Rain Followed the Plow: What is the Potential for Land Cover Change to Impact the Precipitative Sources of Earth's Breadbaskets?

Justin Bagley¹, Ankur Desai, Jonathan Foley
bagley@wisc.edu

[¹] AOS, Center for Sustainability and the Global Environment, UW-Madison

Introduction:
Several recent studies have investigated how crop yields may be influenced by changes in climate due to anthropogenic greenhouse gas forcing. However, there have not been any assessments of the impacts of changing land cover on crop yield in this study. In this study we examined the potential impacts that land cover change (LCC) may have on the major food producing regions of the world. Specifically, we used a simplified linear model to set bounds on the extent that changes in evaporative transpiration due to LCC may influence precipitation and crop yields within earth’s breadbaskets and address the following questions:
1.) Where does the moisture for the major food producing regions of the world come from?
2.) What is the potential for the moisture sources of earth’s breadbaskets to change due to alterations in land cover?
3.) What bounds can be placed on the impact of land cover change on crop yields?

Linear Model:
To calculate changes in precipitation due to LCC we used the following equation:
\[
R = P - \sum_{i=1}^{n} f_i A_i
\]
where \( P \) is precipitation, \( f_i \) is evaporation source, \( A_i \) is area, and \( B \) is evapotranspiration.

Conclusions:
- Alterations to biophysical regulation of surface energy balance and moisture flux due to LCC has the potential to influence precipitation and crop yield in breadbasket regions.
- The evaporative source of breadbasket regions depended on both local meteorological conditions and regional vegetative cover.
- Precipitation in all regions was found to be susceptible to changes in evaporative source due to LCC.
- Reductions in precipitation ranged 5–16%. Reductions in yields ranged from 0–23%.
- Regions with mean soil moisture fraction > 65 had minimal changes in crop yield due to LCC.
- Greatest impacts found for South American soybeans and European wheat.

References:

Figure 1: The observed fractional area (%) of maize (left), soybeans (middle), and wheat (right).

Figure 2: The maize (yellow), soybeans (green), and wheat (blue) growing regions used in this study.

Figure 3: Evaporative source (mm/day) of each region during the growing season as defined by planting/harvesting dates (shaded). Also shown are the observed crop fractional area (%) (crosses), and LCC (green points). The climatological winds (orange).

Figure 4: The observed fractional area (%) of maize (left), soybeans (middle), and wheat (right).

Total Managed Fractional Area (%)