Wood vs. Corn

Which Carbon Footprint Better Supports Renewable Chemistry?

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Background

Environmental, economic, and renewable energy policy incentives have prompted an increase in biomaterials and biofuels in recent years. Today, the primary bio-based raw materials or so-called 1st generation feedstocks consist mostly of starchy crops such as American corn, Brazilian sugarcane, and Thai cassava (Noblet et al., 2012). Efforts to commercialize conversion of 2nd generation feedstocks such as woody biomass and agricultural waste are just beginning.

Woody feedstocks are favorable in that trees are not a food source, and the land does not need to be tilled or fertilized, thus are considered more sustainable at the beginning of its life cycle. The ample wood supply for biobased materials in Maine also makes this industry possible, for there are annually 9.6 to 10.3 million green tons of wood feedstock available for the next 40 years, excluding recovery from spruce budworm (Innovative Natural Resource Solutions LLC, 2017). However, the wet milling technology of corns has a relatively high maturity and low cost compared to the conversions of lignocellulosic biomass. In addition, the co-products such as corn gluten feed and corn germ are ready for other uses (Whitney, 2016).

Given the complexity of the emission trade-offs in each manufacturing step, Life Cycle Assessment (LCA) is the main method for this research. If wood offers stronger life cycle benefits compared to corn, especially related to fossil resource usage and greenhouse gas emissions, this might attract investment in wood-based manufacturing.

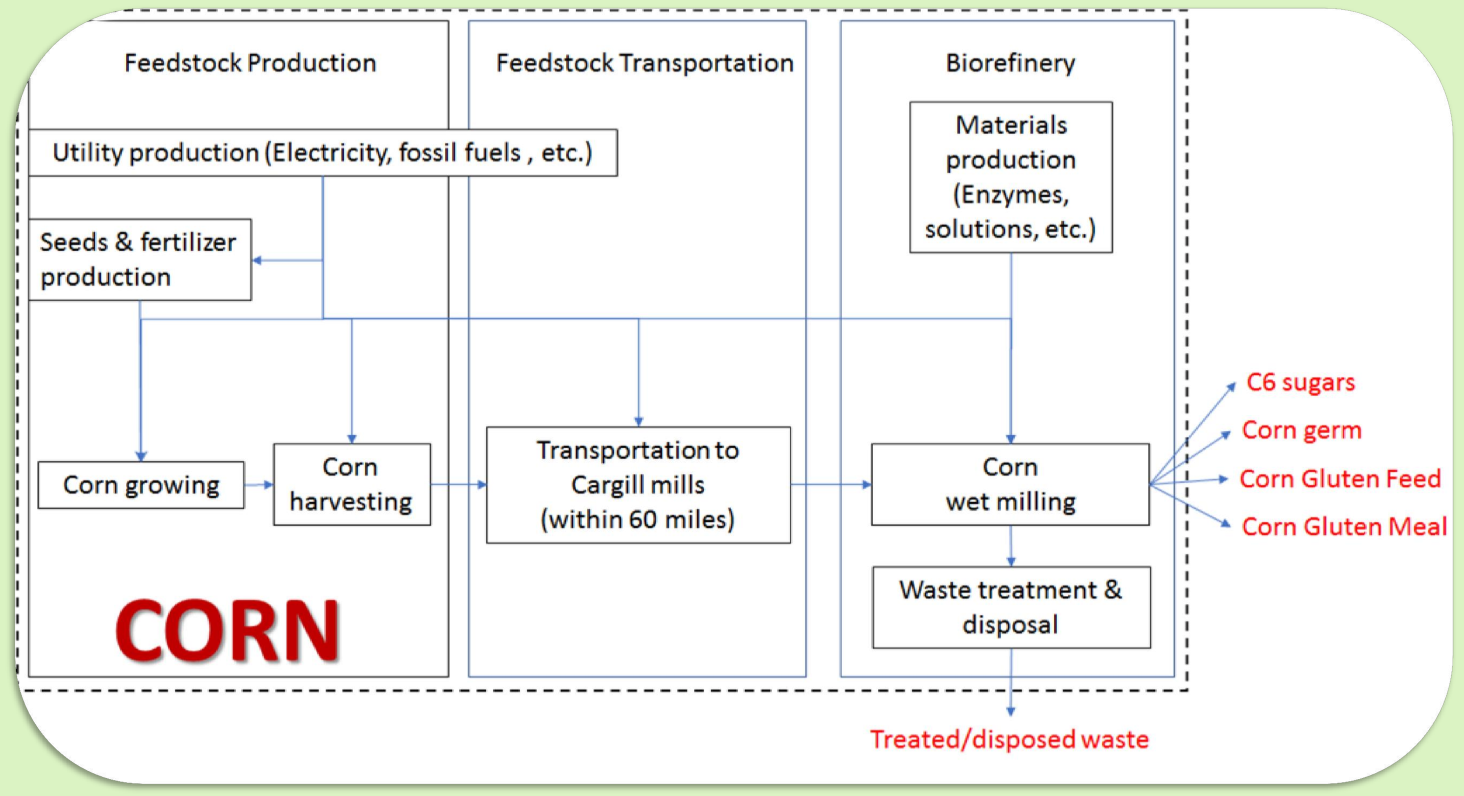
Methods

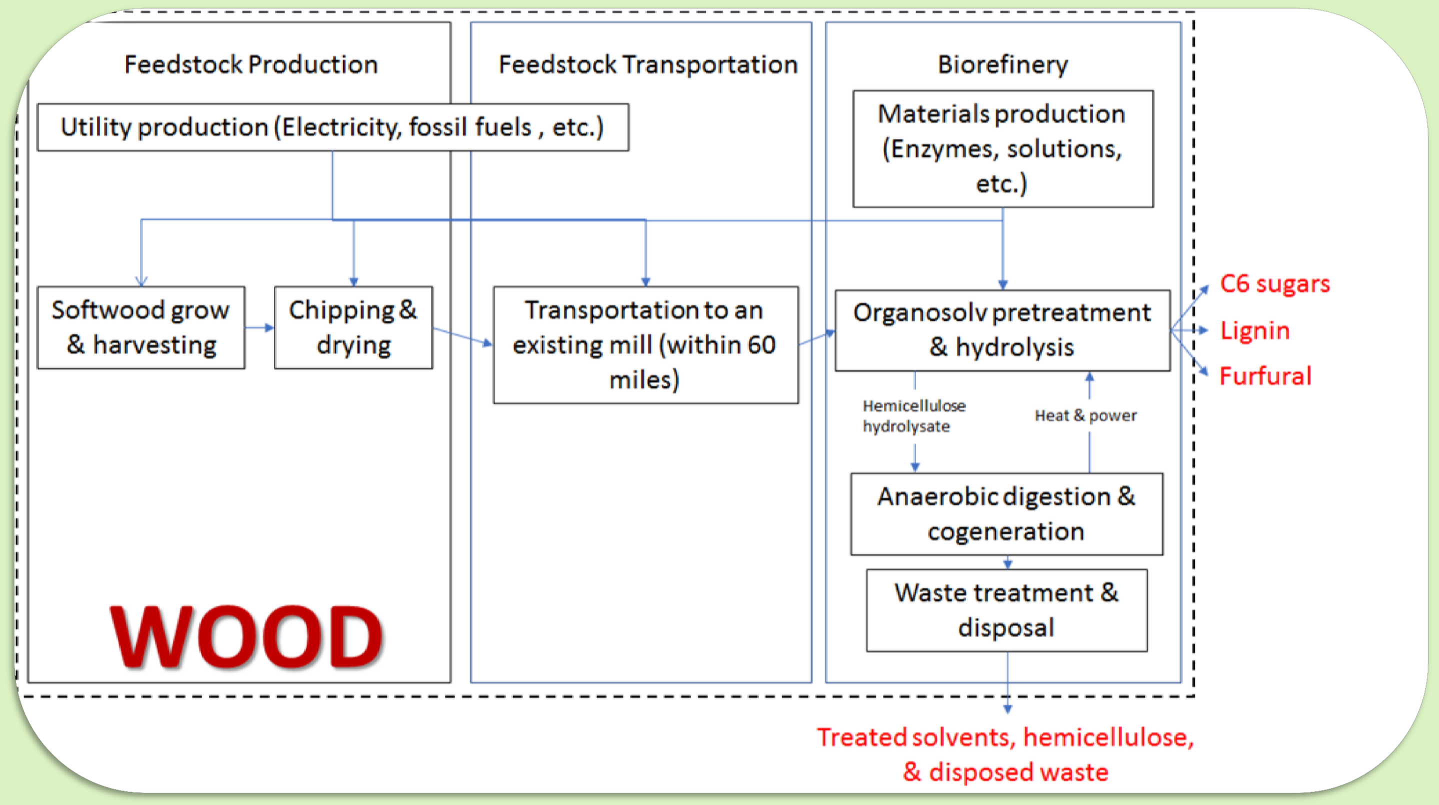
Life Cycle Assessment (LCA) is a technique for assessing the potential environmental aspects and potential aspects associated with a product (or service), by:

- compiling an inventory of relevant inputs and outputs,
- evaluating the potential environmental impacts associated with those inputs and outputs,
- interpreting the results of the inventory and impact phases in relation to the objectives of the study.

- ISO 14040.2: Life Cycle Assessment - Principles and Guidelines

We expect to use the **GREET Model** (the Greenhouse gases, Regulated Emissions, and Energy use in Transportation Model) developed by Argonne National Laboratory to analyze the following life cycles adapted from Moncada et al., 2017. In their study for the Netherlands scenario, when no allocation among co-products is used, the wood system shows a **54% lower non-renewable energy use**, and a **60% lower climate change potential** than those of the corn system.





Corn Life Cycle Assumptions

- Feedstocks include: Yellow dent No.2 corn.
- Typical practices in corn cultivation, harvest, transport and processing at a wet mill.
- Hydrolysis of corn starch to produce industrial sugars.
- Reference to previous LCAs prepared for the production of polylactic acid (PLA), a biobased plastic, by NatureWorks in Blair, Nebraska, from corn sugars.

Wood Life Cycle Assumptions

- Feedstocks include: Low-grade pulpwood (especially softwoods), sawmill residues (mill chips and sawdust).
- Typical practices in forest growth, harvest, transport and processing in Maine.
- Hydrolysis of wood cellulose to produce industrial sugars.
- Co-location of cellulosic sugar production at a current or former pulp & paper mill.

Goals

Do a comparative cradle-to-gate life cycle assessment (LCA) between Maine wood and Midwestern corn as renewable feedstocks for industrial C6 sugars, to determine:

- Which has a more favorable carbon footprint,
- What are other noteworthy differences including land use change, water depletion potential, or human toxicity potential.

Challenges

The biggest difficulty is the life-cycle inventory -- quantifying the energy and raw material inputs and environmental releases associated with each stage of production. Most research about wood as a feedstock uses *ecoinvent* or *GaBi* databases that are expensive to access (Karlsson et al., 2014, Kim & Dale, 2005). The ecoprofiles generated by NatureWorks are useful, but are represented as CO_2 eq./kg of Ingeo product (PLA), yet the energetics of the sub-processes areconfidential (Vink & Davies, 2015). Thus, we need to put together information accessible from open sources, and to validate data credibility. This project is ongoing.

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- Forest Bioproducts Research Institute, Umaine.
- Buck Environment and Climate Change Lab, Colby College.
- Reference list attached.