Indiana Department of Natural Resources
Division of Forestry

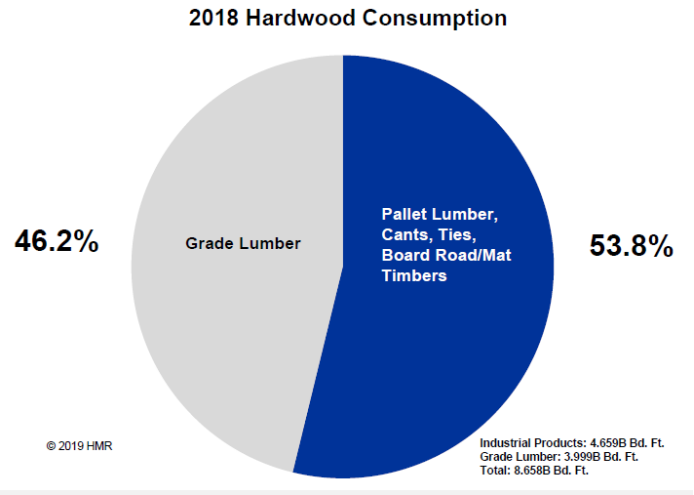
Life cycle analysis for timber harvested on Indiana's State Forests

Life-cycle analysis or life-cycle assessments are used to gauge environmental impacts of products and may attempt to include a wide range of ecological costs arising from production and sourcing of raw materials through utilization and until disposal and eventual breakdown to molecular components. Such studies attempt to more fully diagnose the environmental costs associated with a given product and, when finished comparing competing materials for similar products, allow for insights and conclusions that can contrast with more superficial comparisons. For example, at the superficial level, because a plastic pallet can be used many, many more times (33 trips vs. 100 trips) than a wood pallet, it could be advertised as being more environmentally friendly than a wood pallet. But is that really the case? Life cycle analysis attempts to provide a clearer picture.

The Indiana State Forest system comprises about 150,000 acres of forests that are managed for multiple uses, including sustainable timber harvest. The Division of Forestry targets 12 million board feet (MMBF) of timber to be sold in a given year as described in its enabling legislation "by the employment of good husbandry, timber that has a substantial commercial value may be removed in a manner that benefits the growth of saplings and other trees by thinnings, improvement cuttings, and harvest processes and at the same time provides a source of revenue to the state and counties and provides local markets with a further source of building material."(1) As will be further described in this paper, the substantial economic value also provides for substantial environmental value as hardwood products have perhaps one of the lowest environmental footprints among building materials, making them the smart choice for societies interested in reducing environmental impacts and lessening atmospheric carbon concentrations.

According to the Division of Forestry's Utilization Specialist, the State's 12 MMBF translates to 13.4 MMBF in production at sawmills when overruns are included. (2) This production generally follows two supply chain routes as it is transferred into usable products: industrial and grade lumber.

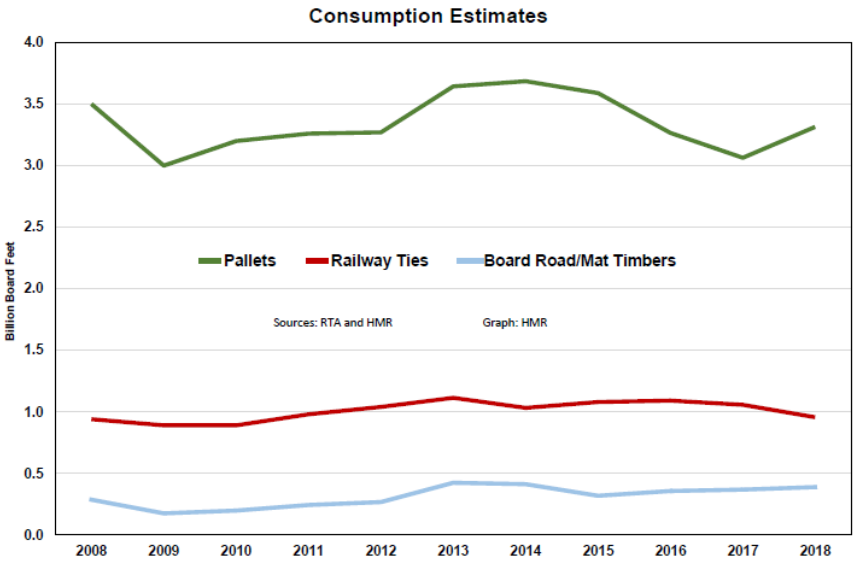
Figure 1: Industrial vs. Grade Lumber



Source: Hardwood Market Report (3)

Just over half of hardwood produced in the United States goes to industrial uses. Using the estimates above from the Hardwood Market Report, we can assume that 7.2 MMBF of the production from Indiana's State Forests goes into industrial products. The vast majority of this lumber is destined for use as pallets. Figure 2 shows the other major industrial products in this category.

Figure 2: Major products for hardwood in industrial category

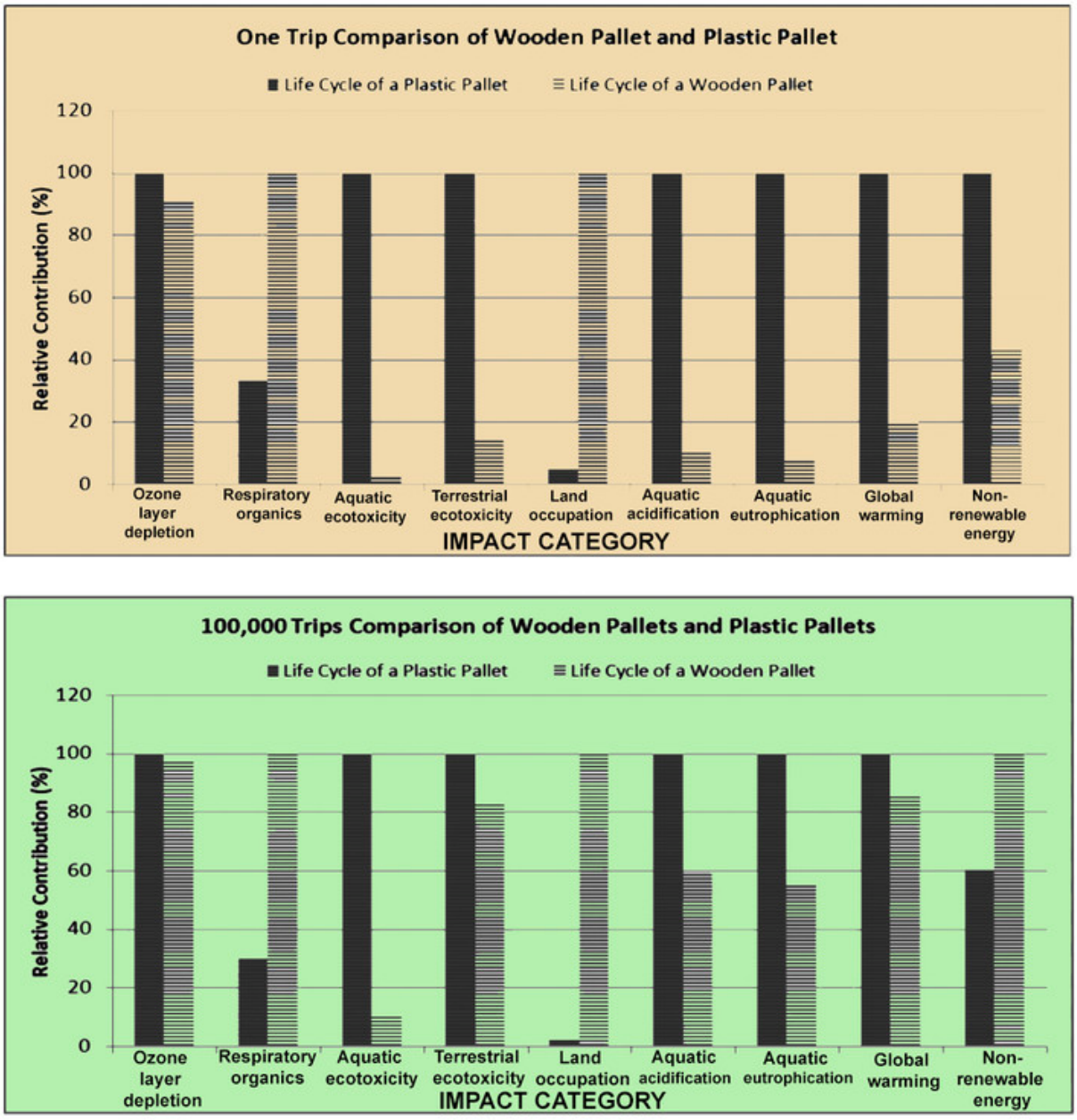


Source: Hardwood Market Report [3]

Industrial pallets are used throughout the world to transport goods in supply chains, from producers and distributors to retailers and consumers. According to Chuck Ray, associate professor of ecosystem science and management in the College of Agricultural Sciences at Penn State, "There are 2 billion pallets in use in this country."[4] Perhaps because it is such a large market, there are a variety of materials that are competing for use in the manufacture of pallets. And according to an article in Hardwood Review Express April 24, 2020 [5], claims that plastic pallets were more environmentally friendly inspired Penn State researcher, Chuck Ray, to conduct "the first academic, peer-reviewed study to compare life-cycle environmental impact of different pallets in use, and it was performed without external funding that could potentially bias the findings."

The findings were published in the Journal of Industrial Ecology and showed that across nine impact categories and on the basis of 1 and 100,000 trip scenarios, hardwood pallets were more environmentally friendly than plastic pallets. The nine impact categories included: influence on ozone layer depletion, respiratory organics, aquatic ecotoxicity, terrestrial ecotoxicity, land occupation, aquatic acidification, aquatic eutrophication, global warming and non-renewable energy.

Figure 3: Impacts of Wood vs Plastic Pallets

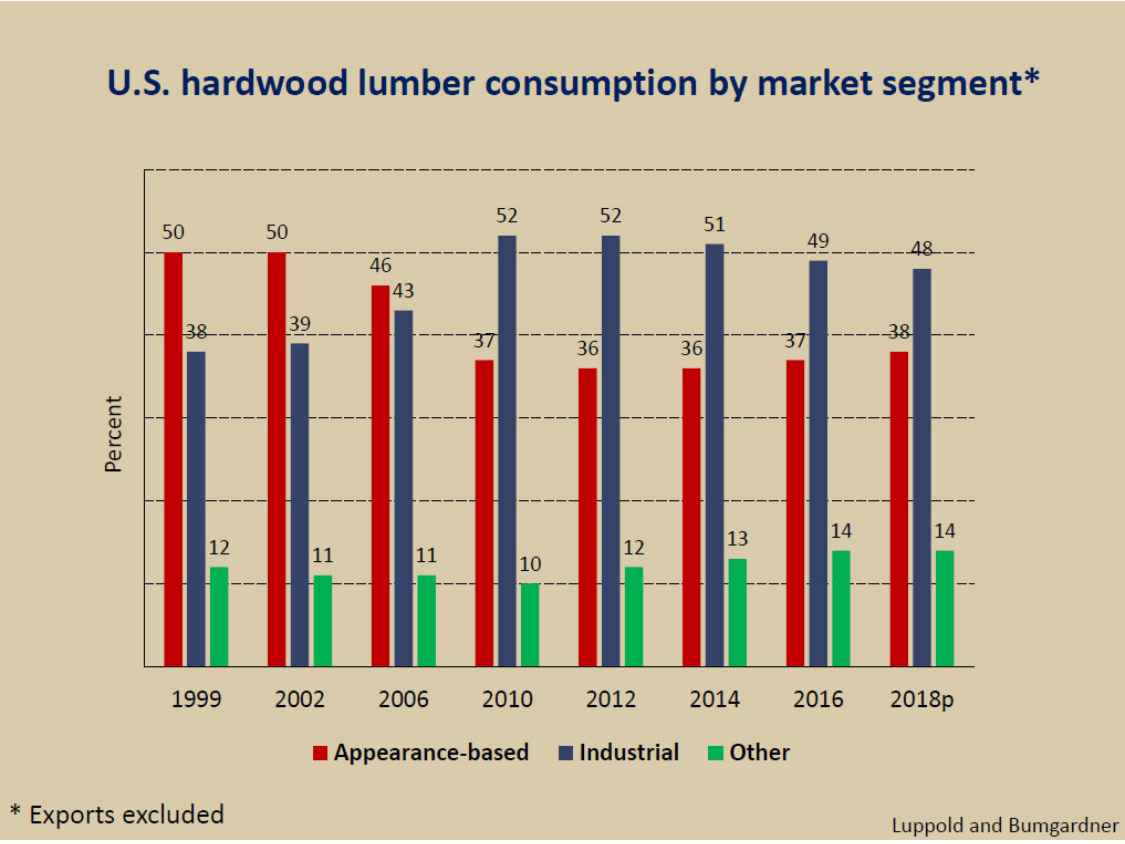


Source: Penn State [4]

Considering the single-use comparison, overall carbon footprint of using hardwoods was 80.3% lower than plastic during their life cycle and given a 166 kg CO_2equivelent Global Warming Potential per plastic pallet[6] we can calculate the amount of carbon that would be saved from the atmosphere if all of the industrial board feet harvested from Indiana's State Forests were used to create hardwood instead of plastic pallets. State Forest timber production could create about 306,383 pallets annually using a standard measure of 23.5 board feet per pallet is used. [7] If these pallets replaced plastic pallets then, beyond all the other positive environmental impacts, 40,840 metric tons of CO_2 would be saved from the atmosphere. This is equivalent of removing 8,878 cars from the road. [8]

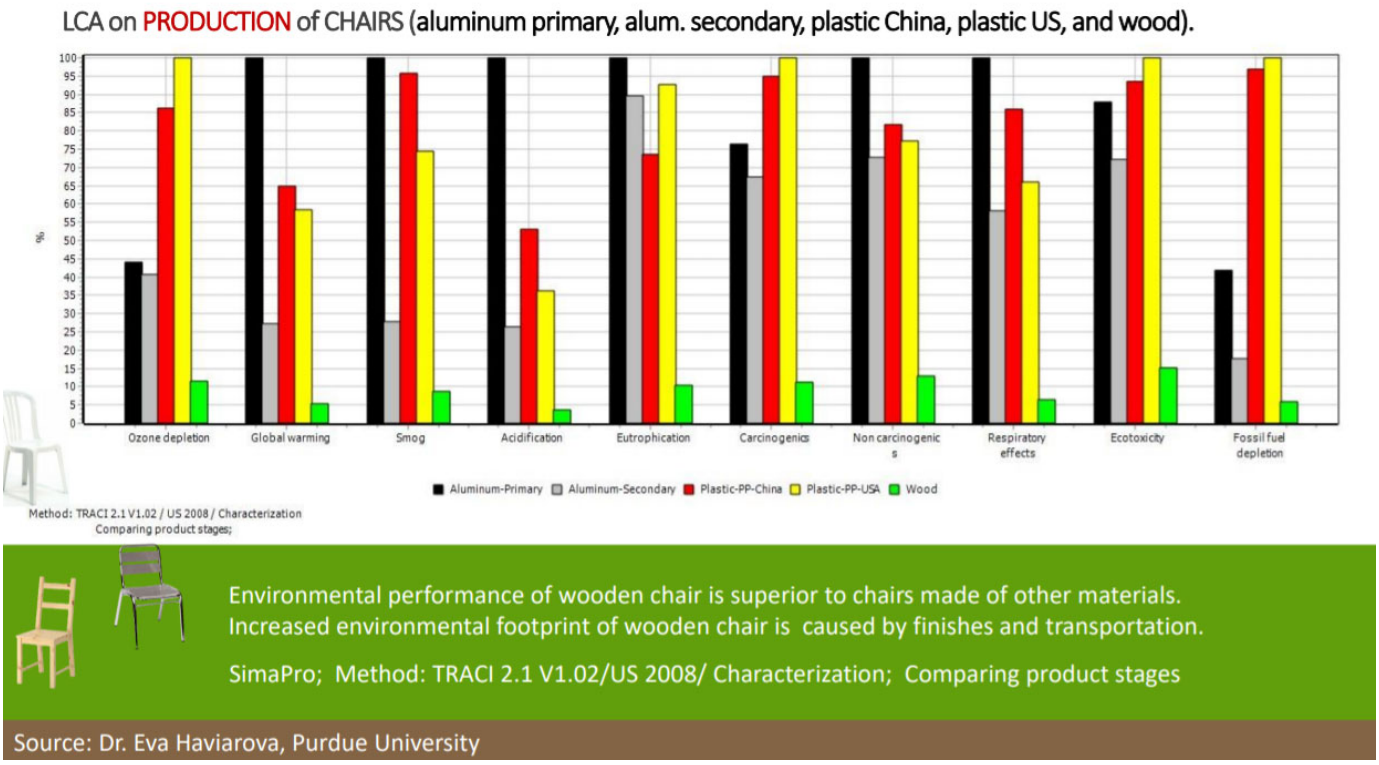
The other major component of hardwood production from Indiana State Forests is grade lumber. Again, using the planned harvest rates of 12 MMB and statistics above, about 6.2 MMBF of grade lumber would be produced in a given year from State Forest harvests. Grade lumber will be used in the manufacture of a large number of products including: flooring, millwork, kitchen cabinets, office furniture and upholstered furniture. Here, however, we will focus on wood furniture, an important segment of grade lumber supply chain that Purdue University has conducted life cycle analysis research upon. Wood furniture is second only to kitchen cabinets in the Appearance grade market segment (see Figure 4) in terms of its hardwood lumber consumption in the United States (9)

Figure 4: Appearance-based vs. Industrial and Other segments



Dr. Eva Haviarova, Professor of Wood Products and project leader at the Wood Research Laboratory at Purdue University's Department of Forestry and Natural Resources describes life cycle assessment as "a tool designed to quantify and evaluate a broad scope of environmental impacts from the selected life cycle of a given product. Life Cycle Assessment is one of the significant ways for the wood industry to promote the environment-friendly property of wood with scientific evidence." The Wood Research Laboratory has done a lot of work on life cycle assessment, including an online calculation tool to compare materials, all available here: https://www.purdue.edu/woodresearch/lca-on-furniture/

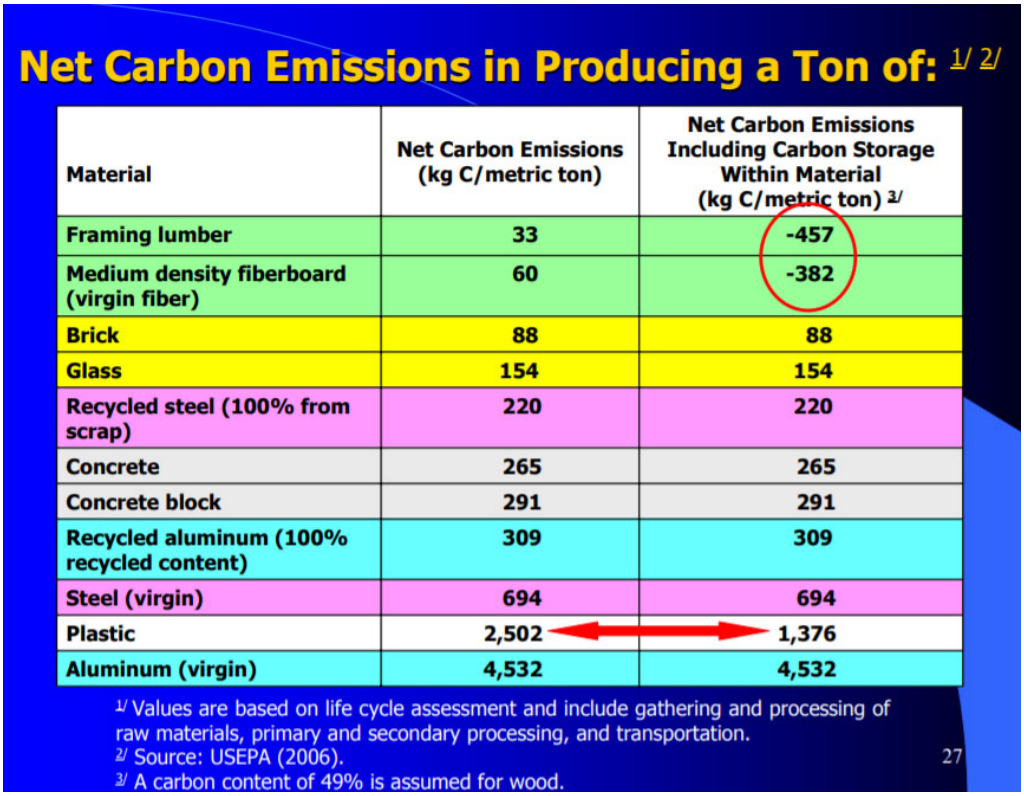
Figure 5: Wood Research Laboratory's life cycle assessment comparison of chairs by material type



Here we see that again hardwood outperforms by a long measure other materials across a broad range (10) of environmental impacts. A chair produced from wood has 95% less global warming impact than a chair produced from aluminum and about 60% less impact than does a plastic chair.

Similar to our example with industrial lumber, we can expand on the amount of carbon potentially saved from the atmosphere by using hardwood in grade lumber applications by using the numbers provided in the figure below.

Figure 6: Carbon emissions by material



Net Carbon Emissions in Producing a Ton of: 1/ 2/

Material	Net Carbon Emissions (kg C/metric ton)	Net Carbon Emissions Including Carbon Storage Within Material (kg C/metric ton) 3/
Framing lumber	33	-457
Medium density fiberboard (virgin fiber)	60	-382
Brick	88	88
Glass	154	154
Recycled steel (100% from scrap)	220	220
Concrete	265	265
Concrete block	291	291
Recycled aluminum (100% recycled content)	309	309
Steel (virgin)	694	694
Plastic	2,502	1,376
Aluminum (virgin)	4,532	4,532

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).
3/ A carbon content of 49% is assumed for wood.

27

Source: Dovetail Inc. (11)

Using the kiln dried weight of our most common hardwood species, red oak, 5.25 pounds per board foot (12), we can assume that the 6.2 MMBF grade lumber would weigh about 16,275 tons and because lumber replacing plastic as a raw material would save 2.47 tons of carbon or about 9 metric tons of CO_2E per ton about 146,475 tons of CO_2E could be reduced if wood were used over plastic. This is equivalent to removing 31,842 cars from the road. We realize that this example is a simplistic illustration and does not account for exact products being accounted for with specific supply chains. That is why life cycle analysis and the life cycle assessments referenced above are so important and why we should strive for the broadest measures of environmental impact and the most exhaustive science to guide us in selecting materials for building a society that is the most sustainable possible.

US wood products are legally harvested and sustainable. Consider these facts assembled by AHEC about sustainability:

According to the United States Department of Agriculture (USDA):

- Between 1953 and 2012 the volume of U.S. hardwood growing stock increased from 5.2 billion cubic meters (m3) to 12.0 billion m3, a gain of over 130%.
- Between 2007 and 2012, the volume of hardwood standing in the U.S. increased at a rate of 124 million m3 a year (even after harvesting and natural mortality is taken into account) – that's about 4 m3 every second.
- U.S. hardwood forests are aging and more trees are being allowed to grow to size before being harvested – the volume of hardwood trees with diameters 48 cm or greater increased nearly four-fold from 0.73 billion m3 in 1953 to 2.7 billion m3 in 2012.

- The total area of hardwood and mixed hardwood-softwood forest types in the U.S. increased from 99 million hectares in 1953 to 111 million hectares in 2012. This area increased consistently throughout the 60-year period and continued at a rate of 401,000 hectares per year between 2007 and 2012 – that's equivalent to adding an area the size of a soccer pitch every minute.

Adapted from https://www.americanhardwood.org/en/environmental-profile/sustainability

Societies need materials to make products for consumption and commerce. It makes sense that in societies that are increasingly concerned about reducing environmental impact, wood should be embraced as a sustainable choice. Through its management of the Indiana State Forest System, the Division of Forestry provides for the future of Hoosiers' state-owned woodlands and through good husbandry protects the wildlife and forest resources while providing Indiana companies the sustainable building materials required in these environmentally conscious times.

References:

(1) Indiana Code 14-23-4-1 Title 14: Natural and Cultural Resources, Article 23: Forestry, Chapter 4: State Forest Management, Section 1: Legislative Intent, accessed 5-26-20
(2) Division of Forestry, Utilization Specialist, personal communication, 1/27/20
(3) Presentation: US Hardwood Markets, The Good, the Bad, and the Ugly, Prepared for OFA, March7, 2019, David Caldwell, Hardwood Market Report, Memphis, TN
(4) Wooden or plastic pallets: Which are more eco-friendly? By Jeff Mulhollem, February 03, 2020 https://news.psu.edu/story/606589/2020/02/03/research/wooden-or-plastic-pallets-which-are-more-eco-friendly last accessed (5/26/20)
(5) Life Cycle Analysis: Wood Pallets "Greener" than Plastic, Hardwood Review Express, April 24, 2020, Tony Burbank
(6) Wooden and Plastic Pallets: A Review of Life Cycle Assessment (LCA) Studies, Ivan Deviatkin, Musharof Khan, Elizabeth Ernst and Mika Horttanainen, October 17 2019, https://www.mdpi.com/2071-1050/11/20/5750/pdf last accessed 5/26/20
(7) What's In a Board Foot? Pallet Enterprise, Ed Brinley, 12/1/06 https://www.palletenterprise.com/articledatabase/view.asp?articleID=2108, last accessed 5/26/20
(8) A typical passenger vehicle emits about 4.6 metric tons of carbon dioxide per year according to the EPA. https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle last accessed 5/26/20
(9) Hardwood Lumber Production, William Luppold and Matthew Bumgardner, https://www.nrs.fs.fed.us/pubs/gtr/gtr-p-24%20papers/18luppold-p-24.pdf last accessed 5/26/20
(10) Life Cycle Assessment (LCA) on Furniture, Purdue University, Wood Research Laboratory, Department of Forestry and Natural Resources https://www.purdue.edu/woodresearch/lca-on-furniture/
(11) Carbon in Harvested Wood Products, Jim Bowyer, Dovetail Partners, Inc., Minneapolis, MNhttps://dovetailinc.org/workshop_materials/bowyercarbonconf3.pdf last accessed 5/26/20
(12) Red oak weighs 5,250 pounds per 1,000 board feet http://www.globalwood.org/tech/tech_wood_weights.htm last accessed 5/26/20