Environmental Implications of Increasing Wood Use in Building Construction

Dr. Jim Bowyer
Dovetail Partners
Minneapolis, MN

Environmental Implications of Increasing Wood Use in Building Construction

- Importance of wood in American society
- Materials comparisons
- Forest trends
- Use of wood incentivizes retention of forests
- Summary

Importance of Wood in American Society

Annual U.S. Consumption of Various Raw Materials, 2011

	Million Metric tons	Million m^3
Roundwood*	145	341
Forest products (wood only)	128	300
Cement	72	23
Steel	90	12
Plastics	40.6	45
Aluminum	3.6	1.3

* Roundwood is the volume of all wood harvested.

More wood is consumed every year in the United States than all metals combined.

Source: Data for wood from UNECE (2013); for cement, steel, and aluminum from the U.S. Geological Survey (2013); and for plastics from the American Plastics Council (2013).

U.S. Forest Products Industry

- 900,000 employees – large % rural
- Top 10 manufacturer in 47 states
- 4.5% of US manufacturing GDP
- $50 billion payroll

Materials Comparisons

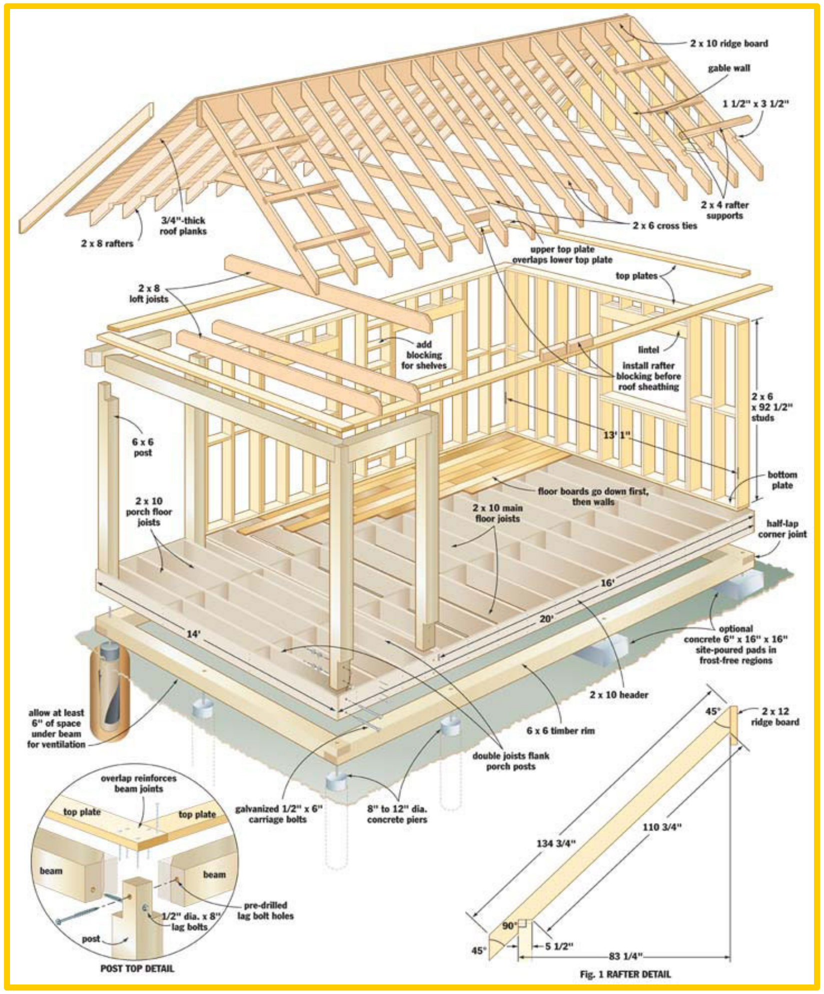
- Basic materials
- Assemblies
- Structures

Life Cycle Assessment

Measure:

All inputs
- Raw materials
- Energy
- Water

All outputs
- Products
- Co-products
- Emissions
- Effluents
- Wastes



Consider all stages in production, use, disposal:

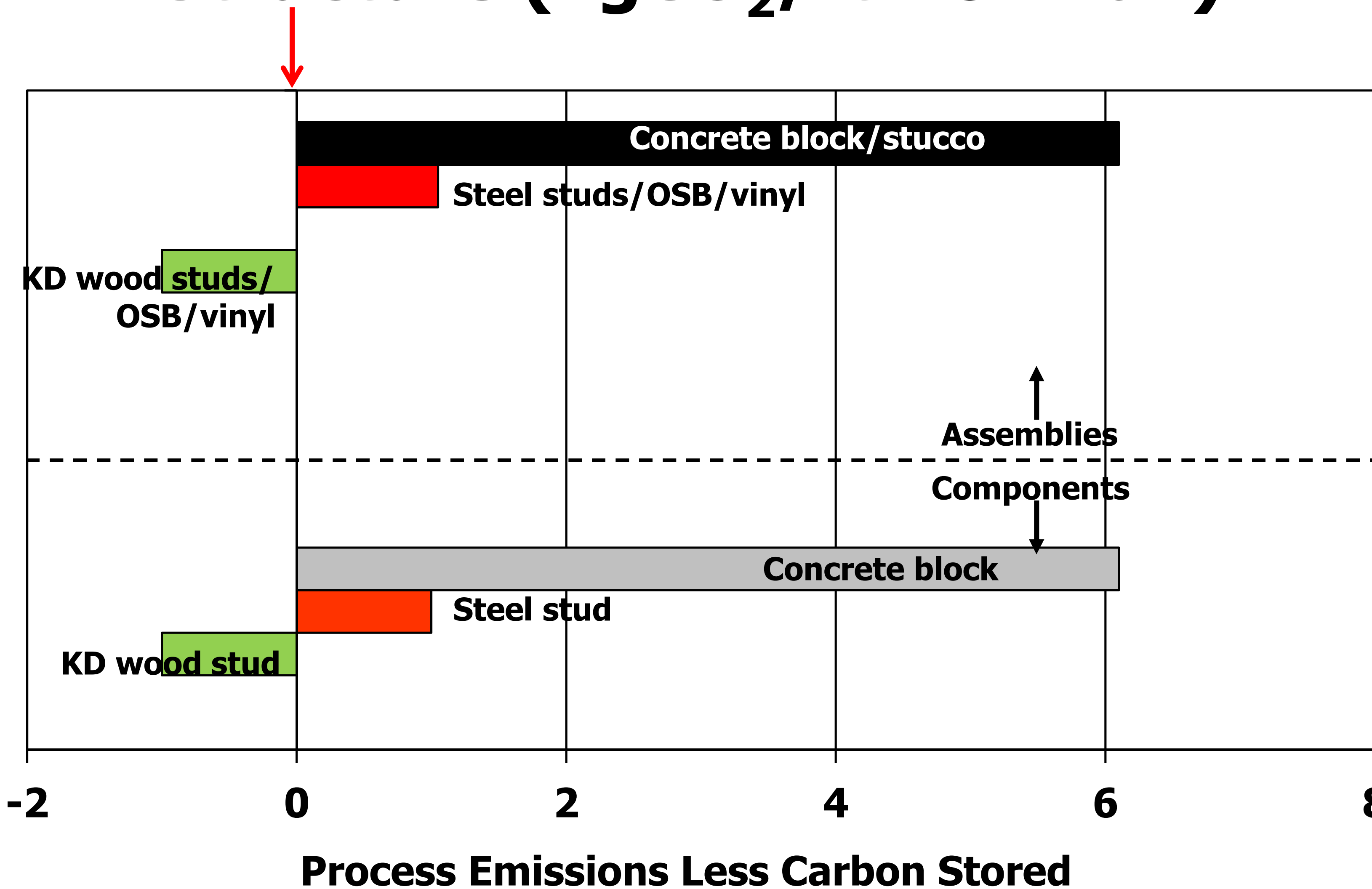
- Extraction
- Transport
- Primary processing
- Conversion to sub-assemblies, finished products
- Maintenance
- Disposal/ Reuse

Carbon Emitted in Manufacture

Material	Total Process Emissions (MTCE/ MT of product)
Framing lumber	0.033
Concrete	0.034*
Concrete block	0.038*
Medium density fiberboard (virgin fiber)	0.088
Brick	0.088
Glass	0.154
Recycled steel (100% from scrap)	0.220
Cement (Portland, masonry)	0.265
Recycled aluminum (100% recycled content)	0.309
Steel (virgin)	0.694
Molded Plastic	2.502
Aluminum (virgin)	4.529

1/ Values are based on life cycle assessment and include gathering and processing of raw materials, primary and secondary processing, and transportation.
2/ Source: USEPA (2006), Exhibit 2-3. *Data for concrete from Flower and Sanjayan (2007); 10% increase in energy consumption assumed for production of concrete block.

Net Product Carbon Emissions: Wall Structure ($kgCO_2/ft.^2$ of wall)



Source: Lippke and Edmonds, Consortium for Research on Renewable Industrial Materials (2009).

Wälludden Project, Växjo, Sweden

Four-story apartment buildings, each containing 16 apartments. Total usable floor area in each building of 12,809 ft^2.

Dodoo, A. 2011. Life Cycle Energy Use and Carbon Emission of Residential Buildings. PhD Dissertation. Department of Ecotechnology, Mid-Sweden University.

Wälludden Project, Växjo, Sweden

Designed and built in wood. Life cycle analysis (LCA) of environmental impacts

LCA of identical building "built" of concrete.

Wälludden Project, Växjo, Sweden

Materials Use in the Buildings (mt)

Material	Wood	Concrete
Lumber	58	23
Particleboard	18	9
Plywood	21	0
Concrete	223	2014
Plasterboard	89	22

Wälludden Project, Växjo, Sweden

	Wood	Concrete	Difference
Energy Consumption in Building Materials Production			
Total energy consumed in producing construction materials (GJ)	2330	2972	-22%
CO_2 Emissions (mt CO_2e)			
Fossil fuel use in mat'l production	51.3	67.7	-24%
Emission from cement reactions [1/]	4.0	21.0	-81%

[1/] It was assumed that 8% of CO_2 emissions from calcination reactions would be reabsorbed by the concrete over a 100-year building life.

Wälludden Project, Växjo, Sweden

	Wood	Concrete	Difference
Energy Consumption in Building Materials Production			
Total energy consumed in producing construction materials (GJ)	2330	2972	-22%
CO_2 Emissions (mt CO_2e)			
Fossil fuel use in mat'l production	51.3	67.7	-24%
Emission from cement reactions [1/]	4.0	21.0	-81%
Long-Term Carbon Storage in Building Materials (mt)			
Carbon stock in building materials	40.3	28.2	+43%
Avoided Carbon Emissions Due to Displacement of Fossil Fuels			
Includes biofuel use in building materials production and biofuel recovery at end of life.	101.2	66.0	+53%

[1/] It was assumed that 8% of CO_2 emissions from calcination reactions would be reabsorbed by the concrete over a 100-year building life.

Key Findings:

The average greenhouse gas (GHG) mitigation over a 100-year perspective is 2 to 3 times better for the wood building than the concrete building. It is also better over 50-year and 300-year building life cycles.

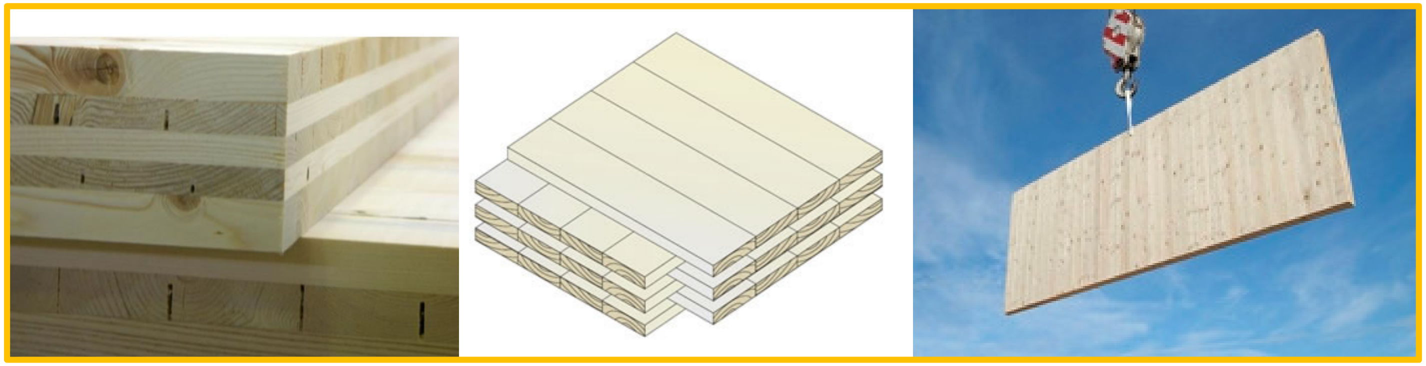
Växjo Wooden City

Part of an effort initiated in 1996 to become a fossil fuel free city and the "greenest city in Europe." Results from the Wälludden Project were the basis for focus on wood construction.

LCA of Mid-Rise Office Building Construction Alternatives: Laminated Timber vs. Reinforced Concrete

Robertson A., Lam F., Cole R. 2012. A Comparative Cradle-to-Gate Life Cycle Assessment of Mid-Rise Office Building Construction Alternatives: Laminated Timber or Reinforced Concrete. *Buildings*. 2012; 2(3):245-270.

Cross-Laminated Timber



Glue-Laminated Timber

LCA of Mid-Rise Office Building Construction Alternatives:

Discovery Place – Building 12
Burnaby, B.C.

153,000 ft^2 office building, constructed in 2009.

- Five story
- Three levels of underground parking
- Cast-in place reinforced concrete structural frame

LCA of Mid-Rise Office Building Construction Alternatives:

Reinforced Concrete

LCA of structural system and enclosure of existing building.

Glulam/CLT

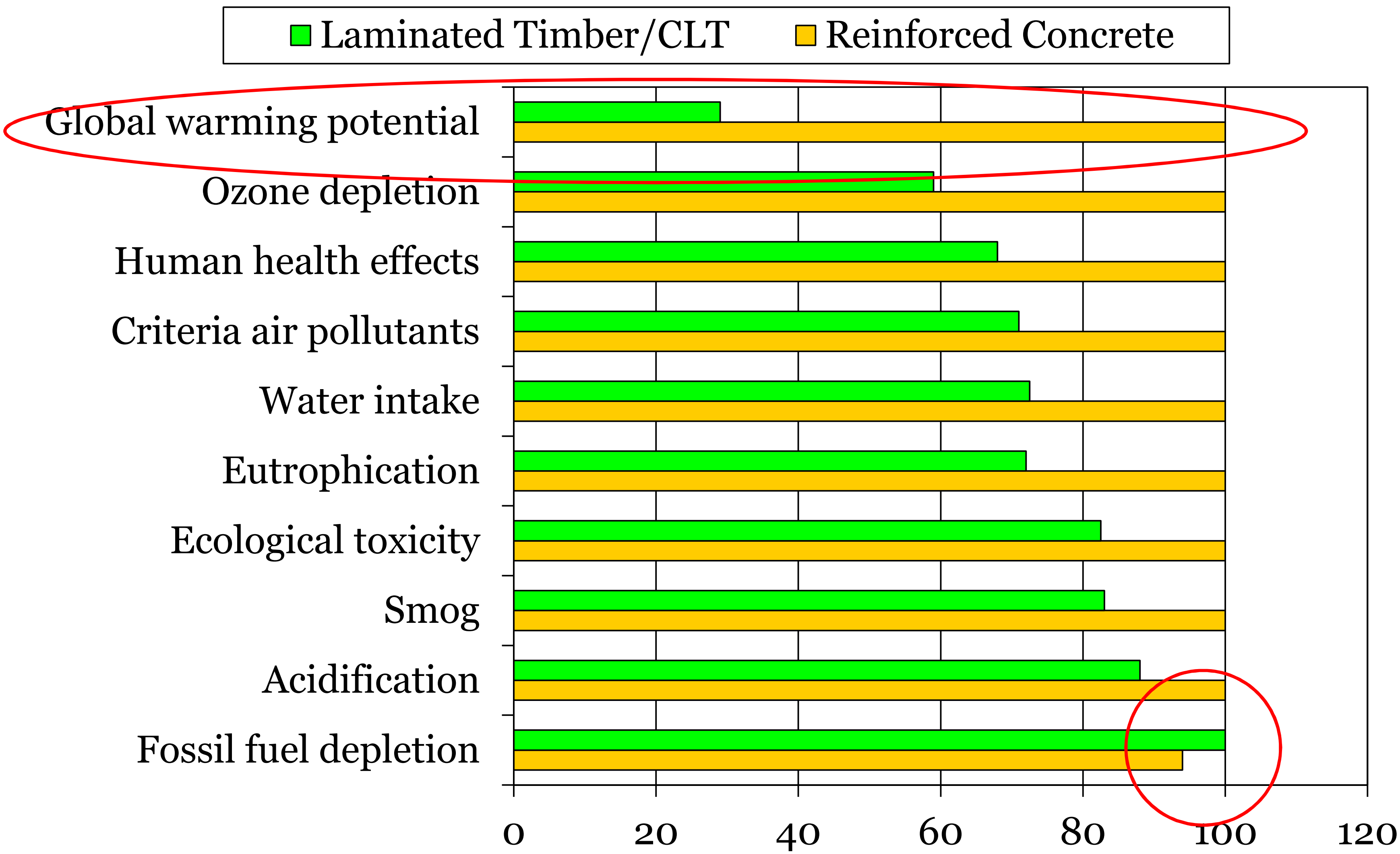
LCA of functionally equivalent structural system and building envelope.

LCA of Mid-Rise Office Building Construction Alternatives:

Glulam/CLT

Design incorporates a combination of glulam and cross laminated timber (CLT) for the vertical and horizontal force resisting systems, in conjunction with reinforced concrete shear core.

Environmental Impact Comparisons



Energy Consumption and CO_2 Emissions in Constructing the Roof of Raleigh-Durham Airport Terminal

Athena Sustainable Materials Institute
(2011)

Energy Consumption and CO_2 Emissions in Constructing the Roof of Raleigh-Durham Airport Terminal

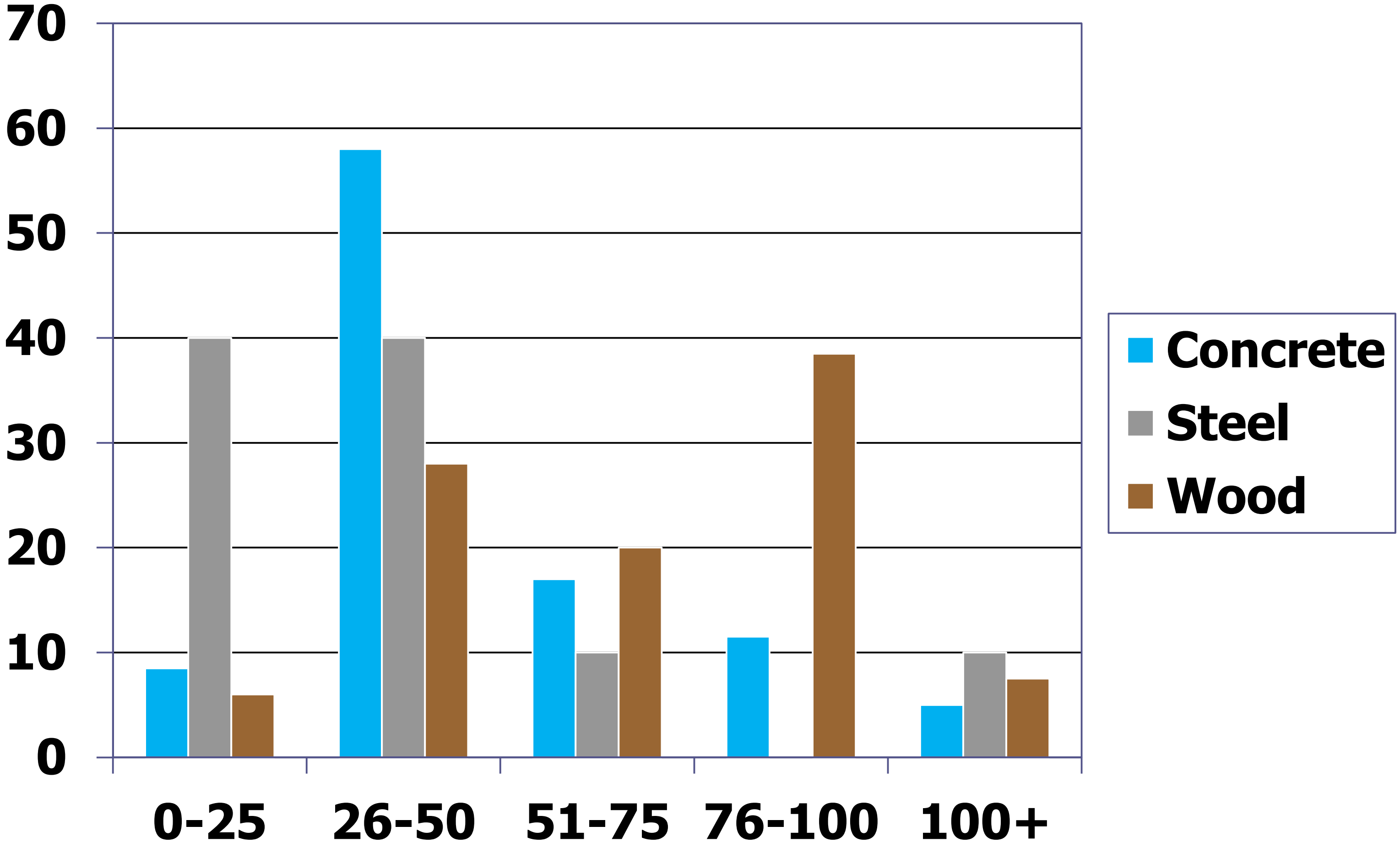
Life cycle assessment showed that use of wood rather than steel for this application resulted in:

- **Energy savings of 5,600 MWh**, equivalent to the electricity use of 500 homes over 1 year or 23 days of operational energy use for the terminal.
- **GWP savings of 1,000 t CO_2e**.

Durability of Wood Structures

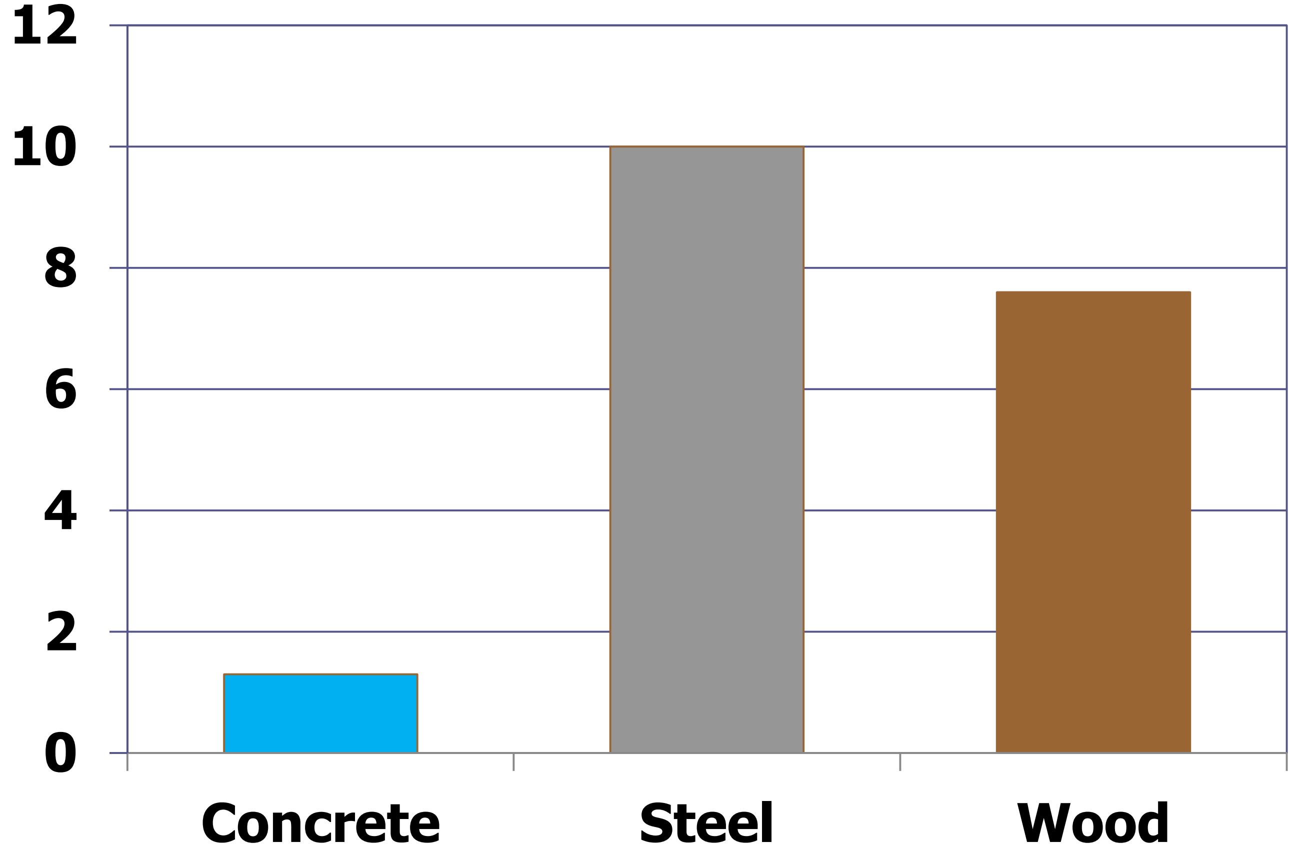
Stave Church 1180-1250 AD

94 Non-Residential Buildings by Structural Material and Age at Demolition, Minneapolis/St. Paul, 2000-2003



Source: O'Connor, J. (2004)

Percent of Each Building Type Demolished Because of Fire Damage



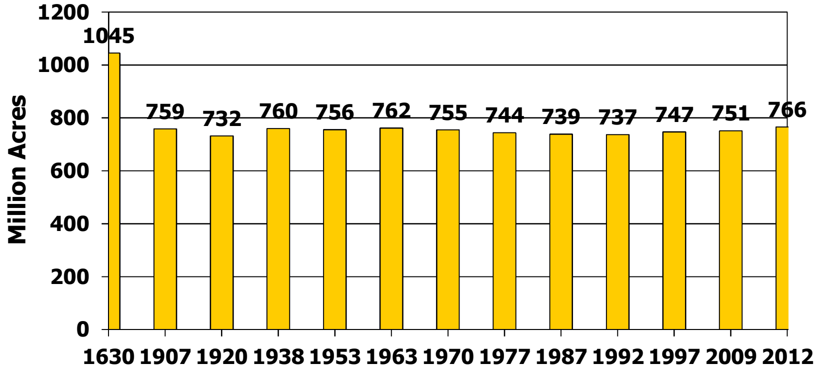
Source: O'Connor, J. (2004)

Key Finding:

Despite a pervasive perception that the useful life of wood structures is lower than other buildings, no meaningful relationship exists between the type of structural material and average service life.

Forest Trends

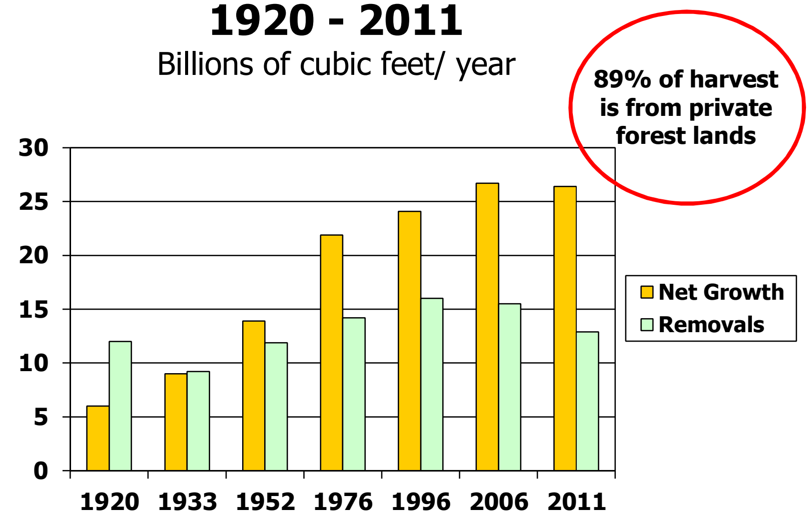
Trends in U.S. Forestland Area 1630-2012



Source: USDA – Forest Service, 2013

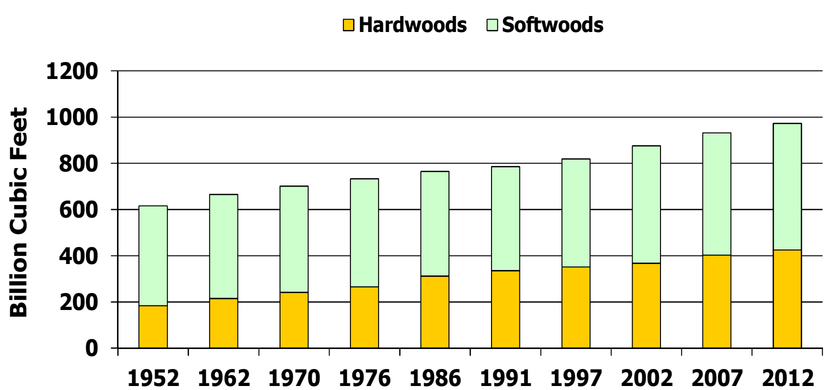
U.S. Timber Growth and Removals, 1920 - 2011

Billions of cubic feet/ year



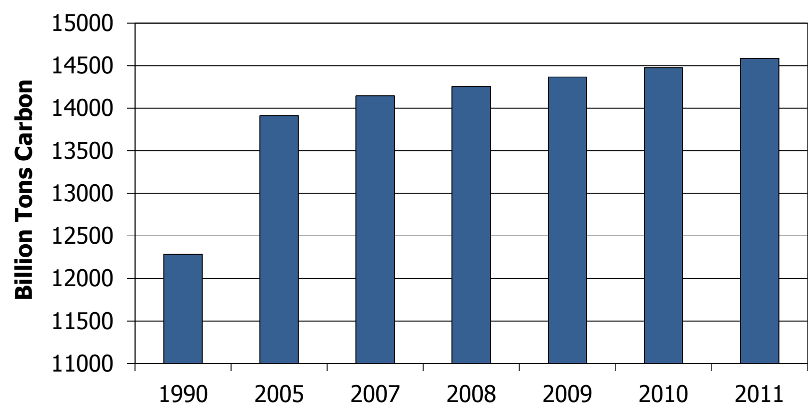
Source: USDA - Forest Service, 2013.

Standing Timber Inventory – U.S. 1952-2012



Source: USDA-Forest Service, 2013.

Carbon in Above-Ground Portion of Standing Trees, U.S. 1990-2011



Source: USEPA (2013). Inventory of US Greenhouse Gas Emissions and Sinks, 1990-2011, p. 7-18.


Counterintuitively, wood demand helps keep land in forest.

"*Industrial roundwood harvest levels in North America and Europe are by far the highest among global regions*."

"*North America and Europe are the only global regions experiencing net sequestration of carbon in forests and in aggregate the net change in forest area in both regions is positive*."

"*High levels of industrial timber harvest are coincident with fairly stable forest cover trends*."

Ince (2010)

"…we identified the rise in timber net returns as the most important factor driving the increase in forest areas [in the United States] between 1982 and 1997."

(Lubowski et al. 2008)

Maintaining Forest Area and Forest Carbon Stocks

The primary threat to maintaining long-term forest carbon stocks is pressure to convert forest land to non-forest uses.

Research clearly shows that strong forest products markets help to prevent deforestation, incentivize afforestation, and enable forest improvements.

Maintaining Forest Area and Forest Carbon Stocks

Periodic harvesting also provides jobs, income, and essential raw materials and products.


Summary

Summary

Maximizing the use of wood in buildings where such use makes sense, and is allowed by code:

- is technically feasible, and would
- help to reduce US energy consumption and carbon emissions,
- increase the economic value of working forest lands,
- increase forest sector and rural incomes,
- provide incentives for maintaining the extent, vitality, and health of forests.