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Remote sensing monitoring of grassland vegetation growth in the Beijing–Tianjin sandstorm source project area from 2000 to 2010

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ABSTRACT

Grassland is not only an important landscape of the Beijing–Tianjin sandstorm source control project area, but also a significant object of the Beijing–Tianjin sandstorm source control project. By taking the situation in 2000 as the base of comparison and using the established grassland vegetation growth model, the monitoring and evaluation of grassland vegetation dynamic variation in the project area from 2000 to 2010 was conducted based on MODIS 16 days NDVI data. The conclusions are as follows: (1) The comparative result of average growth between each year from 2001 to 2010 and the base year was on the good side in general; the grassland growth was good both in the early and later periods of grassland growth peak season than in the first years of the project implementation, indicating that the implementation of the Beijing–Tianjin sandstorm source project has significantly improved the growth conditions of grassland vegetation; (2) With regard to the annual dynamic variation of grassland growth, the area proportions of the grasslands, of which the average grassland growth was on the good side, fluctuated and increased slightly with the time changes in general. The area proportions of the grasslands, of which the average grassland growth was on the bad side, fluctuated and decreased in general. The area proportions of the grasslands with normal growth showed an increasing overall trend; (3) From the regional perceptive on four zones, including the northern arid grassland desertification control zone, Hunshandake sandy land control zone, the farming-pastoral area of desertified land control zone, and the water conservation zone of Yanshan hills and mountains, except that the grassland growth in the farming-pastoral area of desertified land control zone was bad, the average growth of other three zones was good each year from 2001 to 2010 compared with the base year. (4) In respect of space, the regions with big grassland growth variation in the project area were concentrated in the western and eastern sections of the northern arid grassland desertification control zone and the western section of Hunshandake sandy land control zone. The grassland growth variation in the water conservation zone of Yanshan hills and mountains and the farming-pastoral area of desertified land control zone were relatively stable. On one hand, the conclusions of this paper can evaluate the effectiveness of the project control, on the other hand, it can also provide scientific basics to grassland management departments, facilitate the rational utilization of grassland, and preserve the regional ecological balance.

1. Introduction

China's northern area has frequently suffered from sandstorms since the 1990s. Especially in the spring of 2000, sandstorms just occurred 12 times in North China, it was three times more than those happened in the 1990s, and made North China suffer social, economic and other multiple effects and losses. In order to improve and optimize the ecological and environmental conditions of Beijing, Tianjin and surrounding areas, protect and build forest and grass vegetation, restrain desertification expansion and control land, the Chinese government has timely made a project decision to control the ecological degradation and conduct

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construction of ecological circle around Beijing and Tianjin. The project started a pilot in June 2000 and achieved initial success. With the approval by the State Council, the former State Planning Commission, Ministry of Finance, State Forestry Administration, Ministry of Agriculture and Ministry of Water Resources jointly issued the "Beijing–Tianjin sandstorm source control project plan (2001–2010)" in March 2002, and at this point, the Beijing–Tianjin sandstorm source control project was in full swing. The Beijing–Tianjin sandstorm source control project is a landmark project in the field of nationalwide ecological protection and construction. The grassland is an important landscape of the Beijing–Tianjin sandstorm source project area, as well as a significant object of the control. Thus, as the first stage of Beijing–Tianjin sandstorm source control project had been completed in 2010, to conduct a benefit evaluation of the grassland project is not only conducive to objectively evaluate the effectiveness of the entire first phase of the grassland construction project, but also affect the overall ecological benefits in the project area, especially very important to guide the planning of the second stage project and work better in the future (Gonzalo et al., 2010).

Growth remote sensing monitoring of grassland vegetation directly reflects the herbage growth status, it is an important part of ecological status evaluation and can timely provide guidance to agricultural management and production. The growth remote sensing monitoring originated in the 1980s, the USA, Canada, the former Soviet Union and other countries of the EU have done numerous researches and monitoring studies on the indicators and methodologies of crop growth remote sensing monitoring (Beatriz et al., 2009; Ma et al., 2008; Lobell et al., 2003; Adel et al., 2007). After defining the concept of crop growth, the growth monitoring of vegetation entered into the stage of indicator development and quantitative monitoring (John et al., 2013). After 1999, the growth monitoring mainly used the Moderate-resolution Imaging Spectroradiometer (MODIS) data (Pieter et al., 2006; Mao et al., 2012; Zhou et al., 2001; Barbosa et al., 2006; Lobell et al., 2003); Wu et al. (2000) used maximum NDVI image in every 10 days compared with the previous year in the same period to achieve the nationwide crop growth remote sensing monitoring; some researchers discussed the monitoring indicators and reference standards of crop growth, and developed 10-day and monthly MODIS/NDVI comparative models and MODIS/NDVI semi-quantitative monitoring indicator model (Guo et al., 2012; Ma et al., 2008). The crop growth monitoring has a long history, and the monitoring theories and methods are relatively mature, so the growth remote sensing monitoring of grassland vegetation borrowed a part of ideas from the crop remote sensing monitoring methods. The grassland growth monitoring methods currently include direct monitoring method, vegetation growth process monitoring method, contemporaneous comparative method (Wu et al., 2010) and anomaly growth monitoring method (Xu et al., 2013). Tashi (2004) used the NOAA/AVHRR data and ground monitoring data to establish the model of vegetation index and herbage growth, meteorological and elements herbage growth monitoring, and initially developed the level values of herbage growth. Wu et al. (2010) used the morphological characteristics of vegetation index curve to monitor current status of vegetation growth and the vegetation growth trend. The vegetation growth process monitoring is extensively used in the grassland vegetation growth monitoring. The contemporaneous comparative method frequently uses the NDVI for monitoring. Based on the contemporaneous comparative method, Xu et al. (2013) made its improvements in 2013 and put forward the anomaly growth monitoring method, and used the MODIS/NDVI data to adopt the anomaly growth index model and conducted the growth monitoring of grassland vegetation in China in 2008. Among these monitoring methods, the contemporaneous comparative method has simple calculation and is extensively used in practical researches and applications, but this calculation method does not eliminate the shortcomings of vegetation indices. The anomaly growth monitoring method adopted a normalized method to improve the existing shortages of vegetation indices and thus obtained more accurate monitoring results.

In this study, the grasslands of Beijing–Tianjin sandstorm source project area has been taken as the research object, and the grassland vegetation growth index model has been established based on the anomaly growth monitoring method, and carried out the remote sensing monitoring of grassland vegetation growth status in the project area within a period of eleven years from 2000 to 2010, and performed the project results evaluation. The achievements of this paper have important reference value to promote regional economic development, improve ecological status and conduct scientific management and rational utilization of grasslands (Harini et al., 2013).

2. Methods

2.1. Study area

The Beijing–Tianjin sandstorm source project area (Fig. 1) ranges from Darhan Muming'an united banner of Inner Mongolia in the west to Ar Horqin banner of Inner Mongolia in the east and from Dai County of Shanxi province in the south to East Ujimqin banner of Inner Mongolia in the north. It spans a horizontal distance of nearly 700 km from east to west and a vertical distance of nearly 600 km from south to north, covering 75 counties in five provinces (autonomous regions and municipalities) of Beijing, Tianjin, Hebei, Shanxi and Inner Mongolia, including six counties in Beijing, one in Tianjin, 24 in Hebei, 13 in Shanxi and 31 in Inner Mongolia, covering a total land area of 458,000 km^2, of which 101,800 km^2 are desertified land area. The Beijing–Tianjin sandstorm source project area covers a large area and have different bioclimatic zones and soil types. Therefore, the project area is divided into four zones in accordance with arrangement, climate, vegetation, soil and terrain and landscapes of Beijing–Tianjin sandstorm source control project, namely, the northern arid grassland desertification control zone, the Hunshandake sandy land control zone, the farming-pastoral area of desertified land control zone and the water conservation zone of Yanshan hills and mountains.

The Beijing–Tianjin sandstorm source project area consists of plain, mountainous and highland regions. It has suffered from severe desertification as Hunshandake sandy land and Horqin sandy land are distributed in the area, which restrict agricultural management and production in the region. There are two climate belts and five climate zones in the project area, including warm temperate semi-humid zone, temperate semi-humid zone, temperate semi-arid zone, temperate arid zone and temperate extreme arid zone from south to north and east to west. The climate is arid, cold, and windy. A wind is the natural characteristic of desertified regions that plays an important role in the expansion of desertification and the shaping of desertified landform. Strong wind mainly occurs in winter and spring, in which there are the fewest amount of precipitation. Meanwhile, there are the fewest ground surface vegetations in winter and spring, so the arid sandy ground surface could be easily eroded by strong wind and lead to desertification.

The project area's total land area is 45.80×10^4 km^2, of which grassland has the largest range of about 26.63×10^4 km^2, accounting for 58.1% of the total area. The grassland is the biggest ecological system in the project area, mainly including 12 grassland types (Fig. 1), namely Low-land meadow, Warm tussock, Warm shrubby tussock, Tropical tussock, Montane meadow, Apline meadow, Temperate meadow steppe, Temperate steppe desert, Temperate steppe, Temperate desert steppe, Temperate desert, and Marsh. The