

Greenhouse Gas Balance of Willow Crops

KEY POINTS

1. Growing willow biomass crops on cropland and pastureland and using willow to produce renewable bioenergy and bioproducts, like bioplastics or biochemicals, provides real and permanent climate change benefits. This is because willow crops sequester more carbon than they emit over their 23 year life cycle.
2. Willow biomass crops remove more CO₂ from the atmosphere as they grow than is added to the atmosphere by the fossil fuels used during the planting, management, harvesting, and delivery of the willow biomass to a heating, combined heat and power, or biofuels plant. Willow crops convert atmospheric CO₂ into woody biomass that can be used for bioenergy and bioproducts and belowground material that stores carbon for long periods of time in root system and soils.
3. Willow biomass crops provide a variety of other benefits across the landscape such as creating jobs, supporting pollinators and biodiversity, and improving water and soil quality.



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CALCULATING THE GREENHOUSE GAS EMISSIONS FROM WILLOW CROPS

- ESF Researchers identified over 520,000 acres on more than 9,700 parcels that were suitable for growing willow in a five county region (Jefferson, Lewis, Oneida, Oswego, St. Lawrence) in central and northern New York. Cropland and pastureland made up almost 90% of this suitable land for willow production.
- Willow yields on each parcel were predicted using USDA soil information and data from almost three decades of research at ESF and over 1,200 acres of commercial-scale willow fields in New York.
- This research analyzed GHG emissions over a 23-year timeframe that represents seven three-year harvest cycles and a year for planting and a year for removing the willow crop (Figure 1).
- Researchers completed a life cycle analysis (LCA) of willow biomass crops to determine the overall greenhouse gas (GHG) impact of growing, harvesting, and transporting willow biomass to a biomass plant. Changes in soil and willow root system carbon were included in these LCA analyses. The carbon stored in willow stems was not included because when stems are harvested and converted to energy, the carbon in them is returned to the atmosphere where a similar amount of carbon is recycled in the next three year willow crop.
- The LCA was applied to each of the parcels in the five county region to assess how GHG emissions vary spatially across the landscape.



Figure 1. Willow crops grow rapidly above and below ground and provide 7 harvests during their 23 year life cycle. These willows in northern NY are 4 years old. They were harvested after the photograph was taken, and regrew to this height 3 years later (when they were harvested again).

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KEY DISCOVERIES AND POTENTIAL IMPACTS

- Willow crops have a negative GHG footprint when they are grown on cropland and pastureland. In other words, willow crops remove and store more carbon during their 23-year lifespan than is released to the atmosphere by the fossil fuels used during crop production, harvest, and transportation and the decay of leaves.
- The woody biomass produced from willow during its lifespan can further increase climate benefits by replacing fossil fuels that are used to generate heat, power, biofuels and bioproducts.
- On average, across the five county region, the GHG emissions of willow grown on cropland and pastureland were $-127 \text{ kg CO}_2\text{eq/Mg}$ of biomass produced (Figure 2), or just over 11.3 Mg CO_2 per acre over a 23 year period. This sequestered carbon is in addition to the benefits associated with the renewable woody biomass that is produced.
- Grassland comprised approximately 12% of the potential area where willow could be grown and the life cycle GHG emissions for willow on this land was slightly positive at $28 \text{ kg CO}_2\text{eq/Mg}$.
- When willow is grown on cropland and pastureland, soil carbon increases. Whereas when willow is grown on grassland, soil carbon decreases. However, it is important to note that regardless of where willow is grown, it provides additional climate change benefits when it is used as a feedstock in place of fossil-fuel intensive products, such as when willow is used to produce heat, power, or bioplastics rather than producing those products out of fossil fuels.
- The key factors that contribute willow crops climate change benefits are based on their rapid below ground growth and the additional carbon added to the soil. Willow crops store large amounts of carbon in the parts of the plant that are not harvested, such as woody roots and the stump.
- The GHG impact of willow crops varied across the five country region with a more negative GHGs footprint when willow crops were grown closer to the biomass plant (because shorter distances required less transportation based fossil fuel emissions). Changes in soil characteristics across the region also impacted yields and prior land use (i.e., cropland and pasture versus grassland) influenced changes in soil carbon.
- Policymakers can maximize the climate change benefits from willow crops by providing incentives for those crops to be planted closer to biomass plants while simultaneously creating jobs, improving water and soil quality, and supporting biodiversity.

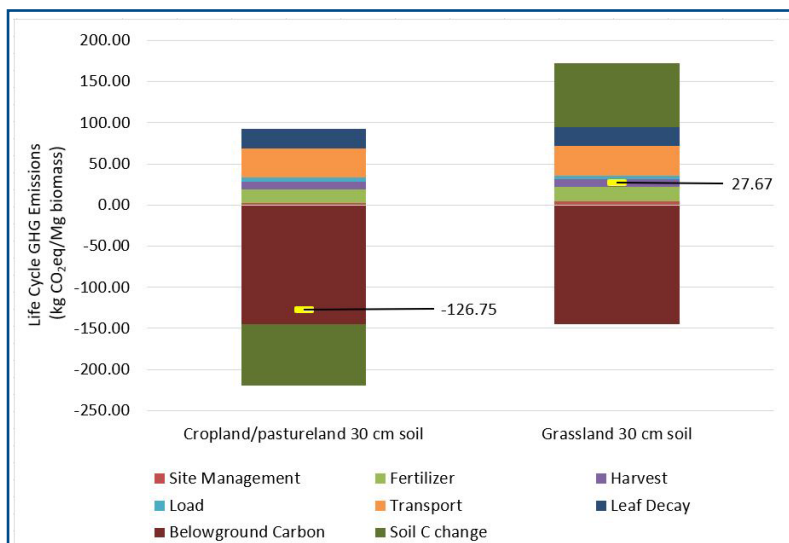


Figure 2. The yellow rectangles in each column shows that the total life cycle greenhouse gas emissions from willow are carbon negative ($-127 \text{ kg CO}_2\text{eq/Mg}$) on cropland/pastureland (i.e., more carbon is sequestered than emitted over the 23 year life of a willow crop) and slightly positive ($28 \text{ kg CO}_2\text{eq/Mg}$) on grassland. These results include soil carbon changes in the first 30 cm of soil. Note: Negative numbers indicate carbon sequestration (i.e., more carbon was stored than emitted based on a LCA analysis); positive numbers indicate more carbon was emitted to the atmosphere than was stored.

For more information about how SUNY ESF and assist in the development of willow biomass crops contract:

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