MULTIPLE AFFORESTATION PROGRAMS ACCELERATE THE GREENNESS IN THE 'THREE NORTH' REGION OF CHINA FROM 1982 TO 2013

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Significance

China has implement several ecological restoration project ever since 1978. However, the effectiveness of planting trees in arid and semi-arid north China have long been questioned. Understanding the status of the vegetation growth in arid region will provide important information for future ecological restoration programs. This study present a three-decade observed greening trend in the 'three north' region by using satellite data. This trend significantly increased since 2000 when several subsequent programs began to implement. The result confirms the achievement of these programs but also proves that planting trees in semi-arid and arid region, with enough human intervention, are applicable.

Introduction

Since 1978, China has launched a series of ecological restoration programs to confront the increasingly devastating environmental problems in the northern region. These programs, including the 'Three North' shelterbelt development program (TNSDP), the Beijing-Tianjin Sand Source Control Program (BSSCP), the Nature Forest Conservation Program (NFCP), and the Grain to Green Program (GTGP), focus on local environment restoration by planting trees in semi-arid and arid regions and by protecting natural forests. However, the effectiveness of these programs has been questioned because this region is not suitable for afforestation by some previous studies. One of the major concerns is that whether these planted trees will survive in the arid and semi-arid region. Here, we report increasing greenness in this region using the satellite-retrieved normalized difference vegetation index (NDVI). The NDVI increase for the Three North region was 0.28%-0.38% yr^{-1} in 1982-2000 and 0.86%-1.12% yr^{-1} in 2000-2013; these values are much higher than the country's means of 0.060%-0.063% yr^{-1} and 0.27%-0.30% yr^{-1}, respectively. Most of the increase occurred in low and sparsely vegetated areas. This significant increase in NDVI confirms the increasing vegetation activity and the achievement of these programs.

Method

We use the NDVI data from both MODIS and AVHRR in our study. Two test method was used including the simple linear regression model and the Mann-Kendall test and Sen's slope trend analysis. We also applied the BFAST method in the time series analysis. To analysis the phenological change effect on vegetation growth, we use the TIMESAT method to analyze the green up date and length of growing season change.

Result & Discussion

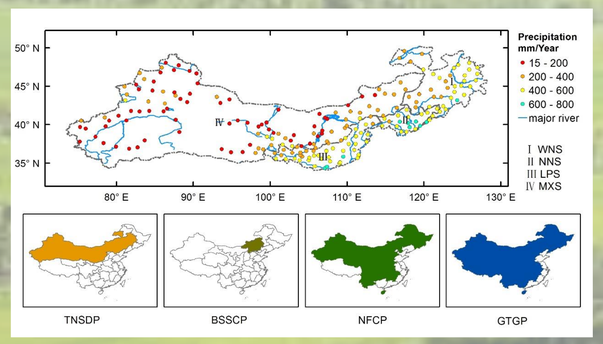

Fig. 1. The location of the three north region and other three major ecological restoration programs in China. The four subdivisions of this region are adopted from the program planning and categorized by multiple characteristics including soil properties, vegetation, climate, and program objection. WNS, NNS, LPS, MXS stand for west northeastern-China subdivision, north northern-China subdivision, loss plateau subdivision and Mongolia-Xinjiang subdivision. Dots represent annual mean precipitation from weather station the earliest since 1951.

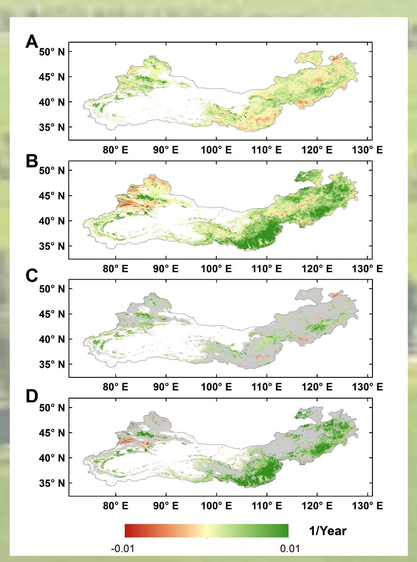

Fig. 2. NDVI trend from 1982-2000 and 2000-2013 derived from both M-K model and linear model. Grey area stand for no significant trend through M-K test, white area stand for bare ground with a growing season (May to September) mean NDVI less than 0.1

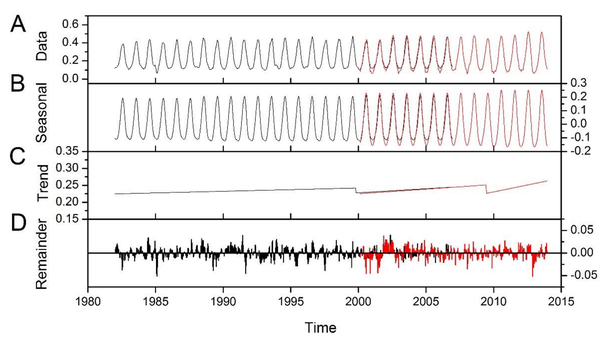

Fig. 3. BFAST seasonal trend analysis of the three north region. 1982-2006 from GIMMS (black) and 2000-2013 from MODIS (red). (A) NDVI time series from the two NDVI datasets. (B) Seasonal component derive from the BFAST model. (C) Trend component from the BFAST model, only the most significant abrupt change is detected for each dataset. (D) The remainder shows the variation of the NDVI after the removal of the seasonal and trend in the time series. Bare ground are screened for analysis.

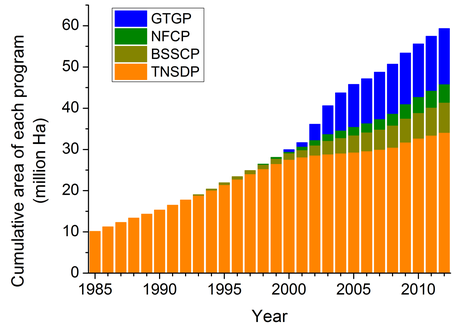

Fig. 5. Cumulative afforested area for each ecological restoration program since 1985.

Table 1. Vegetation growth rate estimated by Sen's slope, linear regression and BFAST model for four subdivision, 'three north' region, south China, and China.

	1982-2000			2000-2013		
	Sen's slope	Linear	BFAST	Sen's slope	Linear	BFAST
WNS	6.66	8.64	7.71	31.73	44.30	7.08*(47.8)
NNS	9.40	14.65	15.7*	39.72	52.20	27.3*(66.9)
LPS	3.84	3.88	10.4*	71.94	83.28	49.2*(26.7)
MXS	12.66	17.54	9.39**	17.12	24.16	11.7**(-2.03)
North	9.58	12.98	7.18	30.79	40.20	17.4*(23.8)
South	0.39	-0.09		5.62	8.85	
China	2.66	2.84		13.32	15.17	

*indicates linear regression model was used with one break point.
**indicates linear regression model was used with two break point.

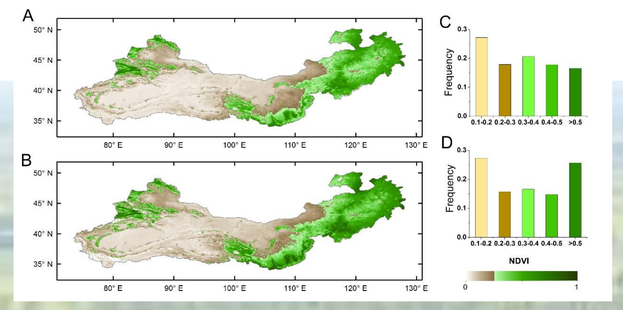

Fig. 4. Mean NDVI for the two periods during growing season. (A) and (C) are the spatial distribution and frequency distribution of mean NDVI for 1982 to 1999. (B) and (D) are the spatial distribution and frequency distribution of mean NDVI for 2000 to 2013.

Summary

1. Two different regression models show a similar trend in north China region with for two separate period.
2. The increasing trend is much higher for the period 2000-2013 than 1982-2000.
3. This increase is mostly attributed to the afforestation programs carried out in north China region.
4. These planted forest are facing increasing danger as the temperature increases and precipitation decreases.

Key references

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Acknowledgements

We thank Dr. Geli Zhang for the comments and suggestions on the study .This study was supported by the National Basic Research Program of China (2013CB956602), and the National Science and Engineering Research Council of Canada (NSERC) Discover Grant.