



Life-Cycle Thinking: What is it and Why Should I Care?

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and

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Society of American Foresters Training
Conference

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Department of Forest and
Wildlife Ecology

- Life Cycle Components
- Life Cycle Relevance
- Methods and CORRIM
- Example
- Questions

The Storm is Brewing:

- What are responsible materials?
- Good choices vs. bad choices?
- Where do forest products fit in?

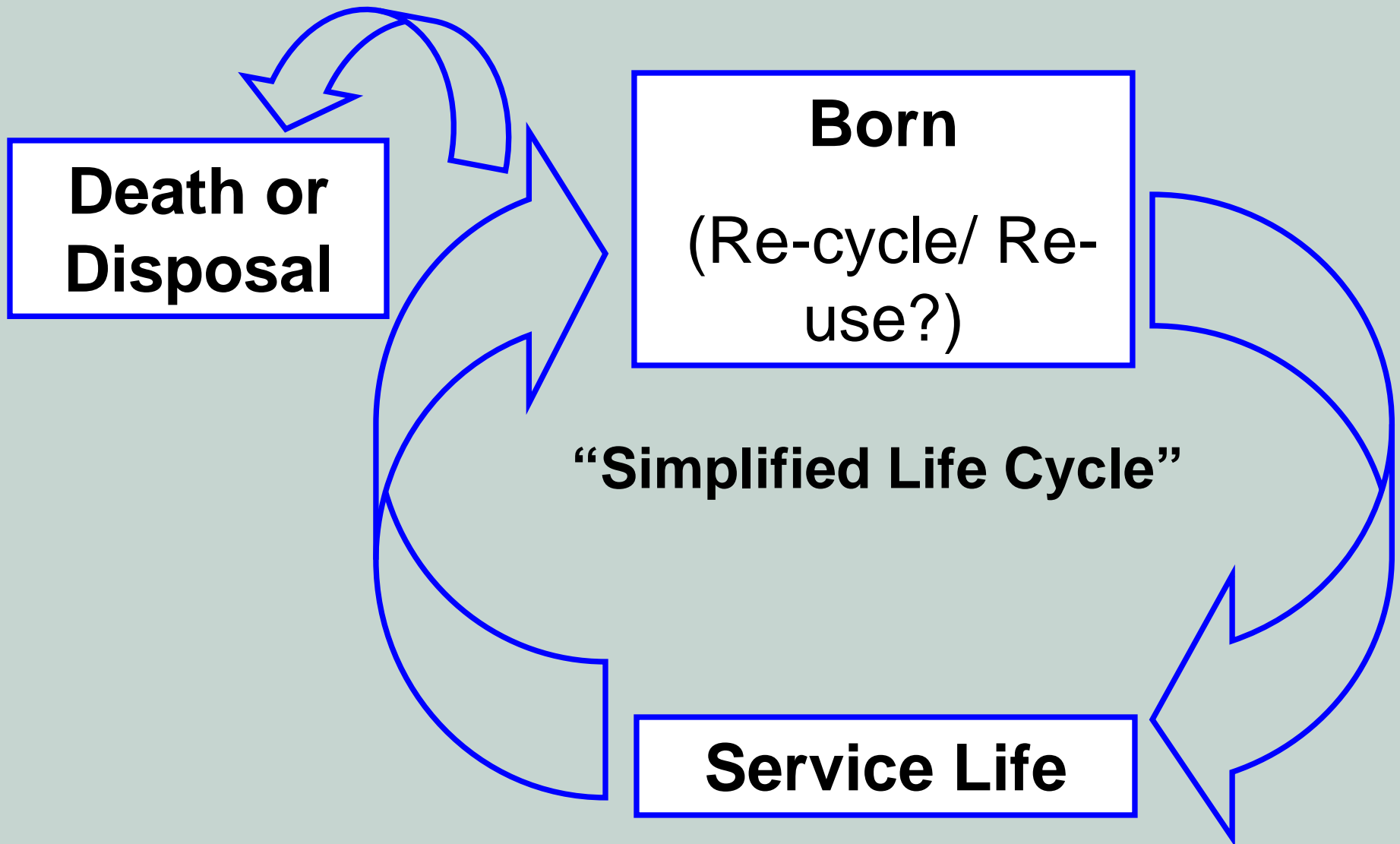


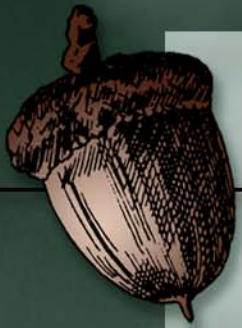


Life Cycle Thinking

- Origins of life-cycle works:
 - Traced to the late 1960's and early 1970's
 - Coca-Cola Company is generally credited with the first use of LCA methodology during efforts to compare various beverage packaging materials in 1969
 - Motivation for 15 early life-cycle efforts partially tied to the oil crisis of the early and mid 1970's
 - Today practiced worldwide by many disciplines

Life Cycle Thinking





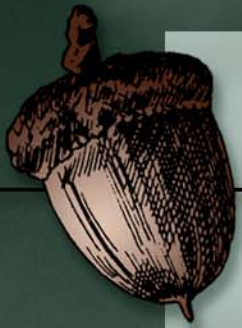
Life Cycle Thinking

Life-Cycle Assessment (LCA):

Systematic approach to uncover the impacts associated with a product or process

Comprehensively quantify inputs and outputs required to manufacture a product:

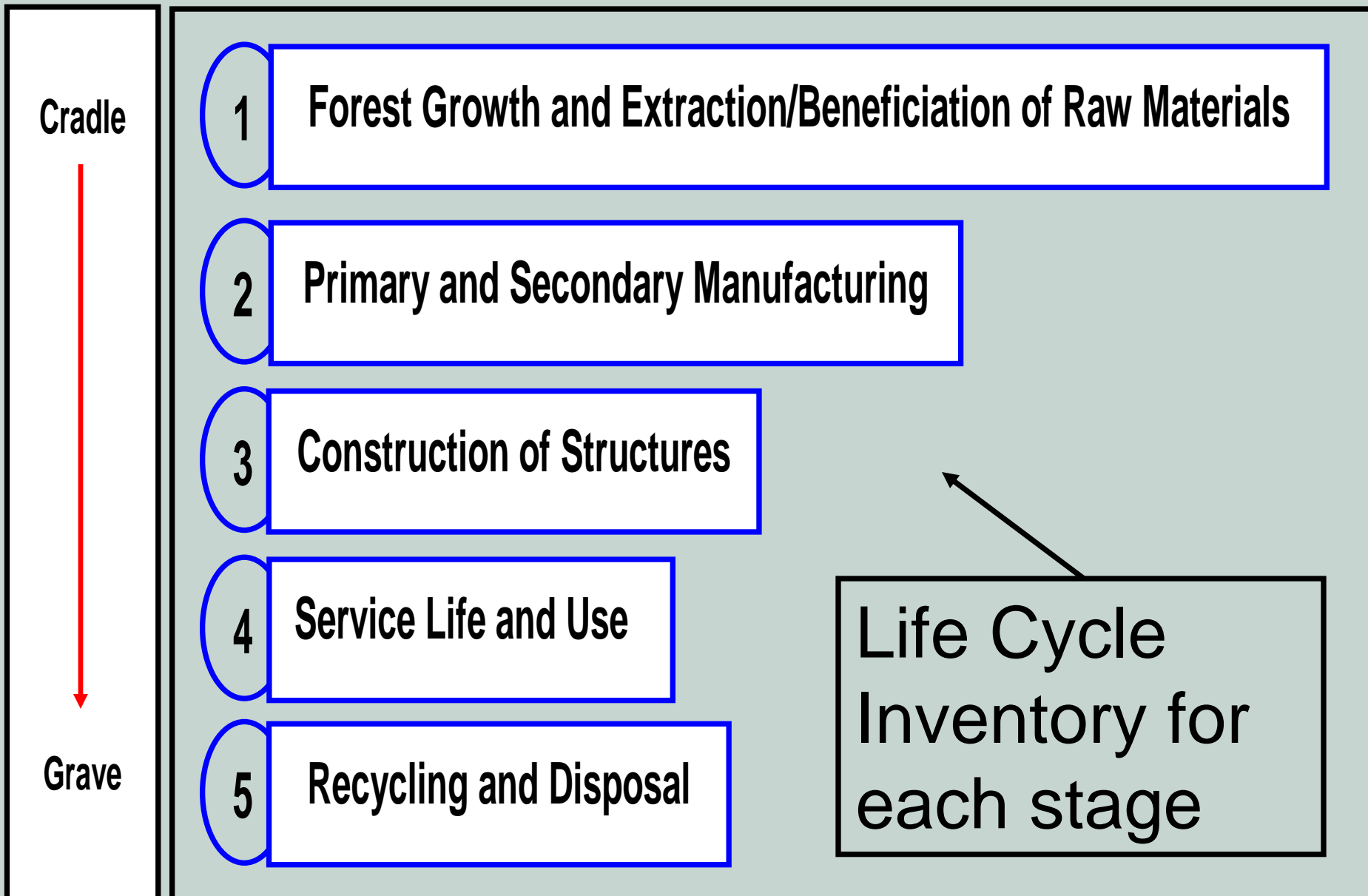
Raw materials, Energy, Products, Co-products, and Emissions



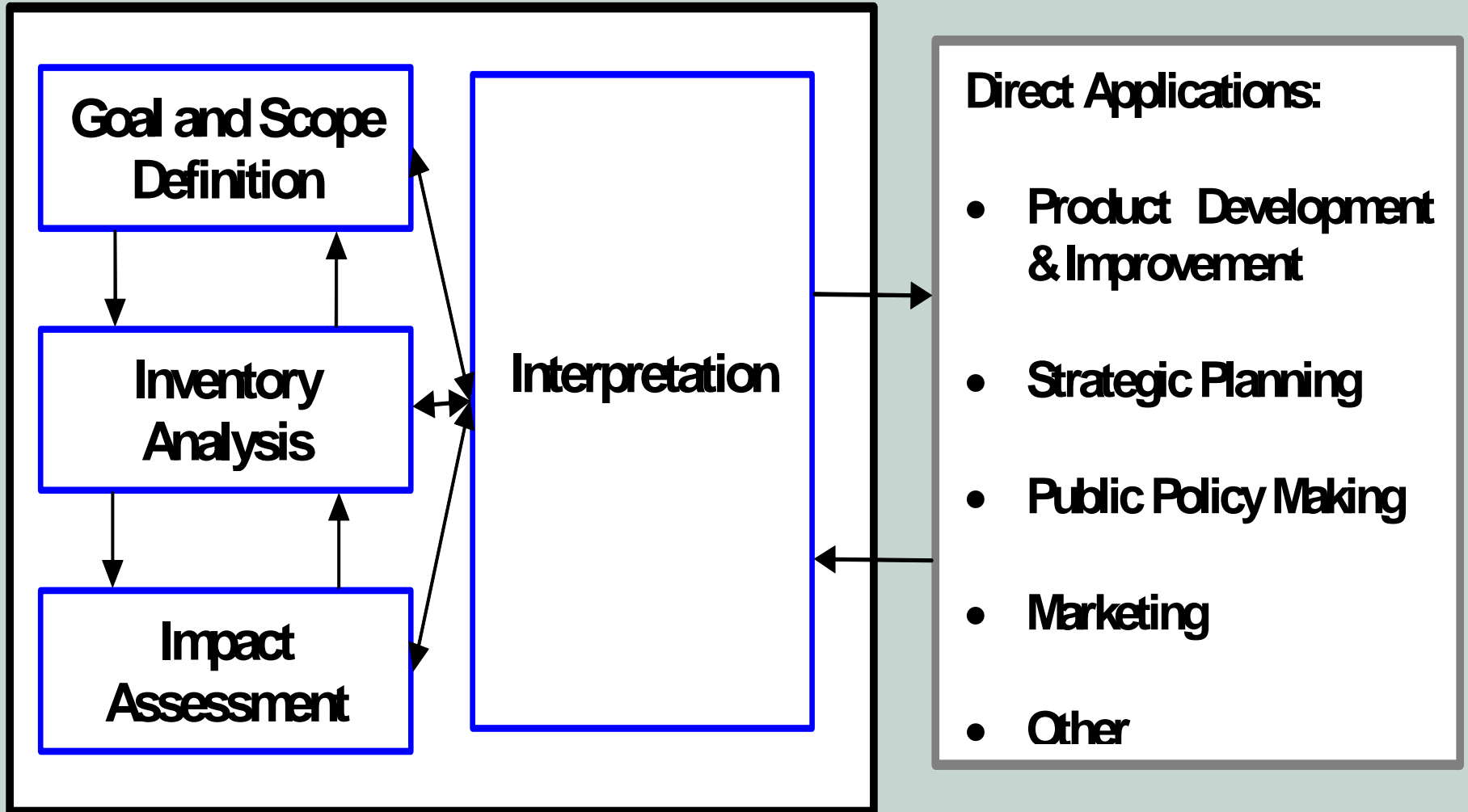
Life Cycle Thinking

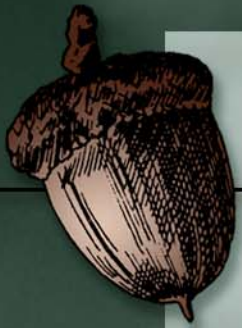
- Life-Cycle Inventory (LCI)
 - Gate to gate vs. Cradle to gate
 - Boundary's (on-site and cumulative)
 - Modules
- Impact assessment
 - How does the product impact global warming potential, water quality, human toxicity, etc.

Life Cycle Thinking



Life Cycle Thinking

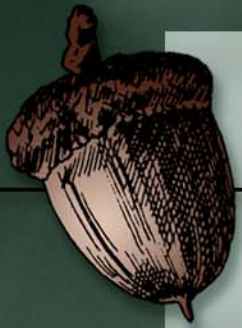




Life Cycle Thinking

Why is any of this important?

1. Environmentally conscious public
2. Green movement
 - Green building
 - Environmental certifications
3. Energy concerns
4. Notion of “responsible materials”

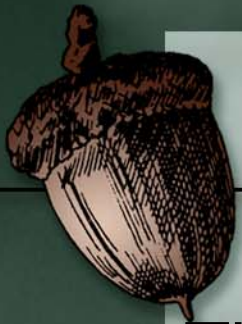


Life Cycle Thinking

“Decisions that discourage the use of wood and other non-wood building products are made each day at all levels of industry and government. While many decisions may be motivated by a desire to protect the environment, individuals making these decisions may not consider the negative consequences associated with using non-wood substitutes.”

CORRIM Website
<http://www.corrим.org>

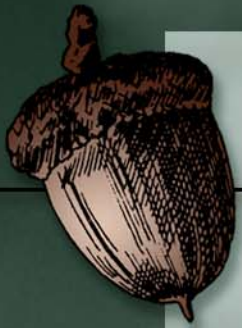
USGBC/LEEDS: wood 13 of 69 possible pts.
Where does life-cycle thinking fit in?



Life Cycle Thinking

The Consortium for Research on Renewable Industrial Materials (CORRIM):

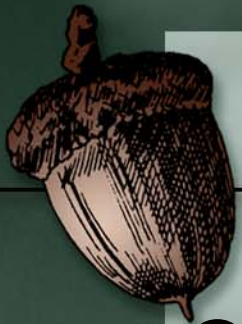
- 15 US and Canadian Research Institution members
- Goal of developing a transparent database that:
 1. Quantify environmental & economic impacts associated with wood building materials
 2. Assist policy makers, building designers, the general public, & manufacturers



Life Cycle Thinking

EXAMPLE:

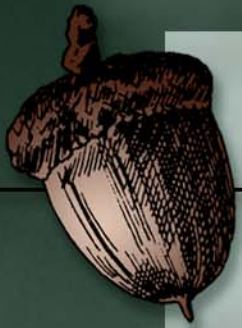
- A Gate-To-Gate Life Cycle Inventory (LCI) of solid hardwood flooring in the eastern United States
- Part of larger initiative generating US regionally based LCI's and life cycle assessments of wood products



Life Cycle Thinking

Objectives:

- Develop baseline information on solid hardwood flooring:
 - resource use
 - energy use and generation
 - emissions associated with manufacture
- Compare baseline information to:
 - substitute or alternative floor coverings derived from non- wood material inputs



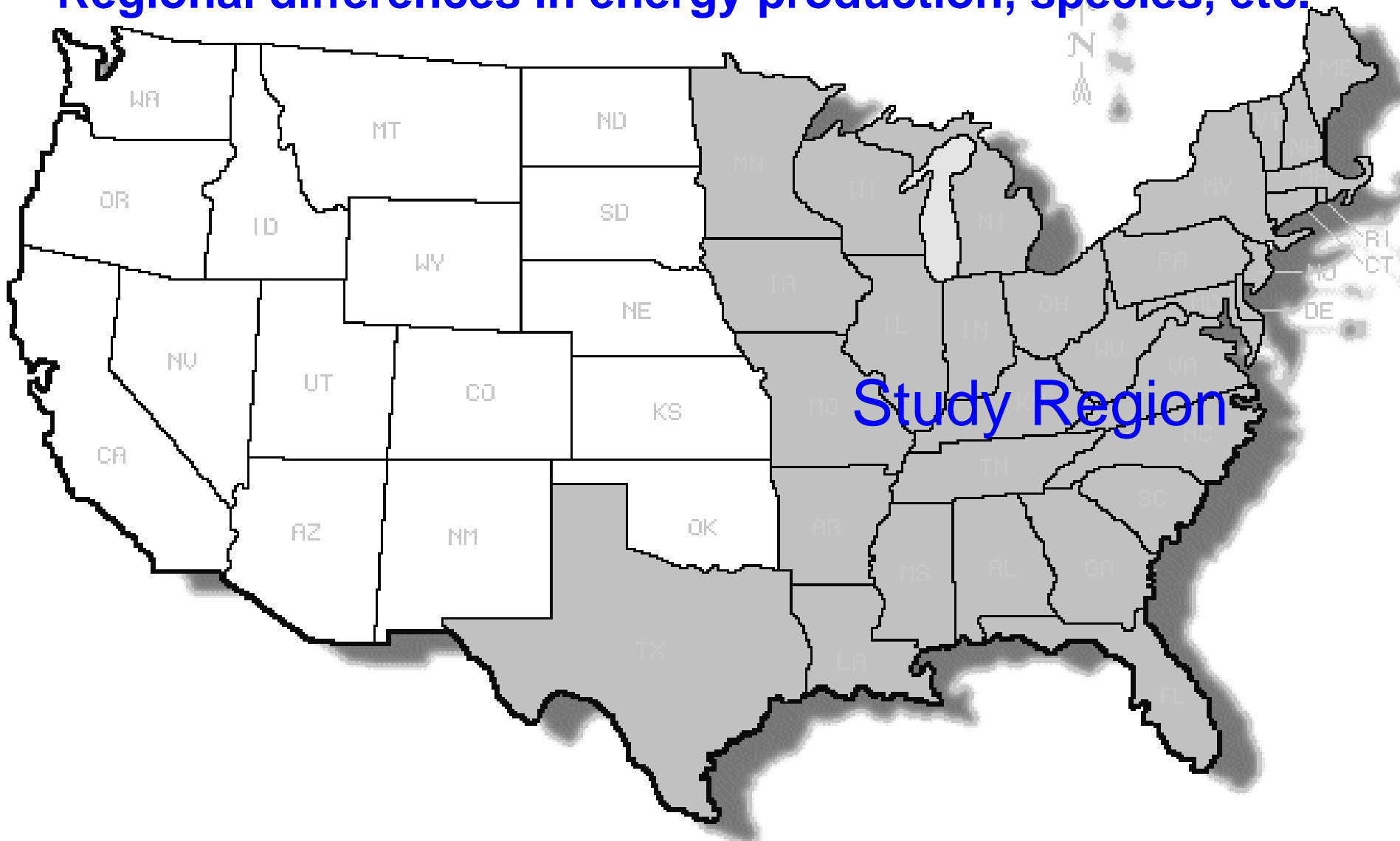
Life Cycle Thinking

Objectives...

- Identify opportunities
 - waste reduction
 - energy and resource efficiencies
 - environmental and process improvement

Life Cycle Thinking

Regional differences in energy production, species, etc.



Solid Hardwood Flooring Defined in Study

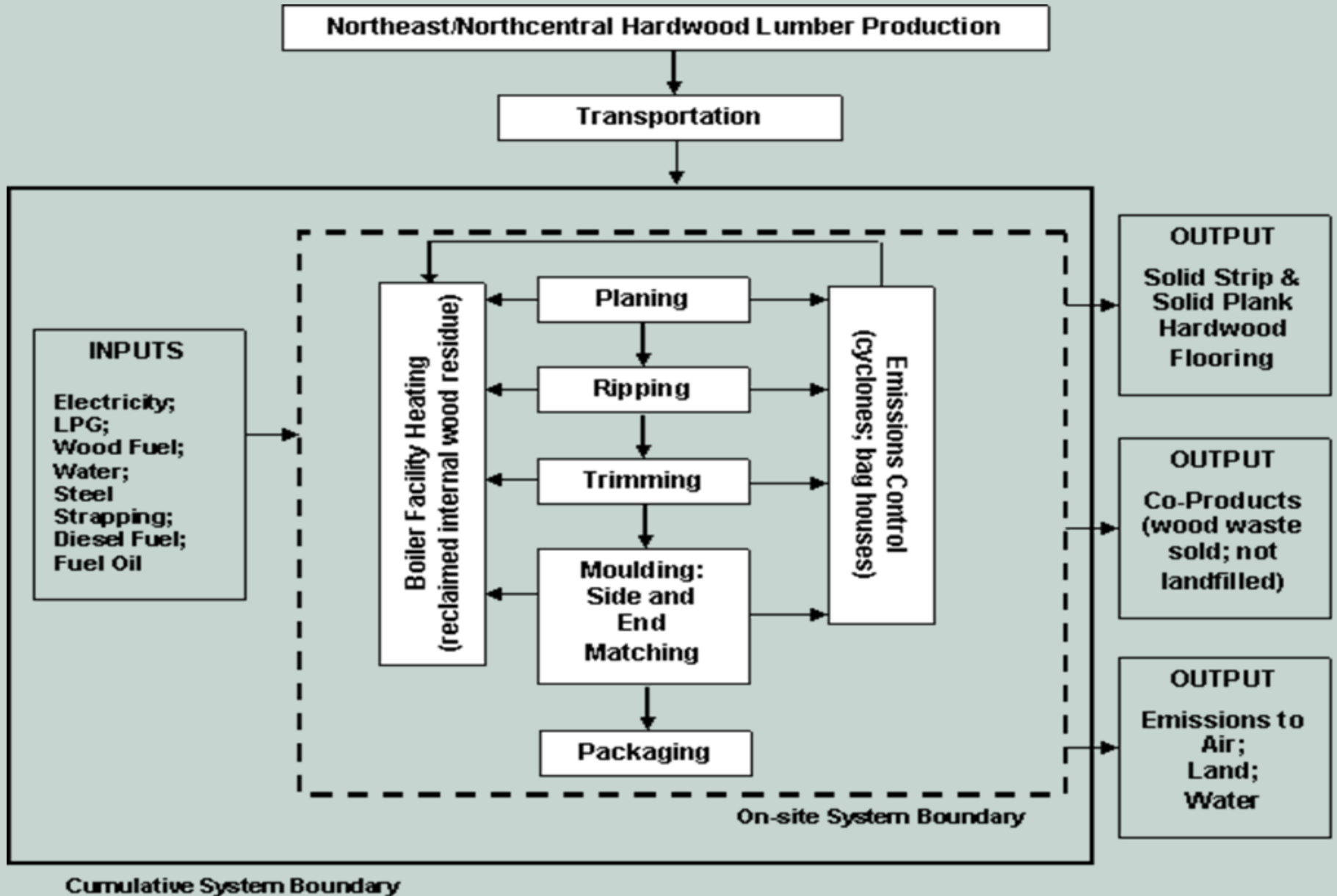
Flooring Classification	Face Widths Inches (cm)	Thickness Inches (cm)
Solid Strip Hardwood	1.5 (3.81), 2.25 (5.71), 3.25 (8.25)	1/3 (0.84), 1/2 (1.27) 3/4 (1.90)
Solid Plank Hardwood	3.0 (7.62), 8.0 (20.32)	

Most common thickness for both flooring classifications is 3/4" but does range (Hosterman 2000)

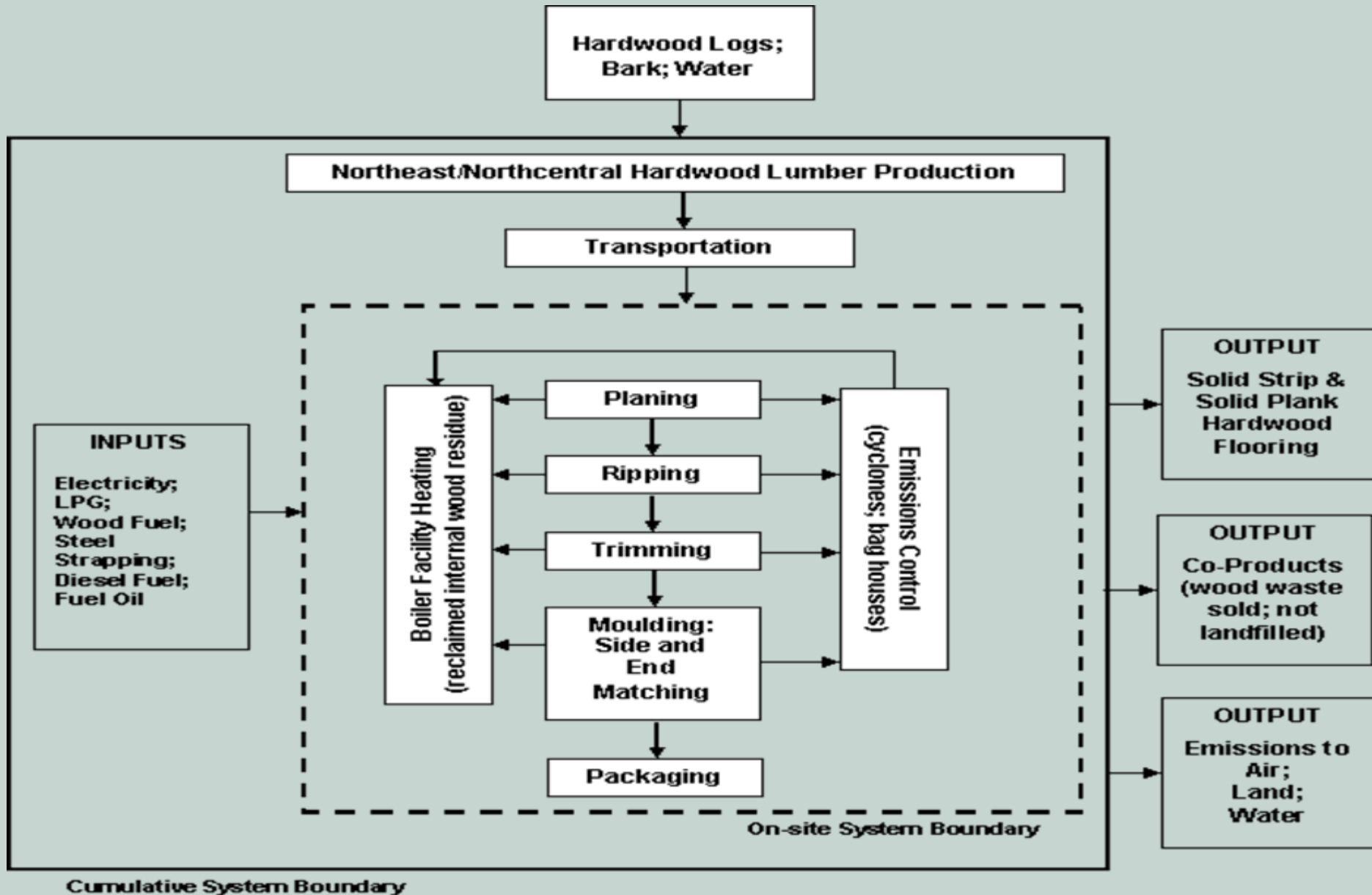
Important:

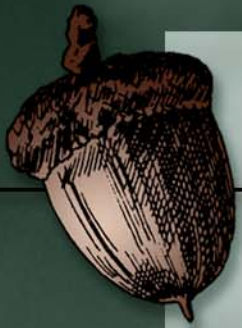
- Parquet and engineered flooring not considered in this inventory
- Only domestic hardwoods

Flooring Gate-to-Gate System Boundary



Extended Gate-to-Gate System Boundary





Life Cycle Thinking

Primary Data Collected:


Used ISO 14000 series standards and protocol guidelines outlined by CORRIM

28% of total US solid hardwood flooring production



Life Cycle Thinking

- Data from Completed Questionnaires:
 - Input into excel spreadsheet
 - Check for outliers/agreement among mills
 - Follow-ups for missing or suspicious data
 - Mass basis calculations from reported dimensions
 - Units harmonized and data weight averaged
 - Modeled using SimaPro software version 7.0

- 
- All inventory results normalized to functional unit of 1.0 m³ of Solid Hardwood Flooring (oven dry basis)
 - SimaPro 7 (modeling software)
 - Licensed LCI data developed in Netherlands
 - Collection of installed databases
 - Matrix calculation routine
 - ISO standards built in (documentation etc.)

Model Inputs by Type for Production of 1.0 m³ of Solid Hardwood Flooring

Inputs to the Model	Quantity in SI Units per 1.0 m ³	Quantity in units per MBF
Materials		
Wood		
Rough Kiln Dry Hardwood Lumber	1419 kg	5509 lb
Water		
From Ground	6.21 l	2.89 Gal
Packaging		
Steel Strapping, cold rolled	0.15 kg	0.58 lb
Fuels		
Electricity		
Purchased	48.4 MJ	13.4 kWh
Wood Hogged Fuel		
Wood Residue Produced On-Site	29.1 kg	113 lb
Fossil		
Natural Gas	0.89 m ³	55.3 ft ³
Fuel Oil #6	0.01 l	0.005 Gal
On-Site Transportation		
Propane	0.12 l	0.055 Gal
Gasoline	0.02 l	0.009 Gal
Off-Road Diesel	0.27 l	0.13 Gal
Emissions		
To Air		
Particulates, unspecified	0.01 kg	0.03 lb
Particulates <10 um	0.007 kg	0.02 lb
To Water		
Discharged to Sewer or Surface	0.01 l	0.005 Gal
To Land		
Fly Ash	1.32 kg	5.12 lb

Weight averaged data from 10 mills; all data allocated by mass to production of 1.0 m³ hardwood flooring (oven-dry basis 657 kg/m³); Values in the table are for on-site boundary only (values for hardwood lumber module not included). 1.76 cubic meters per 1.0 nominal Thousand Board Feet (MBF).

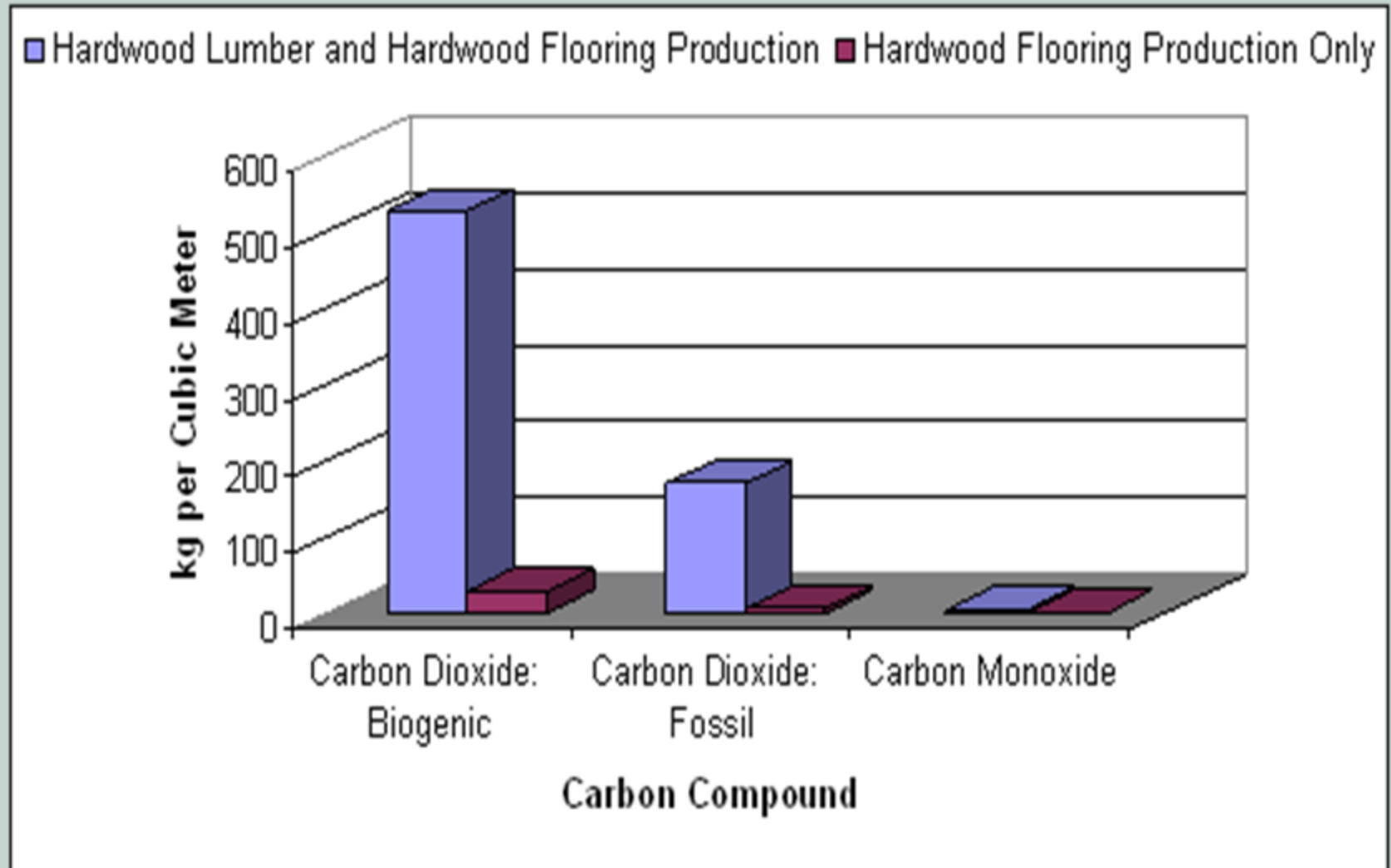
Results

Substance	kg/ m ³	lb/MBF	Substance	kg/m ³	lb/MBF
Raw Materials Consumed			Raw Materials Consumed		
oal, in ground ^a	4.40E+01 MJ	3.71E+00 Btu	Oxygen, in air	6.83E-03	2.65E-02
nergy,hydro ^a	5.18E-01 MJ	4.36E-02 Btu	Scrap, external	2.71E-02	1.05E-01
nergy,unspcfd ^a	6.29E-01 MJ	5.30E-02 Btu	Uranium,in ground	2.92E+00 MJ	2.46E-01 Btu
as,natural,in ground ^a	3.85E+01 MJ	3.25E+00 Btu	Water, process, well, in ground	2.86E+00	1.11E+01
ardwood lumber, ry, NE/NC ¹	6.53E+02	2.53E+03	Wood & wood waste	2.80E+02 MJ	2.36E+01 Btu
on ore, in ground	8.25E-02	3.20E-01	Oil, crude, in ground ^a	7.68E+00 MJ	6.47E-01 Btu
imestone, in ground	1.06E-01	4.10E-01			
Emissions to Air			Emissions to Air		
crolein	5.91E-08	2.29E-07	Kerosene	1.69E-06	6.57E-06
ldehydes	2.08E-05	8.06E-05	Lead	1.74E-05	6.75E-05
mmonia	1.94E-05	7.54E-05	Manganese	1.21E-04	4.70E-04
ntimony	2.63E-08	1.02E-07	Mercury	1.10E-07	4.27E-07
rsenic	1.30E-06	5.06E-06	Metals, unspcfd	7.73E-07	3.00E-06
arium	5.90E-05	2.29E-04	Methane	1.26E-02	4.91E-02
enzene	5.53E-08	2.15E-07	Methane, HCC-30	2.31E-07	8.96E-07
eryllium	1.46E-08	5.67E-08	Methane, CFC-10	6.46E-08	2.51E-07
admium	1.61E-08	6.26E-08	Nitrodimethylamine	1.25E-08	4.84E-08
arbon dioxide, iogenic	2.82E+01	1.09E+02	Naphthalene	4.65E-09	1.80E-08
arbon dioxide, ossil	5.73E+00	2.22E+01	Nickel	7.78E-06	3.02E-05
arbon monoxide	1.95E-01	7.58E-01	Nitrogen oxides	4.68E-02	1.82E-01
hlorine	1.05E-04	4.06E-04	VOC, non-methane	8.53E-03	3.31E-02
hromium	7.83E-07	3.04E-06	Organic, unspcfd	4.49E-05	1.74E-04
obalt	5.49E-08	2.13E-07	Particulates	5.00E-03	1.94E-02
opper	1.04E-09	4.02E-09	Particulates, < 10 um	9.59E-03	3.72E-02
initrogen monox.	3.30E-05	1.28E-04	Particulates, unspcfd	1.46E-07	5.65E-07
ioxins	3.12E-13	1.21E-12	Phenol	1.05E-02	4.06E-02
hene, tetrachloro.	5.59E-08	2.17E-07	Potassium	1.69E-06	6.57E-06
hene, trichlor.	5.58E-08	2.17E-07	Radioactive, unspcfd	7.41E+04 Bq	N/A
ormaldehyde	1.13E-04	4.37E-04	Selenium	4.19E-07	1.63E-06
ydrogen chloride	2.96E-04	1.15E-03	Sodium	2.42E-04	9.37E-04
ydrogen fluoride	4.11E-05	1.59E-04	Sulfur oxides	4.86E-02	1.88E-01
on	5.90E-05	2.29E-04	Zinc	5.91E-05	2.29E-04
Emissions to Water			Emissions to Water		
acidity, unspcfd	1.76E-10	6.83E-10	Manganese	1.32E-04	5.12E-04
cids, unspcfd	1.38E-08	5.36E-08	Mercury	1.34E-10	5.21E-10
mmonia	3.72E-06	1.44E-05	Metal ions, unspcfd	3.77E-06	1.46E-05
io Oxy Demand	3.85E-05	1.49E-04	Nitrate	6.36E-07	2.47E-06
oron	1.46E-04	5.68E-04	Oils, unspcfd	6.66E-04	2.59E-03
admium, ion	1.71E-06	6.64E-06	Organic, unspcfd	1.36E-04	5.26E-04
alcium, ion	1.46E-06	5.65E-06	Phenol	5.84E-08	2.27E-07
hloride	1.73E-03	6.71E-03	Phosphate	1.83E-05	7.10E-05
hromate	9.68E-09	3.75E-08	Sodium, ion	2.68E-06	1.04E-05
hromium	1.71E-06	6.64E-06	Solved solids	3.78E-02	1.47E-01
hem Ox Demand	5.35E-04	2.07E-03	Sulfate	2.18E-03	8.47E-03
yanide	1.06E-07	4.12E-07	Sulfuric acid	3.66E-05	1.42E-04
luoride	6.75E-06	2.62E-05	Suspended solids, unspcfd	3.24E-03	1.26E-02

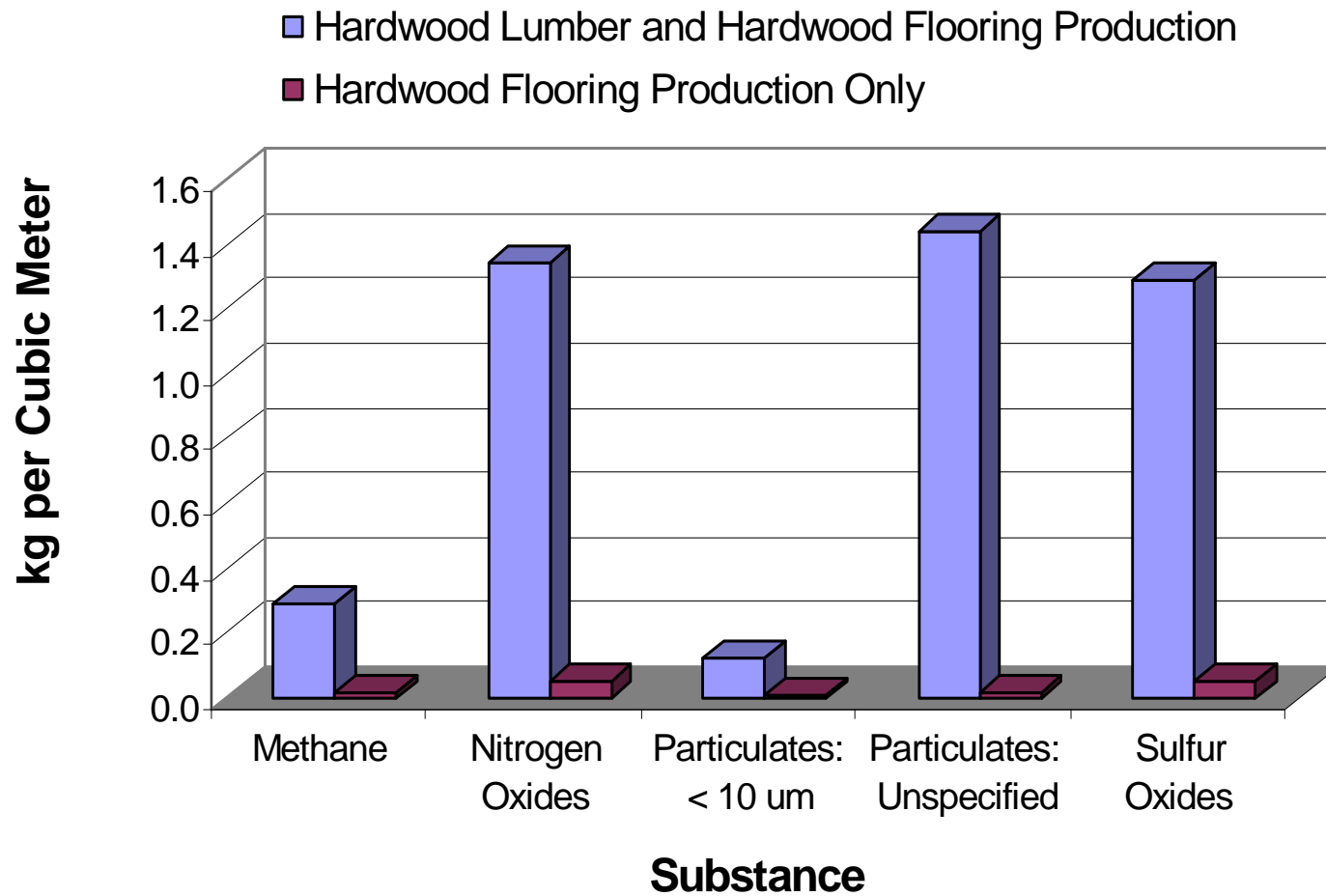
Inventory Model Outputs:

- raw materials consumed;
- emissions to air;
- emissions to water;
- emissions to land

Results




Results



Results

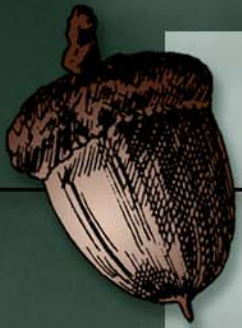
Electricity


Fuel Source	Percent of Total Electricity Production 2006	On-Site Hardwood Flooring Only		Flooring Process with NE/NC Lumber Production	
		MJ/m ³	kWh/MBF	MJ/m ³	kWh/MBF
Coal	51.8 %	25.1	12.2	340	166
Petroleum	3.9 %	1.89	0.92	25.6	12.5
Natural Gas	16.4 %	7.95	3.88	107	52.6
Hydro	2.3 %	1.11	0.54	15.09	7.37
Nuclear	22.8 %	11.05	5.40	149	73.1
Other Renewables	2.8 %	1.35	0.66	18.3	8.98
Total	100 %	48.4	23.6	656	320

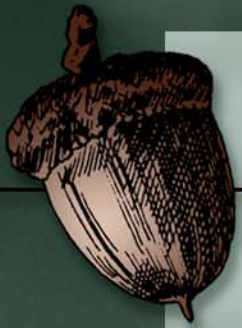
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- Hardwood Flooring Manufacture is a relatively straightforward process
 - Purchased electricity for equipment
 - Most environmental concerns center on kiln drying the hardwood lumber input
 - Energy consumption
 - Volatile organics (compounds capable of photochemical reactions in atmosphere)

Considerations:

- Woody biomass generated on-site is beneficial
 - Value added furnish
 - Wood for on-site fuel (reduced fossil fuels use)
 - Fiber board furnish etc.
- Kiln drying
 - Energy intensive; necessary for stable flooring
 - Innovative use of drying methods represents potentially large energy savings
 - Easier said than done



- 
- Electrical energy used for saws, conveyers and other machine centers
 - Evaluate on a mill by mill basis
 - Replace aging equipment and outdated technology with newer optimized counterparts may increase efficiency
 - Service life of wood flooring vs. others
 - (100+ years; linoleum 18 years)
 - Respiratory advantages of wood flooring (asthma)



Next Steps

Create full cradle-to-gate LCI

(CORRIM: Hardwood Forest Resource to Hardwood Lumber to Solid Hardwood Flooring)

Impact Assessments

to environment & human health

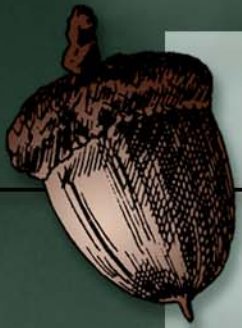
Product Comparisons?

Wood flooring vs. others (carpet, linoleum, ceramic etc.)

Important to understand methods to avoid comparing “apples to oranges”

**Care is always needed in interpreting results
and in making comparisons!**





Life Cycle Thinking

Wisconsin forest management:

- Very active and important to the state
- Forest certification a big tool
- Life-cycle thinking, another tool for recognizing and substantiating the many benefits of our states forests and the work forest managers do



IN LIGNO VERITAS

-In wood there is truth

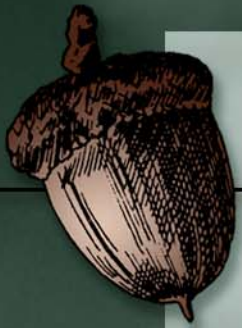


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Questions

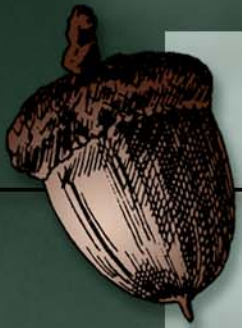


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Acknowledgements

- Scott Bowe, Patrick Eagan, Jim Wilson, and Richard Bergman- technical assistance and support
- CORRIM- technical assistance and software
- Ed Korczak (NWFA)- project promotion and support
- Participating flooring mills



Sources

Consortium for Research on Renewable Industrial Materials (CORRIM). 2001. Research Guidelines for Life Cycle Inventories. CORRIM, Inc. University of Washington, Seattle, WA. April. 47pp.

Hosterman, Nathan S. 2000. A Preliminary Examination of Factors Affecting Manufacture of Value Added Products From Recycled Pallet Parts. Masters Thesis Submitted to the Virginia Polytechnic Institute and State University. 108 pp.


Wahlgren, Kim M. 2007. State of the Industry: Worldly Vision. Hardwood Floors. April/May 2007. pp. 71-92.



Background

CORRIM works closely with the Athena Institute

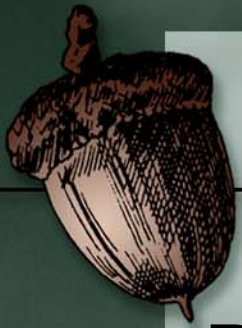
- Athena Institute:
 - Not-for-profit providing scientific information and tools addressing the sustainability of built environments for the general public and building industry
- Athena compiling database of life-cycle inventories for widely used products and processes.
- Currently possible to perform impact comparisons for over 1,000 building assimilations through the database.
 - Publicly available; housed at the National Renewable Energy Laboratories (NREL). www.nrel.gov/lci



Objectives, Scope, and System Boundary

Scope:

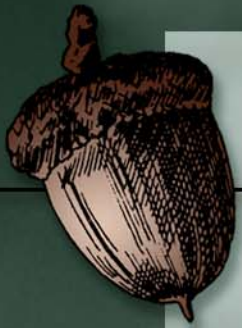
- 2006 US production of solid hardwood flooring estimated at 483 million ft² (Wahlgren 2007)
- Needed a minimum of 5% of eastern production (ISO and CORRIM)
- Target mills representative of the industry



Life Cycle Thinking

Primary Data Collection...

- National Wood Flooring Association identified representative flooring mills and contacts
- April 2007: 18 surveys sent to 10 companies with dedicated production of solid hardwood flooring



Objectives, Scope, and System Boundary

Considerations:

- **Kiln drying process**
 - omitted from on-site gate-to-gate model (secondary data from hardwood lumber module)
 - included in the extended gate-to-gate boundary
- **Pre-finishing**
 - most mills pre-finished at separate facilities
 - quality of data for this process was not adequate