means of artificial planting, aerial seeding, mountain closure and restoration of degraded forest. (3) Relocation of forest employees with subsidies and social services, restructure of forest industry and efficient utilization of timber.	Eighteen provinces (Yunnan, Sichuan, Chongqing, Guizhou, Hubei, Hunan, Tibet, Gansu, Qinghai, Xinjiang, Ningxia, Inner Mongolia, Shanxi, Shaanxi, Henan, Heilongjiang, Jilin and Hainan).
Conversion of Cropland into Forests Program (CCFP)	Initialed in 1999 and expanded nationwide in 2001	Conversion of marginal croplands on steep slopes back to forest and grassland. (1) Sloping cropland would be retired or converted, and sparsely vegetated mountains and sandy lands would be revegetated. The targeted slopes were those over 15° in the northwest China and over 25° elsewhere. (2) Compensating involved rural households with grain and cash subsidies.	Twenty-five provinces and municipalities (Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan, Guangxi, Hainan, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang).
Desertification Combating Program around Beijing and Tianjing (DCBT)	Initialed in 2001, as an outgrowth of National Sand Control Project (1993–2000)	Reduction in the hazard of sandstorms in Beijing and adjacent areas. (1) Conversion of farmland to forest or grassland. Roughly 2.6 million ha of cropland would be converted to forest and grass coverage. (2) Rehabilitation of degraded land by means of vegetation recovery and restraint on overgrazing. Over 4.9 million ha of degraded and sandy area would be afforested or revegetated based on the local conditions. (3) Construction of water conservation facilities and regulating drainage areas. (4) Ecological resettlement and compensation for involved farmers and herders. (5) Establishment of monitoring systems of desertification and dust storm.	Six provinces and municipalities (Beijing, Tianjin, Hebei, Shanxi, Shaanxi, Inner Mongolia).
Key Shelterbelt Development Programs in the Three-North Region and in the Middle and Lower Reaches of the Yangtze River (KSDP)	Initiated independently since 1970s and integrated into a shelterbelt system since 2001	Building a shelterbelt network to alleviate wind-induced erosion, landslides, flooding, and to protect grasslands, riverbanks and coastal lines.	Twenty-seven provinces and municipalities (Beijing, Hebei, Shanxi, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Jiangsu, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Guangdong, Guangxi, Hainan, Chongqing, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang).
Wildlife Conservation and Nature Reserve Development Program in Forestry Sector (WCNR)	Initiated in 2001	Promoting the establishment of nature reserves and wildlife conservation. (1) Increasing the number of nature reserves, from 1405 in 2001 to 1800 by 2010, 2000 by 2030 and 2500 by 2050,	Thirty-one provinces and municipalities (Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Shang-

	with a total area of 172.8 million ha. (2) Stipulating that the priority protected areas are administered by the central and provincial governments, while smaller and less critical areas are managed by regional governments. (3) Enhancement of wetland restoration measures, ecotourism development and wildlife breeding. (4) Strengthening the monitoring and evaluation of reserves and biodiversity.	hai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Guangdong, Guangxi, Hainan, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang).

Table 2. Investment of China's key forestry ecological development programs (million CNY).

Year	Source	NFPP	CCFP [1]	DCBT	KSDP	WCNR
1979–1995	Total	–	–	174	4001	–
	Central government	–	–	85	1881	–
1996–2000	Total	12,454.	1877	1658	9896	–
	Central government	11,406	1802	508	4087	–
2001–2005	Total	38,642	80,532	11,656	13,971	2085
	Central government	36,454	73,425	10,061	6666	1128
2006–2010	Total	39,858	130,401	17,581	18,107	3843
	Central government	34,734	117,365	16,041	6641	2259
2011–2015	Total	119,092	113,874	12,039	43,318	8487
	Central government	104,700	94,893	10,916	28,659	6024
2016–2018	Total	321,253	395,107	47,618	108,603	20,054
	Central government	295,503	350,012	41,750	63,156	14,673
1979–2018	Total	531,298	721,791	90,726	197,896	34,469
	Central government	482,796	637,497	79,362	111,091	24,082

[1] The investment of the DCBT during 1993–2000 refer to that of National Sand Control Project.

3.2. Conversion of Cropland into Forests Program (CCFP)

The CCFP was proposed in 1999 and expanded nationwide in 2001. The aim was to convert marginal croplands on steep slopes back to forest and grassland. The restoration measures included retirement or conversion of sloping cropland and compensating involved rural households [17,18]. The CCFP is extensive in geographic coverage, including 25 provinces and municipalities (Table 1) [9]. From 1999 to 2018, the total investment to the CCFP reached CNY 721.8 billion (USD 109.9 billion), of which 88.3% was contributed by the central government (Table 2) [9].

3.3. Desertification Combating Program Around Beijing and Tianjing (DCBT)

Since 1993, National Sand Control Project has been launched on a vast geographic scale to counteract desertification [9]. In 2000, severe sandstorms struck northern China and caused enormous environmental disruption and personal injury, raising the concern about the hazard of sandstorms. The DCBT was initiated in 2001, as an outgrowth of National Sand Control Project. The DCBT aimed to inhibit desertification and improve the environment in Beijing, Tianjin and their vicinity [17]. Efforts to halt the desertification in other regions overlapped with or became part of the CCFP [9]. The restoration measures included conversion of farmland, vegetation recovery and restraint on overgrazing, construction of water conservation facilities, ecological resettlement and compensation for involved people, and establishment of monitoring systems of desertification and dust storms [17]. The DCBT covered six provinces and municipalities, 706,000 km^2 of land area (202,200 km^2 of sandy land) (Table 1) [9]. By the end of 2018, the total investment to the DCBT was CNY 90.7 billion (USD 13.8 billion), including the investment to the National

Sand Control Project during 1993–2000. Therein, 87.5% of the total investment was contributed by the central government (Table 2) [9].

3.4. Key Shelterbelt Development Programs in the Three-North (the Northeast, Northwest and North China) Region and in the Middle and Lower Reaches of the Yangtze River (KSDP)

The KSDP consists of the Three-North Shelterbelt Development Program, the Shelterbelt Development Program in Watershed Areas of the Yangtze River, the Shelterbelt Development Program Along Coastal Areas, the Shelterbelt Development Program in Watershed Areas of the Pearl River, the Greening Program in the Taihang Mountain Areas, the Forestry Schistosomiasis Prevention Project, etc. [9]. The programs were originally launched independently in various regions from the 1970s and 1980s. They have been integrated into a shelterbelt system since 2001, in order to build a shelterbelt network to alleviate wind-induced erosion, landslides, flooding and to protect grasslands, riverbanks and coastal lines [17]. These projects covered extensive geographic areas, including the "Three Norths" (i.e., the Northwest, North and Northeast), the Yangtze River basin, the coastal areas, the Pearl River basin and the Taihang Mountain Range (Table 1) [9]. From 1979 to 2018, the total investment to the KSDP is CNY 197.9 billion (USD 30.1 billion), of which 56.1% was contributed by the central government (Table 2) [9]. Unlike the NFPP and CCFP, the state financial investment to the KSDP is relatively limited, so the program largely relied on regional investments and local supports [26].

3.5. The Wildlife Conservation and Nature Reserve Development Program in the Forestry Sector (WCNR)

The WCNR, initiated in 2001, aimed to promote the establishment of nature reserves and enhance wildlife conservation. The conservation measures included increasing the number of nature reserves, stipulating administration of priority protected areas by governments, enhancement of wetland restoration, ecotourism development, wildlife breeding, monitoring and evaluation of reserves and biodiversity [17]. The WCNR scattered all over the country, covering 31 provinces and municipalities (Table 1) [17]. The total investment to the WCNR was CNY 34.5 billion (USD 5.3 billion) over the period of 2001–2018, and 69.9% was from the central government (Table 2). The program also encourages the participation of non-governmental domestic and international entities [9].

4. The Environmental Effects

In past twenty years, China has made a great contribution in greening the world, accounting for a growth of 25% in global leaf area with only 6.6% of the global vegetated area [27]. According to the Continuous National Forest Inventories during 1973–2018, the percentage of forest cover increased from 12.7% in 1973 to 22.96% in 2018, the total forest area increased from 121.9 million ha to 220.5 million ha, and the forest stocking volume increased from 8.7 billion m^3 to 17.6 billion m^3 [4,20]. The area of natural forests in China reached 140.4 million ha, and the area of plantation forests in China (80.0 million ha) was largest in the world [4]. During 2000 to 2010, about 1.6% (157,315 km^2) of China's territory displayed a significant increase in percentage of tree cover, whereas 0.38% (37,268 km^2) experienced a significant loss [28]. Since 1980, the trend of forest shrinkage and cropland sprawl was reversed, as a large increase in forest area occurred in southeast and southwest China [29]. The implementation of forestry ecological development programs positively drove the forest expand and regrowth, as well as the conversion of dominant forest category from timber forests to shelter forests [15, 20]. By the end of 2018, the KSDP and CCFP played the most important role in enlarging the afforestation area in China, accounting for 54.6 million ha and 28.6 million ha of the afforestation area growth, respectively (Table 3) [9].

Table 3. Afforestation area of China's key forestry ecological development programs (million ha).

Year	NFPP	CCFP	DCBT [1]	KSDP
1979–1995			0.4	27.4
1996–2000	1.2	1.1	1.1	10.5
2001–2005	3.6	16.6	2.6	3.2
2006–2010	4.8	5.2	2.1	5.2
2011–2015	2.6	3.0	2.2	5.4
2016–2018	1.3	2.6	0.6	3.0
1979–2018	13.4	28.6	9.0	54.6

[1] The afforestation area of the DCBT during 1993–2000 refer to that of National Sand Control Project; the WCNR does not contribute to afforestation.

According to the first China Ecosystem Assessment (CEA), ecosystem services (food production, carbon sequestration, water and soil retention, flood mitigation and sandstorm prevention) were improved at the national level from 2000 to 2010. The CCFP targeting forest restoration and NFPP played an important role for carbon sequestration and soil retention. The CCFP targeting grassland restoration was more effective for sand fixation, rather than CCFP targeting forest restoration. NFPP was significantly effective for water retention [30]. A study conducted by State Forestry Administration (SFA) of China reported that the forest-regulated water volume increased by 282.8 billion m^3/year, the soil conservation increased by 3.7 billion ton/year, the fertilizer conservation increased by 0.2 billion ton/year, the carbon storage increased by 0.2 billion ton/year, and the oxygen release increased by 0.7 billion ton/year during 1973–2013 [20]. Studies by Piao et al. (2005) and Fang et al. (2007) revealed that the forestry in China has become a significant carbon sink [31,32].

The CEA reported a gradual decline of ecosystem service for the habitat provision for biodiversity from 2000 to 2010 [30]. However, according to a meta-analysis including 103 studies in 28 provinces and 103 study sites, the ecological restoration significantly enhanced biodiversity by 43% for degraded ecosystems. The biodiversity level in restored ecosystems was still lower by an average of 13% than that in natural systems [33]. The restored ecosystems were relatively simple in structure and species composition; therefore, the biodiversity would not recover to the level observed in natural ecosystems [34–36]. The programs improved habitat of wildlife. For example, the implementation of NFPP in Sichuan strengthened the protection of remaining forests across geographic ranges of the giant panda (*Ailuropoda melanoleuca*) [37], and it inhibited illegal harvesting of natural forests [38]. The NFPP and CCFP also modified the energy consumption strategy from fuelwood consumption to electricity [38,39]. Between 2001 and 2013, the overall habitat suitability and habitat area of giant panda increased throughout the entire ranges, despite a few areas showing habitat degradation. The panda habitat showed a higher proportional growth outside nature reserves than inside the reserves, due to the combined contribution of the WCNR, NFPP and CCFP [40].

The programs also cause negative effects, mainly due to inflexible planning, insufficient assessment of local condition and over-emphasizing for forest growth. First, most programs are enthusiastic about tree planting rather than restoration of original vegetation (i.e., shrubs, grassland) [41]. However, in the dryland areas in western China where the annual rainfall is lower than 400 mm, native grass and drought-tolerant shrubs would better survive rather than trees. Long-term survival rate of trees across the Three Norths Shelter Forest System Project from 1952 to 2005 was only 15% [26,41]. When grasslands are invaded by planted trees or shrubs, the deep-rooted woody plants transpire large amount of water and lower the water table, making it harder for native grasses and other species to survive [36]. Second, most programs focused on the rapid increase in vegetation coverage and improvement of certain ecosystem functions (for example, soil retention and sand fixation). The diversity of planted tree species is relatively low, especially in the

CCFP. For example, the poplar accounted for 40% of forested area in Henan Province during 2000–2005; in Jiangxi Province, 60% of the converted land was planted with oil camellia in 2006 [25]. Tree species for afforestation were selected based on their tolerance of poor soil and fast growth. The dominated trees species planted (i.e., rubber and eucalyptus, fruit trees, etc.) may not be the local species, and some of them even caused negative effects. For example, the poplars contribute little in combating desertification because of the limited precipitation. However, the poplar hemorrhaged water through transpiration and lowered the water table in arid areas, reducing the survival of grass and shrubs [36,42]. As the sunlight is reduced under the dense canopy of poplar, the understory vegetation hardly survives [43]. The vast amount of poplar shelterbelt in northern China also decreased soil bulk density, soil total P and available K [44]. Therefore, in environmentally fragile areas, the inaccurate afforestation actions seem to exacerbate ecosystem degradation (deterioration of soil ecosystems, decreased vegetation cover and exacerbated water shortages) [36].

4.1. NFPP

The NFPP benefited the recovery of natural forest and elevated the ecosystem function of the natural forest-based ecosystems. According to the monitoring reports by the SFA, the NFPP have accomplished the major targets of logging bans and harvest reductions [4]. However, since the timber harvest is prohibited in most regions, China has to import large amount of forest products from other countries to meet the demands for wood, paper and other materials. This may exert negative effect on forests of other countries [45]. NFPP was effective in protecting and enlarging forest area. From 1998 to 2018, over 90 million ha of natural forests have been protected, the area of natural forest increased by 28.5 million ha and the stocking volume of natural forest increased by 3.8 billion m^3 [4]. Until 2017, in the provinces where NFPP was implemented, the forest cover increased by an average of 172.4%, which is significantly higher than in provinces where the NFPP was not implemented (an average increase of 63.0%) [46]. Native species (e.g., pine and China fir) are generally encouraged in the NFPP, although non-native species (e.g., poplar and Hinoki cypress) were planted in some areas [25].

The logging ban in the natural forests has a positive environmental impact in ecologically sensitive areas, especially in mountainous areas [30], although a complete inhibition of logging may not optimize sustainable management of forests [47]. The NFPP contribute to the soil and water retention, carbon sequestration, sandstorm prevention and restoration of wildlife habitat in the northeastern provinces and eastern Inner Mongolia [17]. The implementation of NFPP reduced 90% of the sand content in the water flux during 2000–2016, recorded by the Huayuankou hydrological monitoring station in the lower reaches of Yellow River. The desertificated land of Inner Mongolia decreased by 0.5 million ha from 2009–2016. The area of soil erosion decreased by 1.5 million ha, and annual soil erosion amount decreased by 77.0 million tons in Sichuan Province in the upper reaches of Yangtze River [9].

4.2. CCFP

The CCFP made tremendous advances in vegetation restoration (especially at the Yellow River basin) and halting the sandification. Until 2019, 5.2 million ha of cropland have been converted into forests and grasslands [48]. By the end of 2013, the afforestation area of the CCFP was 9.2 million ha in the upper and middle reaches of Yangtze River, and 7.3 million ha in the upper and middle reaches of the Yellow River, accounting for 14.0% and 48.5% of forest area within their basins, respectively. Meanwhile, the afforestation area of the CCFP was 7.2 million ha at the key ecological function zone of north China (i.e., Xinjiang, Inner Mongolia, Ningxia, Gansu, Shanxi) [17]. The afforestation area of the CCFP on desertification land and severe desertification land accounted for 42.3% and 38.9% of the total forest area of the ecological function zone [17,20].

Cao et al. (2018) reported that the trend of ecosystem degradation had generally reversed within the 25 provinces covered by the CCFP [49]. A study performed by the Forest Economics and Development Research Center (FEDRC) of China's SFA and Australian National University (ANU) revealed that the land retirement and conversion of the CCFP induced water balance and reduced soil erosion along the Yellow River basin. The CCFP is predicted to reduce the water runoffs by 450 million m^3, accounting for 0.8% of the total surface water resources from 2000 to 2020 [50]. The afforestation and conservation policies of CCFP in the Three Gorges Reservoir area (TGRA) effectively reduce soil erosion, with an annual drop rate of 1.3%. The most significant decrease was observed in the terrain slope zones between 25 and 35°, where intensive forest restoration occurred [51]. The CCFP conserves water resources and reduces desertification through reduced irrigation in Gansu Province, as trees absorbed dust in the air, reduced wind by 30%–50% and increased air humidity by 15%–25% [46]. The CCFP also caused combined effects with the NFPP, reducing the sediment (53 million tons per year) and increasing water retention (684 million tons per year) in Sichuan Province, where the two programs overlapped in geographic coverage [52].

4.3. KSDP

The KSDP had built ecological shelter zone at major river basins, coastal lines and key ecological function zones, by means of afforestation, reforestation and other land rehabilitation schemes [9]. According to Fang et al. (2001), forest carbon storage in northwestern and northern China increased significantly from the late 1970s to 1998, probably due to forest expansion and regrowth through the Three-North Shelterbelt Development Program [53]. The forests in the Three-North Shelterbelt Development Program region had strong carbon sequestration capacity, and the ecological benefits of carbon sequestration continuously increased during 1990–2015 [54]. However, Wang et al. (2010) proposed that the Three-North Shelterbelt Development Program may not be as effective in combating desertification as expected, because the region affected by the program was relatively small-scaled and the area most responsible for the storm production was not included [55]. The Shelterbelt Development Program in Watershed Areas of the Yangtze River gradually decreased the area of soil erosion and increased the productivity and protection capability of forest in the Yangtze River Basin [56,57]. The Greening Program in the Taihang Mountain Areas gradually elevated the regional forest cover, raising the forest cover by 11.2%, and the stocking volume increased by 7.4% per year during 1994–2013. The ecosystem function of forest was elevated in aspects of soil retention, wind prevention and sand fixation [58,59].

4.4. DCBT

The implementation of the DCBT positively affected the environment in north China. From 1999 to 2004, the desertified land decreased by 6416 km^2. Meanwhile, the wind erosion and sandstorm were weakened, and days of strong winds were reduced in Beijing and adjacent areas [17]. Since 2005, the DCBT also caused positive effect in Hebei, Inner Mongolia, Gansu and Qinghai [60,61]. However, as the program covered the arid, semi-arid and semi-humid regions, the scarcity of water resources restricted the survival and expansion of planted vegetation. Extraction of underground water for irrigating the trees, shrubs and grassland would increase the risk of water resource exhaustion [62].

4.5. WCNR

The implementation of the WCNR has steadily promoted the establishment of nature reserves and the conservation of wild plants and animals. From 2005 to 2015, the number of nature reserves increased from 1740 to 2301, of which the number of national reserves increased from 198 to 359 [17]. At the end of 2015, the area of natural reserves had reached 125.5 million ha [17]. According to the report by the SFA, these reserves functioned to protect 90% of the terrestrial eco-zones and 45% of the wetland [17]. Over 300 rare and endangered animal species (i.e., giant panda, Siberian Tiger, *Rhinopithecus* and *Grus japonensis*) and more than 130 rare and endangered plant species are included in the reserves [17]. Chinese Research Academy of Environmental Sciences and Peking University conducted a ten-year survey of 227 protected areas mainly for protecting forest ecosystems, and their results indicated that 52.7% of protected areas had positive effects on reducing deforestation [63]. In spite of the increasing number of nature reserves, the land area of nature reserves decreased by 3% from 2007 to 2014, due to the diminished size and revocation of some reserves [64]. The function of nature reserves in biodiversity protection should be emphasized in the implementation of the WCNR, rather than growth in amount.

5. Major Challenges

Despite the tremendous achievements of growing forest area and overall improvement of ecosystem service, there are still challenges in the implementation of these programs.

First, restoration measures were not flexible according to local environmental conditions (such as the precipitation and topography). Most programs (except WCNR) are enthusiastic about rapid growing of vegetation cover, especially enlarging forest area. However, relatively large amounts of money and effort targeted afforestation in the northwestern region, where it is not suitable for tree growth due to low precipitation, cold weather and high altitudes [14]. Tree planning has often failed in cooler arid regions of northern China [65]; by contrast, the southern regions with warm and humid climate received less afforestation investment due to demands for agriculture and urbanization [14]. For the arid and semi-arid dryland areas, grass and drought-tolerant shrubs should be planted rather than trees [41]. In severely degraded ecosystems, human ameliorative measures are essential for facilitating plant survival and forest recovery. For example, in degraded tropical forests, the extreme environmental conditions (i.e., high surface temperature and impoverished soil) cause physical barriers to seedling establishment. Controlling soil and water loss should be taken as the initial stage to ensure seedling survival. Removing litter from the forest floor should be avoided to retain soil moisture and promote the establishment of native species [66].

Second, the restored ecosystems were relatively simple in structure and species composition. Appropriate pioneer species and species diversity are crucial for long-term ecosystem recovery and succession [34,66]. The study by Ren et al. (2007) introduced a single hardy species (pine or eucalyptus) in degraded Xiaoliang Tropical Forest and turned barren land into a forest. The pure pine stand died out completely in 5 years due to insect attacks and heat stress, while the eucalyptus forest has poor-developed understory. Constructing a mixed forest is more likely to restore the ecosystem similar to the pre-disturbance state [66].

Third, the programs covered a high proportion of remote and mountainous regions, with relatively low level of socioeconomic development. People's livings highly rely on the agriculture, pasture or forest product (i.e., timber, medicinal materials and fruits). The NFPP restricted the forest exploitation, and the CCFP has changed the permitted land use types in program areas. As a result, the local residents lost their main source of income as the programs were implemented. Farmers intended to return to farming after the programs ended because they had no alternative ways to earn a living [67,68]. The compensation provided to these people should be improved [18]. In addition, rural economic transformation and job training should be supported by the local and central government, in order to improve employment and alleviate poverty.

Fourth, most programs are specifically targeted to certain ecosystem functions (for example, the CCFP is specifically targeted to reduce soil erosion by converting croplands to vegetation). Since these programs overlapped in geographical range, their restoration goals should be integrated to restore multiple ecosystem functions [37].

Fifth, after afforestation, long-term planning and subsequent management should be emphasized to preserve the newly established forests [15]. Management measures (i.e., fertilizer, irrigation, forest thinning) would promote plant growth and forest succession [69–71]. The NFPP focused on protection by harvest reduction, while the forest management was neglected. Proper management and utilization would improve the productivity of forest and benefit the implementation of programs in the long run.

Sixth, the government should give adequate attention to the assessment and monitoring of long-term environmental impacts. Integrative assessments on a large geographic scale that includes a series of indicators of ecosystem function (for instance, net primary productivity, carbon sequestration, desertification, flooding control, soil erosion, water quality and biodiversity preservation) are urgently needed. In addition, as the NFPP and CCFP received most of the research concern, more efforts should be made to assess the impact significance of the DCBT, KSDP and WCNR.

6. Conclusions

In this study, we have provided a comprehensive review of the specific contents and environmental effects of the key forestry ecological development programs in China. These programs, with large geographic range, huge financial supports and local efforts, have made substantial progress in increasing the vegetation coverage and overall ecosystem service. We believe that these programs can greatly benefit China and the world in alleviating environmental problems and improving socioeconomic condition (i.e., poverty alleviation, economic restructure) in the long run. For proper implementation and long-term achievement, flexible planning, deliberate restoration efforts, careful assessments and proper management are needed for large-scale ecological restoration projects. Meanwhile, the scientific communities need to be more actively involved in execution and assessment of these programs.

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References

1. FAO (Food and Agriculture Organization of the United Nations). *Global Forest Resources Assessment 2015: How Have the World's Forests Changed?* Food and Agriculture Organization of the United Nations: Rome, Italy, 2015.
2. Guo, K.; Liu, C.C.; Xie, Z.Q.; Li, F.Y.H.; Franklin, S.B.; Lu, Z.J.; Ma, K.P. China vegetation classification: Concept, approach and applications. *Phytocoenologia* **2018**, *48*, 113–120, doi:10.1127/phyto/2017/0166.
3. López-Pujol, J.; Zhang, F.M.; Ge, S. Plant biodiversity in China: Richly varied, endangered, and in need of conservation. *Biodivers. Conserv.* **2006**, *15*, 3983–4026, doi:10.1007/s10531-005-3015-2.
4. SFGA (State Forestry and Grassland Administration). *China Forest Resources Report 2014–2018*; China Forestry Publishing House: Beijing, China, 2019.
5. WWF (World Wide Fund for Nature). *Report Suggests China, Grain-to-Green Plan is Fundamental to Managing Water and Soil Erosion*; WWF: Gland, Switzerland, 2003. Available online: http://www.wwfchina.org/english/local.php?loca=159 (accessed on 20 January 2018).
6. He, F.N.; Ge, Q.S.; Dai, J.H.; Rao, Y.J. Forest change of China in recent 300 years. *J. Geogr. Sci.* **2008**, *18*, 59–72, doi:10.1007/s11442-008-0059-8.
7. Liu, J.G.; Diamond, J. China's environment in a globalizing world. *Nature* **2005**, *435*, 1179–1186, doi:10.1038/4351179a.
8. Dai, L.M.; Wang, Y.; Su, D.K.; Zhou, l.; Yu, D.P.; Lewis, B.J.; Qi, L. Major forest types and the evolution of sustainable forestry in China. *Environ. Manag.* **2011**, *48*, 1066–1078, doi:10.1007/s00267-011-9706-4.

9. SFGA (State Forestry and Grassland Administration). *China Forestry and Grassland Yearbook*; China Forestry Publishing House: Beijing, China, 2019.
10. Wortley, L.; Hero, J.M.; Howes, M. Evaluating ecological restoration success: A review of the literature. *Restor. Ecol.* **2013**, *21*, 537–543, doi:10.1111/rec.12028.
11. Lamb, D. Undertaking large-scale forest restoration to generate ecosystem services. *Restor. Ecol.* **2018**, *26*, 657–666, doi:10.1111/rec.12706.
12. Ma, Z.L.; Song, C.S.; Zhang, Q.H. *The Transition of Chinese Forest;* China Forestry Publishing House: Beijing, China, 1997. (In Chinese)
13. Fan, B.M.; Dong, Y. Percentage of forest coverage in different historic periods of China. *J. Beijing For. Univ.* **2001**, 23, 60–65. (In Chinese)
14. Ahrends, A.; Hollingsworth, P.M.; Beckschäfer, P.; Chen, H.F.; Zomer, R.J.; Zhang, L.B.; Wang, M.C.; Xu, J.C. China's fight to halt tree cover loss. *Proc. R. Soc. B Biol. Sci.* **2017**, *284*, 20162559, doi:10.1098/rspb.2016.2559.
15. Song, C.H.; Zhang, Y.X. Forest cover in China from 1949 to 2006. In *Reforesting landscapes: Linking Pattern and Process. Landscape Series*; Nagendra, H., Southworth, J., Eds.; Springer: Dordrecht, The Netherlands, 2010; Volume 10, pp. 341–356, doi:10.1007/978-1-4020-9656-3_15.
16. Zheng, H. *Forestry Policy and Management in Ancient China*; Beijing Forestry University: Beijing, China, 2013.
17. SFA (State Forestry Administration). *China Forestry Development Report*; China Forestry Publishing House: Beijing, China, 2017.
18. Xu, J.T.; Yin, R.S.; Li, Z.; Liu, C. China's ecological rehabilitation: Unprecedented efforts, dramatic impacts, and requisite policies. *Ecol. Econ.* **2006**, *57*, 595–607, doi:10.1016/j.ecolecon.2005.05.008.
19. Yin, R.S. Forestry and the environment in China: The current situation and strategic choice. *World Dev.* **1998**, *26*, 2153–2167, doi:10.1016/S0305-750X(98)00106-5.
20. SFA (State Forestry Administration). Evaluation project of forest ecosystem service in China. In *China Forest Resources and Ecosystem Function—40 Years of Monitoring and Evaluation*; China Forestry Publishing House: Beijing, China, 2018.
21. Ministry of Environmental Protection of China and Chinese Academy of Sciences. *National Ecosystem Service Zoning in China*; Ministry of Environmental Protection and CAS: Beijing, China, 2015.
22. The Eighteenth National Congress of the Communist Party of China Report. Available online: http://cpc.people.com.cn/18/ (accessed on 5 January 2021).
23. Bai, Y.; Jiang, B.; Wang, M.; Li, H.; Alatalo, J.M.; Huang, S. New ecological redline policy (ERP) to secure ecosystem services in China. *Land Use Policy* **2016**, *55*, 348–351, doi:10.1016/j.landusepol.2015.09.002.
24. Afionis, S. International environmental agreements: An introduction. *Int. Environ. Agreem. Politics Law Econ.* **2013**, *13*, 219–223, doi:10.1007/s10784-012-9194-x.
25. Liu, J.G.; Li, S.X.; Ouyang, Z.Y.; Tam, C.; Chen, X.D. Ecological and socioeconomic effects of China's policies for ecosystem services. *PNAS* **2008**, *105*, 9477–9482, doi:10.1073/pnas.0706436105.
26. Li, Z. *Conserving Natural Forests in China: Historical Perspective and Strategic Measures*; Chinese Academy of Social Sciences: Beijing, China, 2001.
27. Chen, C.; Park, T.; Wang, X.; Piao, S.; Xu, B.; Chaturvedi, R.K.; Fuchs, R.; Brovkin, V.; Ciais, P.; Fensholt, R.; et al. China and India lead in greening of the world through land-use management. *Nat. Sustain.* **2019**, *2*, 122–129, doi:10.1038/s41893-019-0220-7.
28. Viña, A.; McConnell, W.J.; Yang, H.B.; Xu, Z.C.; Liu, J.G. Effects of conservation policy on China's forest recovery. *Sci. Adv.* **2016**, *2*, e1500965, doi:10.1126/sciadv.1500965.
29. Liu, M.L.; Tian, H.Q. China's land cover and land use change from 1700 to 2005: Estimations from high-resolution satellite data and historical archives. *Glob. Biogeochem. Cycles* **2010**, *24*, GB3003, doi:10.1029/2009GB003687.
30. Ouyang, Z.Y.; Zheng, H.; Xiao, Y.; Polasky, S.; Liu, J.G.; Xu, W.H.; Wang, Q.; Zhang, L.; Xiao, Y.; Rao, E.M.; et al. Improvements in ecosystem services from investments in natural capital. *Science* **2016**, *352*, 1455–1459, doi:10.1126/science.aaf2295.
31. Piao, S.L.; Fang, J.Y.; Zhu, B.; Tan, K. Forest biomass carbon stocks in China over the past 2 decades: Estimation based on integrated inventory and satellite data. *J. Geophys. Res. Biogeosci.* **2005**, *110*, doi:10.1029/2005JG000014.
32. Fang, J.Y.; Guo, Z.D.; Piao, S.L.; Chen, A.P. Terrestrial vegetation carbon sinks in China, 1981–2000. *Sci. China Ser. D Earth Sci.* **2007**, *50*, 1341–1350, doi:10.1007/s11430-007-0049-1.
33. Huang, C.B.; Zhou, Z.X.; Peng, C.H.; Teng, M.J.; Wang, P.C. How is biodiversity changing in response to ecological restoration in terrestrial ecosystems? A meta-analysis in China. *Sci. Total Environ.* **2019**, *650*, 1–9, doi:10.1016/j.scitotenv.2018.08.320.
34. Aerts, R.; Honnay, O. Forest restoration, biodiversity and ecosystem functioning. *BMC Ecol.* **2011**, *11*, 29, doi:10.1186/1472-6785-11-29.
35. Tang, Z.Y.; Wang, Z.H.; Zheng, C.Y.; Fang, J.Y. Biodiversity in China's mountains. *Front. Ecol. Environ.* **2006**, *4*, 347–352.
36. Cao, S.X.; Chen, L.; Shankman, D.; Wang, C.M.; Wang, X.B.; Zhang, H. Excessive reliance on afforestation in China's arid and semi-arid regions: Lessons in ecological restoration. *Earth Sci. Rev.* **2011**, *104*, 240–245, doi:10.1016/j.earscirev.2010.11.002.
37. Loucks, C.J.; Dinerstein, E.; Wang, H.; Olson, D.M.; Zhu, C.Q.; Wang, D.J. Giant pandas in a changing landscape. *Science* **2001**, *294*, 1465, doi:10.1126/science.1064710.
38. Bearer, S.; Linderman, M.; Huang, J.Y.; An, L.; He, G.M.; Liu, J.G. Effects of fuelwood collection and timber harvesting on giant panda habitat use. *Biol. Conserv.* **2008**, *141*, 385–393, doi:10.1016/j.biocon.2007.10.009.

39. Viña, A.; Bearer, S.; Chen, X.D.; He, G.M.; Linderman, M.; An, L.; Zhang, H.M.; Ouyang, Z.Y.; Liu, J.G. Temporal changes in giant panda habitat connectivity across boundaries of Wolong Nature Reserve, China. *Ecol. Appl.* **2007**, *17*, 1019–1030, doi:10.1890/05-1288.
40. Yang, H.B.; Viña, A.; Tang, Y.; Zhang, J.D.; Wang, F.; Zhao, Z.Q.; Liu, J.G. Range-wide evaluation of wildlife habitat change: A demonstration using Giant Pandas. *Biol. Conserv.* **2017**, *213*, 203–209, doi:10.1016/j.biocon.2017.07.010.
41. Cao, S.X. Why large-scale afforestation efforts in China have failed to solve the desertification problem. *Environ. Sci. Technol.* **2008**, *42*, 1826–1831, doi:10.1021/es0870597.
42. Yin, R.S.; Yin, G.P.; Li, L. Assessing China's ecological restoration programs: What's been done and what remains to be done? *Environ. Manag.* **2010**, *45*, 442–453, doi:10.1007/s00267-009-9387-4.
43. Cao, S.X.; Chen, L.; Yu, X.X. Impact of China's Grain for Green Project on the landscape of vulnerable arid and semiarid agricultural regions: A case study in northern Shaanxi Province. *J. Appl. Ecol.* **2009**, *46*, 536–543, doi:10.1111/j.1365-2664.2008.01605.x.
44. Wu, Y.; Wang, W.J.; Wang, Q.; Zhong, Z.L.; Pei, Z.X.; Wang, H.M.; Yao, Y.L. Impact of poplar shelterbelt plantations on surface soil properties in northeastern China. *Can. J. For. Res.* **2018**, *48*, 559–567, doi:10.1139/cjfr-2017-0294.
45. Liu, J.G. Forest Sustainability in China and Implications for a Telecoupled World. *Asia Pac. Policy Stud.* **2014**, *1*, 230–250, doi:10.1002/app5.17.
46. Ma, Y.; Fan, S. Ecological-economic effects of Grain to Green Program in desertification areas. *J. Nat. Resour.* **2005**, *20*, 590–596. (in Chinese)
47. Yang, H. China's natural forest protection program: Progress and impacts. *For. Chron.* **2017**, *93*, 113–117, doi:10.5558/tfc2017-017.
48. SFGA (State Forestry and Grassland Administration). *China's Conversion of Cropland into Forests and Grassland 20 Years Report (1999–2019)*; State Forestry and Grassland Administration: Beijing, China, 2020.
49. Cao, S.X.; Liu, Y.J.; Su, W.; Zheng, X.Y.; Yu, Z.Q. The net ecosystem services value in mainland China. *Sci. China Earth Sci.* **2018**, , 595–603, doi:10.1007/s11430-017-9153-4.
50. Jia, Y.W.; Zhou, Z.H.; Qiu, Y.Q.; Yan, D.H.; Zhang, L.; Xie, C.; Zhang, Z.T. The potential effect of water yield reduction caused by land conversion in the Yellow river basin. In *A Study of Sustainable Use of Land Resources in Western China*; Zhang, L., Bennett, J., Wang, X.H., Xie, C., Zhao, J.C., Eds.; Report jointly prepared by the National Forest Economics and Development Research Center, Australian National University, and Australian Center for international Agricultural Research: Canberra, Australia, 2006.
51. Teng, M.J.; Huang, C.B.; Wang, P.C.; Zeng, L.X.; Zhou, Z.X.; Xiao, W.F.; Huang, Z.L.; Liu, C.F. Impacts of forest restoration on soil erosion in the Three Gorges Reservoir area, China. *Sci. Total Environ.* **2019**, *697*, 134164, doi:10.1016/j.scitotenv.2019.134164.
52. Liu, C. *An Economic and Environmental Evaluation of the Natural Forest Protection Program*; SFA Center for Forest Economic Development and Research: Beijing, China, 2002.
53. Fang, J.Y.; Chen, A.P.; Peng, C.H.; Zhao, S.Q.; Ci, L.J. Changes in forest biomass carbon storage in China between 1949–1998. *Science* **2001**, *292*, 2320–2322, doi:10.1126/science.1058629.
54. Chu, X.; Zhan, J.; Li, Z.; Zhang, F.; Qi, W. Assessment on forest carbon sequestration in the Three-North Shelterbelt Program region, China. *J. Clean. Prod.* **2019**, *215*, 382–389, doi:10.1016/j.jclepro.2018.12.296.
55. Wang, X.M.; Zhang, C.X.; Hasi, E.; Dong, Z.B. Has the Three Norths Forest Shelterbelt Program solved the desertification and dust storm problems in arid and semiarid China? *J. Arid Environ.* **2010**, *74*, 13–22, doi:10.1016/j.jaridenv.2009.08.001.
56. Guo, Z.S. Problems and countermeasure of the construction of the system of protection forests in the Changjiang River. *World For. Res.* **2009**, *22*, 10–13. (In Chinese)
57. He, Y.J.; Chen, X.P.; Ye, X.S.; Tian, Y.X.; Li, X.Q. Ecological functions of shelter forest along Yangtze River in Hunan Province. *Chin. J. Ecol.* **2004**, *23*, 121–125, doi:10.1016/j.jce.2003.10.003.
58. Zhai, H.B.; Hu, Y.S. *Assessment Report of Taihang Mountain Greening Program* (1994–2013); Academy of Forest Inventory and Planning, SFA: Beijing, China, 2015.
59. Hu, Y.S.; Zhai, H.B.; Tian, Y. Analysis on sustainability of Taihang Mountain Greening Program construction. *For. Econ.* **2017**, *39*, 48–52, 76, doi:10.13843/j.cnki.lyjj.2017.09.009.
60. Yin, R.S. An integrative evaluation of China's ecological restoration programs (paper presented at the International Symposium on Evaluating China's Ecological Restoration Programs, Beijing China, 2007, October 19
61. Zan, G.S.; Wang, J.H. Land cover and sandification tendency of Bashang (Northern Hebei) and the causes. In *Dynamics of Desertification and Sandification in China*; Zhu, L.K., Eds.; China Agriculture Press: Beijing, China, 2006.
62. Li, M.Z.; Zhang, X.P. Problems and countermeasures in Implementing Sandstorm Source Control Project in and around Beijing and Tianjin. *J. Beijing For. Univ.* **2004**, *3*, 76–79, doi:10.13931/j.cnki.bjfuss.2004.03.017. (In Chinese)
63. Feng, C.T.; Cao, M.; Wang, W.; Wang, H.; Liu, F.Z.; Zhang, L.B.; Du, J.H.; Zhou, Y.; Huang, W.J.; Li, J.S. Which management measures lead to better performance of China's protected areas in reducing forest loss? *Sci. Total Environ.* **2020**, 142895, doi:10.1016/j.scitotenv.2020.142895.
64. Ma, Z.J.; Chen, Y.; Melville, D.S.; Fan, J.; Liu, J.G.; Dong, J.W.; Tan, K.; Cheng, X.F.; Fuller, R.A.; Xiao, X.M.; et al. Changes in area and number of nature reserve in China. *Conserv. Biol.* **2019**, *33*, 1066–1075, doi:10.1111/cobi.13285.
65. Xian, J.L.; Xia, C.Q.; Cao, S.X. Cost-benefit analysis for China's Grain for Green Program. *Ecol. Eng.* **2020**, *151*, 105850, doi:10.1016/j.ecoleng.2020.105850.

66. Ren, H.; Li, Z.A.; Shen, W.J.; Yu, Z.Y.; Peng, S.L.; Liao, C.H.; Ding, M.M.; Wu, J.G. Changes in biodiversity and ecosystem function during the restoration of a tropical forest in south China. *Sci. China Ser. C Life Sci.* **2007**, *50*, 277–284, doi:10.1007/s11427-007-0028-y.
67. Cao, S.X.; Shang, D.; Yue, H.; Ma, H. A win-win strategy for ecological restoration and biodiversity conservation in southern China. *Environ. Res. Lett.* **2017**, *12*, 1–9, doi:10.1088/1748-9326/aa650c.
68. Uchida, E.; Xu, J.T.; Rozelle, S. Grains for green: Cost-effectiveness and sustainability of China's conservation set-aside program. *Land Econ.* **2005**, *81*, 247–264, doi:10.3368/le.81.2.247.
69. Stovall, J.P.; Carlson, C.A.; Seiler, J.R.; Fox, T.R.; Yanez, M.A. Growth and stem quality responses to fertilizer application by 21 loblolly pine clones in the Virginia Piedmont. *For. Ecol. Manag.* **2011**, *261*, 362–372, doi:10.1016/j.foreco.2010.10.018.
70. Hirata, R.; Ito, S.; Araki, M.G.; Mitsuda, Y.; Takagi, M. Growth recovery of young hinoki (*Chamaecyparis obtusa*) subsequent to late weeding. *J. For. Res.* **2014**, *19*, 514–522, doi:10.1007/s10310-014-0450-5.
71. Russell, M.B.; Amateis, R.L.; Burkhart, H.E. Implementing regional locale and thinning response in the loblolly pine height-diameter relationship. *South. J. Appl. For.* **2010**, *34*, 21–27, doi:10.1093/sjaf/34.1.21.