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Dataset Development of Changes in Afforested Area of Key Forestry Ecological Projects in China (2002–2020)

LU Dan ZHANG Chunhua* CAO Yue MA Jie WANG Ran

School of Resources and Environmental Engineering, Ludong University, Yantai 264025, China

Abstract: Benefiting from large-scale ecological projects implemented over the past decades, the Grain for Green Project and afforestation initiatives, forest coverage in China has substantially increased. Investigating changes in afforestation area under key forestry ecological projects is therefore of great significance for enhancing forest carbon sequestration and achieving carbon neutrality nationwide. Based on data from the China Forestry Statistical Yearbook and the China Forestry and Grassland Statistical Yearbook, we combined statistical and spatial analyses to examine the spatiotemporal dynamics of afforestation area under key forestry ecological projects in China between 2002 to 2020 at national, regional, and provincial scales. The results show that the afforestation area under China's key forestry ecological projects decreased from 6.78×10^6 ha in 2002 to 2.42×10^6 ha in 2020, with a cumulative total of 64.98×10^6 ha over 19 years. The Grain for Green Project contributed the largest share (27.62×10^6 ha), followed by the Three-North Shelter Forest Project and Yangtze River Shelter Forest Project, and the Natural Forest Protection Project. At the regional scale, North China accounted for the largest cumulative afforestation area, followed by Northwest and Southwest China. At the provincial scale, Inner Mongolia and Shaanxi ranked first and second in cumulative afforestation area, respectively. The dataset includes the following data from China from 2002 to 2020: (1) annual total afforestation area and proportion of key forestry ecological projects in 31 provinces; (2) annual afforested area from different key forestry ecological projects; (3) the cumulative afforested area from different key forestry ecological projects in each province; (4) annual afforested area of key forestry ecological projects in 6 regions; The dataset is archived in .xlsx data format, and consists of 1 file with data size of 240 KB. This dataset supported the completion of the first author's Master degree of Science thesis.

Keywords: afforestation area; key forestry ecological projects; China Forestry Statistical Yearbook; spatial and temporal dynamics; China; Master degree of Science thesis

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***Corresponding Author:** Zhang, C. H., School of Resources and Environmental Engineering, Ludong University, zchqs@126.com

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1 Introduction

Forests constitute the dominant component of terrestrial ecosystems, accounting for more than 80% of Earth's carbon sink[1,2]. Within nature-based solutions, afforestation is widely regarded as one of the most cost-effective approaches for absorbing anthropogenic CO_2 emissions, mitigating the global greenhouse effect, and enhancing forest carbon sequestration[3–5]. Since 2000, terrestrial ecosystems worldwide have exhibited a persistent "greening" trend, to which China's large-scale afforestation and ecological restoration projects have been identified as major contributors[6,7]. As the world's largest afforestation country, China has implemented a series of major forestry ecological projects over recent decades, including the Three-North and Yangtze River Shelter Forest Project, the Grain for Green Project, and the Natural Forest Protection Project, resulting in substantial increases in both forest area and carbon sink capacity[8–10]. National forest inventory data indicate that China's forest coverage increased from 18.2% in 1999–2003 to 23.0% in 2014–2018, with afforestation contributing more than two-thirds of the total gain[11]. However, compared with earlier periods, the rate of forest expansion has slowed in recent years. In pursuit of its 2060 carbon neutrality target, China continues to intensify afforestation efforts and has set goals to increase forest coverage to 26% by 2035 and 30% by 2050. A systematic understanding of the spatiotemporal dynamics of afforestation area is therefore essential not only for evaluating the effectiveness of major ecological projects, but also for optimizing land greening strategies, enhancing forest carbon sequestration, and supporting the national "dual carbon" strategy[12].

In recent years, scholars have conducted extensive research on national key forestry ecological projects, achieving substantial progress in areas such as vegetation restoration[13,14], forest carbon sequestration[15,16], and ecosystem services[17,18]. Existing studies suggest that the carbon sequestration capacity of forest ecosystems, as well as their potential to mitigate climate change, largely depends on afforestation area and its spatial distribution. At present, data on afforestation area and spatial distribution in China are derived mainly from 2 sources: nationwide baseline surveys and satellite-based information extraction. Baseline datasets, including land surveys, forest resource inventories and annual statistics released by the National Forestry and Grassland Administration, provide relatively systematic information on provincial afforestation area and classify it by afforestation purpose, planting mode and major ecological project type. These data provide an essential basis for greening policy formulation, forest ecosystem service assessment, and carbon sink accounting. Owing to its broad spatial coverage, strong temporal continuity and relatively limited dependence on ground conditions, remote sensing has become an important means of acquiring large-scale forest area information. In afforestation research, its applications have mainly focused on the identification and mapping of potential afforestation space. For example, Xu, *et al*.[19] estimated the area and 30-m spatial distribution of potential afforestation land in China for the year 2020 based on land-cover data and Liebig's law of the minimum. Yao, *et al*.[5] combined remote-sensing big data with tree-growth suitability models to map the spatial pattern of tree-planting potential in China at a spatial resolution of 1 km. Although these studies have improved understanding of afforestation area and spatial distribution in China, estimates from different sources still vary considerably because of differences in afforestation definitions, threshold criteria, classification systems and data sources[5,20].

Overall, existing studies have provided an important foundation for understanding afforestation patterns and their ecological effects in China. However, limitations remain in characterizing the long-term spatiotemporal dynamics of actual afforestation area. Previous studies have focused primarily on identifying potential afforestation space, assessing vegetation restoration outcomes, and evaluating carbon sequestration effects, whereas systematic analysis of the long-term dynamics of actual afforestation area is still relatively

limited. Although satellite-based estimates offer strong spatial continuity, they still differ from statistical survey data in terms of afforestation definitions, identification accuracy and correspondence with categories of key forestry ecological projects, making it difficult to accurately capture the actual scale and spatiotemporal evolution of afforestation implemented under different projects. Existing studies of afforestation area have largely concentrated on local regions, individual projects or single years, and comprehensive comparative analyses based on a unified statistical framework that simultaneously cover the national, regional and provincial levels remain scarce. To address these gaps, this study draws on afforestation area data for key forestry ecological projects in China from 2002 to 2020 provided by the National Forestry and Grassland Administration. By integrating statistical methods with spatial analysis, it systematically examines the spatiotemporal dynamics of afforestation area under different projects across multiple scales and further reveals patterns of centroid shift and regional differentiation. The results help to fill existing gaps in long-term analysis of actual afforestation area and in the fine-grained characterization of major projects, provide scientific data for optimizing afforestation planning, evaluating project effectiveness and developing strategies to enhance forest carbon sequestration in China.

2 Metadata of the Dataset

The metadata of the Dataset on changes in afforested area of key forestry ecological projects in China (2002–2020)[21], including the dataset name, authors, geographic region, year of the dataset, data format, data size, data files, data publisher, are summarized in Table 1.

3 Methods

3.1 Study Area

This study focuses on the areas in China covered by widely implemented key forestry ecological projects, encompassing 31 provincial-level administrative regions: Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Guangdong, Guangxi, Hainan, Chongqing, Sichuan, Guizhou, Yunnan, Xizang, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang. Results from the 2023 National Land Change Survey show that China currently has 2.84×10^8 ha of forest land and 2.47×10^8 ha of forest area, with a forest coverage exceeding 25%. The area of existing planted forests has reached 92.41×10^6 ha, ranking first in the world. China is recognized as the country with the fastest and largest growth in forest resources worldwide[23].

3.2 Data Sources

The data used in this study were obtained from the China Forestry Statistical Yearbook (2002–2017)[24,25] and the China Forestry and Grassland Statistical Yearbook (2018–2020)[26]. The dataset includes annual afforestation area associated with key forestry ecological projects across different regions of China, including the Natural Forest Protection Project, the Grain for Green Project, the Three-North and Yangtze River Shelter Forest Project, the Beijing and Tianjin Sand Source Control Project, the Fast-growing and High-yield Timber Forest Base Construction Project, the Rocky Desertification Control Project, and the National Reserve Forest Construction Project. The dataset covers all provinces in China's mainland. For national statistics reported in this study, Hong Kong, Macao and Taiwan Province are temporarily excluded. Afforestation area under the Fast-Growing and

Table 1 Metadata summary of the Dataset on changes in afforested area of key forestry ecological projects in China (2002–2020)

Items	Description
Dataset full name	Dataset on changes in afforested area of key forestry ecological projects in China (2002–2020)
Dataset short name	ChinaAfforestedArea2002-2020
Authors	Lu, D., School of Resources and Environmental Engineering, Ludong University, ludan_717@163.com Zhang, C. H., School of Resources and Environmental Engineering, Ludong University, zchqs@126.com Cao, Y., School of Resources and Environmental Engineering, Ludong University, plcaoyue@163.com Ma, J., School of Resources and Environmental Engineering, Ludong University, 19861556716@163.com Wang, R., School of Resources and Environmental Engineering, Ludong University, wangran202409@126.com
Geographical region	China's mainland (data for Hong Kong, Macau, and Taiwan not available)
Year	2002–2020
Data format	.xlsx
Data size	240 KB
Data files	(1) Annual total afforestation area and proportion of key forestry ecological projects in 31 provinces; (2) annual afforested area from different key forestry ecological projects; (3) the cumulative afforested area from different key forestry ecological projects in each province; (4) annual afforested area of key forestry ecological projects in 6 regions
Foundation	National Natural Science Foundation of China (42471132)
Data publisher	Global Change Research Data Publishing & Repository, http://www.geodoi.ac.cn
Address	No. 11A, Datun Road, Chaoyang District, Beijing 100101, China
Data sharing policy	(1) *Data* are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use *Data* subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute *Data* subject to written permission from the GCdataPR Editorial Office and the issuance of a *Data* redistribution license; and (4) If *Data* are used to compile new datasets, the "ten percent principle" should be followed such that *Data* records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset[22]
Communication and searchable system	DOI, CSTR, Crossref, DCI, CSCD, CNKI, SciEngine, WDS, GEOSS, PubScholar, CKRSC, OARL

High-yield Timber Forest Base Construction Project is reported only for 2002–2011, afforestation area under the Rocky Desertification Control Project only for 2017–2020, and afforestation area under the National Reserve Forest Construction Project only for 2019–2020.

3.3 Data Preprocessing

Using data from the China Forestry Statistical Yearbook and the China Forestry and Grassland Statistical Yearbook, the original afforestation area for the period of 2002–2020 were compiled and organized. Based on these sources, a dataset was constructed covering the annual afforestation area of key forestry ecological projects and their cumulative afforestation area for each province and region in China from 2002 to 2020.

This study employs a linear regression method ($y=ax+b$) to examine the interannual variation of afforestation area under different key forestry ecological projects in China from 2002 to 2020. The regression coefficient a is calculated using the following Equation.

$$a = \frac{n\sum_{i=1}^{n} x_i y_i - \sum_{i=1}^{n} x_i \sum_{i=1}^{n} y_i}{n\sum_{i=1}^{n} x_i^2 - \left(\sum_{i=1}^{n} x_i\right)^2} \quad (1)$$

where n represents the number of years and equals 19; x_i denotes the time sequence (1, 2, 3,⋯, 19); and y_i represents the afforestation area of key forestry ecological projects in the

i-th year (ha). When $a>0$, it indicates an increasing trend in afforestation area, whereas when $a<0$, it indicates a decreasing trend.

To explore the spatial variation of afforestation area under key forestry ecological projects, a spatial database of cumulative afforestation area for 31 provinces in China over the period 2002–2020 was established using the ArcGIS 10.8 platform. Spatial visualization was then conducted for the afforestation area of different key forestry ecological projects across provinces. The Natural Breaks (Jenks) classification method was applied to divide the afforestation area into 5 categories. Different color gradients were used to represent the gradient differences in afforestation scale across regions. Based on this approach, the spatial variation of cumulative afforestation areas under key forestry ecological projects in China from 2002 to 2020 were analyzed.

4 Data Results

4.1 Dataset Composition

The dataset includes the following data from 2002 to 2020: (1) annual total afforestation area and proportion of key forestry ecological projects in 31 provinces; (2) annual afforested area from different key forestry ecological projects; (3) the cumulative afforested area from different key forestry ecological projects in each province; (4) annual afforested area of key forestry ecological projects in 6 regions. The dataset is archived in .xlsx format.

4.2 Interannual Variation of National Afforestation Area

From 2002 to 2020, the afforestation area under key forestry ecological projects in China exhibited an overall declining trend. However, significant differences existed among project types. In general, except for the Three-North and Yangtze River Shelter Forest Project and the National Reserve Forest Construction Project, most projects showed a continuous decrease in afforestation area. Among them, the Fast-growing and High-yield Timber Forest Base Construction Project and the Grain for Green Project experienced the most pronounced declines.

The total afforestation area in China increased from 6.78×10^6 ha in 2002 to a peak of 8.26×10^6 ha in 2003, and then continuously declined to 2.42×10^6 ha in 2020, representing an overall decrease of approximately 64% (Figure 1a). The afforestation area under the Natural Forest Protection Project showed relatively small fluctuations and remained generally stable, reaching a temporary peak around 2009 (Figure 1b).

The Grain for Green Project exhibited a typical pattern of "decline-rebound- stabilization" and is one of the most fluctuating project types. Its afforestation area was 4.42×10^6 ha in 2002. Although a brief recovery occurred, it never returned to the 2003 level. By 2020, it had fallen to 6.69×10^5 ha, representing a reduction of 89% (Figure 1c).

The Three-North and Yangtze River Shelter Forest Project and the Beijing and Tianjin Sand Source Control Project showed an overall "decline-increase" trend. The former experienced a marked decrease from 2002 to 2006, followed by a temporary peak in 2009. The latter exhibited a fluctuating pattern of decline followed by increase, with a peak in 2003 (Figure 1d, 1e).

The Fast-growing and High-yield Timber Forest Base Construction Project and the Rocky Desertification Control Project showed an "increase-decrease" pattern. Among them, the former experienced the largest decline, with afforestation area dropping rapidly from 2002 to 2011, resulting in an overall decline of 98% (Figure 1f). The Rocky Desertification Control Project reached its peak around 2018 and then decrease slightly (Figure 1g). In contrast, the National Reserve Forest Construction Project started relatively late but had

shown a clear increasing trend since 2019 (Figure 1h).

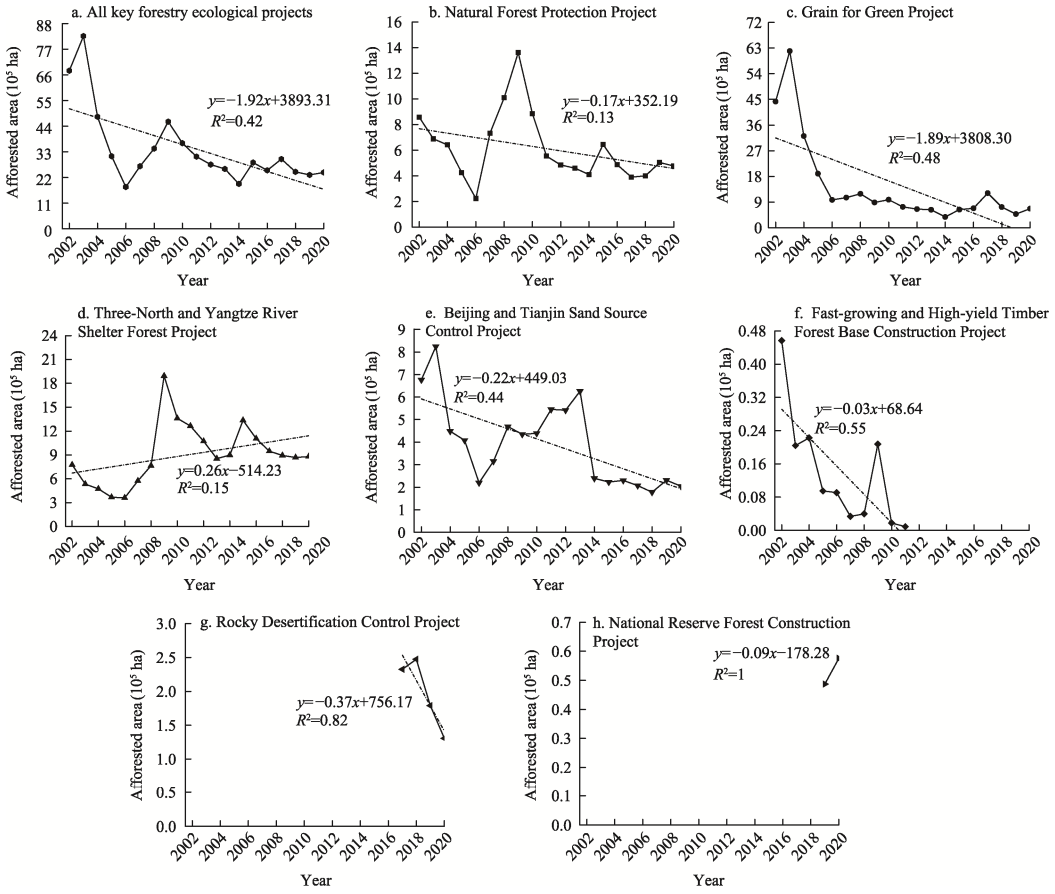


Figure 1 Afforestation area trends of key forestry ecological projects in China (2002–2020)

4.3 Interannual Variation of Regional-Scale Afforestation Area

At the regional scale, the afforestation area under key forestry ecological projects across 6 regions of China[27] generally showed a declining trend from 2002 to 2020. However, the magnitude and stage characteristics of changes in afforestation area varied significantly among regions.

The afforestation area under the Grain for Green Project declined in most regions, with the most pronounced decreases observed in North and East China. In North China, the afforestation area decreased from 8.92×10^5 ha in 2002 to 9.86×10^4 ha in 2020, representing a decline of 89%. In Northeast China, the decrease was nearly 100%, with afforestation activity approaching 0 in later years (Figure 2a, 2b). In contrast, Southwest China exhibited the greatest fluctuations, reaching high levels in the early period and then gradually declining. The Natural Forest Protection Project remained relatively stable overall, with only minor variations across regions. A noticeable peak occurred in Southwest China around 2009, while other regions generally maintained stable or slowly declining trends. The Three-North and Yangtze River Shelter Forest Project exhibited regionally differentiated patterns. North and East China showed a “decline-increase-decline” pattern, while Northeast, South, Southwest, and Northwest China generally followed a “increase-decrease” pattern. Notably, Northwest China experienced a marked increase after 2007 and then stabilized (Figure 2c–2f). The Beijing and Tianjin Sand Source Control Project was distributed only in

North China. Its afforestation area showed an overall decline, from 6.76×10^5 ha in 2002 to 1.95×10^5 ha in 2020. However, fluctuations were relatively pronounced before 2014, after which the trend became stable. The Fast-growing and High-yield Timber Forest Base Construction Project accounted for a relatively small proportion across regions. Except for East and Southwest China, most regions exhibited a continuous decline. The Rocky Desertification Control Project was primarily concentrated in South and Southwest China, where it has remained at relatively high levels in recent years, while other regions have generally experienced declines.

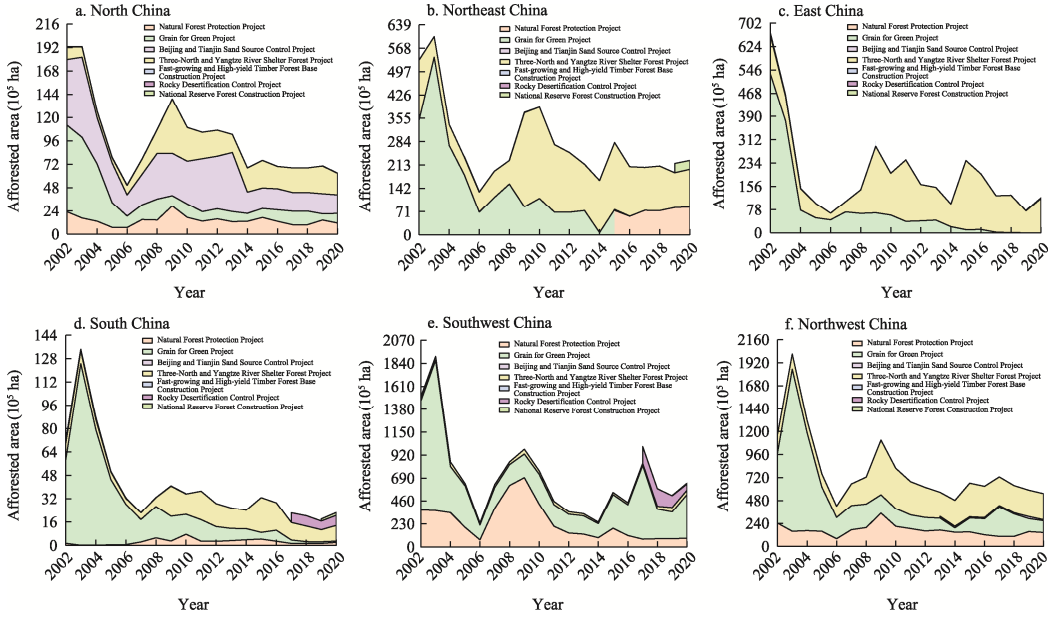
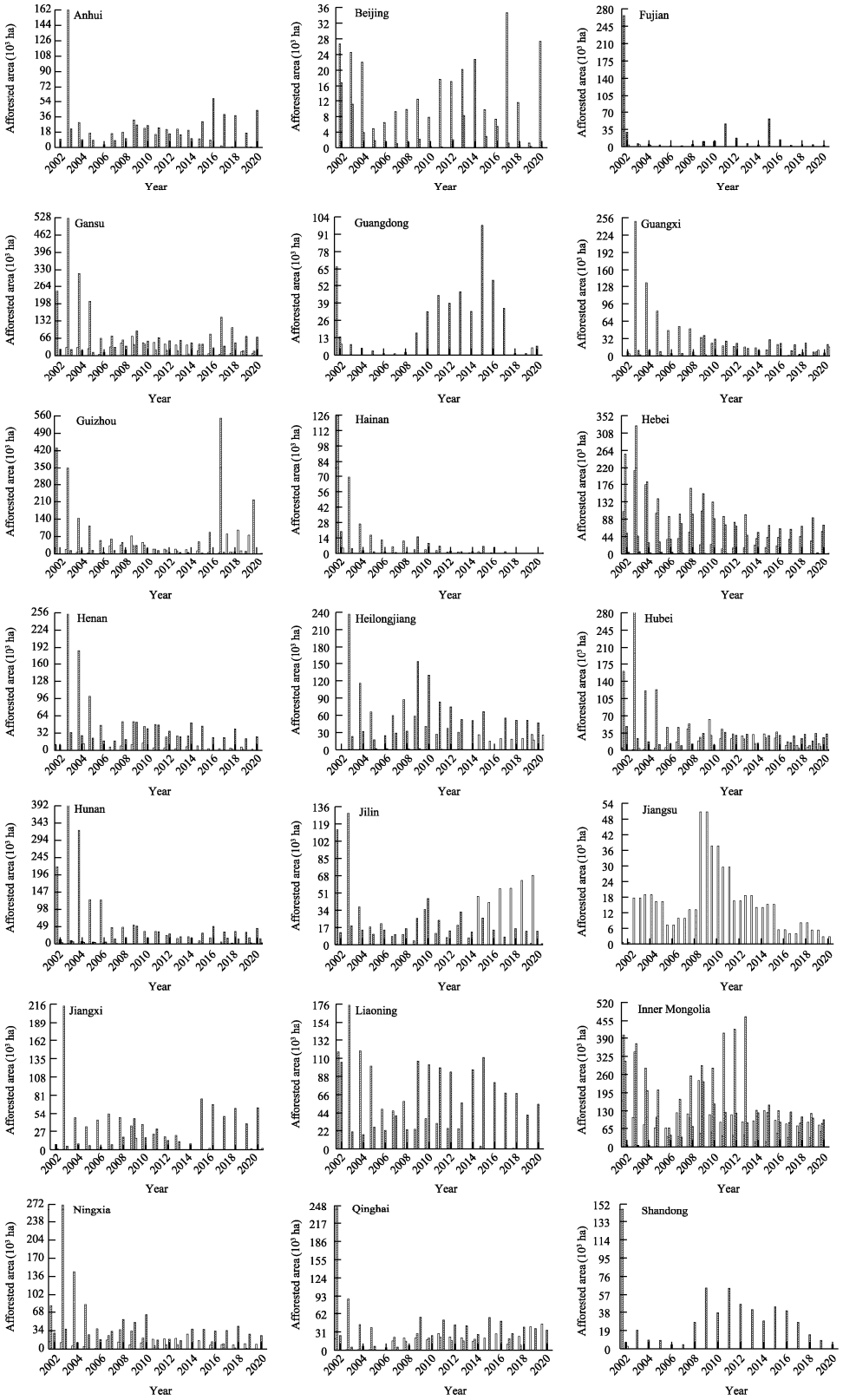


Figure 2 Interannual variation of afforestation area of key forestry ecological projects in different regions of China (2002–2020)

4.4 Provincial-Scale Afforestation Area Interannual Variation

At the provincial scale, changes in afforestation area under different key forestry ecological projects exhibited obvious spatial heterogeneity (Figure 3). Overall, 3 typical patterns could be identified: a stable pattern (e.g., Shaanxi, Shanxi), a "U-shaped" pattern (e.g., Guizhou, Hebei), and an inverted "U-shaped" pattern (e.g., Jiangsu, Sichuan). In addition, some provinces showed a continuous declining trend.

The Grain for Green Project exhibited a significant decline in most provinces. Only Chongqing showed continuous growth, with afforestation area increasing by more than twofold. In contrast, some provinces in Northeast and South China (e.g., Heilongjiang, Henan) experienced decreases close to or reaching 100%, indicating a marked contraction in the regional implementation of this project. The Natural Forest Protection Project showed significant growth in a few provinces, such as Jilin and Qinghai, while traditional key regions (e.g., Sichuan, Yunnan, and Inner Mongolia) exhibited declining trends. The Three-North and Yangtze River Shelter Forest Project increased significantly in regions such as Inner Mongolia and Guizhou, but significant declines in areas such as Shanghai and Liaoning, highlighting strong regional disparities. The Rocky Desertification Control Project was primarily concentrated in a few provinces, such as Guizhou and Hubei, where it exhibited stage-wise increases in recent years, while most other regions experienced an overall decline.


Anhui
Beijing
Fujian
Gansu
Guangdong
Guangxi
Guizhou
Hainan
Hebei
Henan
Heilongjiang
Hubei
Hunan
Jilin
Jiangsu
Jiangxi
Liaoning
Inner Mongolia
Ningxia
Qinghai
Shandong
Afforested area (10^3 ha)
Year

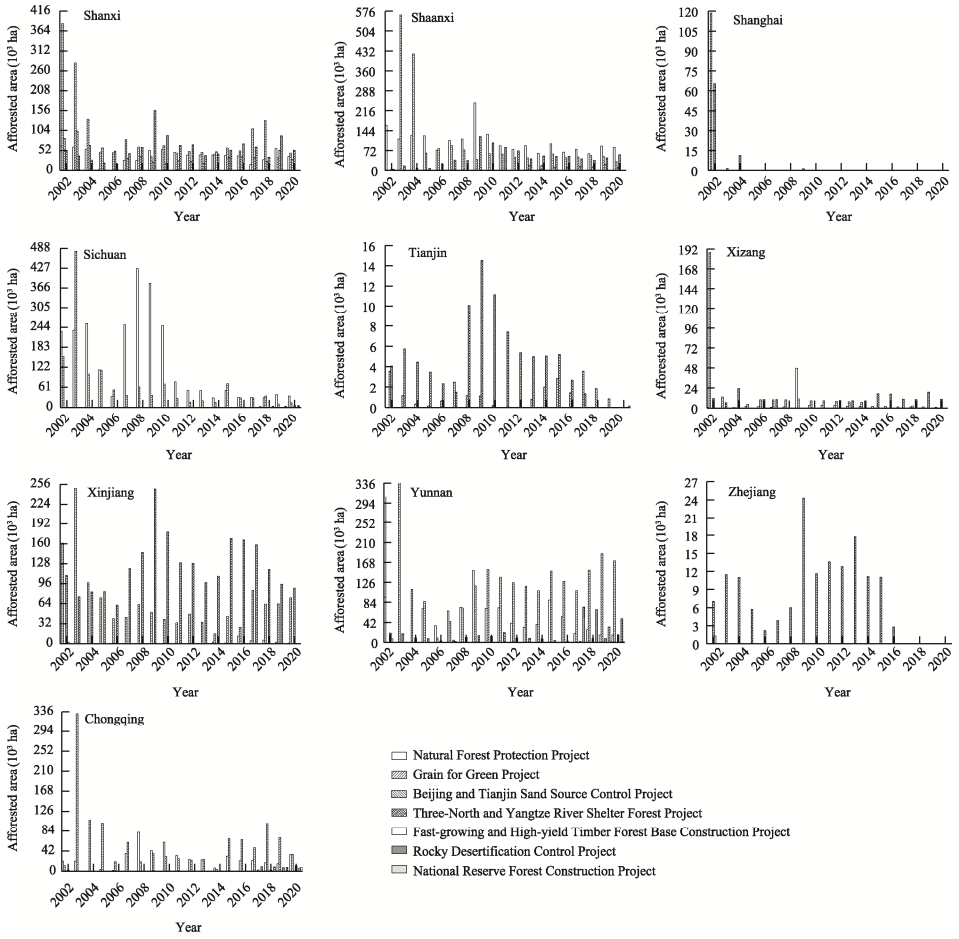


Figure 3 Interannual variation of afforestation area of key forestry ecological projects in different provinces of China (2002–2020)

4.5 Spatial Distribution of Cumulative Afforestation Area

Overall, the total afforestation area under key forestry ecological projects in China exhibited a spatial pattern of "higher in the west and lower in the east, higher in the north and lower in the south". This pattern was mainly due to the formation of large-scale, rapid afforestation in northeastern and southwestern provinces, where forest area is significantly larger than in other regions of China[28].

At the provincial scale, the total afforestation area exhibited a clear clustering distribution. Inner Mongolia (96.39×10^5 ha), Shaanxi (48.16×10^5 ha), and Yunnan (41.75×10^5 ha) ranked among the highest in the country and served as core regions for afforestation activities. In contrast, eastern coastal region (e.g., Shanghai, Jiangsu, and Zhejiang) had relatively small afforestation scales and generally showed declining trends (Figure 4a). In terms of change direction, afforestation area has generally decreased in northern and some eastern provinces (e.g., Hebei, Liaoning, and Shandong), while southwestern and northwestern regions (e.g., Guizhou, Yunnan, and Shaanxi) showed varying degrees of increase. This indicates a gradual shift in the focus of ecological engineering toward western region of China.

Different project types exhibited clear spatial clustering characteristics. The afforestation area of the Natural Forest Protection Project was primarily concentrated in Sichuan (26.01×10^5 ha) and Inner Mongolia (20.08×10^5 ha), indicating its dominant role in key forest

regions of southwest and north China (Figure 4b). The Grain for Green Project was mainly distributed in Yunnan (26.19×10^5 ha), Guizhou (22.29×10^5 ha), and Gansu (20.69×10^5 ha), forming a concentration zone centered in the southwest-northwest region (Figure 4c).

The Three-North and Yangtze River Shelter Forest Project was highly concentrated in north China, with Xinjiang (23.62×10^5 ha), Inner Mongolia (16.78×10^5 ha), and Hebei (12.91×10^5 ha) as the main distribution areas (Figure 4d). The Beijing and Tianjin Sand Source Control Project showed even stronger spatial concentration, with Inner Mongolia and Hebei occupying a dominant position. Inner Mongolia alone accounted for 42.16×10^5 ha, exceeding half of the total afforestation area. (Figure 4e).

The Rocky Desertification Control Project was primarily distributed in the karst regions of southwest China, with the highest concentrations in Guizhou (2.51×10^5 ha) and Yunnan (2.25×10^5 ha), while other provinces showed relatively low participation (Figure 4f). The National Reserve Forest Construction Project exhibited an emerging clustering pattern, mainly distributed in Heilongjiang (5.21×10^4 ha) and Guangxi (2.72×10^4 ha), with significant growth after 2019 (Figure 4g). The Fast-growing and High-yield Timber Forest Base Construction Project was relatively small in scale, largely concentrated in Hebei and Hunan, and showed a more dispersed spatial distribution (Figure 4h).

Overall, the spatial differentiation of various key forestry ecological projects reflected a transition in China's ecological governance from east to west and from a balanced distribution to a concentration in key regions. It also highlighted the distinct division of roles among projects in terms of ecological function and regional suitability.

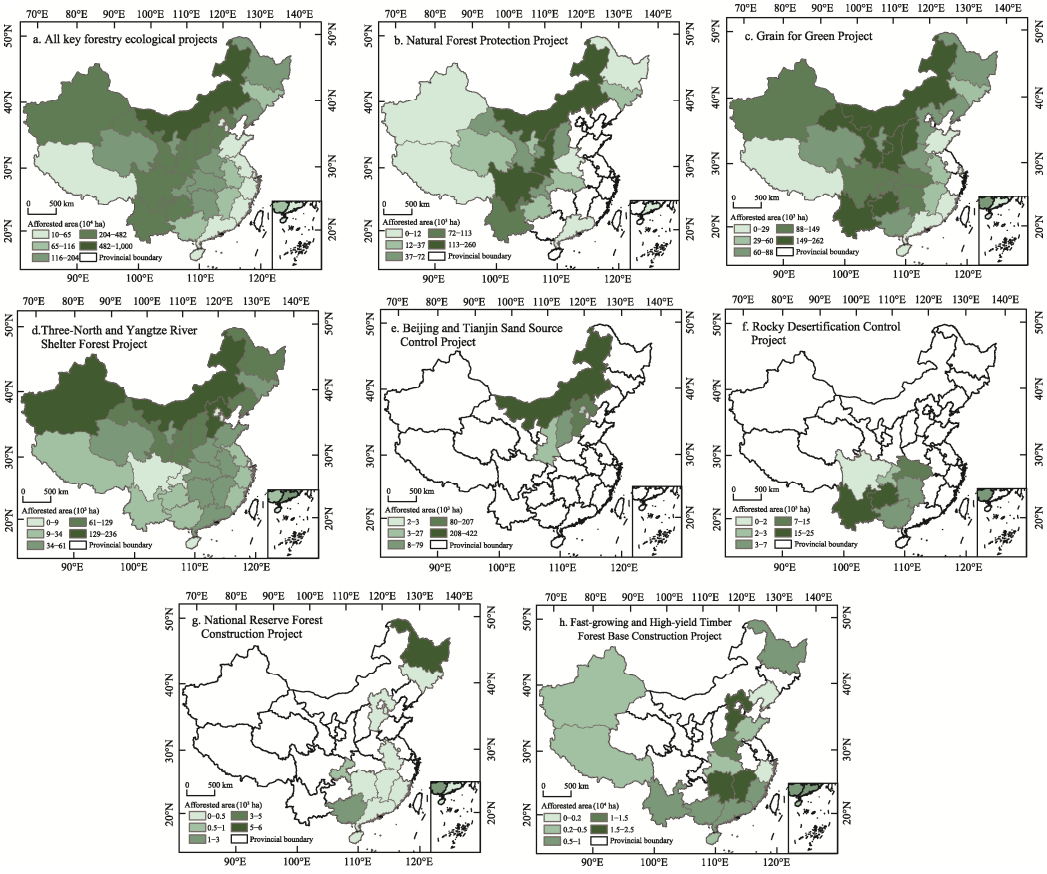


Figure 4 Spatial distribution maps of cumulative afforestation area under different key forestry ecological projects in China (2002–2020)

5 Discussion and Conclusion

This study was based on afforestation area data for key forestry ecological projects released by the State Forestry Administration and the National Forestry and Grassland Administration from 2002 to 2020. By combining mathematical statistics and spatial analysis methods, it systematically examined the spatiotemporal dynamics of afforestation area under different key forestry ecological projects at national, regional, and provincial scales. From 2002 to 2020, the cumulative afforestation area under key forestry ecological projects in China reached 64.98×10^6 ha. Overall, it exhibited a fluctuating pattern, with rapid growth in the early stage followed by a decline, decreasing from 6.78×10^6 ha in 2002 to 2.42×10^6 ha in 2020, and showing a slight rebound in recent years. This fluctuation reflects adjustments in national ecological construction strategies and the stage-specific characteristics of project implementation. The contributions of different projects varied over time. After 2009, the Grain for Green Project and the Three-North and Yangtze River Shelter Forest Project became the dominant contributors to afforestation. Spatially, the afforestation area exhibited a "higher in the west, lower in the east" pattern. North China (18.75×10^6 ha), Northwest China (15.12×10^6 ha), and Southwest China (13.50×10^6 ha) served as core regions. At the provincial level, Inner Mongolia (96.39×10^5 ha), Shaanxi (48.16×10^5 ha), and Yunnan (41.75×10^5 ha) ranked as the top three in total afforestation area.

Based on data from the China Forestry and Grassland Statistical Yearbooks (2002–2020), this study applied a multi-scale framework (national-regional-provincial) combined with a spatiotemporal coupling approach to clearly characterize the dynamics of afforestation area across key forestry ecological projects. It revealed both the national spatial pattern of "higher in the west, lower in the east" and the temporal trend of "fluctuating evolution", while identifying the dominant regions and stage-specific differences among projects. This provides a systematic perspective for understanding the dynamics of project implementation.

However, some limitations remain. The study focuses primarily on afforestation area and lacks analysis linking afforestation quality and ecological benefits. It also provides limited interpretation of driving mechanisms, such as policy adjustments and natural factors, and does not extend to future trend projections. Future research could strengthen a three-dimensional coupling framework integrating "quantity-quality-benefit", deepen analysis of policy and natural drivers, and align with emerging strategies such as the dual carbon goals, thereby enhancing the study's relevance for optimizing ecological engineering practices. This dataset supported the completion of the first author's Master of Science thesis.

Author Contributions

Lu, D. contributed to the data collection and sorting, data processing, and linear regression analysis, as well as drafted the paper manuscript. Zhang, C. H. contributed to the overall design of the dataset and research plan guidance, and participated in revising and guiding the data paper. Cao, Y., Ma, J. and Wang, R. assisted in collecting and organizing the data.

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Conflicts of Interest

The authors declare no conflicts of interest.

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