Economic Impacts of Biochar-Induced Yield Increases in the United States

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OBJECTIVE

Biochar together with bio-oil and producer gas is a co-product from the pyrolysis of biomass such as crop residues or switchgrass. Biochar as a soil amendment has the potential to increase crop yields above trend. This can result in avoided land-use change in the United States and elsewhere leading to carbon negative renewable energy when coupled with biofuel production. Our objective is to identify areas that are most likely to adopt biochar as a soil amendment to increase revenue from higher yields. We also assess the potential supply of biochar given available biomass resources.

METHOD

We use a newly developed biochar module of the Agricultural Production Systems sIMulator (APSIM) to determine the magnitude and probability of a crop yield increase after an assumed biochar application of 5 t ha^{-1} on cropland. Biochar feedstocks analyzed are corn stover, switchgrass, and woody biomass. Next, we calculate the expected county-level yield over the next 20 years for six major crops, i.e., corn, soybeans, wheat, sorghum, rice, and peanuts. Given low and high commodity prices (which were determined by the lowest and highest prices over the last 20 years), we can calculate farmers' willingness-to-pay (WTP) per metric ton of biochar. Biochar remains in the soil for a significant period of time and only needs to be applied in the first year.

RESULTS

Figure 1 shows that under low commodity prices, only a small amount of land will be covered if the biochar price is \$200 t^{-1}. Under high commodity prices, a biochar price of \$200 t^{-1} would make over half of the area covered by the six crops profitable for the application of biochar. Figure 2 shows the WTP under low commodity prices for biochar from two different feedstocks. A high WTP is observed along the Mississippi in the Southern parts of the country as well as in Illinois and eastern Nebraska.

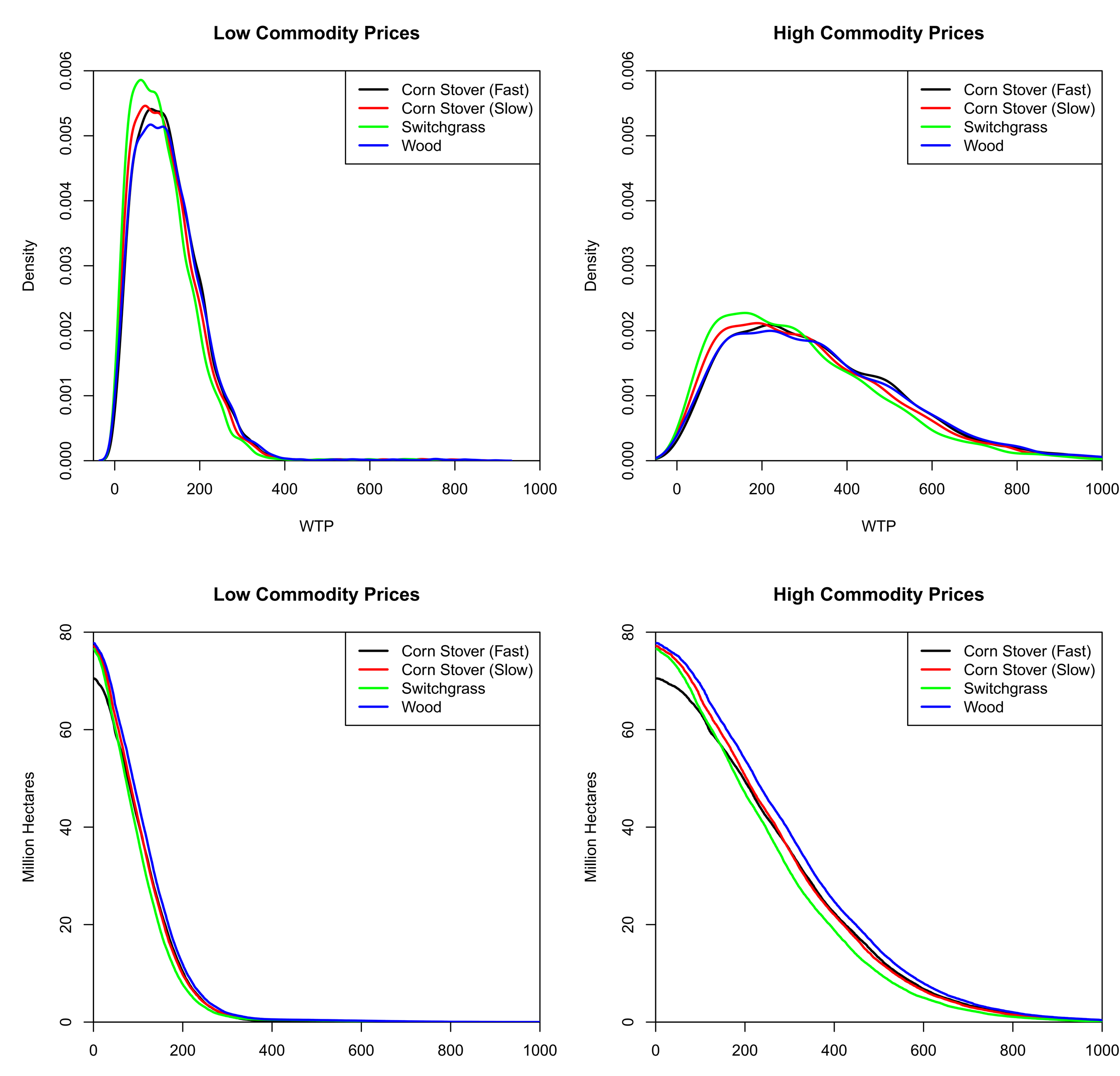

Fig. 1: Kernel density estimation of WTP and area covered under two commodity price scenarios and four biochar feedstocks.

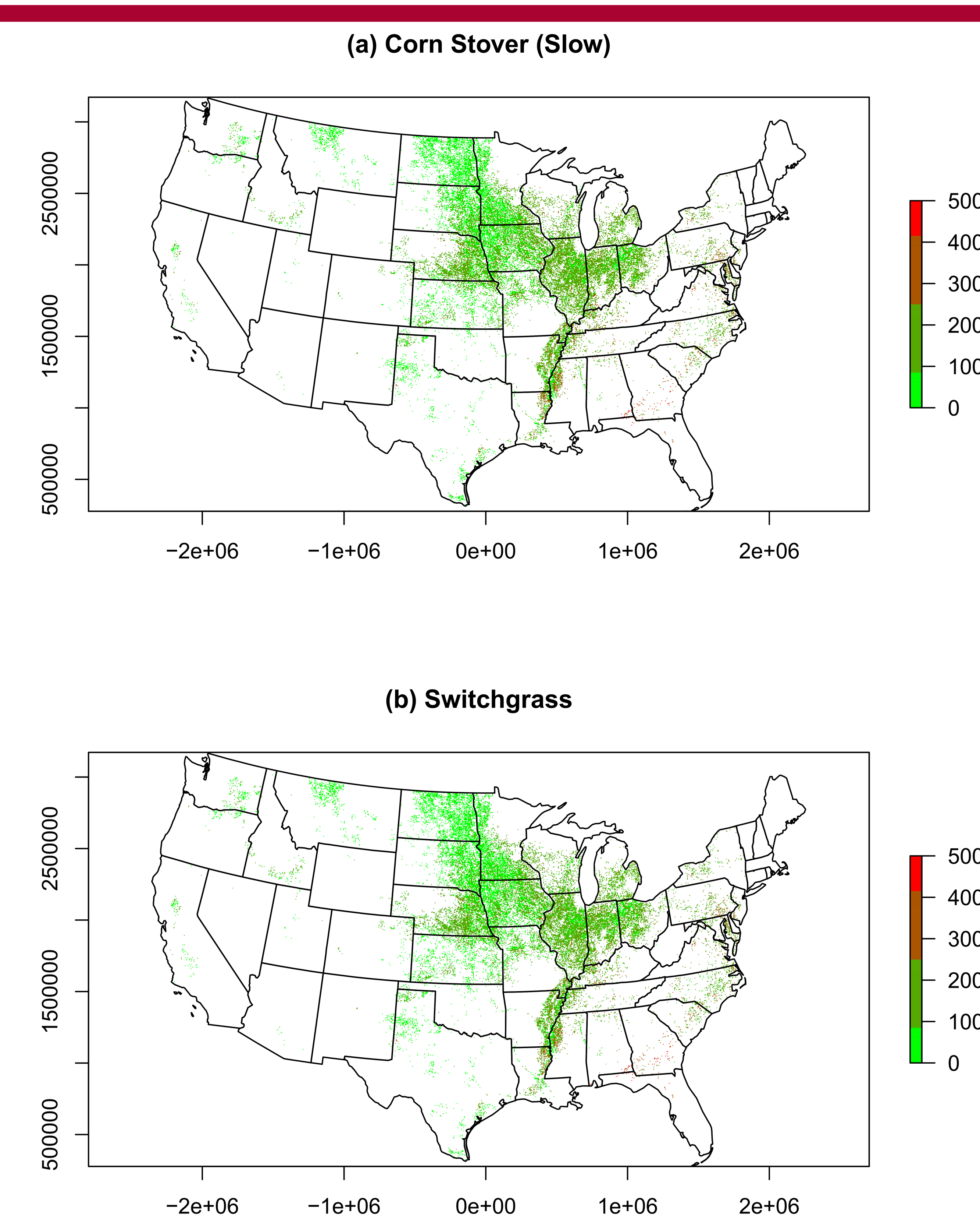

Fig. 2: WTP (\$ t^{-1} ha^{-1}) under low crop prices for biochar from stover and switchgrass.

LIMITED BIOCHAR AVAILABILITY

The large scale application of biochar is hindered by limited supply of biomass feedstock. If biochar is applied to corn area only (35.11 million ha in 2016), 11% and 25% could be treated each year from corn stover alone assuming reduced tillage and no-tillage removal rates, respectively. If the area of soybeans is included for the treatment, 6% and 13% can be treated, respectively.

COMMODITY PRICE EFFECTS

Previous research shows that the most profitable allocation of crop area to switchgrass is in the Southwest. Thus, there is a "spatial match" between a high demand for biochar and the area that is most likely to grow the feedstock. This leads to price stabilization in the long-run.

CARBON NEGATIVE ENERGY

Carbon negative energy through biochar application is achieved if bio-oil is used as an energy source and the co-produced biochar results in a yield increase. The yield increase can be attributed to bio-oil leading to a credit for avoided indirect land-use change.

CONCLUSIONS

Additional benefits need to be taken into account for a viable biochar industry such as carbon credits and/or a reduction in nitrogen application. Sequestration of carbon in soils due to the biochar applications are an additional source of reductions in net GHG emissions not considered in this analysis.

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