Preliminary life cycle comparison of corn production with and without tillage

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Abstract

We present a preliminary comparison of the environmental life cycle impacts of corn production with and without tillage. Impact categories analyzed are SOC, GHG emissions, Energy use, and nitrate leaching. The scope of this study is from maize planting through harvesting at Gilmore City, Iowa. The functional unit is 1 kg of yellow dent corn grain (15.5% moisture, w.b.). The life cycle inventory model includes not only farm inputs such as seeds, fertilizer, herbicides, and fuel use, but also the emissions and resource consumption related to the production of the inputs. In the absence of complete measured data, the DNDC model was used to predict nitrate leaching, and soil GHG emissions at the field. Soil erosion was not analyzed for this research plot study.

Method & Approach

- DNDC Modeling

DNDC was used to predict soil N_2O emission and soil NO_3^- leaching. Field data from site at ISU Agronomy and Agricultural Engineering Farm was used to calibrate DNDC and extrapolated to model Gilmore City (due to lack of GHG data from Gilmore City). The calibration results are shown in Figure 1. DNDC model was run for 20 years to predict average N_2O emissions and NO_3^- leaching.

DNDC fails to match one large N_2O emission peak, resulting in a 45% error under estimate of cumulative N_2O emissions. Further analysis will be done to quantify model uncertainty when site-specific experimental data are available.

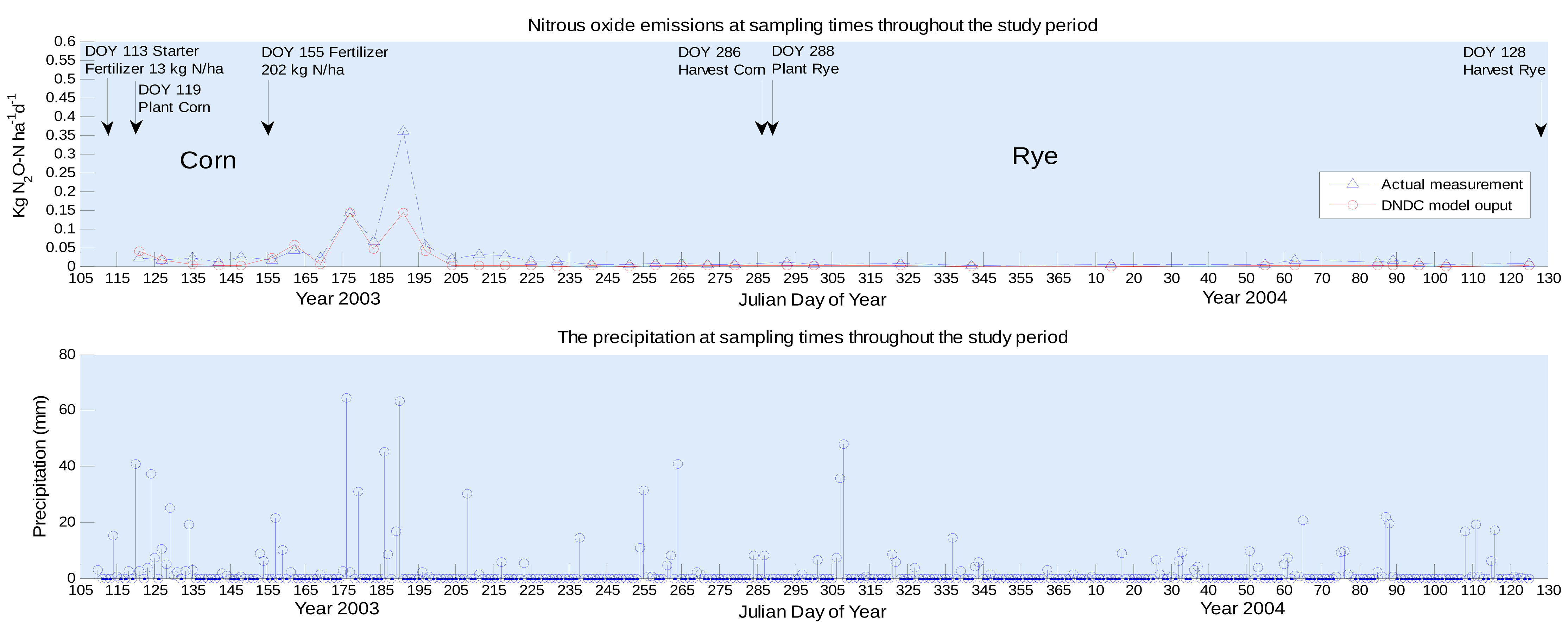

Figure 1. DNDC model calibration

- Life Cycle Inventory

Life cycle inventory includes upstream resource use and emissions associated with farm inputs. Farm input use is estimated for farm-scale practices. Data are from Gilmore site, Ecoinvent database, IPCC Fourth Assessment Report, DNDC model, and literature. Diesel and lubricant use was calculated according to ASAE D497.4 and ISU extension specification of implements and tractor size.

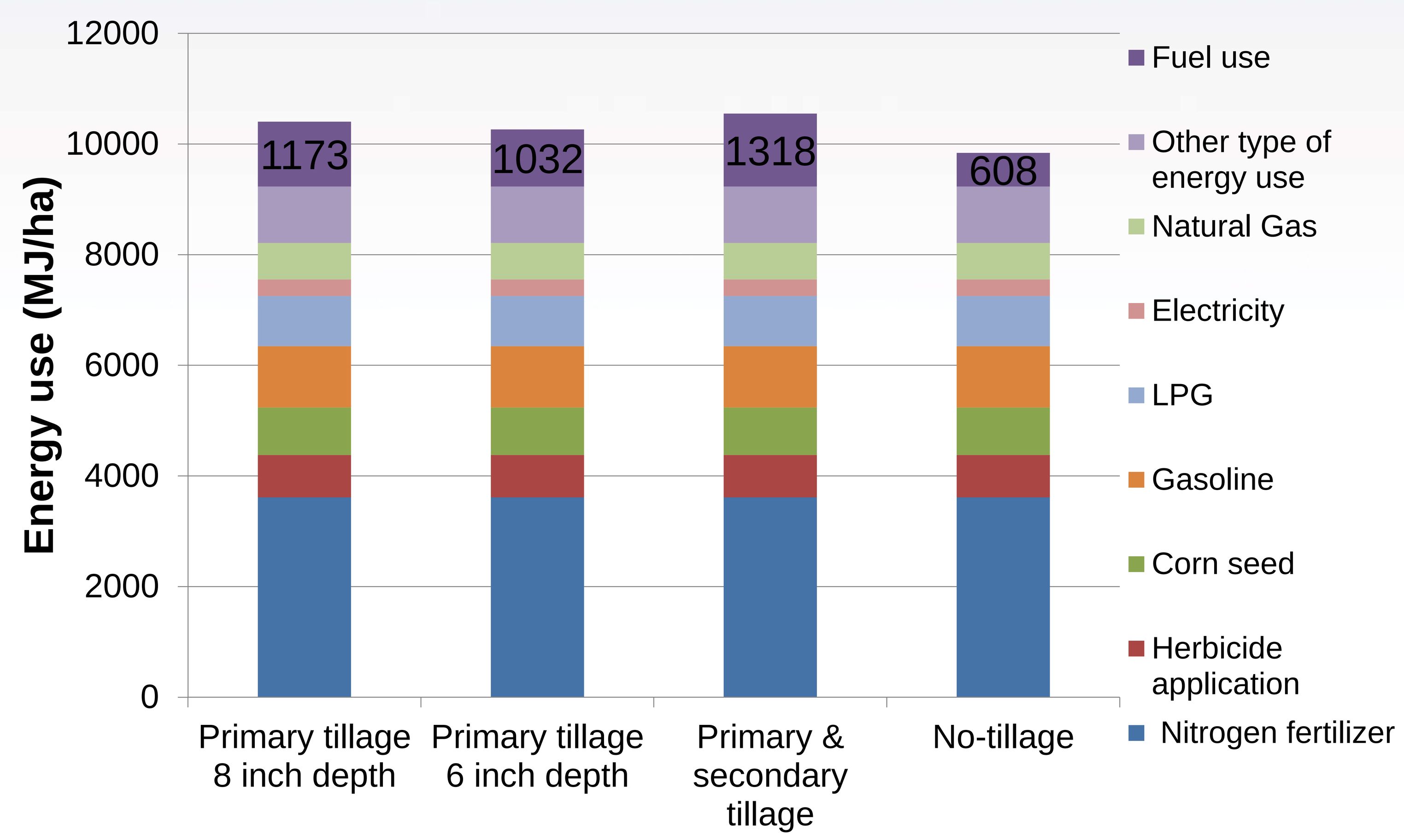

Figure 2. Life Cycle energy use by tillage system.

- Energy Analysis

Energy use varied between treatments mainly due to diesel use in tillage. At Gilmore City, fall primary tillage was to 8 in. using a chisel plow. A less deep primary tillage (6 in.) and secondary tillage (field cultivator to 5 in.) were also modeled to show the sensitivity of energy use to tillage practice. Total life cycle energy use is shown in Figure 2. Nitrogen use is the largest component of energy use. Tillage consumes about twice as much fuel as the no-tillage treatment.

- GHG Analysis

As shown in Figure 3, GHG emissions vary between tillage systems due to diesel use and soil GHG emissions.

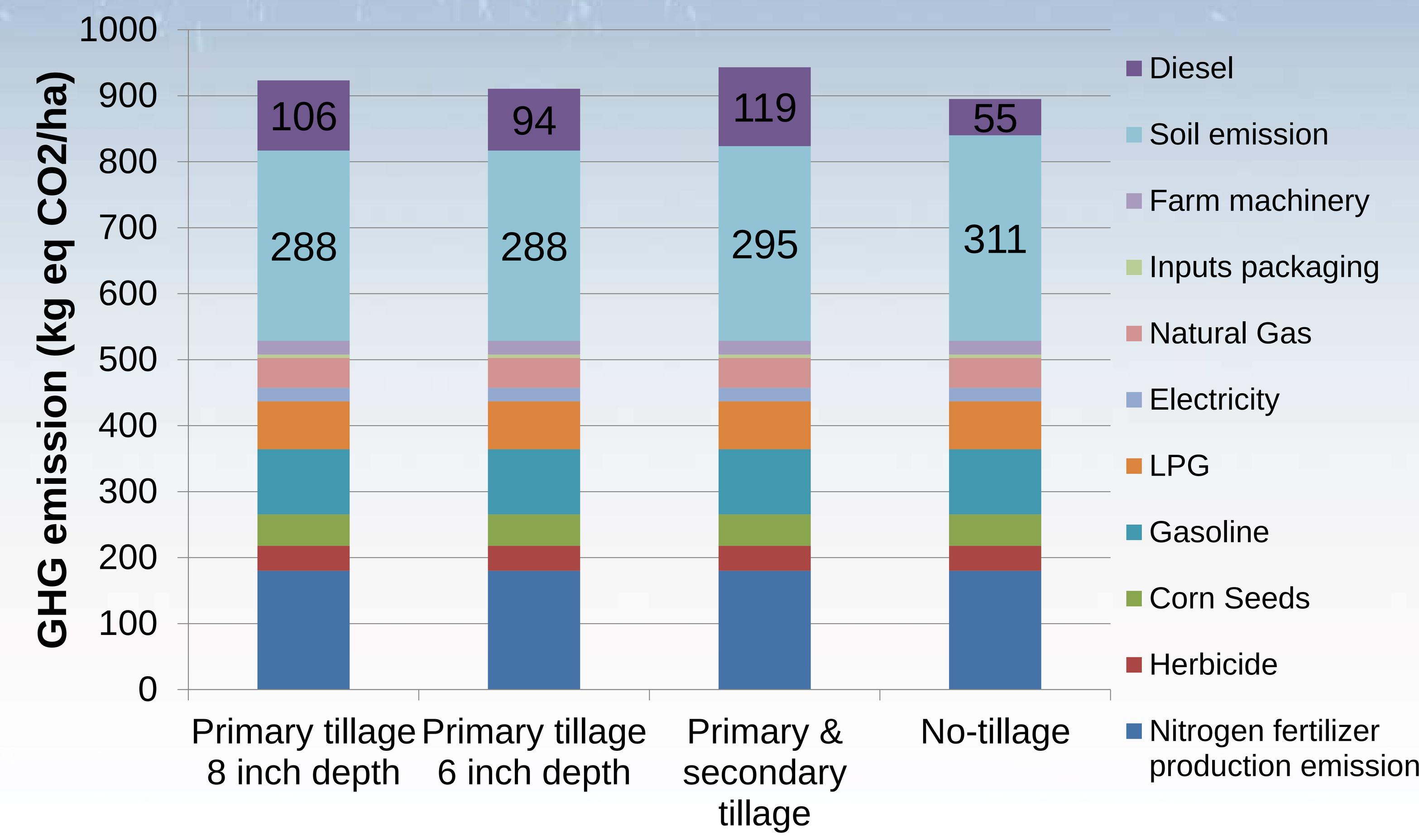

Figure 3. Life cycle GHG emissions

- Life Cycle Impact Assessment

Energy use, ΔSOC, GHG emission, and NO_3^- leaching are impact categories. Energy use, GHG emissions, and NO_3^- leaching are shown in Fig. 4 *per kg of corn*. Impacts of tillage are lower than those of no-tillage treatment.

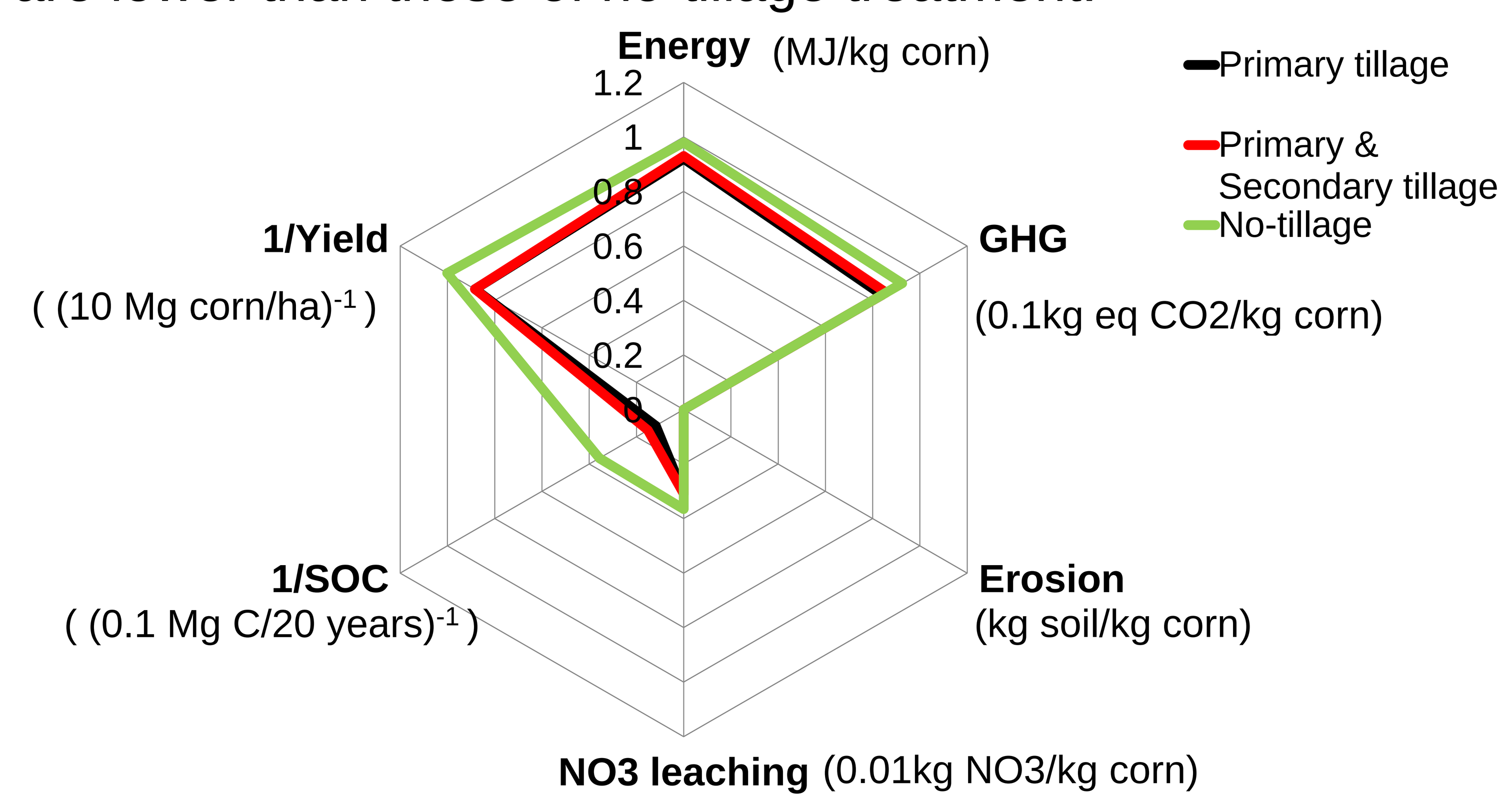

Figure 3. Life cycle impacts

CONCLUSION

- This preliminary analysis relies on several simulated variables.
- ΔSOC is based on DNDC model not calibrated to SOC data from this site.
- No-till yield is lower than with tillage in this first year.
- No-tillage consumed more fossil energy and emitted more total GHGs *per unit corn* on a life cycle basis than tillage.
- Soil erosion is an important impact that will be modeled in future analysis at landscape scale.

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