NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Indirect Land Use GHG

Reference Flow: 1 m^2 of land transformation

Brief Description: Indirect GHG emissions from land transformation in U.S.

Section I: Meta Data

Geographical Coverage: United States **Region:** National

Year Data Best Represents: 2009

Process Type: Basic Process (BP)

Process Scope: Gate-to-Gate Process (GG)

Allocation Applied: No

Completeness: All Relevant Flows Captured

Flows Aggregated in Data Set:

☑ Process ☐ Energy Use ☐ Energy P&D ☐ Material P&D

Relevant Output Flows Included in Data Set:

Releases to Air:	☑ Greenhouse Gases	☐ Criteria Air	☐ Other
Releases to Water:	☐ Inorganic	☐ Organic Emissions	☐ Other
Water Usage:	☐ Water Consumption	☐ Water Demand (throughput)	
Releases to Soil:	☐ Inorganic Releases	☐ Organic Releases	☐ Other

Adjustable Process Parameters:

Tracked Input Flows:

Tracked Output Flows:

Land transformation *Reference flow*

Carbon dioxide	*Indirect GHG emissions from land transformation*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage1-5_C_Indirect_Land_Use_GHG_2012.01.xls*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

This unit process provides a summary of relevant input and output flows for the indirect GHG emissions from land transformation. Indirect GHG emissions from land transformation are applied only to displacement of agricultural land. The reference flow of this unit process is: 1 m^2 of land transformation.

Boundary and Description

Land use effects can be divided into direct and indirect. Direct land use change is determined by tracking the change from an existing land use type (native vegetation or agricultural lands) to a new land use that supports production (i.e., the production required for the supply chain of an LCA). Indirect land use effects are changes in land use that occur as a result of the direct land use effects. For instance, if the direct effect is the conversion of agricultural land to land used for energy production, an indirect effect might be the conversion to new farmland of native vegetation, but at a remote location, in order to meet ongoing food supply/demand. This unit process accounts only for the GHG emissions from indirect land use change. Direct land use change is accounted for in other unit processes.

When land is converted to agricultural, there is a change to the carbon balance in above-ground biomass, below-ground biomass (roots), and soil carbon. The indirect land use change GHG factor used in this analysis account for these three types of carbon flows.

Above ground biomass: This analysis accounts for the change in CO_2 emissions for above-ground biomass by factoring the carbon fraction in harvested biomass and the annual yield rate of a crop and comparing it to CO_2 emissions from crop biomass to the CO_2 emissions of previously grown biomass (either grass or forest biomass). For example, this analysis uses a yield rate of 0.05 kg/(m^2-year) and a carbon fraction of 0.4 in harvested biomass, which translates to 0.02 kg of carbon/(m^2-year). The

corresponding factor for forest roots is 8 kg/(m^2-yr). The difference in carbon content between these two land use types is 7.98; converting carbon to CO_2 (using a molecular mass ratio of 44/12) translates to 29.3 kg CO_2/m^2 from above-ground biomass caused by changing from forest to crop.

Below ground biomass (i.e., roots): This analysis accounts for the change in CO2 emissions for below-ground biomass. The carbon contents of crop, forest, and grassland roots are different. For example, forest roots sequester 2 kg of carbon per square meter per year; the corresponding factor for crop roots is lower, at 0.2 kg. The difference between these two factors is 1.8 kg of carbon, which represents the annual amount of carbon that is no longer stored in roots when the land use is changed from forest to crop. Converting this loss of carbon sequestration by roots to carbon dioxide (using a molecular mass ratio of 44/12) translates to an increase of 6.6 kg of CO_2 emissions from below-ground biomass caused by changing from forest to crop.

Soil organic matter (SOM): The composition of soil also changes with changes to land use type. The soil carbon for crops is 6.2 kg CO_2/m^2 lower for crops than for forest or grassland. Due to data limitations, this factor is assumed to be the same whether the previous land type was forest or grassland.

The combined indirect CO_2 emissions from land use change are 42.0 kg CO_2/m^2 when changing from forest to crop and 7.90 kg CO_2/m^2 when changing from grassland to crop. Since the locations of new crops that are established in response to displaced crops are unknown, this analysis calculates the weighted average of the indirect land use CO_2 factors for forest and grassland. This weighted average is calculated according to the percent split between forest and grassland area in the U.S. – a 49/51 split, respectively. The weighted average indirect land use factor is 24.6 kg CO_2/m^2.

Table 1 shows the indirect land use change factors corresponding to changes from forest or grassland to cropland. **Table 2** shows the flow of this unit process.

Figure 1: Unit Process Scope and Boundary

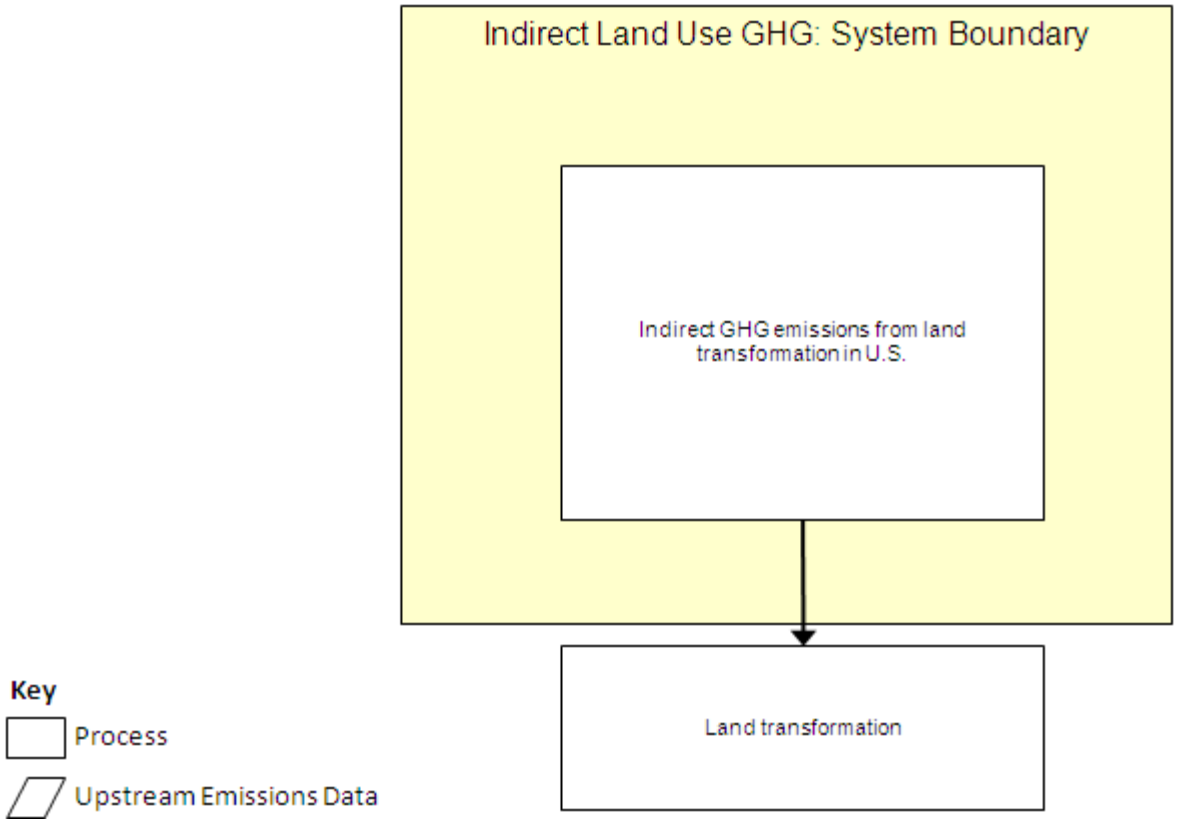

Table 1: Indirect Land Use GHG Emissions

Carbon Sink/Source	Forest to Crop	Grassland to Crop	U.S. Weighted Average	Units
Above-Ground Carbon	29.2	0.660	14.6	kg CO_2e/m^2
Below-Ground Carbon	6.60	1.03	3.76	kg CO_2e/m^2
Soil Organic Matter (SOM)	6.21	6.21	6.21	kg CO_2e/m^2
Total	42.0	7.90	24.6	kg CO_2e/m^2

Table 2: Unit Process Input and Output Flows

Flow Name	Value	Units (Per Reference Flow)
Outputs		
Indirect land transformation	1	m^2
Carbon dioxide	24.6	kg

* **Bold face** clarifies that the value shown *does not* include upstream environmental flows.

Embedded Unit Processes

None.

References

Harris et al. 2009 — Harris et al., 2009. Land use change and emission factors: Updates since proposed RFS rule. Environmental Protection Agency. Washington, D.C.

Section III: Document Control Information

Date Created: December 5, 2012

Point of Contact: Timothy Skone (NETL), Timothy.Skone@NETL.DOE.GOV

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