

# Spatio-temporal Analysis of Forestation Area Changes in China (1991–2014)

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**Abstract:** Plantation forest is an important part of forest resources and plays an important role in the sustainable development of China. The plantation forest in China has increased rapidly in last four decades. The area of plantation forests has ranked first in the world with a long time. In order to understand the ecological and economic impact of the forestation area, it is necessary to collect detailed yearly afforestation data. The process and results of the Regional-yearly forestation dataset of China (1991–2014) are introduced in this paper. The dataset includes total area of afforestation, shelterbelt afforested area, economic forest afforested area, firewood forest afforested area, timber forest afforested area and special use forest afforested area in China from 1991 to 2014. The dataset is achieved in .xlsx data format with the data size of 32.2 KB.

**Keywords:** Forestation area; regional; yearly; China; 1991–2014

## Dataset Availability Statement:

The dataset supporting this paper was published and is accessible through the *Digital Journal of Global Change Data Repository* at: <https://doi.org/10.3974/geodb.2020.09.19.V1>.

## 1 Introduction

Forest carbon sink is an important part of the global carbon cycle. Forest has dual properties of carbon source and carbon sink. It can convert CO<sub>2</sub> into organic matter by photosynthesis. However, forest destruction will release carbon from forest ecosystem to atmosphere<sup>[1]</sup>. Afforestation data is an important basic data to study the change of forest carbon storage. Fang *et al.* investigated the carbon storage of forest biomass in China from 1949 to 1998<sup>[2]</sup>. The research showed that the increased forestation area and forest regeneration were the main driver of the increase of carbon storage in China<sup>[2]</sup>. Besides, forest has a profound impact

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[2] Liu, S. S., Huang, X. Y., Peng, Z. W., *et al.* Regional-yearly forestation dataset of China (1991–2014) [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2020. <https://doi.org/10.3974/geodb.2020.09.19.V1>.

on soil water reservoirs, river hydrology, and the water cycle associated with the ocean although forest water storage accounts for a small proportion of global water storage, and its transpiration connects water flux from soil to atmosphere<sup>[3]</sup>. Moreover, plantation forest plays a huge ecological function in soil and water conservation, wind and sand fixation, climate regulation, and maintaining biodiversity. The yearly forestation area data reflects the changes of forestry structure in China and can be used for studies such as regional carbon budget and water consumption.

2 Metadata of the Dataset

The metadata of the Regional-yearly forestation dataset of China (1991–2014)<sup>[4]</sup> is summarized in Table 1. It includes full name, short name, authors, year of the dataset, data format, data size, data files, data publisher, and data sharing policy, etc.

Table 1 Metadata summary of the Regional-yearly forestation dataset of China (1991–2014)

Items	Description
Dataset full name	Regional-yearly forestation dataset of China (1991–2014)
Dataset short name	RegionalForestationChina_1991–2014
Authors	Liu, S. S. AAT-3465-2020, School of Geographical Sciences, Fujian Normal University, xinqingweiyu@163.com Huang, X. Y., School of Geographical Sciences, Fujian Normal University, hxy1050250101@163.com Peng, Z. W., School of Geographical Sciences, Fujian Normal University, 13420173263@163.com Lin, W. K. AAT-3956-2020, School of Geographical Sciences, Fujian Normal University, wenkelin0210@gmail.com Zhao, S. AAT-3964-2020, School of Geographical Sciences, Fujian Normal University, ygwork123@163.com Wu, Y. F., School of Geographical Sciences, Fujian Normal University, yfwu111@163.com Chen, Y. L. AAP-3042-2020, School of Geographical Sciences, Fujian Normal University, chenyl@fjnu.edu.cn Xue, X. H., School of Geographical Sciences, Fujian Normal University, 610262806@qq.com Wang, C. G., School of Geographical Sciences, Fujian Normal University, 786194687@qq.com
Geographical region	China
Year	1991–2014
Data format	.xlsx
Data size	32.2 KB
Data files	One form file with six worksheets, consisting of total afforested area and shelterbelt, economic forest, firewood forest, timber forest, special use forest afforested area data.
Foundation(s)	National Natural Science Foundation of China (41901124)
Data publisher	Global Change Research Data Publishing & Repository, <a href="http://www.geodoi.ac.cn">http://www.geodoi.ac.cn</a>
Address	No. 11A, Datun Road, Chaoyang District, Beijing 100101, China
Data sharing policy	<b>Data</b> from the Global Change Research Data Publishing & Repository includes metadata, datasets (in the <i>Digital Journal of Global Change Data Repository</i> ), and publications (in the <i>Journal of Global Change Data &amp; Discovery</i> ). <b>Data</b> sharing policy includes: (1) <b>Data</b> are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use <b>Data</b> subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute <b>Data</b> subject to written permission from the GCdataPR Editorial Office and the issuance of a <b>Data</b> redistribution license; and (4) If <b>Data</b> are used to compile new datasets, the ‘ten per cent principal’ should be followed such that <b>Data</b> records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset <sup>[5]</sup>
Communication and searchable system	DOI, DCI, CSCD, WDS/ISC, GEOSS, China GEOSS, Crossref

### 3 Processes and Methods of Dataset Development

The process of dataset development was divided into two steps. Firstly, the forestation area data was collected according to the five categories of forestation, including shelterbelt, economic forest, firewood forest, timber forest and special use forest. Secondly, the forestation area data was carried out by the zonal statistics.

The regional-yearly forestation dataset of China (1991–2014) was developed based on the data collection from 24 years records of the China Forestry Yearbook<sup>[6–12]</sup> and China Forestry Statistical Yearbook<sup>[13–29]</sup>. No data available from Hong Kong, Macao and Taiwan.

After collecting the forestation data, zonal statistics were carried out by the six regions. North China covers the area of Beijing, Tianjin, Hebei, Shanxi, and Inner Mongolia; Northeast China covers the area of Liaoning, Jilin, and Heilongjiang; East China covers the area of Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong; South Central China covers the area of Henan, Hubei, Hunan, Guangdong, Guangxi, Hainan; Southwest China covers the area of Chongqing, Sichuan, Guizhou, Yunnan, and Tibet and Northwest China covers the area of Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang.

## 4 Results

### 4.1 Data File

The regional-yearly forestation dataset of China (1991–2014) consists of a .xlsx file with six worksheets. The dataset includes: (1) Total area of afforestation in China (Tab.1); (2) Shelterbelt afforested area in China (Tab.2); (3) Economic forest afforested area in China (Tab.3); (4) Firewood forest afforested area in China (Tab.4); (5) Timber forest afforested area in China (Tab.5); (6) Special use forest afforested area in China (Tab.6).

### 4.2 Data Results Analysis

The trend line analysis method is used to evaluate the general trend of forestation area and the trend of area of different afforested categories at the national and regional scales. Meanwhile, the forestation area at the national and regional scales is compared and analyzed to evaluate the overall quantity of forestation area in China. Furthermore, the area of different afforested categories is compared between regions and within regions to evaluate the structural differences of forestation area in each region.

The time series forestation area was fitted with a linear model to evaluate the change trend of forestation area in the whole country, each region and each afforested category respectively. Results are showed in Table 2. The total forestation area increased steadily from 1991 to 2014 at national scale, showing an increasing trend of 2.443 km<sup>2</sup> per year. The shelterbelt afforested area showed an increasing trend of 1,282.8 km<sup>2</sup> per year and the special use forest afforested area showed an increasing trend of 4.63 km<sup>2</sup> per year, while the timber forest, economic forest and firewood forest afforested area showed a decreasing trend of 938.83 km<sup>2</sup>, 245.82 km<sup>2</sup> and 100.32 km<sup>2</sup> per year respectively.

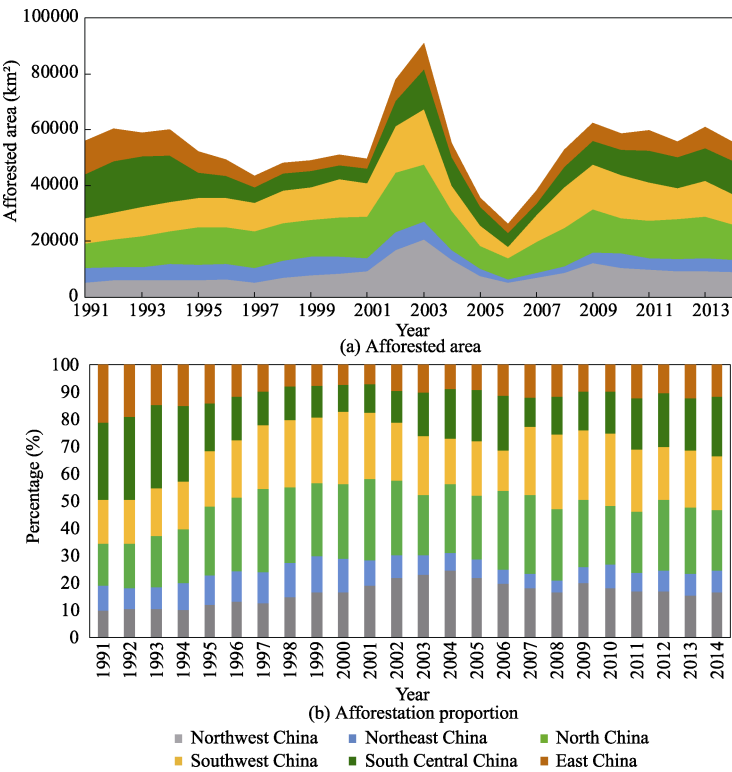
At the regional scale, the total forestation area of Northwest China, Southwest China and North China showed an increasing trend from 1991 to 2014, with an annual increase of 196.18 km<sup>2</sup>, 109.93 km<sup>2</sup> and 91.007 km<sup>2</sup> respectively, while the total forestation area of South Central China, East China and Northeast China showed a decreasing trend, with an annual decrease of 181.75 km<sup>2</sup>, 123.22 km<sup>2</sup> and 89.654 km<sup>2</sup> respectively. Among them, the shelterbelt afforested area in each region showed an increasing trend, which played a major role in the increase of forestation area in each region. The economic forest afforested area showed a decreasing trend except for Southwest China, and it also played an important role

in the increase of total forestation area in Southwest China. The special use forest afforested area showed an increasing trend except for Northeast China and compared with other afforested categories, the trend of annual increase or decrease is not significant.

**Table 2** Annual change rate of different afforested categories (km<sup>2</sup>/year)

Type	Region	China	Northwest China	Northeast China	North China	Southwest China	South Central China	East China
Total area		2.443	196.18	-89.654	91.007	109.93	-181.75	-123.22
Shelterbelt		1,282.8	320.09	105.97	370.6	195.22	213.15	77.795
Economic forest		-245.82	-14.895	-36.967	-115.79	117.85	-108.6	-87.42
Firewood forest		-100.32	-23.169	-19.706	-6.634	-9.36	-15.238	-26.217
Timber forest		-938.83	-87.756	-136.64	-157.66	-194.26	-272.76	-89.737
Special use forest		4.63	1.912	-2.307	0.493	0.484	1.694	2.355

Figure 1 shows the comparison of total forestation area of the whole country and each region. At national scale, the total forestation area fluctuated slightly from 1991 to 2001 and 2007 to 2014, but it was basically stable, which the annual total forestation area remained about 50,000 km<sup>2</sup>. From 2002 to 2006, the total forestation area showed a rapid rise and then a sudden decline. At regional scale, from 1991 to 1994, the proportion of afforestation in South Central China was the largest, with an average of 29.21%; the proportion of afforestation in North China was the largest during the period from 1995 to 2002, 2004 to 2007 and 2012 to 2014, with an average of 26.73%; the proportion of afforestation in Northwest China was the largest in 2003, with a number of 22.87%, but there was no significant difference compared with that in North China of which the proportion was 22.24%; From 2008 to 2011, the largest proportion of afforestation was in Southwest China, with an average of 25.73%, which accounted for 27.62% in 2008, 25.71% in 2009, 22.84% in 2011. There was no significant difference between Southwest China and North China, which accounted for 26.01%,



**Figure 1** Statistical chart of total forestation area in China

24.51% and 22.52% respectively. Therefore, North China is the main area of afforestation in China. The proportion of afforestation in Northeast China was the smallest from 1991 to 1996 and from 2002 to 2014, with an average of 7.60%; the proportion of afforestation in East China was the smallest from 1997 to 2001, with an average of 8.05%. The small proportion of afforestation in these two regions is most likely due to the abundance of existing forest resources compared with other regions.

Figure 2 shows comparison of the areal trend of different afforested categories in each region. From 1991 to 2014, the shelterbelt afforested area in all the regions showed a highly consistent trend. Besides, it reached the peak in 2003 for all the regions. The economic forest afforested area in each region showed two bell trend from 1991 to 2014, implying that the economic forest afforestation policy was transiting from quantity priority to quality priority; the firewood forest afforested area in each region decreased and then tended to be flat in general, which may be derived by the development and utilization of fossil fuels, electric energy and other energy sources; the timber forest afforested area in Northwest China, Northeast China and North China gradually decreased and then tended to be flat, while that in East China, South Central China and Southwest China showed a fluctuating upward trend, which may be due to the priority of planting fast-growing tree species in timber forest. Besides, the natural conditions such as water and heat in these regions are superior to that of the other three regions. The special use forest afforested area showed a fluctuating growth trend in all the regions except Northeast China.

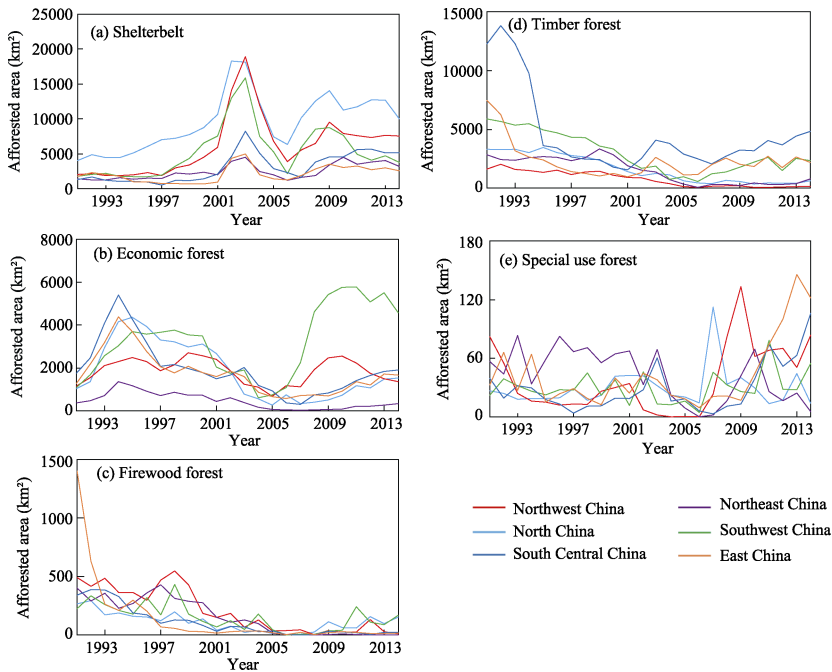
Figure 3 shows comparison of the area of different afforested categories. The shelterbelt afforested area was a largest part of the total forestation area in each region and the proportion of special use forest afforest area was the smallest from 1991 to 2014. After 2000, the proportion of firewood forest, economic forest and timber forest afforested area decreased significantly compared with that before 2000, which reflected the policy transition of timber usage to ecological protection. In Southwest China, the annual forestation area of economic forest increased significantly after 2006, which was much larger than that of timber forest. The average annual economic forest afforested area from 2006 to 2014 was about 2.5 times of the area of timber forest. This is because of the superior water and heat conditions in Yunnan and the full development of forest products. In East China, the economic forest afforested area of was larger than that of timber forest from 1993 to 2002. From 2003 to 2014, the timber forest afforested area exceeded that of economic forest. From 2002 to 2014, the shelterbelt afforested area gradually increased. The average annual shelterbelt afforested area was 2.7 times that of economic forest and 1.5 times that of timber forest. In South Central China, the annual forestation area of shelterbelt exceeded that of timber forests except 2006 and 2007 and it ranked the first place in the total forestation area of the region from 2001 to 2014. The afforestation structure of East China and South Central China gradually shifted to the shelterbelt.

Table 3 shows the conversion ratio of forestation area and change of forest coverage rate from fifth forest resources inventory to the eighth forest resources inventory in China<sup>[30–33]</sup>. About 30% of the national forestation area has been transferred to the plantation area, and the cumulative net increased plantation area has increased the national forest coverage by 3.43%, accounting for 52.71% of the net increased national forest coverage in the inventory period. Artificial afforestation plays an important role in improving the national forest coverage.

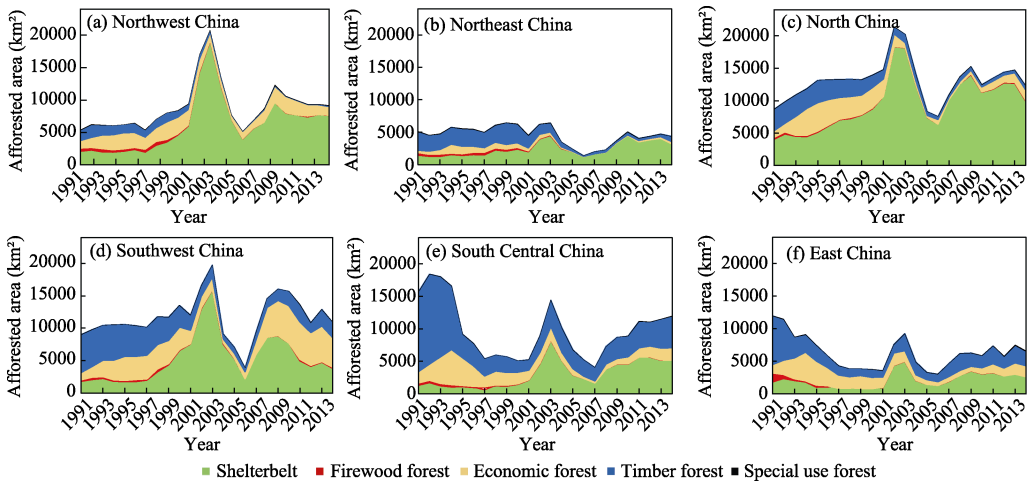
## 5 Discussion and Conclusion

Forest plays an import role in ecological function, such as regulating water, fixed soil, retaining fertilizer, fixed carbon, releasing oxygen, producing anion, absorbing pollution gases

and dust-retention and so on<sup>[34]</sup>. Forest functional diversity and its importance in material circulation and ecosystem objectively determine the necessity and importance of forest management. In the most recent years, China actively promotes the construction of forestry ecological engineering, which has an impact in protecting forest resources, developing forest resources and building a green China. China's forest coverage has increased from the initial 12.7% to 22.96%. Based on the results of the fourth to eighth forest resources inventory data, about 30% of the national forestation area has been transferred to the plantation area on average, and the contribution rate of the net increase of plantation area to the improvement of forest coverage rate has exceeded 50%. Artificial afforestation has a huge ecological effect. The yearly forestation area of different categories and regions provide basic data for re-searching carbon and water cycles in different regions<sup>[35]</sup>.



**Figure 2** Annual area changes of different afforested categories in China



**Figure 3** Annual area composition of different afforested categories in six regions of China

**Table 3** Conversion ratio of forestation area and changes of forest coverage rate

Inventory period \ Categories	Plantation coverage (%)	Net increase of plantation area (km <sup>2</sup> )	Forestation area during the period (km <sup>2</sup> )	Proportion of forestation area transferred to net increased plantation area during the period (%)	Net increase in forest area (km <sup>2</sup> )	Net increased forest coverage (%)	Forest coverage rate of net increased plantation area (%)	Proportion of increased forest coverage in net increased forest coverage (%)
The Fifth (1994–1998)	4.86	102,520	252,932.6	40.53	137,030	1.43	1.07	74.82
The Sixth (1999–2003)	5.54	65,924	318,222.94	20.72	159,683	1.66	0.69	41.28
The Seventh (2004–2008)	6.43	84,311	207,707.29	40.59	205,430	2.15	0.88	41.04
The Eighth (2009–2013)	7.22	76,416	297,400.43	25.69	122,300	1.27	0.79	62.48

From 1991 to 2014, the forestation area in the North showed an increasing trend, while it showed the opposite in the South. Overall, North China was the main afforestation region in China. The shelterbelt forestation contributes mostly for the increase of forestation area both in the whole country and in each region.

Due to a long span of statistical data, the change of statistic caliber may bring errors. For example, the statistic caliber of forestation area in 1991 was in Mu, while it changed to hectare since 1992. Besides, Chongqing was separated from Sichuan since 1997, and the statistical yearbook changed accordingly.

**Author Contributions**

Chen, Y. L. and Liu, S. S. designed the dataset. Liu, S. S., Peng, Z. W., Lin, W. K., Zhao, S. Wu, Y. F., Xue, X. H., Wang, C. G. collected and processed the dataset. Liu, S. S. and Huang, X. Y. wrote the data paper.

**Conflicts of Interest**

The authors declare no conflicts of interest.

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