

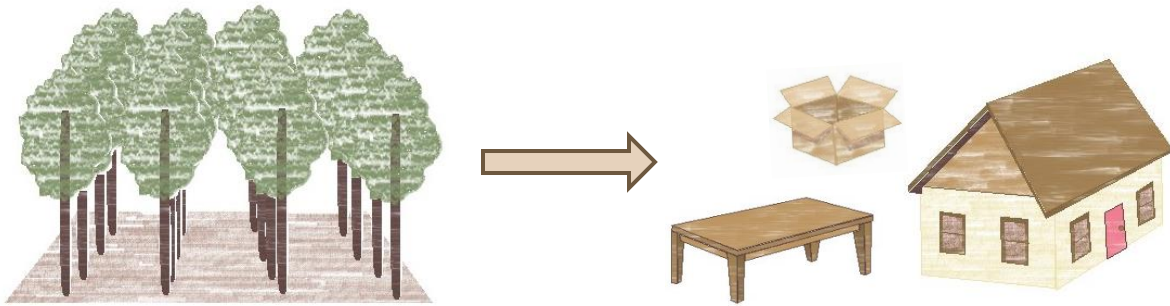
LobWISE: A User's Guide

Loblolly Wood Inventory, Storage, and Emissions

Version 1.1

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Just want the basics? Stick to the purple text.

Introduction

What is LobWISE? LobWISE is an excel-based model that tracks carbon in loblolly pine wood from harvest, through use and landfilling, to eventual emission into the atmosphere.

What can it be used for? LobWISE takes harvest volume inputs and tells the user the remaining carbon storage and emission pulses for any given year after harvest, up to 120 years. This information could be used for many types of analyses related to forest management or wood products. For example, the amount of carbon remaining stored in wood products and landfills each year after harvest could be coupled with biomass amounts from a growth and yield model to evaluate the total carbon storage from a given stand over time and how that carbon is affected by management changes. The model also relies on many parameters, and those parameters can be adjusted to evaluate resulting changes in wood product carbon storage. For example, the user could change the consumption patterns of lumber use in various products (e.g., housing, buildings, shipping pallets, etc.) and evaluate carbon implications of those changes.

Which wood products can LobWISE be used to model? Loblolly pine. Where data are available, LobWISE parameters are specific to loblolly pine grown in the southern US. Most consumption, mill efficiency, and residue use data are for softwoods from the southern US, so LobWISE can generally be applied to all southern pine (*Pinus taeda* L., *Pinus palustris* Mill., *Pinus echinata* Mill., and *Pinus elliottii* Engelm.) grown in the southern US.

Getting Started

To get started, you will need some kind of harvest data. This can be real harvest data or outputs of a growth and yield model. The harvest data can be in either green weight (US tons) or volume (cu. ft.). Toggle the appropriate button in the maroon “INPUT METRIC” box at the top.

Diameter-based inputs vs. manual inputs: The user has the option to input harvest data based on diameter or specify the amount of each log type. If using the diameter-based option, the model will automatically “cull” your wood to different mills based on southwide averages and the log types you selected. For basic runs from a growth and yield model, we recommend using the diameter-based option with all specialty logs unchecked, unless you know that a portion of your stand is likely to be sold to a specific mill type, such as a veneer mill. The specialty log options could also be used, for example, to test the carbon impacts of including a certain mill type in your sale. For runs that are based on timber products output (TPO) data, where the specific log types are known, or to evaluate the carbon potential of a single log type, we recommend using the manual inputs. Toggle the appropriate button in the maroon “INPUT TYPE” box at the top.

Fossil fuel emissions: The user has the option to include fossil fuel emissions from procurement (*i.e.*, forestry operations), transportation (*i.e.*, transporting the logs from the harvest site to the mill), and/or production (*i.e.*, fossil fuel energy used by the mill to produce the primary product). If this option is checked, the tC-equivalent to the fossil fuel emissions will be deducted from the carbon stored in products. This is done by calculating the amount of the initial GHG pulse in year 0 that remains in the atmosphere, according to the updated Bern carbon cycle equation given in the IPCC 5th Assessment Report. Fossil fuel emissions will also be included in the emissions report. Fossil fuel emissions after year 0, such as emissions involved in recycling processes, transportation from the mill to a store, transportation to landfills, etc., are not included. The emissions reported, including fossil fuel emissions, are single emission pulses for each year, whereas the carbon stored in products represents cumulative sequestration by the forest prior to harvest. Because of this difference in accounting, storage and emissions should not be directly compared to assess the global warming potential of products or silvicultural systems. LobWISE uses this fossil fuel deduction as a proxy for dynamic carbon accounting to offer a simplified method to account for differences in fossil fuel emissions between log type mixes.

Construction and manufacturing waste: This option accounts for wood wasted when primary products are manufactured or built into secondary products. For example, when lumber and non-structural board are used to make a chair, there may be scraps that are discarded into the waste system. Selecting this option discards 5.6% (construction) and 8% (manufacturing) of carbon between the mill and year 0 of the product being in use. This is the reason there may be less total carbon in secondary products than primary products. We recommend keeping these checked.

Methane tax: When products decay in a landfill, methane is emitted. Some methane is captured and burned to produce electricity, but some is emitted into the atmosphere. Therefore, tradeoffs exist between burning wood products (no storage, but also no methane emissions) and storing them in a landfill (storage, but also methane emissions). When this option is checked, the additional CO₂e emitted from a methane pulse rather than a CO₂ pulse is deducted from the storage in that

year. We recommend keeping this checked unless you are using dynamic carbon accounting to directly compare forest sequestration with emissions.

Example of a filled-out input page:

INSTRUCTIONS:
 1. Input harvest data into either the diameter-based input boxes (green) or the manual input boxes (purple). If using the diameter-based boxes, check any speciality logs that are included in the harvest. The model will use regional averages to calculate volumes of the speciality logs. If you don't know if there are any speciality logs, leave these unchecked. Use the manual inputs only if you know the exact amounts of each log type. Inputs can be in either greenweight or volume. You may also choose whether or not to include carbon storage deductions for fossil fuel emissions, landfill methane emissions, and construction and manufacturing waste (yellow). Default settings include all deductions. You may choose to edit the default parameters (e.g. lifespans, product mixes, etc.) if you have specific data to determine new parameters.
 2. Run scenarios when finished inputting harvest data.

INPUT METRIC (choose one):
 Greenweight (US tons) Volume (cu.ft.)

INPUT TYPE (choose one):
 Use diameter-based inputs Use manual inputs

FOSSIL FUEL EMISSIONS:
 Include fossil fuel emissions from procurement (forestry operations)
 Include fossil fuel emissions from transport (harvest site to mill)
 Include fossil fuel emissions from production (at the mill)

CONSTRUCTION AND MANUFACTURING WASTE:
 Include "construction tax" to account for waste at time of construction
 Include "manufacturing tax" to account for waste in manufacturing after the mill

METHANE EMISSIONS:
 Include a "methane tax" on products decaying in landfills

DIAMETER-BASED INPUTS

DIAMETER CLASS	5-8.9"	9-12.9"	13-18.9"	19+"
model or real harvest	Greenweight (tons)	Greenweight (tons)	Greenweight (tons)	Greenweight (tons)
data:	37.0	64.0	27.0	0.0

-- OR --

VOLUME INPUTS

DIAMETER CLASS	5-8.9"	9-12.9"	13-18.9"	19+"
model or real harvest	Volume (cu.ft. OB)	Volume (cu.ft. OB)	Volume (cu.ft. OB)	Volume (cu.ft. OB)
data:	0	0	0	0

SPECIALTY LOG TYPES (select all that apply - default is none checked)

Part of this harvest will be sold as veneer logs Part of this harvest will be sold as pole logs Part of this harvest will be sold as composite logs (to be chipped for OSB) Part of this harvest will be sold for pellet manufacture

Run HWP C Scenario **Run Emissions Scenario** **Edit Parameters**

See Carbon Storage Over Time

When you are finished inputting harvest data and choosing your input settings, click the "Run HWP C Scenario" button or toggle to the "Single" tab.

WHERE IS THE WOOD GOING?

Primary Product Type	Lumber	Plywood	OSB	Non-structural panels	Engineered wood	Poles	Pulp and paper products	Landscaping	Bedding	Miscellaneous	Total	Pellets	Otherwise burned	Procurement - FF emissions	Transport - FF emissions	Production - FF emissions	Totals - FF emissions
% of Log Carbon	20.2%	0.0%	3.0%	1.9%	1.0%	0.0%	48.3%	2.9%	1.2%	2.2%	80.7%	-3.1%	-16.3%	-3.6%	-2.7%	-23.3%	-29.8%

Secondary Product Type	Single family homes	Multi-family homes	Manufactured home	Single family home upkeep	Multi-family home upkeep	Manufactured upkeep	Building	Other new structure	Other (non-residential upkeep, etc.)	Pallets	Other shipping	Poles	Posts/Pilings	Bedding	Landscaping	Corrugated boxes	Sanitary products
% of Log Carbon	7.1%	1.1%	0.4%	5.5%	0.8%	0.6%	1.1%	0.6%	1.8%	2.9%	0.5%	0.0%	0.0%	1.2%	2.9%	27.4%	10.6%

Where is the wood going? This section shows the percentage of the carbon from the originally harvested logs that is in each primary and secondary product in year 0. For example, in this scenario, 3.0% of log carbon was made into OSB and 7.1% of log carbon was put into newly constructed single family homes. The fossil fuel emissions are given as a percentage of log carbon (even though it was not carbon from the log that was emitted) to offer the user an idea of how the fossil fuel consumption compares to the storage from wood products. In this example, 29.05 tC were stored in harvested logs, but 8.65 tC (i.e., 31.71 tCO₂e) (i.e., 29.8%) were emitted from fossil fuel consumption used to harvest and produce the wood products.

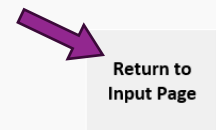
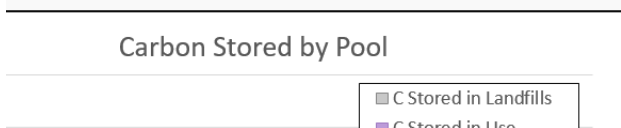
CARBON DECAY OVER TIME

Years Since Harvest	C Still in Use	C in Landfill	Total C Remaining	% of Original C Remaining
	t C	t C	t C	(%)
C Removed from Stand			29.05	100.00%
0	22.88	0.10	14.33	79.10%
1	19.56	1.98	13.46	74.14%
2	15.32	4.14	11.88	67.06%
3	14.09	4.39	11.26	63.79%

Carbon decay over time – The “C Still in Use” column shows the carbon that is still in products (e.g., houses, furniture, boxes, etc.) being used at any point in time. The “C in Landfill” column shows all carbon stored from products in both municipal solid waste (MSW) and construction and demolition (C&D) landfills. The “Total C Remaining” column is the combination of the first two columns and shows the total amount of carbon, originating from the harvest, that has not yet been emitted into the atmosphere. If the fossil fuel deduction option was selected, this column will have decayed GHG amounts from fossil fuel emissions subtracted from the storage. If the methane deduction option was selected, this column will also have methane pulse amounts subtracted from the storage. For total C remaining without the deduction, uncheck the fossil fuel emissions and methane deduction boxes on the input page or sum “C Still in Use” and “C in Landfill”. The “% of Original C Remaining” column shows the percentage of carbon that was in the harvested logs that still remains in use or in landfills and does not include deductions from fossil fuels or methane. The “C Removed from the Stand” row shows the carbon stored in the harvested logs before they are made into primary products at the mill. The “0” row shows the carbon after primary products have been through the mill and have been manufactured or constructed into secondary products. The “1” row shows carbon one year after the products entered the market. *These outputs are in metric tonnes (t) of carbon.*

Landscaping	Bedding	Miscellaneous	Total	Pellets	Otherwise Burned	Procurement - FF emissions	Transport - FF emissions	Production - FF emissions	Totals - FF emissions
2.9%	1.2%	2.2%	80.7%	-3.1%	-16.3%	-3.6%	-2.7%	-23.5%	-29.8%

Other new structure	Other (non-residential upkeep, etc.)	Pallets	Other shipping	Poles	Posts/Pilings	Bedding	Landscaping	Corrugated boxes	Sanitary products	Packaging cardboard	Disposable food related products	Miscellaneous paper products
0.6%	1.8%	2.9%	0.5%	0.0%	0.0%	1.2%	2.9%	27.4%	10.6%	5.5%	3.2%	



Click the “Return to Input Page” button or toggle back to the “Inputs” tab to run another scenario or to see the emissions outputs.

See Emission Pulses for Each Year

INSTRUCTIONS:
 1. Input harvest data into either the diameter-based input boxes (green) or the manual input boxes (purple). If using the diameter-based boxes, check any speciality logs that are included in the harvest. The model will use regional averages to calculate volumes of the speciality logs. If you don't know if there are any speciality logs, leave these unchecked. Use the manual inputs only if you know the exact amounts of each log type. Inputs can be in either greenweight or volume. You may also choose whether or not to include carbon storage deductions for fossil fuel emissions, landfill methane emissions, and construction and manufacturing waste (yellow). Default settings include all deductions. You may choose to edit the default parameters (e.g. lifespans, product mixes, etc.) if you have specific data to determine new parameters.
 2. Run scenarios when finished inputting harvest data.

INPUT METRIC (choose one):
 Greenweight (US tons) Volume (cu.ft.)

INPUT TYPE (choose one):
 Use diameter-based inputs Use manual inputs

Run HWP C Scenario **Run Emissions Scenario**

Edit Parameters

FOSSIL FUEL EMISSIONS:

Include fossil fuel emissions from procurement (forestry operations)

Include fossil fuel emissions from transport (harvest site to mill)

Include fossil fuel emissions from production (at the mill)

CONSTRUCTION AND MANUFACTURING WASTE:

Include "construction tax" to account for waste at time of construction

Include "manufacturing tax" to account for waste in manufacturing after the mill

METHANE EMISSIONS:

Include a "methane tax" on products decaying in landfills

DIAMETER-BASED INPUTS

GREENWEIGHT INPUTS

Diameter class	5-8.9"	9-12.9"	13-18.9"	19+"
model or real harvest	Greenweight (tons)	Greenweight (tons)	Greenweight (tons)	Greenweight (tons)
data:	37.0	64.0	27.0	0.0

-- OR --

VOLUME INPUTS

Diameter class	5-8.9"	9-12.9"	13-18.9"	19+"
model or real harvest	Volume (cu.ft. OB)	Volume (cu.ft. OB)	Volume (cu.ft. OB)	Volume (cu.ft. OB)
data:	0	0	0	0

SPECIALITY LOG TYPES (select all that apply - default is none checked)

Part of this harvest will be sold as veneer logs Part of this harvest will be sold as pole logs Part of this harvest will be sold as composite logs (to be chipped for OSB) Part of this harvest will be sold for pellet manufacture

Click the "Run Emissions Scenario" button or toggle to the "Emissions" tab to see emission pulses for each year.

INSTANTANEOUS GHG EMISSION PULSES BY TYPE AND SOURCE

Years Since Harvest	Fossil Fuels	CO ₂ from Wood Products	CO ₂ from MSW Landfills	CO ₂ from C&D Landfills	CH ₄ from MSW Landfills	CH ₄ from C&D Landfills
	t CO ₂ e	t CO ₂ e	t CO ₂ e	t CO ₂ e	t CO ₂ e	t CO ₂ e
0	-31.71	-22.26	0.00	0.00	0.00	0.00
1	0.00	-5.29	0.00	0.00	0.00	0.00
2	0.00	-7.48	-0.07	0.00	-0.13	0.00
3	0.00	-3.34	-0.14	0.00	-0.28	0.00

GHG emissions by type and source: These outputs are in metric tonnes (t) of CO₂-equivalents. To convert from tCO₂e to tC, multiply by 12/44. Fossil fuel emissions are shown in the "Fossil Fuels" column and are only given for year 0. The "CO₂ from Wood Products" column shows emissions from products that are burned (e.g., burned for electricity production, burned as waste, etc.) or decay (i.e., physically rot) and are not landfilled. The other columns show emissions from landfills (i.e., municipal solid waste landfills or construction and demolition landfills), either as CO₂ or as methane. Methane that is produced in the landfill but is then captured or oxidized is considered a CO₂ emission.

GHG Emission Pulses by Type and Source

■ CO₂ - MSW Landfills

■ CO₂ - C&D Landfills

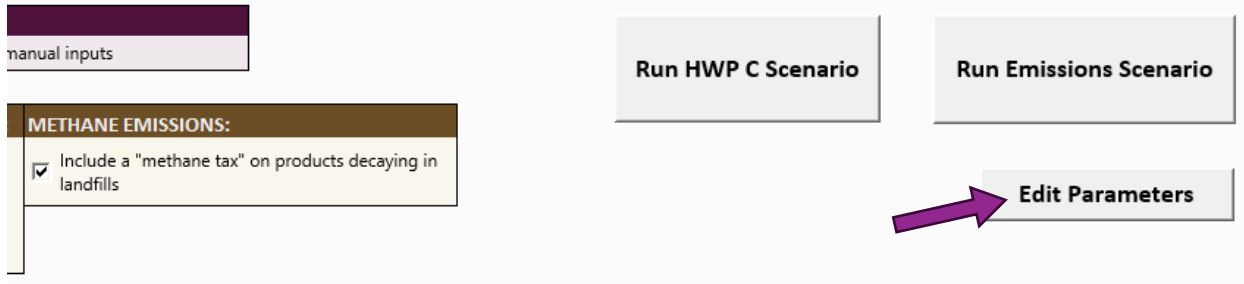
■ CH₄ - MSW Landfills

■ CH₄ - C&D Landfills

Return to Input Page

Click the "Return to Input Page" button or toggle back to the "Inputs" tab to run another scenario or see the emissions outputs.

Adjusting Parameters



Click the “Edit Parameters” button or toggle to the “Parameters” tab to view or change the parameters used in the model.

Examples of parameter adjustments:

Sawmill Efficiency

Sawmill efficiency	
<12.9 in DBH	0.35
13-18.9 in DBH	0.4
19+ in DBH	0.5

The sawmill efficiency parameters specify what percent of saw log carbon is transformed into lumber. For example, the default parameter specifies that 40% of the carbon in 13-19” logs is made into lumber.

End Uses of Primary Products

General End Use Category by Product	
Lumber	
New Residential	0.317
Residential Upkeep	0.305
New Non-residential	0.067
Shipping	0.169
Manufacturing	0.08
Other	0.054
Softwood Plywood	
New Residential	0.485
Residential Upkeep	0.232
New Non-residential	0.058
Shipping	0.059
Manufacturing	0.09
Other	0.077

The general end use category by product parameters specify what percent of the carbon in each primary product is used for each end use category. For example, 8% of lumber and 9% of plywood is used in manufacturing.

Lifespans

Product Weibull Coefficients (How long will the product stay in use?)			** the modal estimate is meant to represent the number of years after which approximately half of the original product carbon has been recycled, emitted, or landfilled **				
	modal estimate	k	λ		modal estimate	k	λ
Single Family Home (whole house)	125	150	2.63				
Floors - lumber	112	135	2.63	Floors - engineered wood	112	135	2.63
Walls - lumber	112	135	2.63	Walls - engineered wood	112	135	2.63
Roofs - lumber	125	150	2.63	Roofs - engineered wood	125	150	2.63
Foundations - lumber	125	150	2.63	Foundations - engineered wood	125	150	2.63
Decks - lumber	13	16	2.63	Decks - engineered wood	13	16	2.63
Exterior doors - lumber	112	135	2.63	Exterior doors - engineered wood	112	135	2.63
Interior doors - lumber	112	135	2.63	Interior doors - engineered wood	112	135	2.63
Garage doors - lumber	25	30	2.63	Garage doors - engineered wood	25	30	2.63
Windows - lumber	30	36	2.63	Windows - engineered wood	30	36	2.63
Moulding - lumber	112	135	2.63	Moulding - engineered wood	112	135	2.63
Shelving - lumber	100	120	2.63	Shelving - engineered wood	100	120	2.63
Cabinets - lumber	50	60	2.63	Cabinets - engineered wood	50	60	2.63
Countertops - lumber	100	120	2.63	Countertops - engineered wood	100	120	2.63

Manufactured home	70	84	2.63
Single family home upkeep	37	45	2.63
Multi-family home upkeep	33	40	2.63
Manufactured upkeep	21	25	2.63
Building	70	84	2.63
Other new structure	60	72	2.63
Other (non-residential upkeep, etc.)	21	25	2.63
Pallets	1	1	2.63
Other shipping	2	2	2.63
Poles	60	72	2.63
Posts/pilings	30	36	2.63
Bedding	1	1	2.63
Landscaping	2	2	2.63
Corrugated Boxes	1	1	2.63
Sanitary Products	1	1	2.63
Packaging Cartonboard	1	1	2.63
Disposable Food Related Products	1	1	2.63
Miscellaneous Paper Products	1	1	2.63
Furniture	13	16	2.63
Other manufacturing	7	8	2.63
Miscellaneous	4	5	2.63

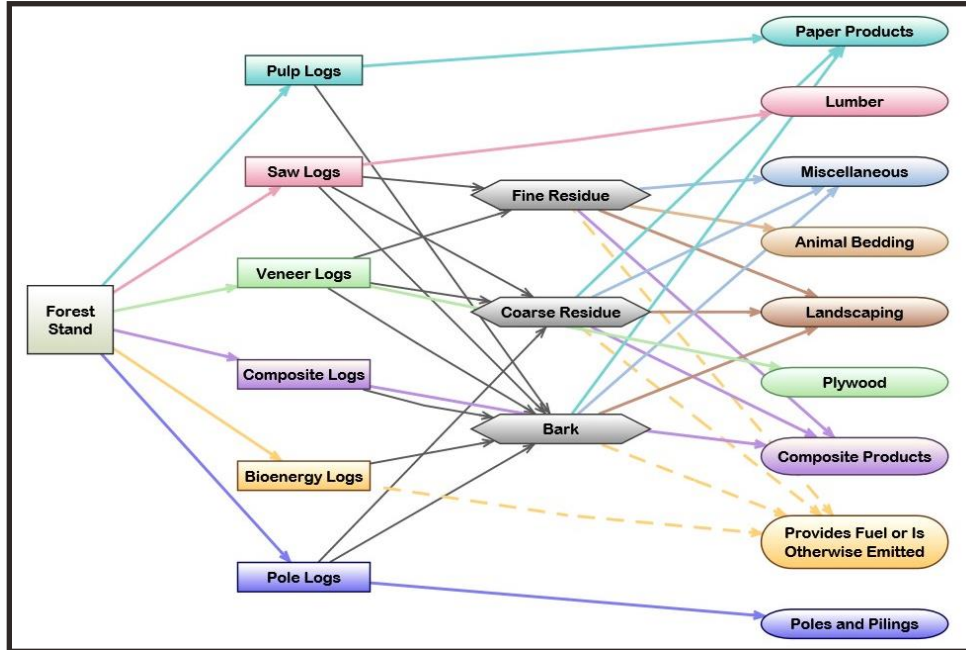
LobWISE transitions products out of use based on these estimated lifespans. The longer the lifespan, the longer a product will stay in use. For products other than housing, there is a single lifespan for each product (red box). For example, the default lifespan for furniture is 13 years. For single family and multi-family housing, each individual part of the house has its own lifespan, and the same part made from different material may have a different lifespan. For example, in a single family house, the house as a whole is expected to stay in use for 125 years, but the estimated lifespan of a lumber deck is only 13 years. Similarly, the estimated lifespan of shelving made from lumber is 112 years, but if the shelving is made from OSB, the lifespan is shortened to 100 years. Many of the housing part lifespans (lifespans with a light blue arrow) are a percentage of the whole-house lifespan (yellow circle). Therefore, you can simply change the lifespan of the house and the other parameters will automatically adjust.

Recycling Rates

Recycling (as same product)	
Pallets	
Portion of pallets recycled as pallets	0.7
Number of times pallets are recycled	3
Paper and pulp products	
Portion of corrugated boxes recycled as corrugated	0.914
Number of times corrugated boxes are recycled	5
Portion of sanitary products recycled as sanitary pr	0
Number of times sanitary products are recycled	5
Portion of packaging cartonboard recycled as packa	0.208
Number of packaging cartonboard is recycled	5
Portion of disposable food related products recycle	0
Number of times disposable food related products	5
Portion of miscellaneous paper products recycled	0.081
Number of times miscellaneous paper is recycled	5

The recycling parameters specify the recycling rate of various pulp and paper products and shipping pallets and the number of times that each can be recycled.

How does it work?



Forest stand to primary products - In LobWISE, logs are divided into eight different log types, depending on the mill they go to (and their size, for saw logs). Wood volume (cu. ft.) or weight (US tons) is converted to carbon in metric tonnes. Carbon is around half the mass of biomass, and biomass is around half the mass of green weight (the other half is water). Therefore, the carbon in a log is around 1/4 of the green weight of the log. The logs then undergo a simulated milling process, where residue carbon is separated from the logs and used for pellet production, burned at the mill, used for pulp production, etc. The remaining wood carbon is used for primary products.

Primary products to emission (next page) - LobWISE uses consumption parameters to sort primary product carbon into secondary products, such as housing and corrugated boxes. The secondary products transition out of use after a period of time according to a Weibull distribution and estimated lifespans. Once transitioned, the products may be recycled as the same product (*e.g.*, paper products), downcycled into a different product (*e.g.*, construction and demolition debris), landfilled (*i.e.*, municipal solid waste landfill or construction and demolition landfill), or emitted. Carbon that is recycled or downcycled repeats the transition process. Carbon that is landfilled decays in the landfill according to a first order decay function with half-lives for paper and solid wood products. Methane is produced in both landfill types and is captured in municipal solid waste landfills.

