Take Home Message

While afforestation is an effective carbon sequestration strategy, trees are less reflective than a barren landscape and absorb more incoming sunlight. We estimated that afforestation across the Mid Atlantic region of the United States from 1900 to 2000 contributed to an additional carbon dioxide sequestration of 5.70 GtCO₂. At the same time, the decreased amounts of sunlight reflected by the surface resulted in a warming effect equivalent to 1.01 GtCO₂. Therefore, regional afforestation had a net effect of sequestering only 4.69 GtCO₂.

Introduction

In the 19th century, much of the forests throughout the Mid Atlantic U.S. were cut down for lumber, cropland, and pastures. As population and agricultural production moved westwards, many forests have gradually grown back. In this study, we estimate the additional CO₂ sequestration by planting new forests, additional energy absorbed due to the decrease in albedo, and net effect on global warming.

Methods

The year 1900 marked a turning point for vegetation cover across the Mid Atlantic. (Figure 2) Therefore, all calculations of increased CO₂ sequestration and warming promoted by decreased albedo are relative to forested areas in 1900. To calculate area of each plant type, we used data from the National Center for Atmospheric Research (NCAR) Community Land Model simulations from 1850 to 2005.

We determined the CO₂ sequestration rate of the forests using a weighted average of the observed maximum carboxylation rate (Vc,max) based on the regional forest composition. This Vc_max was plugged into a canopy model, which allowed us to calculate an annual sequestration rate. (Figure 4)

We estimated changes in albedo from measured albedo values for each plant type in the summer and winter, with and without snow. By using historical percentage snow cover data for each latitude and month, we calculated the change in albedo for each month.

Results

We estimated a 1.7% decrease in average albedo from a peak of 0.154 in 1900 (Figure 3). This decrease caused a warming effect equivalent to 1.01 GtCO₂ between the years 1900 and 2000. Over the same time period, the increase in forest area led to an additional 5.70 GtCO₂ sequestered. The net effect of these results is equivalent to an additional 4.69 GtCO₂ sequestered. This means that the albedo had a 18% “take back” effect on the effectiveness of CO₂ sequestration from afforestation (Figure 5).

Conclusions

Afforestation has two main effects on the global climate: cooling from CO₂ sequestration, and warming from change in albedo. This study shows that although afforestation has an overall cooling effect on the climate, this effect is somewhat diminished by the warming from albedo, suggesting that global estimates of the cooling potential of afforestation should be reduced.