NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Direct and Indirect Land Use for Southern Pine Biomass Production

Reference Flow: 1 kg of SWRC Biomass Ready for Transport

Brief Description: This unit process quantifies direct and indirect land GHG emissions associated with the production of Southern pine short rotation woody crop (SRWC) biomass. Also included is an evaluation of transformed land area per the reference flow.

Section I: Meta Data

Geographical Coverage: US **Region:** N/A

Year Data Best Represents: 2011

Process Type: Basic Process (BP)

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

Allocation Applied: No

Completeness: Individual Relevant Flows Recorded

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 Pollutants	☐ Other
Releases to Water:	☐ Inorganic Emissions	☐ Organic Emissions	☐ Other
Water Usage:	☐ Water Consumption	☐ Water Demand (throughput)	
Releases to Soil:	☐ Inorganic Releases	☐ Organic Releases	☐ Other

Adjustable Process Parameters:

Southern Pine Yield	*Annualized yield of Southern pine biomass, per acre*
Indirect Fraction	*Fraction of cropland converted directly to SRWC that is indirectly converted back to cropland*

Tracked Input Flows:

None.

Tracked Output Flows:

SRWC Biomass Ready for Transport [Intermediate Product]	*Biomass production quantity available for transport*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage1_C_Land_Use_Direct_Indirect_2012.01.xls*, which provides additional details regarding calculations, data quality, and references as relevant.

Goal and Scope

The scope of this process covers the production of Southern pine short rotation woody crop (SWRC) biomass from harvest to the boundary for LC Stage #2 (e.g., transport of biomass). The process is based on the reference flow of 1 kg of chipped SWRC, as described below, and shown in **Figure 1.** Considered are the air emissions of carbon dioxide due to direct and indirect land use change and indirect nitrous oxide emissions from indirect fertilizer application.

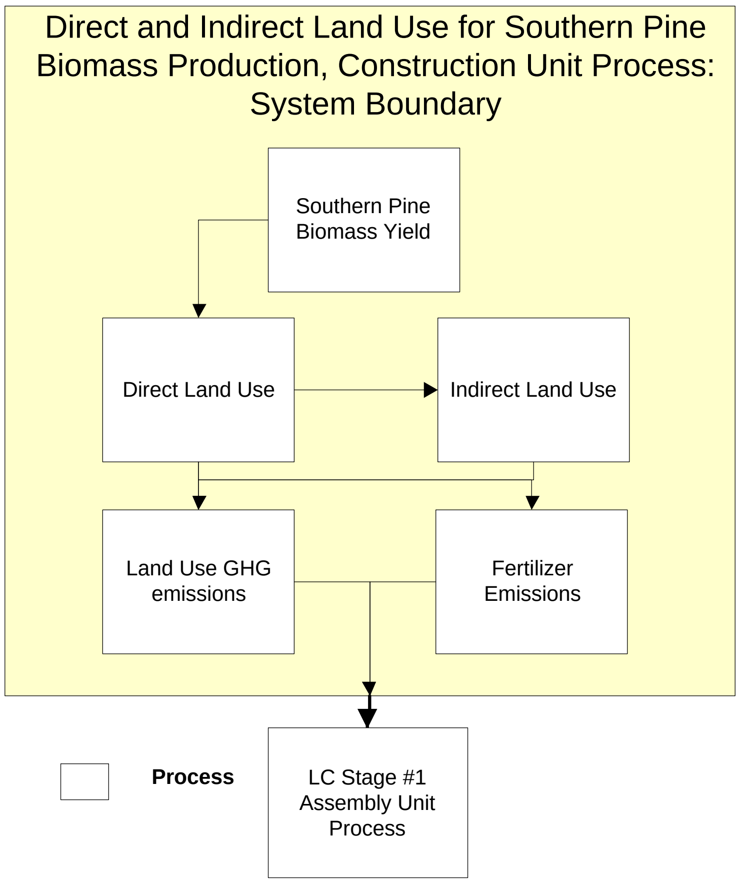
Boundary and Description

Land use GHG emissions were evaluated for Southern pine biomass cultivation. Briefly, initiation of cultivation activities for Southern pine biomass in areas where Southern pine biomass is not presently grown would result in a net change in land use, from the pre-existing land use type to the new land use type (i.e., Southern pine cultivation). A given land area may contain certain carbon stocks – these may include aboveground biomass, belowground biomass (roots), and soil organic matter. When an existing land use type is altered, or transformed, to a new land use type, changes in the amount of carbon stored in these carbon stocks can occur. For example, clearing/grading a forest or scrubland would result in the loss from the site of carbon that was previously stored in aboveground biomass.

Potential effects of land use change can be categorized into direct and indirect effects. Direct effects occur as an immediate result of land use change, at the site where the change occurs. Land clearing/grading discussed above is an example of direct land use change. Indirect land use change occurs as a result of direct land use change, typically offsite from areas that would suffer direct land use change. For example, if a Southern pine plantation displaces row crops, new areas may be put into production for row crops, but at a different location. Indirect land use is often more difficult to quantify than direct land use. However, like direct land use, indirect land use can also result in important changes to carbon stocks at the affected site.

The procedure followed here for the evaluation of net CO2 emissions from direct land use is based on a similar analysis promulgated by the U.S. Air Force Research Laboratory (IAWG 2011) which is in turn based on the methods utilized by EPA in support of its Renewable Fuel Standard program (RFS2). The analysis contained here was updated to reflect the specific parameters of this study (Southern pine production, in the Southeastern U.S.), based on recently published data available from NETL/RAND (NETL 2011). Direct land use change emissions were evaluated based on changes in carbon stored in aboveground, belowground, and soil organic matter (SOM) carbon stocks. Existing land use is assumed to be either cropland or pasture. The net change in carbon stored in each of the three carbon stocks indicated was estimated by comparing estimated carbon stock values for the existing land use to estimated carbon stock values for the new land use, accounting for changes in carbon storage that occur over time. Key values used for this analysis are shown in **Table 1**.

Figure 1: Unit Process Scope and Boundary



Briefly, aboveground biomass carbon storage for existing and new land use types was estimated by assuming that any existing aboveground biomass would be oxidized during transformation to the new land use type. The resulting carbon debt is factored into overall net GHG emissions resulting from direct land use change. Following the initial land use change event, on site growth of vegetation and changes in soil carbon dynamics drive either carbon uptake or emission during the biomass cultivation period. As shown in **Table 1**, carbon uptake is indicated for the conversion of cropland to

Southern pine, while carbon emission is indicated for conversion of pastureland to Southern pine.

Table 1: Key Values for the Direct and Indirect Land Use Analysis

Flow	Value	Units	Reference
Carbon Emitted from Aboveground Biomass Removal for Existing Cropland[1]	0.00	kg C/ha	NETL 2011
Carbon Emitted from Aboveground Biomass Removal for Existing Pastureland	1643	kg C/ha	NETL 2011
Carbon Uptake (negative value) for Roots Plus SOM, Conversion of Cropland to SRWC	-473	kg C/ha-yr	NETL 2011
Carbon Emission (positive value) for Roots Plus SOM, Conversion of Pastureland to SRWC	220	kg C/ha-yr	NETL 2011
Fraction of Crop Land Directly Converted to Southern Pine that is Indirectly Converted Back to Cropland (Default Value)	0.30	Unitless	IAWG 2011
Fraction of Pasture Land Directly Converted to Southern Pine that is Indirectly Converted Back to Pasture (Default Value)	0.30	Unitless	IAWG 2011

Indirect land use was calculated assuming that conversion would occur at a remote location, and that a default value of 30% of all cropland and pasture lost during direct land use would be replaced at a remote location. Carbon uptake or emissions were then calculated based on the same procedure discussed for direct land use, except using uptake and emission values for transformation to cropland or pasture, rather than to Southern pine production.

Table 2 provides a summary of modeled input and output flows. Additional details regarding input and output flows, including calculation methods, are contained in the associated DS sheet.

[1] Presumes that all aboveground biomass would be harvested or otherwise removed during the normal agricultural cycle, prior to the occurrence of land transformation associated with the study.

Table 2: Unit Process Input and Output Flows

Flow Name*	Value	Units (Per Reference Flow)
Inputs		
Area of production land, direct	**2.12E-02**	**m^2/kg**
Area of production land, indirect	**6.37E-03**	**m^2/kg**
Outputs		
SRWC Biomass Ready for Transport [Intermediate Product]	1.00E+00	kg
CO2e Emissions due to Direct Land Use Change	2.24E-02	kg
CO2e Emissions due to Indirect Land Use Change	8.28E-02	kg
N2O indirect emissions due to indirect fertilizer application	3.03E-06	kg

* **Bold face** clarifies that the value shown *does not* include upstream environmental flows. Upstream environmental flows were added during the modeling process using GaBi modeling software, as shown in Figure 1.

Embedded Unit Processes

None.

References

IAWG 2011 — Aviation Fuel Life Cycle Assessment Working Group. (2011). Advanced Alternative Energy Technologies Subtask: Life Cycle Greenhouse Gas Analysis of Advanced Jet Propulsion Fuels: Fischer-Tropsch Based SPK-1 Case Study (No. AFRL-RZ-WP-TR-2011-2138).

NETL 2011 — NETL. 2011. Documentation for the Calculating Uncertainty in Biomass Emissions Model, Version 2.0 (CUBE 2.0): Contents and Use. November 15, 2011.

Noblis 2012 — White et al., Model for the Production of Jet Fuel from Coal and Woody Biomass: A Comparative Analysis of Coal/Wood Co-Gasification and Separate Coal and Wood Gasification Configurations. Noblis. 2012.

Section III: Document Control Information

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