ABSTRACT
Because vegetation growth in the Northern Hemisphere is typically nitrogen-limited, increased nitrogen deposition could have an attenuating effect on rising atmospheric CO$_2$ by stimulating the accumulation of biomass. Given the high carbon to nitrogen ratios and long lifetimes of carbon in wood, a most significant effect of nitrogen fertilization is expected in forests. Forest inventories indicate that the carbon content of northern forests have increased concurrently with increased nitrogen deposition since the 1950s [Spiecker et al., 1996]. In addition, variations in atmospheric CO$_2$ indicate a globally significant carbon sink in northern mid-latitude forest regions [Schimel et al., 2001]. It is unclear however, whether elevated nitrogen deposition or other factors are the primary cause of carbon sequestration in northern forests. We argue that the elevated nitrogen deposition is unlikely to enhance vegetation carbon sink significantly because of its differentiating effect on the carbon sequestration capacity of uneven aged forests and climatic limitations on carbon sequestration in the Northern Hemisphere. We estimate the potential of forests with lifted nitrogen limitation to decelerate CO$_2$ concentrations rise in the atmosphere and therefore to mitigate climate warming. We also outline areas of the Northern Hemisphere which are most sensitive to increased nitrogen deposition.

METHODS
To determine the effect of increased nitrogen deposition on carbon sequestration in Northern Hemisphere we investigated changes in modeled carbon fluxes from 1948 to 2002 under different environmental change scenarios. Carbon fluxes were simulated using a well established biogeochemical process model BIOME-BGC [Thornton, 1998; Running and Hunt, 1993], which simulates carbon, nitrogen and water cycles. The global model performance (forest growth) was analyzed by Churkina and Running [2000]. The model performance (carbon and water fluxes) was also favorably compared with measurements over networks of sites in Europe [Churkina et al., 2003] and in North America [Thornton et al., 2002]. The climate drivers were obtained from NCEP Reanalysis database. The distributions of nitrogen deposition for both industrial and pre-industrial scenarios were from MOGUNTIA model results [Dentener and Crutzen, 1994]. To outline forest areas most sensitive to enhanced nitrogen deposition, we assumed continuous forest coverage of the Northern Hemisphere with deciduous broadleaf and evergreen needleleaf forests as well as constant pre-industrial (0.0001 kg N m$^{-2}$yr$^{-1}$) and industrial nitrogen depositions (0.0016 kg N m$^{-2}$yr$^{-1}$) homogeneously distributed over the study area. The nitrogen deposition constants for these scenarios were assigned according to Holland et al. [2005; 1999].

RESULTS
We estimated the potential of forests in the Northern Hemisphere with lifted nitrogen levels to decelerate CO$_2$ concentrations rise in the atmosphere and therefore to mitigate climate warming. Our model predicts that increased nitrogen deposition combined with CO$_2$ fertilization caused 8.1 Pg of carbon to accumulate in forests between 1948 and 2002. The accumulated carbon was distributed between evergreen needleleaf (3.9 Pg), deciduous broadleaf (4.0 Pg), and deciduous needleleaf (0.21 Pg) forests.

We also found that not all forests of the Northern Hemisphere are sensitive to increased nitrogen deposition. Climatic limitations and soil characteristics play here a significant role. Forests located in rather cold, wet climates and at higher elevations would benefit from the nitrogen fertilization the most. Forests growing in Western Europe, Siberia, North-east Asia, and Eastern United States (humid and rather cold climate due to high elevation) would benefit stronger and uptake more carbon in response to the enhanced nitrogen deposition than forests located in the central United States and Central Asia where climate is dry (Fig. 1). Other studies also confirm this pattern [Vetter et al., 2005]. Experimental studies claimed that temperate forests are not particularly sensitive to nitrogen fertilization [Nadelhoffer et al., 1999].

Our study suggests that during the last 55 years additional carbon uptake in the forests associated with increased nitrogen deposition was not as significant as previous studies demonstrated. Reforestation and change in nitrogen deposition patterns however may alter this additional carbon uptake.
Fig. 1. Areas of the Northern Hemisphere where carbon sequestration is sensitive to increased atmospheric nitrogen deposition. Forests are assumed to be in equilibrium with climate. The maps show average change in carbon sequestration in response to increased nitrogen deposition and CO$_2$ fertilization over the last 20 years. It is assumed that Northern Hemisphere is continuously covered with

a) Deciduous broadleaf forest  b) Evergreen needleleaf forest

REFERENCES


