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A framework for assessing the effects of afforestation and South-to-North Water Transfer on nitrogen and phosphorus uptake by plants in a critical riparian zone

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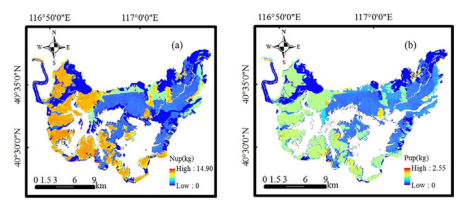
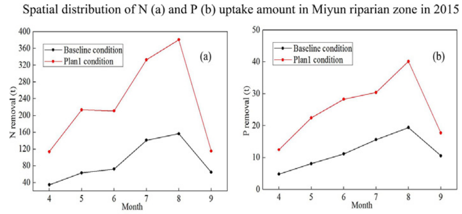
HIGHLIGHTS

- Miyun Reservoir is affected by SNWT and large-scale afforestation.
- A framework including an ecological simulation tool and scenario setting methods is proposed.
- It can identify the effects of these two projects on N and P uptake by plants in Miyun Reservoir riparian zone.
- The afforestation can offset the negative effect on N (P) removal caused by SNWT.
- This study can provide useful scientific reference for the effective management of Miyun Reservoir.

GRAPHICAL ABSTRACT



Spatial distribution of N (a) and P (b) uptake amount in Miyun riparian zone in 2015



The effects of afforestation on N (a) and P (b) in Miyun riparian zone in 2015

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ABSTRACT

The uptake of nitrogen (N) and phosphorus (P) by plants in riparian zones can significantly decrease the water pollution risk. Moreover, the vegetation area in riparian zone can be impacted by raising of water level and afforestation. As the largest reservoir in North China, the Miyun Reservoir is affected by the South-to-North Water Transfer (SNWT) and large-scale afforestation. However, few efficient technology frameworks that can be used to assess the effects of similar anthropogenic projections on N and P uptake by plants at riparian zone catchment scale have been reported. Therefore, this study proposed a framework including an ecological simulation tool coupled with multi-source data and scenario setting methods to identify the effects of these two projects on the uptake of N and P by plants in Miyun Reservoir riparian zone from April to September in 2015. The results show that the total N and P uptake by plants in Miyun Reservoir riparian zone are 1214.18 t and 148.66 t in growing seasons. After afforestation, the N (P) removal will increase by 2.56 (2.17) times in the impacted area (below 160 m in elevation). When the water level rises to 150 m in elevation, the joint effects of afforestation and SNWT will increase the total N and P removals by 851.18 t and 83.33 t. This implies that the afforestation can offset the negative effect on N (P) removal caused by SNWT. Overall, this study can provide useful scientific reference for the design and effective management of the riparian zone.

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1. Introduction

In recent years, non-point source (NPS) nitrogen (N) and phosphorus (P) pollution have become two important factors causing water quality deterioration in the world (Blackburn et al., 2017; Dong et al., 2014; Lou et al., 2018; Nanus et al., 2008). The riparian zone, as the last barrier for the NPS control, does not only improve the quality of reservoir water, but also plays a key role in maintaining the health and sustainable development of the reservoir-catchment ecosystem as a whole (Dosskey et al., 2010; Mander et al., 2005; Sobota et al., 2012; Tang et al., 2014; Wang et al., 2015).

Based on vegetation production and other environmental factors (Klemas, 2014), the plants can significantly assimilate N and P and have a key role to play in N and P cycling in the riparian zone (Collins et al., 2013; Lyons et al., 2000; Neilen et al., 2017; Sabater et al., 2003). However, most of the current studies use the field sampling and mathematical statistics to analyze the N and P uptake by plants in riparian zones (Dong et al., 2014; Guo et al., 2015; Hale et al., 2018; Hall et al., 2015; Jiang et al., 2015; Kreiling et al., 2011; Li et al., 2009; Neilen et al., 2017; Reddy et al., 1999; Sabater et al., 2003; Saleh et al., 2018; Ye et al., 2017), so that these results inadequately address the mechanism processes and are difficult to give overall solutions at the catchment scale. Fortunately, remote sensing technology can provide underlying data with high temporal and spatial resolutions at large-scale area (Islam and Sado, 2000; Zhang et al., 2009; Zhao et al., 2018). Moreover, several studies have attempted to simulate the N and P uptake at riparian zone

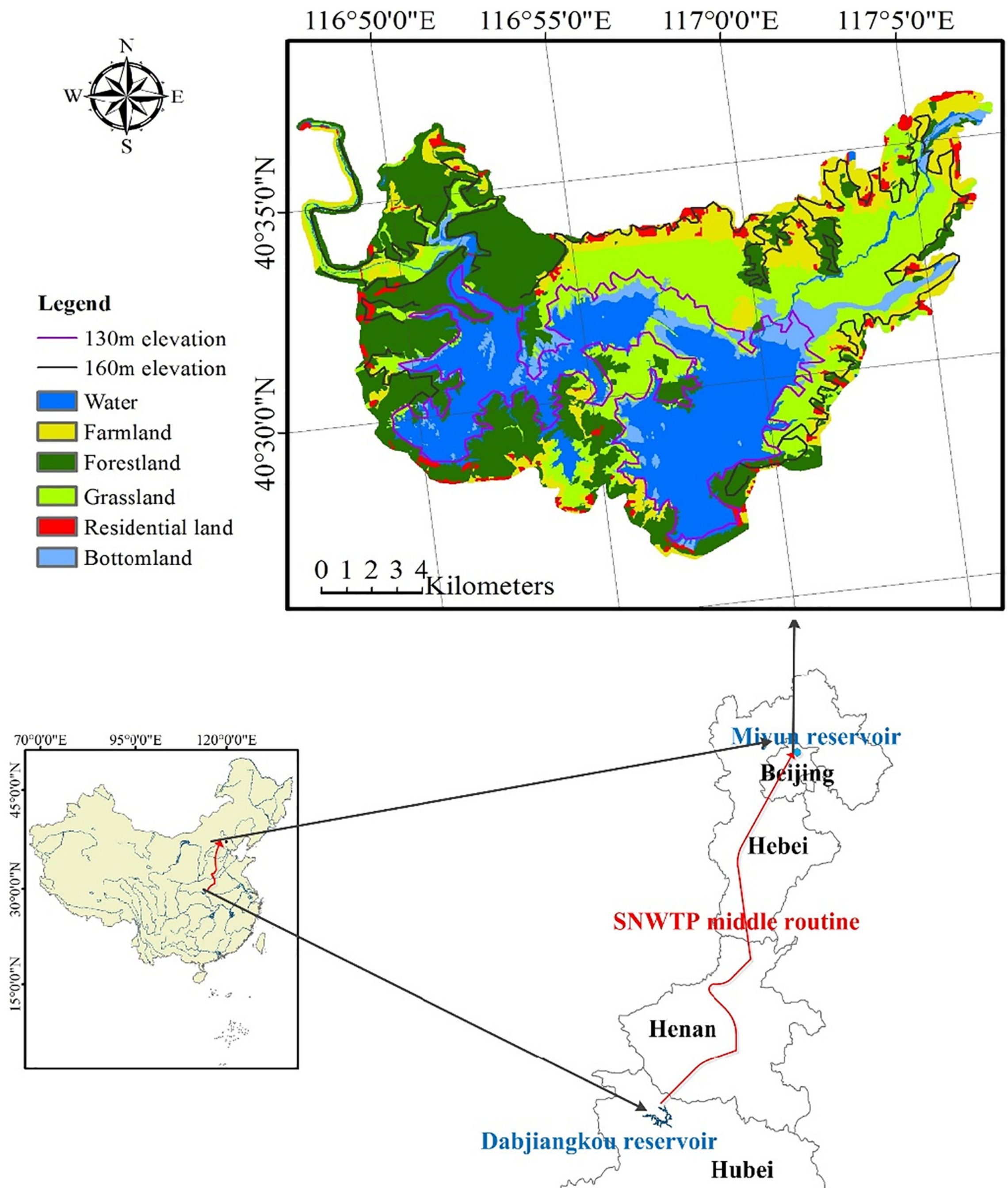

Fig. 1. The map of study area containing the middle route of SNWTP in China, the location and land use types of Miyun Reservoir in 2015.