Cross Laminated Timber Manufacturing, Use, and Research: Progress in Low Grade Appalachian Hardwoods

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Outline

Research & Demonstration Update

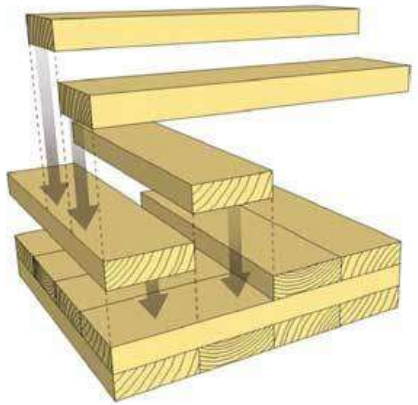
Commercial Development – Hardwoods?

- **HWD CLT Disadvantages**
- **HWD CLT Advantages**
- **Advancing HWD CLT Potential**

INTRODUCTION

Cross Laminated Timber

- Utilization of **local species** will grant sustainability to the region and consequently establish CLT panels worldwide (1).
- The Appalachian Region has a positive growth/harvest ratio of **2.45**, increasing 300,000 acres in the last 25 years (2). A diverse region with over 50 trees species, which more than **20 species** can be used commercially (3).



References:

(1) Brandner, R. (2013) Production and technology of cross laminated timber (CLT): a state-of-the-art report. In: Harris R, Ringhofer A, Schickhofer G (eds) Focus solid timber solutions—European conference on cross laminated timber (CLT). The University of Bath, Bath.

(2) Oswalt, S. N., Brad Smith, W., Miles, P. D., Pugh, S. A., & Brad, W. (2014). Update of the 2010 RPA Assessment. Washington.

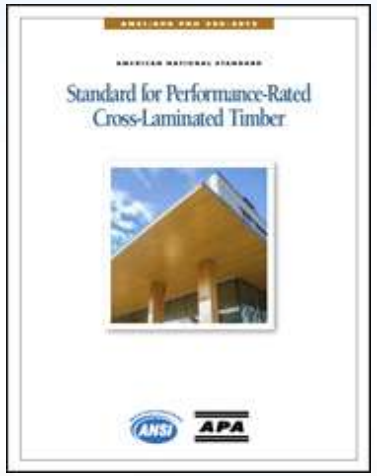
(3) Miller, G. W., & Kochenderfer, J. N. (1998). Maintaining Species Diversity in the Central Appalachians. Journal of Forestry, (July), 28–33.

Cross Laminated Timber – Board specifications

- **Species restriction**
  - ANSI/APA PRG 320-2018 *Standard for Performance-Rated Cross-Laminated Timber covers CLT use in North America*
  - ***Hardwoods are not specified in current PRG 320 standard****
- **Boards dimensions, width, thickness, length**
  - Major direction – width not less than 1.75x thickness
  - Minor direction – width not less than **3.5x thickness**
  - Thickness not less than **5/8 inch (16mm)** or more than 2 inches (51mm)

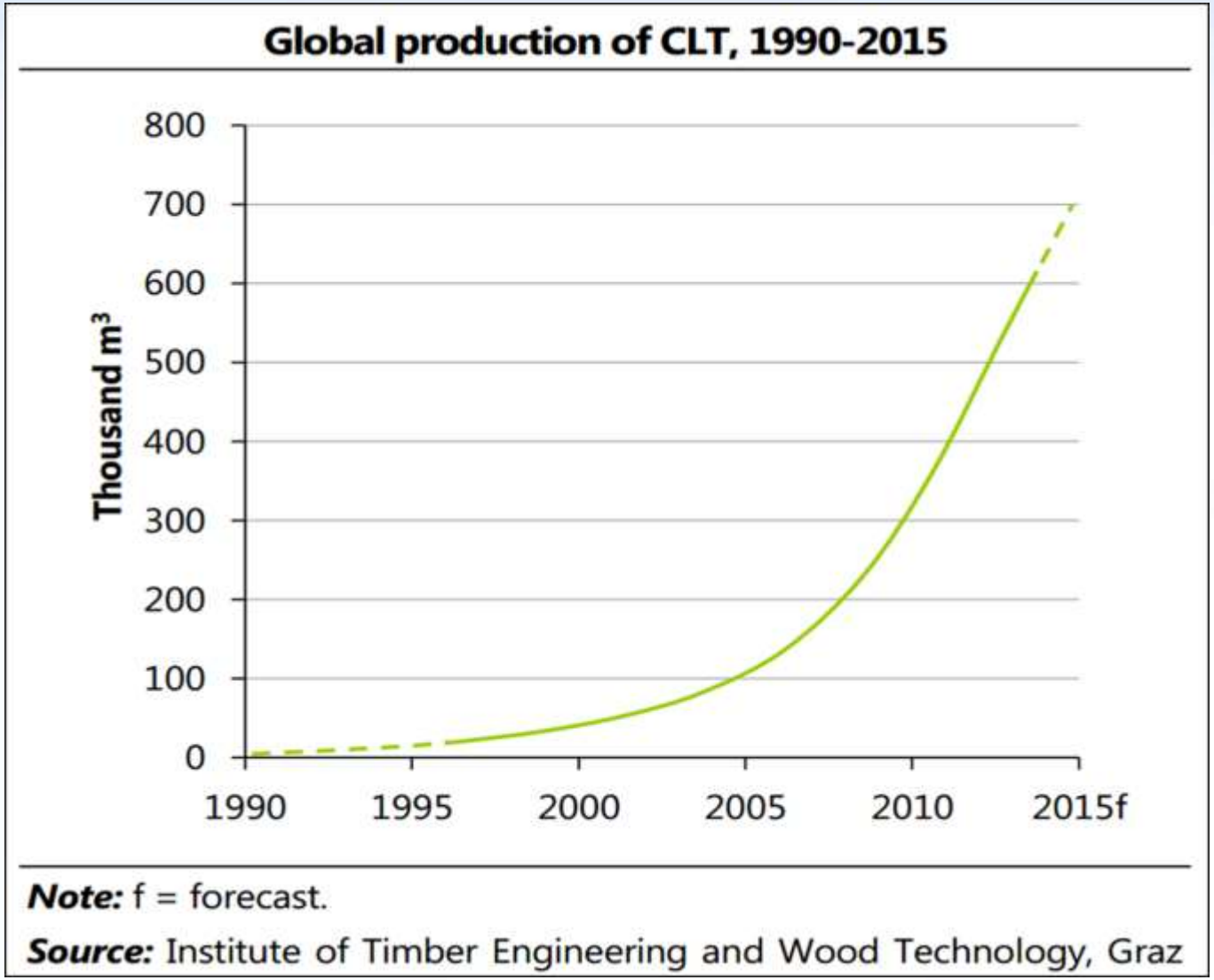
Cross Laminated Timber – Board specifications

- **Visual grade**
  - Major direction - #2 (Structural grading, e.g. NeLMA)
  - Minor direction - #3 (Structural grading, e.g. NeLMA)
- **MSR grade** (PRG 320, C16, and C24)



	PRG 320	C16	C24
Specific Gravity	0.35	0.31	0.35
MOE mean		1.276×10^6 psi (8,800 MPa)	1.566×10^6 psi (10,800 MPa)
MOE min	**1.2×10^6 psi** (8,273 MPa)	0.841×10^6 psi (5,800 MPa)	1.044×10^6 psi (7,200 MPa)

INTRODUCTION



Nabholz Constructing the Largest Cross-laminated Timber project in United States

Courtesy of Leers Weinzapfel Associates, Modus Studio, Mackey Mitchell Architects

https://www.nabholz.com/cross-laminated-timber-project-america-nabholz/

Outline


Research Update


Commercial & Development – Hardwoods?

- HWD CLT Disadvantages
- HWD CLT Advantages
- Advancing HWD CLT Potential

Recent CLT Efforts at WVU

2012: Development of Low-Grade Hardwood Cross-Laminated Timbers (USDA/NIFA: Led by Virginia Tech, WVU – Adhesion) – *Dr. DeVallance & Daniel Hovanec*

2014: Demand and Product Innovations for Green Products Sourced from Appalachian Hardwoods (USDA FS - WERC) - *Dr. DeVallance & Rafael Azambuja*

2014: Evaluating low-grade, mixed Appalachian hardwoods for mechanical and adhesive properties required to produce CLT panels (WVU Hardwood Research Trust) – *Dr. DeVallance & Rafael Azambuja*

2017: Producing CLT Panels from Low Value Appalachian Hardwoods, Part 1 (USDA FS - WERC) – *Drs. McNeel, Hassler, and DeVallance*

2018: Producing CLT Panels from Low Value Appalachian Hardwoods, Part 2 (Funded - USDA FS - WERC) – *Drs. DeVallance, Hassler, and McNeel*

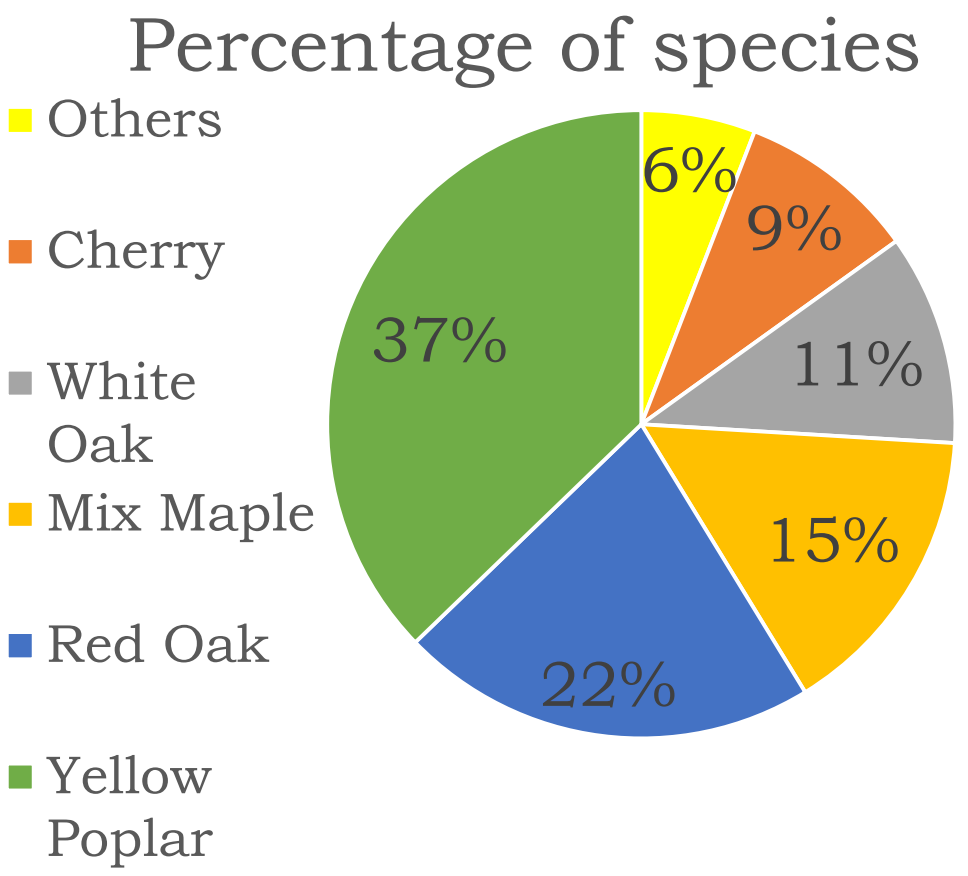
RESEARCH EFFORTS

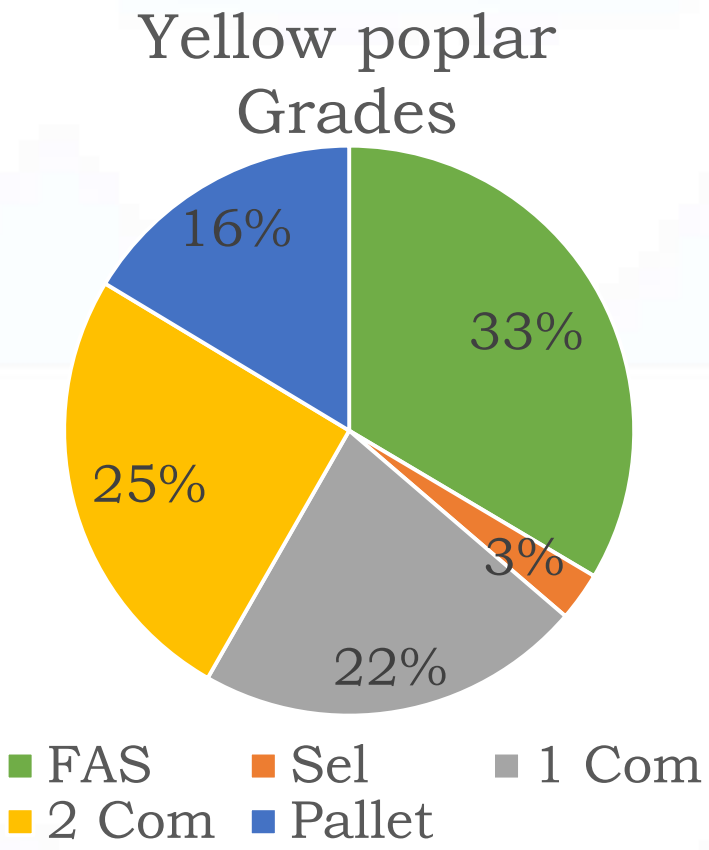
General Objectives

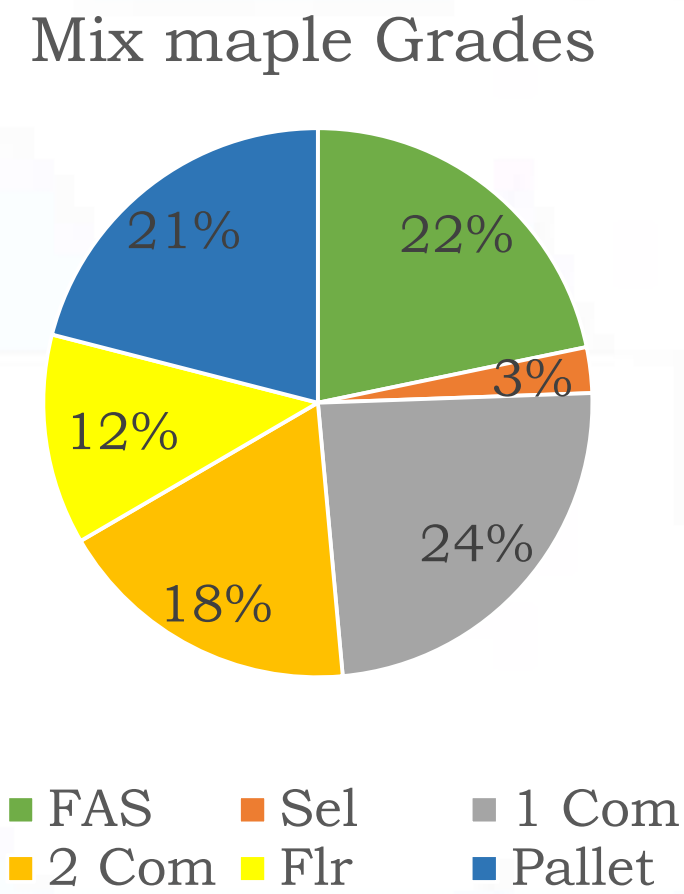
- Determine which species from the Appalachian region have the most potential to be used in production of CLT panels (on-going)
- From these species determine the available dimension and grade of the boards to be used in CLTs production (on-going)
- Determine the structural lumber grade within low-grade hardwoods that can be effectively used in manufacturing CLT (on-going)
- Evaluate optimized CLT panel lay-up from low-grade lumber (on-going)
- Demonstrate hardwood CLT production technology (planned)
- Demonstrate hardwood CLT use (planned)

RESEARCH EFFORTS: Preliminary Mill Data

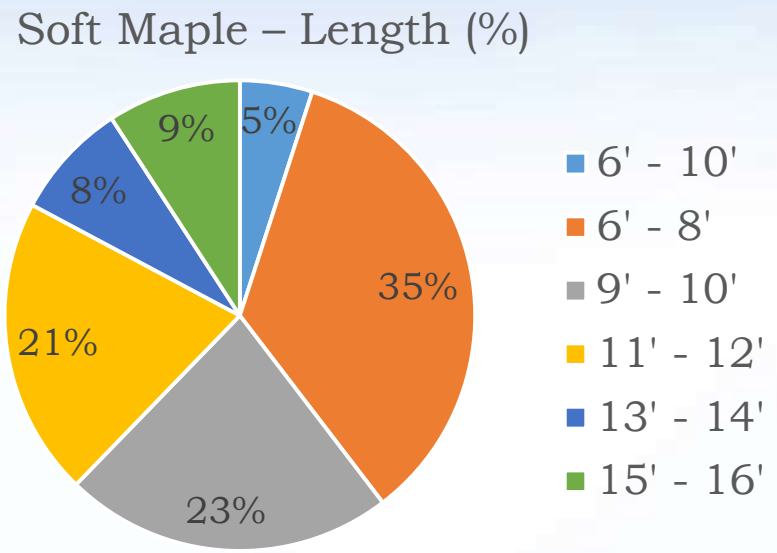
Yellow-poplar and maple are species of interest based on preliminary research

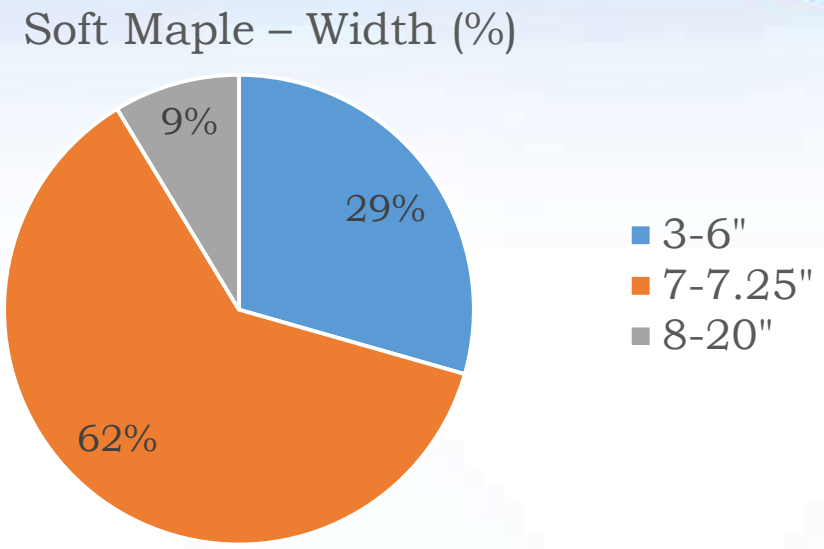


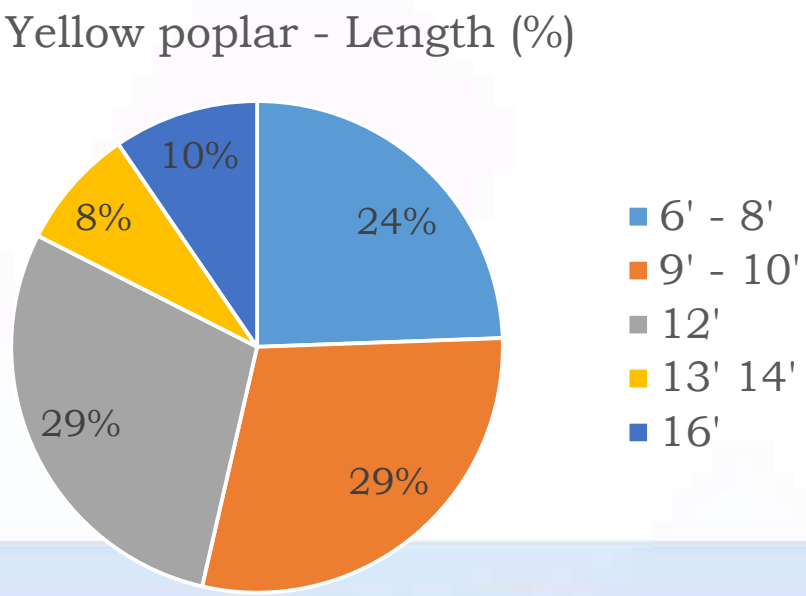


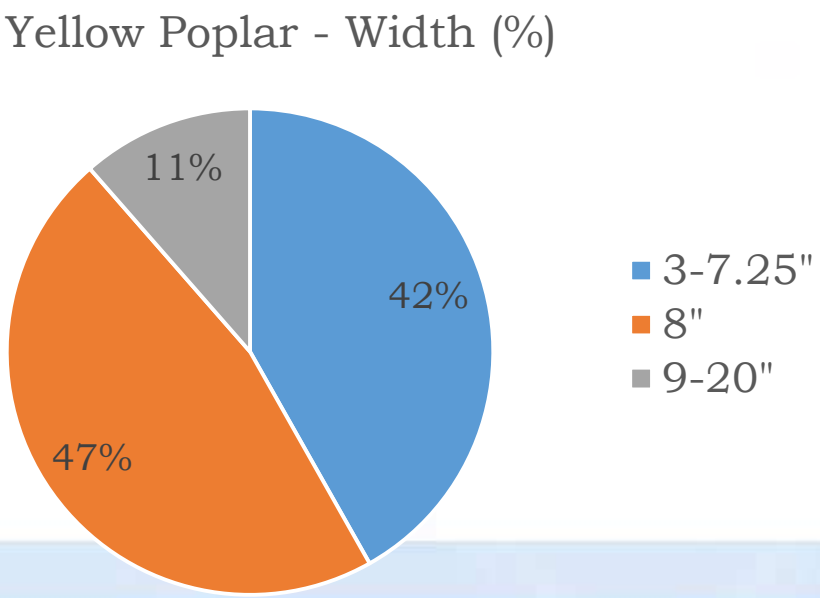


RESEARCH EFFORTS: Length and Width Category









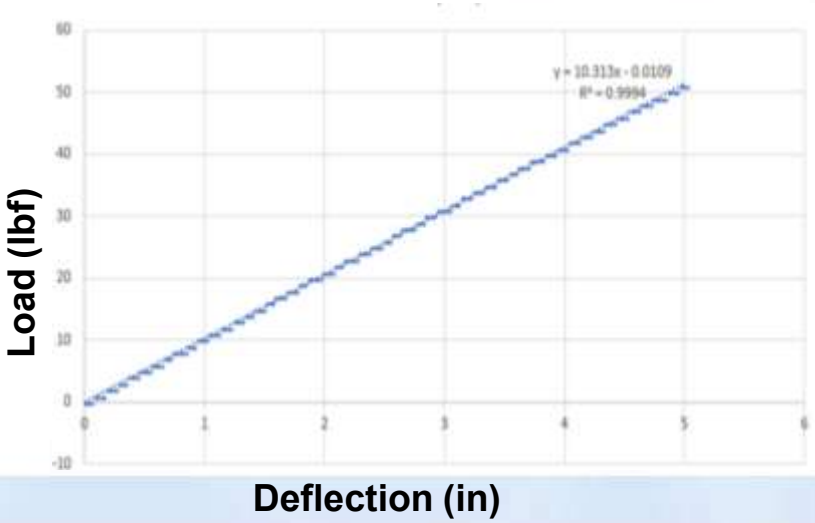
RESEARCH EFFORTS: Phase 1: Structural Grades

Vibration and Machine Stress Rating (MSR)

- NHLA grades are not structural grades
- Yellow-poplar and Red maple #2 Common NHLA graded boards were evaluated for structural property distribution
- Modulus of Elasticity (MOE) was evaluated using transvers vibration and MSR Proof loading

Vibration evaluation

Proof Loading

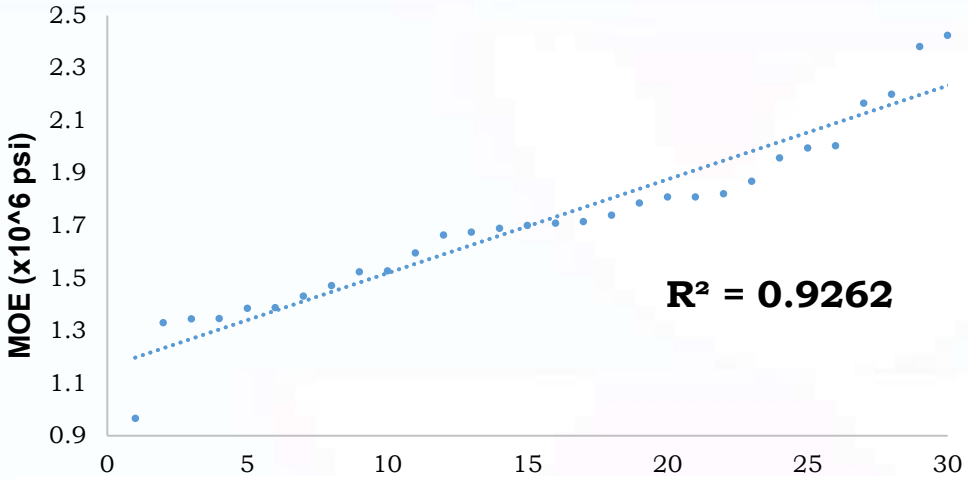


RESEARCH EFFORTS: Phase 1: Structural Grades

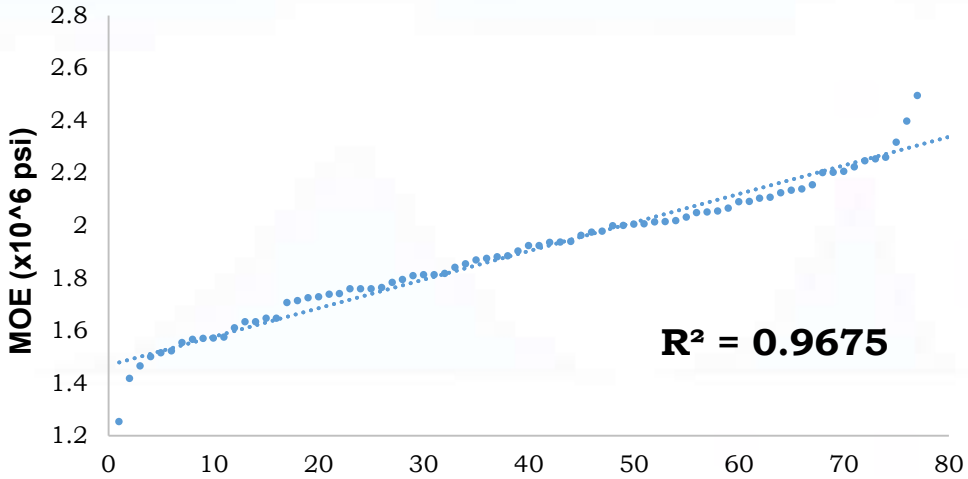
Proof Load MOE

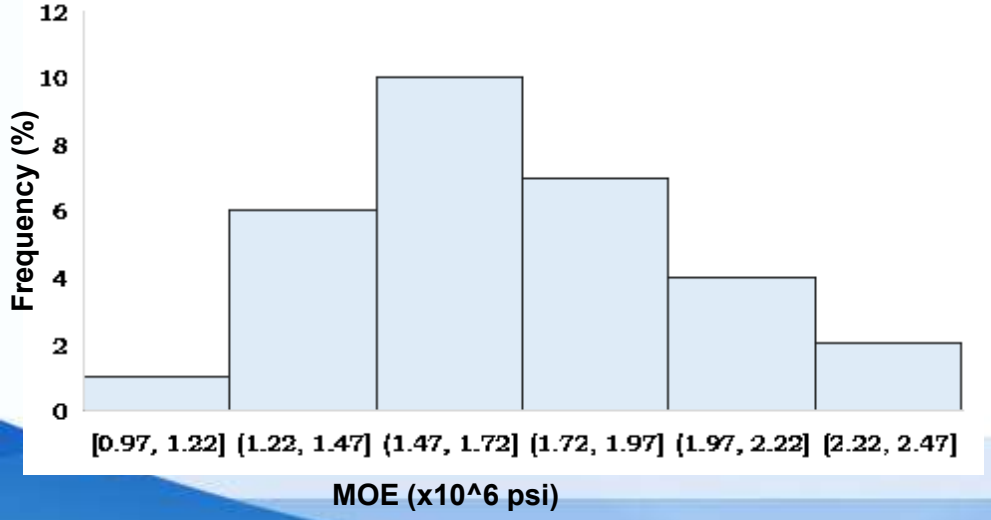
	MOE (10^6 psi)	
	YP - PL	RM -PL
Mean	**1.71**	**1.89**
Median	1.71	1.90
Kurtosis	0.30	-0.29
Skewness	0.25	-0.07
Minimum	0.97	1.25
Max	2.42	2.50
5th	**1.34**	**1.51**
40%	1.67	1.82

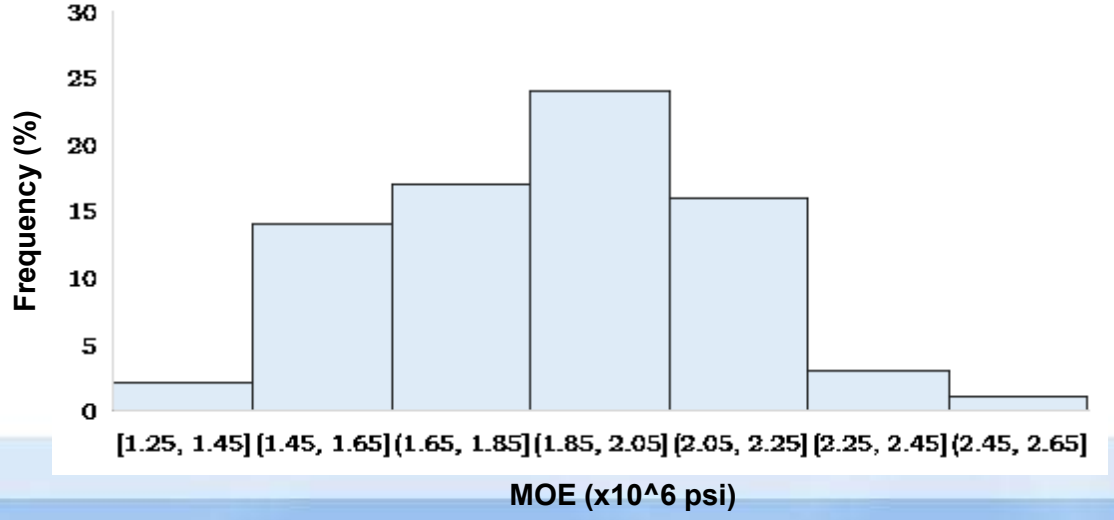
YP - PL



RM - PL







RESEARCH EFFORTS: Structural Grades

MOE results compared favorably to laminations used in commercially available softwood CLTS

Table 3 - CrossLam® CLT Allowable Design Properties for Laminations [1]

CLT Grade	Major Strength Direction						Minor Strength Direction					
	$F_{b,0}$ (psi)	$E_{,0}$ (10^6 psi)	$F_{t,0}$ (psi)	$F_{c,0}$ (psi)	$F_{V,0}$ (psi)	$F_{s,0}$ (psi)	$F_{b,90}$ (psi)	E_{90} (10^6psi)	$F_{t,90}$ (psi)	$F_{c,90}$ (psi)	$F_{V,90}$ (psi)	$F_{s,90}$ (psi)
V2.1	875	1.4	450	1150	135	45	500	1.2	250	650	135	45
V2M1.1	875	1.4	450	1150	135	45	875	1.4	450	1150	135	45
E1M4	2100	1.8	1575	1875	160	50	500	1.2	250	650	135	45
E1M5	2100	1.8	1575	1875	160	50	875	1.4	450	1150	135	45

Notes:

1. Tabulated values are allowable design values and not permitted to be increased for the lumber size adjustment factor in accordance with the NDS.
2. The CLT grades are developed based on APA Product Report PR-L314. Please refer to specific grade layups for complete panel information.
3. The design values shall be used in conjunction with the section properties provided by the CLT manufacturer based on the actual layup used in manufacturing the CLT panel (see tables above).
4. Values are calculated per 1 foot wide section of panel.
5. The panel weight is based on SPF lumber values in the 2015 NDS.

CrossLam® Design Guide v4.0 - USA 19

http://www.structurlam.com/wp-content/uploads/2016/10/US-Design-Guide-2018.pdf

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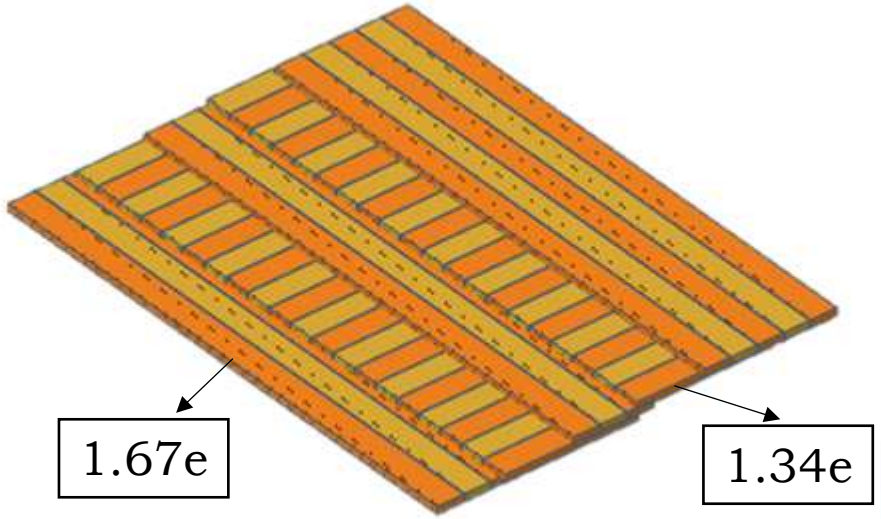
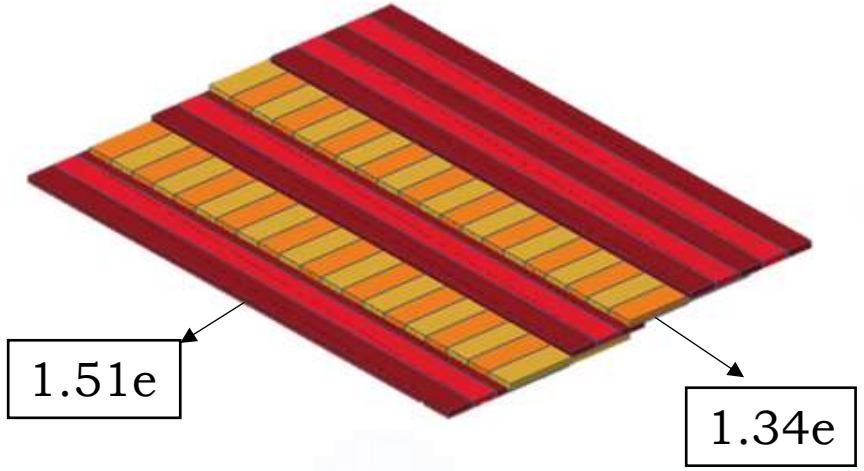
RESEARCH EFFORTS: Phase 1 Conclusions

- General information/assumptions indicted that 2 Common and 3 Common (pallet grade) hardwood lumber is 4/4 thicknesses.
- Knowing the standard require 3.5x thickness, every board above 4” in width would be acceptable to produce CLT panels.
- From available data, 99% of yellow-poplar and 95% of soft maple met this dimension criteria.
- Only 1% of yellow-poplar #2A common (NHLA graded) did not met the minimum requirement of 1.2e from PRG-320.
- Since boards are end-jointed, there are no restrictions for lengths.
- When performing an economic analysis, #2 NHLA graded hardwood lumber and #2 structurally graded softwoods should not be compared.

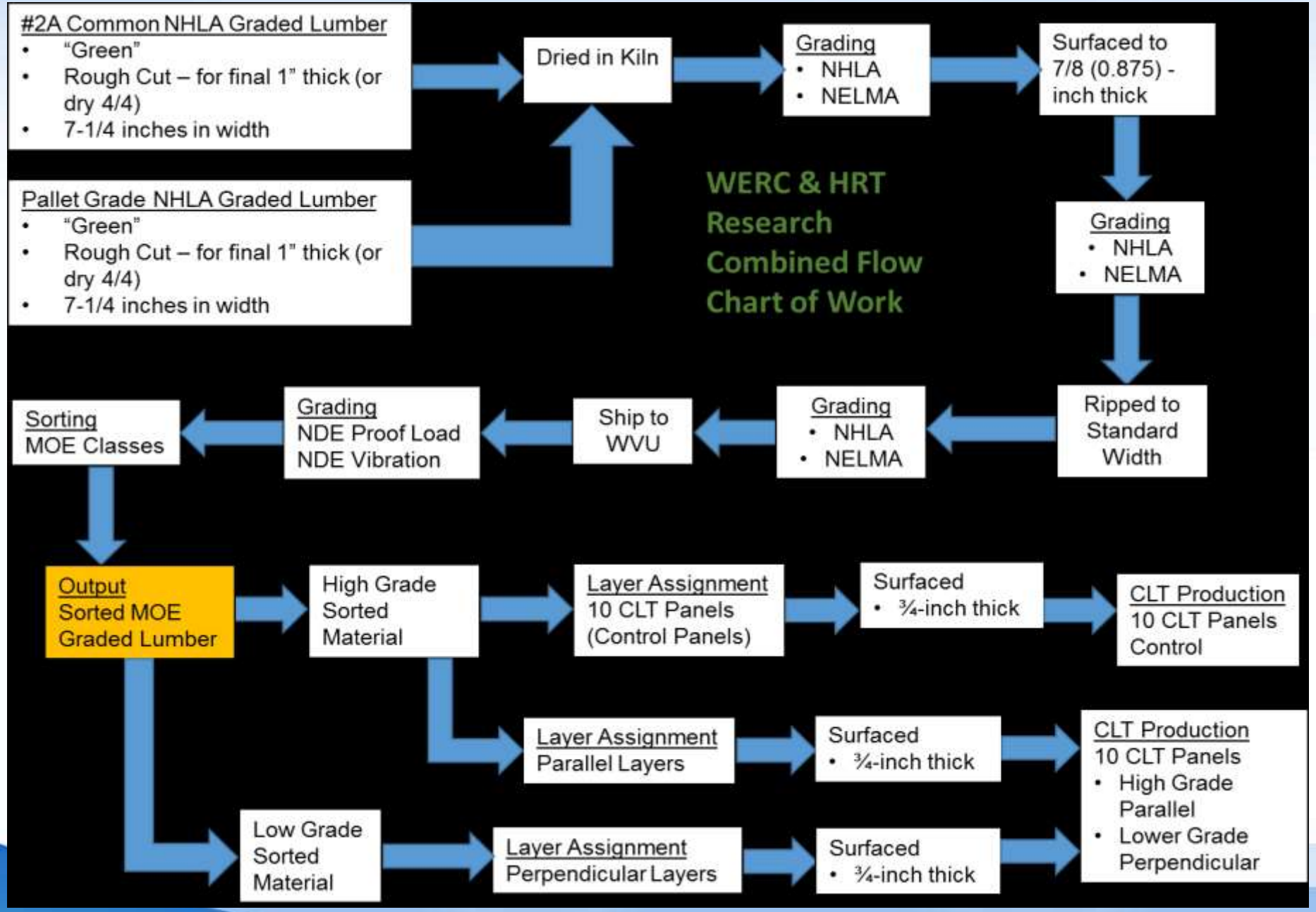
RESEARCH EFFORTS: On-going

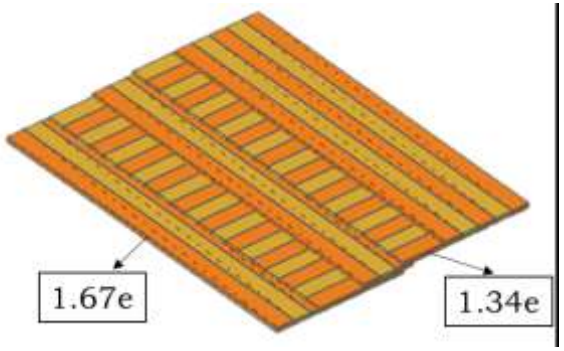
- Mill studies throughout the Appalachian Region are being conducted to determine available species and grades (WERC Wood Innovation Funding).
- Work is underway using Yellow-poplar to grade 4m bdft of 2 common and 4m bdft of 3 Common (pallet grade) lumber using NHLA, NELM, Transverse Vibration, and MSR techniques (WERC Wood Innovation Funding).
- Yellow-poplar and mixed maple are being evaluated for optimal lamination placement and to look at the influence of mixed species layering (HRT funding).





RESEARCH EFFORTS: On-going





RESEARCH EFFORTS: Wood Innovation, Part 2

Producing CLT panels from Low Value Appalachian Hardwoods: Part 2, Demonstrating CLT Panel Production, Properties, and Use

1. **Further evaluate the structural grades and suitability of No. 2A Common and lower (e.g., No. 3A Common) and pallet grade hardwood lumber within CLT panels.**
2. **Demonstrate mill based production of CLT panels using mixtures of No. 2 Common and pallet grade lumber in optimized configurations.**
3. **Provide data to further the acceptance of hardwood CLT panels under the ANSI/APA PRG 320 standards.**
4. **Perform CLT demonstration workshops and utilize hardwood CLTs within a demonstration structure at West Virginia University.**

RESEARCH EFFORTS: Other Hardwood Research

Grant Number: 2016-DG-11083150-053

Status: In Progress

Contact Information: Virginia Tech
College of Natural Resources and Environment
Department of Sustainable Biomaterials
1650 Research Tech Drive
Blacksburg, VA 24061
540-231-0978
http://www.sbio.vt.edu/

Description: The goal of this project is to provide hardwood lumber producers with information to assist them in entering the cross laminated timber (CLT) market with material produced from low value hardwoods. The goal will be accomplished by first determining manufacturing capabilities of current hardwood producers for the production of raw materials used in CLTs. Current capabilities and limitations of traditional hardwood lumber producers will be determined through a survey of industries in in the Appalachian region. Secondly, with the support of the local hardwood industry on specific procurement, manufacturing, costing and quality control procedures (such as visual strength grading), an analytical tool will be developed to assist manufacturers with making decisions for the successful production of raw materials for CLTs.

Objectives: Project objectives are: 1. Conduct a survey to determine the current technical limitations of hardwood lumber producers for the production of CLT raw materials. 2. Develop an analytical tool for hardwood lumber manufacturers to determine the best production mix of traditional lumber products vs CLT raw materials. 3. Develop and conduct workshops and other dissemination activities to inform hardwood lumber manufacturers, state, and federal organizations of the results of the project.

Keywords: Virginia, hardwoods, cross laminated timber, CLT, workshop, survey

Funding:

US Forest Service Grant	$ 208,977
Cooperative Funding	$ 112,539
Total	$ 321,516

Results: No references are available at this time.

VERC Project Management Information System (WERC-PMIS)
Version 2.0.01 released on 5/1/2018. (Database last updated 4/27/2018 by Ed Cesa.)
USDA Forest Service, State and Private Forestry, National Information Center

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Slide Courtesy of Patrick Donahue, pdonahue@d.umn.edu, University of Minnesota - Duluth

RESEARCH EFFORTS: Other Hardwood Research

Slide Courtesy of Patrick Donahue, pdonahue@d.umn.edu, University of Minnesota - Duluth

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- **HWD CLT Disadvantages**
- **HWD CLT Advantages**
- **Advancing HWD CLT Potential**

US Commercial CLT Facilities With PRG 320 Certification

SmartLam, LLC is proud to be the first manufacturer of Cross Laminated Timber products in the United States. Our focus is to develop practical, innovative, and sustainable solutions to satisfy all our customer's project requirements.

***Note: Sterling (Illinois) also makes TerraLam CLT Mats for non-structural applications

US Commercial CLT Facilities: Planned

DOTHAN, Alabama – **International Beams**, a producer of engineered wood products, announced today that it will invest nearly $20 million to open a manufacturing facility near Dothan to produce innovative timber panels and beams using Southern Pine lumber.

IB said its project will create 60 full-time jobs on a two-shift operation, with the possibility that figure could rise by 25 positions over a five-year period. Anticipated capital investment in the new facility is $19.6 million.

IB X-LAM USA Announces APA Certification of Structured Glue-Laminated Timber (GLULAM)

Dothan – June 1, 2018 – IB X-LAM USA announced that their plant in Dothan, AL has met certification requirements of APA – The Engineered Wood Association to manufacture structural glue-laminated timbers, enabling the facility to produce glulam beams and columns.

In addition to Glulam, IB X-LAM USA also plans to manufacture cross-laminated timber (CLT) at the Dothan facility. Equipment for CLT production is currently being installed and is expected to be complete in Fall 2018.

Positive Customer Impact

Many customers will benefit from the first CLT operation in the Southeast. Glulam and CLT is manufactured using sustainably farmed wood and provides significant environmental benefits over other building materials, such as concrete and steel. The CLT panels are fabricated to strict tolerances in the plant, greatly reducing labor costs on construction sites. IB X-LAM USA will offer CLT and Glulam with finish grade lamella for projects that incorporate the inherent beauty created by exposed timber that can positively affect the occupant of a space.

Katerra Announces New Mass Timber Facility

Spokane Valley, Wash. To Be Home To New Factory For Emerging Building Technology

Menlo Park, CA – September, 2017 – Katerra, a technology company redefining the construction industry, today announced its plans to open a new factory in Spokane Valley, Washington, where it will produce mass timber products including cross-laminated timber (CLT) and Glulam. Mass timber represents the future of high performance building technology as a new market for building materials that are safe, efficient, economical, and environmentally friendly.

Design-Build Giant Katerra Acquires Lord Aeck Sargent, Michael Green Architecture

The 150,000-square-foot Catalyst Building in Spokane, Washington, will be the state's first office building constructed of cross-laminated timber. It will also be connected to an energy resource sharing 'eco-district' planned for the development.

US Commercial CLT Facilities: Planned

Maine -- from Paper to Pre-Fab

On February 13, LignaCLT Maine, LLC announced plans to construct a manufacturing plant at a pre-existing paper mill facility in Millinocket, Maine. LignaCLT is planning to manufacture CLT and glulam (where lumber is glued together in the same direction) and expects to directly employ about 100 people at the $30 million facility beginning next year. Millinocket was selected because it was home to Great Northern Paper Co. for over one hundred years, and has access to the facilities that traditionally supported paper mills – hydroelectric dams (i.e. cheap power), good roads, and low-grade softwoods, primarily spruce.

LignaCLT Maine's parent company LignaTerra Global is a Charlotte, North Carolina company. On the decision to open a mass timber facility in Maine, CEO and co-founder Nick Holgorsen commented that "the type of trees that are important to the cross-laminated timber production process are plentiful here in Maine. Second, we know that Maine has a dedicated, productive workforce with timber industry experience. We see this as an opportunity to provide jobs and help communities thrive." After the closure of the Millinocket mill, the median age in town increased to 48 and median income dropped to under $30,000. The hope is that CLT can help bring people and prosperity back to the region.

Just two days later, on February 15, Montana-based SmartLam announced plans to open a second manufacturing facility in Maine. The company was awarded $3 million from the Maine Technology Asset Fund 2.0 program, and the total project cost is estimated to be $23.5 million. While site selection is still underway, the facility is expected to bring 100 direct and 200 indirect jobs to the state.

The three-year old SmartLam is growing by leaps and bounds, producing more than 12 million board feet per year of CLT at its Columbia Falls, Montana factory. To keep up with growing demand from architects and designers on the East Coast, SmartLam looked towards Maine's woodbasket for a potential second manufacturing site.

Bringing the companies to Maine required several years of work from a dozen or more non-profits, universities and community colleges. The research on wood products occurring at the University of Maine and local colleges was also a critical factor in attracting the companies.

- **LignaCLT Maine announced facility in Maine on 2/13/18 (low-grade spruce)**
- **SmartLam announced facility in Maine on 2/15/18 (assumed spruce/fir)**
- **Eastern Hemlock also potential in NE**

Commercial Hardwood CLTs?

So where does that leave US hardwoods in CLT manufacturing, specifically for construction?

Answer: Currently R&D and Demonstration only

- The American Hardwood Export Council (AHEC) presents '**The Smile**' by architect Alison Brooks for the London Design Festival…
- The Smile is a cross-laminated (CLT) tulipwood (**yellow-poplar**) structure exhibited at the Rootstein Hopkins Parade Ground of the Chelsea College of Arts, London, England…
- Endless stair: 2013 London Design Festival

Hardwood CLT Demonstrations

First Hardwood CLT Project in U.S.

TUESDAY, AUGUST 01, 2017

POSTED IN CLT , INDIANA CLT PROJECT , YUGON KIM , NHLA , NATIONAL HARDWOOD LUMBER ASSOCIATION , IKD , ARCHITECTURE , HARDWOOD ARCHITECTURE , HARDWOOD , HARDWOOD LUMBER , HARDWOOD CLT , HARDWOOD INDUSTRY , HARDWOOD FIBER , HARDWOOD SPECIES , CROSS LAMINATED TIMBER , INDIANA , INDIANA HARDWOODS , INDIANA FORESTRY , INDIANA FORESTRY INDUSTRY , ARCHITECT

In an effort to enhance awareness around using wood as an innovative building material, The United States Forest Service awarded Boston based architectural firm, IKD, $250,000 to fund the construction of the first hardwood cross laminated timber (CLT) project in the United States.

The Indiana Hardwood CLT Project uses low-grade hardwood to create a high quality CLT product that will then be used in commercial projects. NHLA is honored to have helped IKD with this project and would like to recognize NHLA board member Dave Bramlage of Cole Hardwoods for helping to secure the necessary materials for this project. Oak, Hickory, Maple, Ash and Beech

Yugon Kim (Critic, Interior Architecture) has just completed the first hardwood Cross Laminated Timber (CLT) structure in the United States for the Columbus Exhibition in Columbus, Indiana.

True or False ?

The idea is that low-value hardwood, such as grade 3 common oak, maple, and ash, can be used to create high-value Cross Laminated Timber which can then be used in commercial applications. CLT, a relatively new engineered wood product that is an incredibly strong, fireproof, lightweight alternative to steel and concrete, can be used to construct mid- to high-rise buildings in urban settings. In the United States, however, CLT is currently made only of softwoods; the hardwood variety is not available as it is in Europe. Hardwood CLT offers numerous benefits over softwood, included superior mechanical properties, material volume savings, and higher quality appearance in visible settings.

Ref: http://academicaffairs.risd.edu/2017/09/yugon-kim-completes-first-hardwood-clt-structure-and-hardwood-clt-commerical-production-in-the-united-states/

Note: This was not the first hardwood CLT timber project in the US. First funded demonstration HWD structure, however.

Hardwood CLT Buildings

WORLD'S FIRST BUILDING MADE FROM HARDWOOD CLT

Kathryn Allen
Materials World magazine, 1 Aug 2017

First used publicly in 2013, American tulipwood cross-laminated timber has been used to build a cancer support centre in Oldham, UK.

Maggie's Oldham, UK, is the world's first building made from hardwood cross-laminated timber (CLT). Located at specialist NHS cancer hospitals, Maggie's Centres provide professional support to people living with cancer. Maggie's Oldham, situated in the grounds of the Royal Oldham Hospital, is the 21st Centre to open.

Jon Cardwell – The building features a thermo-treated American ash decking.

CLT is a prefabricated wood panel, consisting of several sheets of timber layered in alternating directions to increase strength. The 27.6m3 of American tulipwood and 1.1m3 of American ash that make up Maggie's are equivalent to 55.22m3 and 2.1m3, respectively, of sawn wood prior to processing.

Growing in all 33 of the US States that host hardwoods, tulipwood is the fourth-most abundant timber in US hardwood forests. With the speed of growth greater than the level of harvesting, tulipwood is also under-exploited. It is fast-growing, naturally reseeds and is a carbon store – at the point of fabrication, having been felled, dried and transported, the tulipwood was calculated to store more CO2 than its processing and transportation had generated.

Around 70% stronger in bending than typical CLT-grade softwood, American tulipwood CLT is also light and sustainable. Planet Ark's report, Wood Housing, Health and Humanity 2015, is one of several recent studies reporting measureable health and wellbeing benefits of wood in the built environment.

2018
2017
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Outline

Research & Demonstration Update

Commercial Development – Hardwoods?

- **HWD CLT Disadvantages**
- **HWD CLT Advantages**
- **Advancing HWD CLT Potential**

DISADVANTAGES: HARDWOOD FOR CLT PANELS

- Hardwood lumber is sawn and **"face" graded for appearance**, NOT dimensionally graded for structural characteristics.
- It is **difficult to impossible to have an architect or engineer sign off on the use of hardwood CLT panels** because of the lack of structural grading standards (ANSI/APA PRG-320).
- You **can't use high quality NHLA grade lumber in hardwood CLT's** because the **cost** of the raw material will be significantly more than panels made from softwoods.
- We don't yet know if CLT panels can be made from **low grade hardwood and still compete with softwood panels** in terms of cost, utility, and grade…
- Potential issues with **adhesion** with some hardwood species.

ADVANTAGE OR DISADVANTAGE: DECAY RESISTANCE

Table 3–10. Grouping of some domestic and imported woods according to average heartwood decay resistance

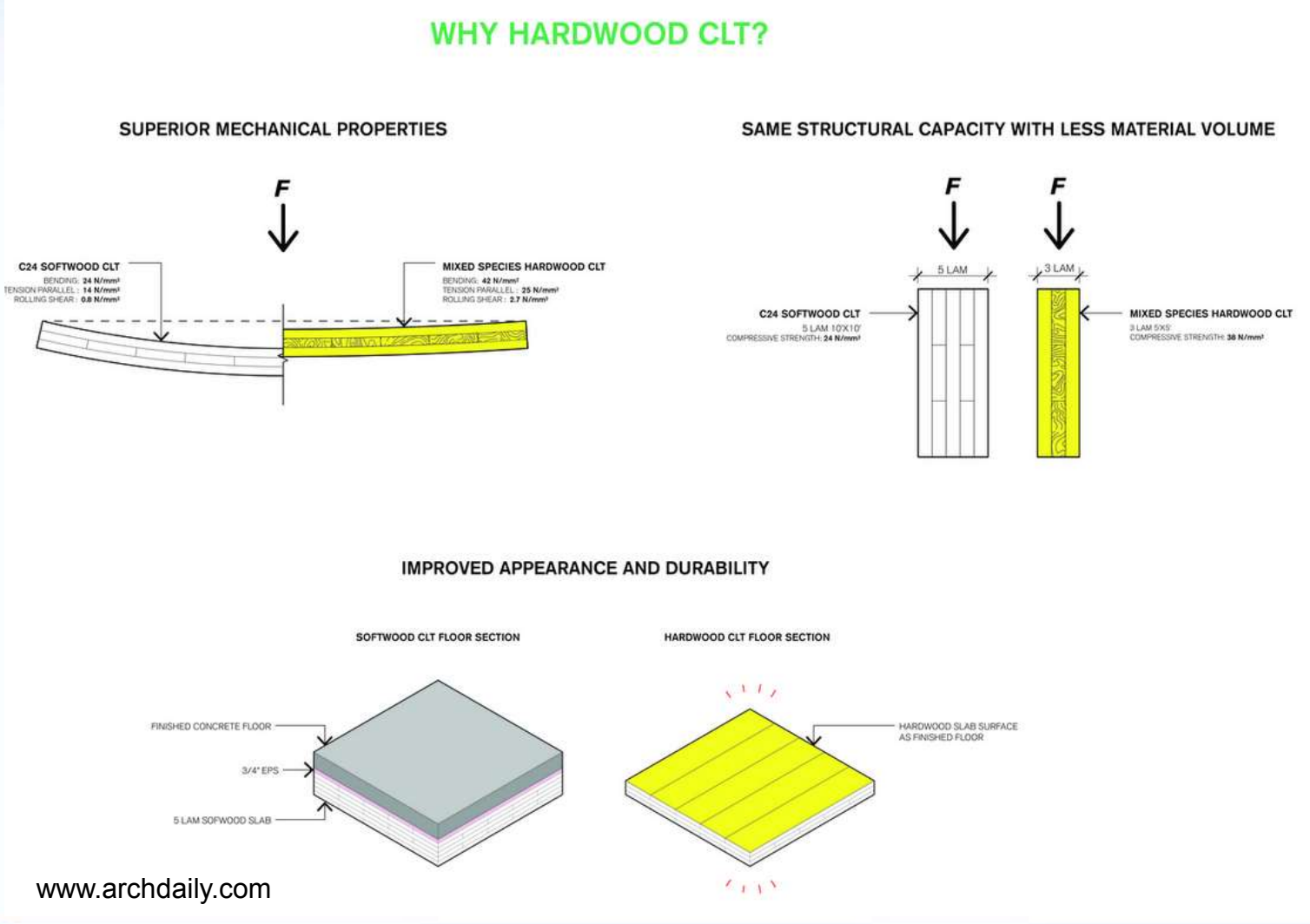
Resistant or very resistant	Moderately resistant	Slightly or nonresistant
Domestic		
Baldcypress, old growth	Baldcypress, young growth	Alder, red
Catalpa	Douglas-fir ←	Ashes
Cedar	Larch, western	Aspens
Atlantic white	Pine, longleaf, old growth	Beech
Eastern redcedar	Pine, slash, old growth	Birches
Incense	Redwood, young growth	Buckeye
Northern white	Tamarack	Butternut
Port-Orford		Cottonwood
Western redcedar		Elms
Yellow	Pine, eastern white, old growth	Basswood
Cherry, black		Firs, true
Chestnut		Hackberry
Cypress, Arizona		Hemlocks
Junipers		Hickories
Locust,		Magnolia
Black[a]		Maples ←
Honeylocust		Pines (other than those listed)[b]
Mesquite		Spruces ←
Mulberry, red[a]		Sweetgum
Oaks, white[b] ←		Sycamore
Osage orange[a]		Tanoak
Redwood, old growth		Willows
Sassafras		Yellow-poplar ←
Walnut, black		
Yew, Pacific[a]		

Source: USDA Wood Handbook

- Decay resistance varies between hardwoods and softwoods, specifically in potential CLT material

ADVANTAGES: HARDWOODS FOR CLT PANELS

- Potential to reduce material volume and meet same strength properties?



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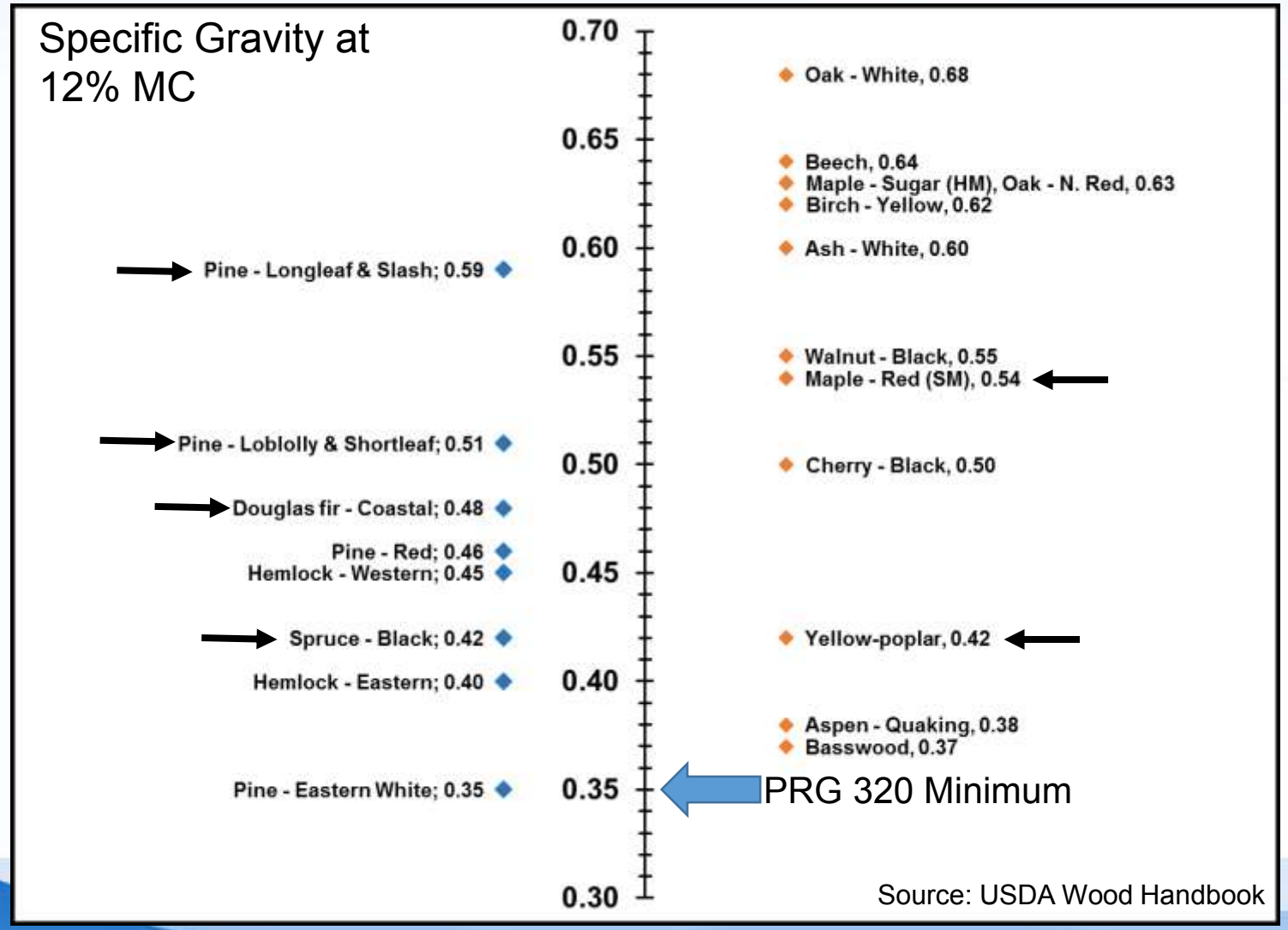
- Is this actually the case?
- Is it this simple?
- Many items need addressed, such as adhesion, machinability, processing, and strength of economically available species.

ADVANTAGE?: HARDWOODS FOR CLT PANELS

- However, available species, costs, and adhesion properties may limit the opportunity to use higher strength hardwood category species



- In some cases, hardwoods may have better strength to SG ratio
- However, much of this depends on defect location, size, species, and specific property

ADVANTAGE?: HARDWOODS FOR CLT PANELS

- Our prior research indicated yellow-poplar and combinations of red maple and yellow-poplar meet PRG 320 requirements given proper lay-up
- Some hardwoods, however, may have difficulty meeting PRG 320 adhesion requirements

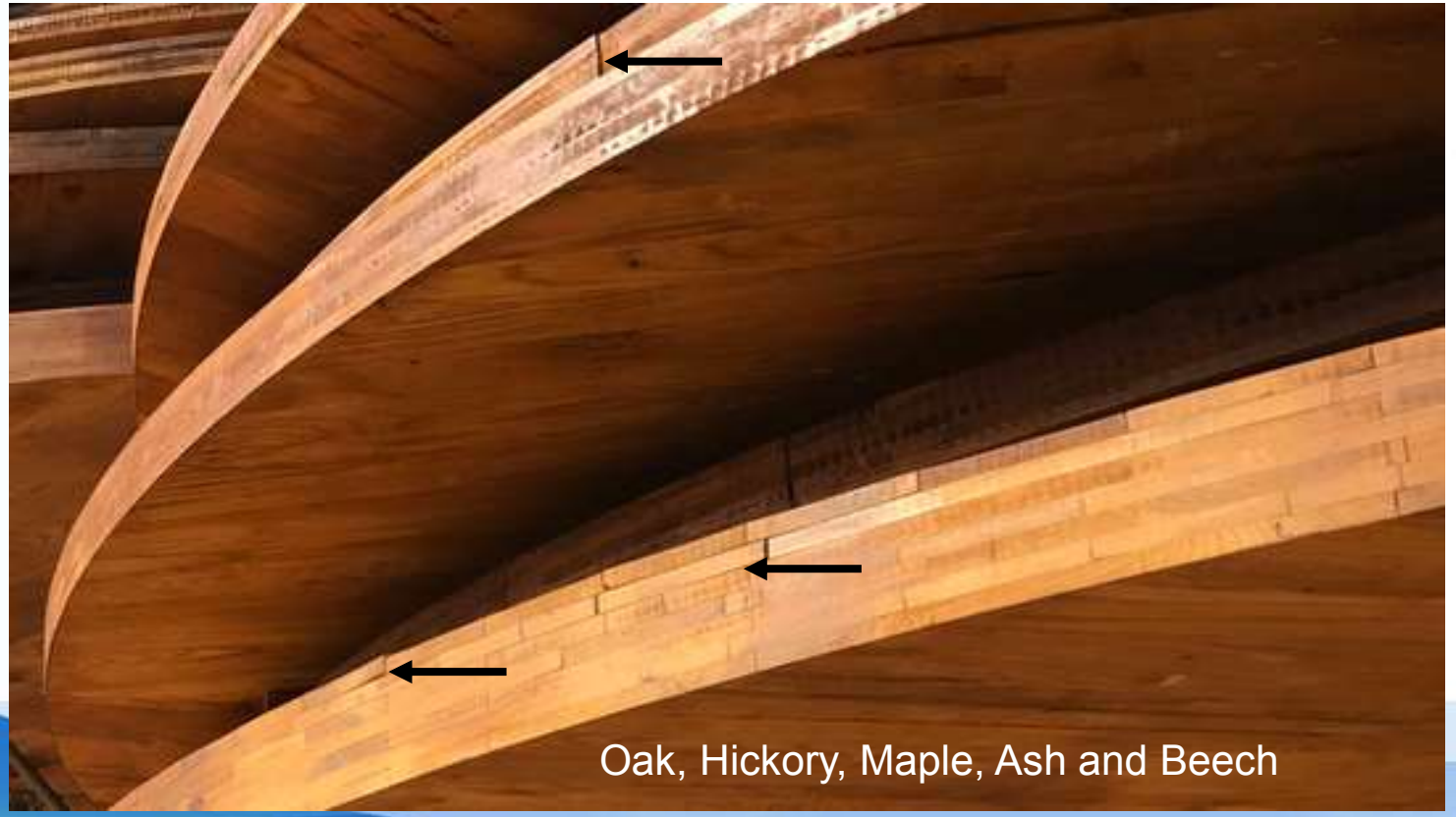


Table 10–1. Categories of selected wood species according to ease of bonding

U.S. hardwoods	U.S. softwoods	Imported woods	
Bond easily[a]			
Alder	Fir	Balsa	Hura
Aspen	White	Cativo	Purpleheart
Basswood	Grand	Courbaril	Roble
Cottonwood	Noble	Determa[b]	
Chestnut, American	Pacific		
Magnolia	Pine		
Willow, black	Eastern white		
	Western white		
	Redcedar, western		
	Redwood		
	Spruce, Sitka		
Bond well[c]			
Butternut	Douglas-fir	Afromosia	Meranti (lauan)
Elm	Larch, western[d]	Andiroba	Light red
American	Pine	Angelique	White
Rock	Sugar	Avodire	Yellow
Hackberry	Ponderosa	Banak	Obeche
Maple, soft	Redcedar, eastern	Iroko	Okoume
Sweetgum		Jarrah	Opepe
Sycamore		Limba	Peroba rosa
Tupelo		Mahogany	Sapele
Walnut, black		African	Spanish-cedar
Yellow-poplar		American	Sucupira
			Wallaba
Bond satisfactorily[e]			
Ash, white	Yellow-cedar	Angelin	Meranti (lauan), dark red
Beech, American	Port-Orford-cedar	Azobe	Pau marfim
Birch	Pines, southern	Benge	Parana-pine
Sweet		Bubinga	Pine
Yellow		Karri	Caribbean
Cherry			Radiata
Hickory			Ramin
Pecan			
True			
Madrone			
Maple, hard			
Oak			
Red[b]			
White[b]			

Source: USDA Wood Handbook

POTENTIAL OPPORTUNITIES: HARDWOOD CLT PANELS

- Our preliminary research indicates that Hardwood CLT panels could use what is viewed as **low grade appearance lumber (2 common and below),** which is produced in abundance by Appalachian sawmills.
- Current hardwood manufacturing method requires a system for **MSR and Structural Grading** to better categorize low grade appearance lumber for use in CLTs to be advanced.
- **Tremendous potential for new construction** – ranging from large commercial structures to simple two bedroom homes.
- Many medium to large capacity sawmills in Appalachia have the potential to **modify their existing operations to produce CLT panels.**
- **Capital costs** for CLT panel manufacturing are **low to moderate**, while the labor costs are generally manageable.
- Potential to produce **stronger, thinner, more durable and asthetically pleasing, and lighter weight CLT panels from hardwoods**, if hurdles and specific species are selected.

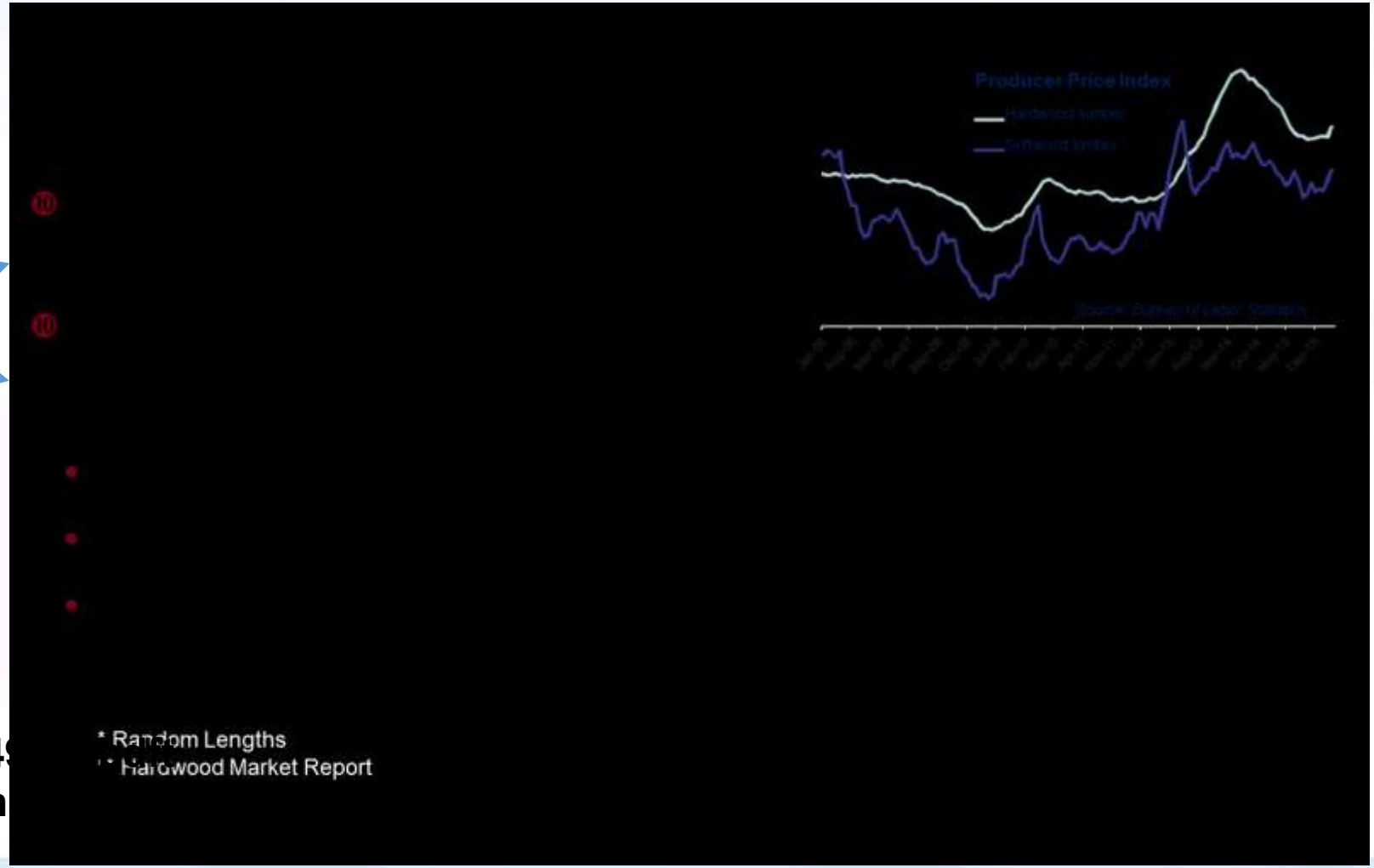
HURDLES TO CLT MANUFACTURING IN APPALACHIA

- We need a better understanding of the regional, national, and international **CLT Panel markets**.
- **Prices for the hardwood lumber** in CLT panels **need to be competitive** with softwood structural lumber, particularly with SYP!
- **Lumber grading** techniques need to **address CLT manufacturing** needs (WVU is addressing this issue through funded research).
- Hardwood lumber used for CLT panels needs to be **viewed as traditional construction lumber**, not specialty furniture/cabinet material.
- **Barriers** to inclusion of hardwoods into **PRG 320 need to be overcome** (i.e., need research and test data).
- Need to **stop comparing** economic and panel configuration comparisons of **NHLA graded hardwoods to softwood structural grades**.

Cost Considerations: Better Data Needed

- Need to **stop comparing** economic and panel configuration comparisons of **NHLA graded hardwoods to softwood structural grades**.

NOT STRUCTURALLY COMPARABLE and CHANGES FREQUENTLY



2x6 #2&btr West SPF, KD was $4
(April 13, 2018 – Random Length

Slide Courtesy of Patrick Donahue, pdonahue@d.umn.edu, University of Minnesota - Duluth

HARDWOOD PROCUREMENT QUESTIONS

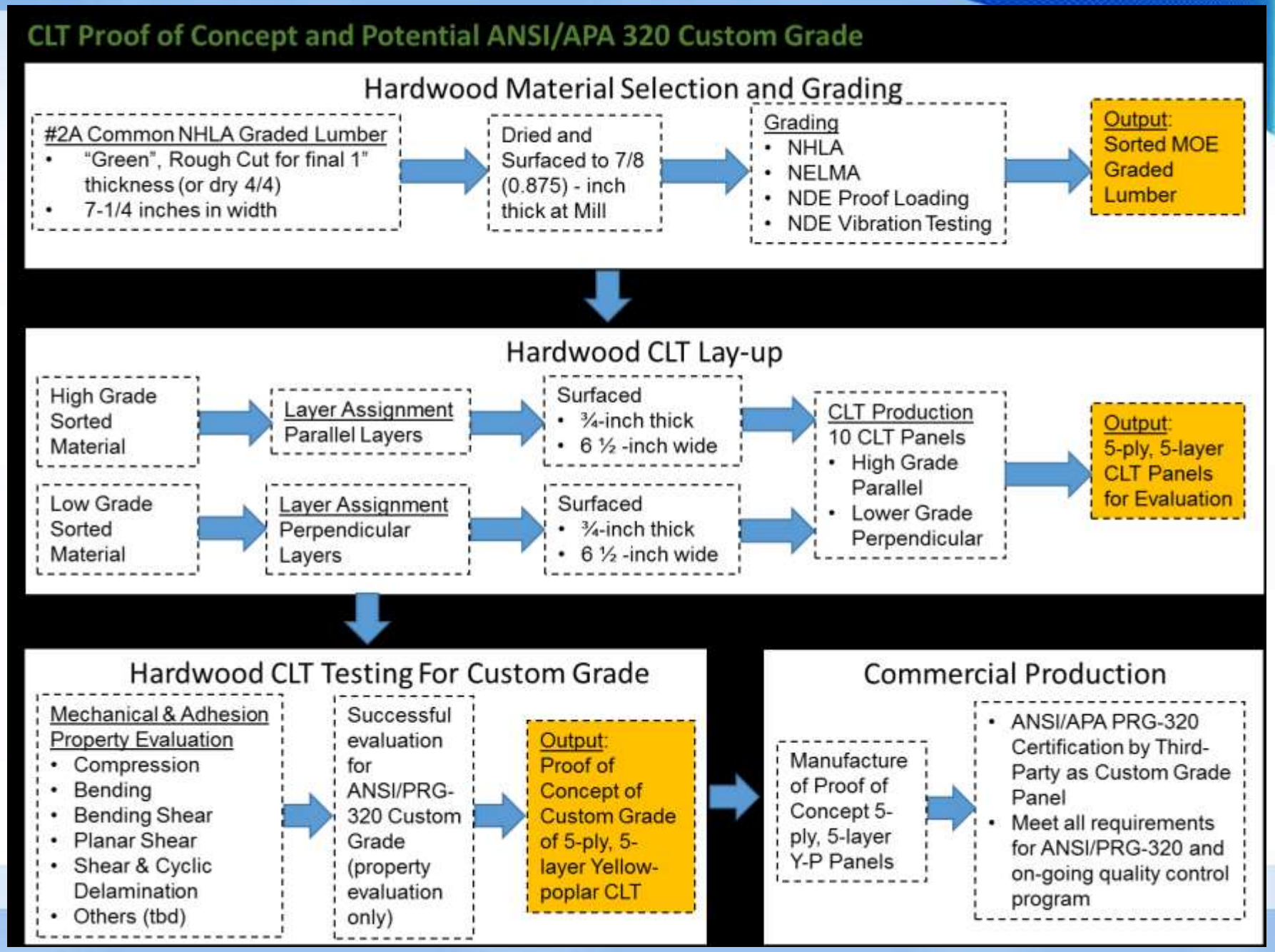
- Can the Appalachian Region provide enough hardwood lumber to support multiple hardwood CLT plants?
- Can an individual hardwood mill provide enough lumber for a CLT manufacturing facility?
- Consider an average CLT plant produces 12-24MMBF/year, how many average hardwood sawmills are needed?
- How much of the hardwood mill output is suitable for CLT production?
- Do the current hardwood processing methods make sense for a CLT production industry?
- Others……?

What needs to be done if we seriously want to produce hardwood CLT panels…

- Hardwood Associations and state Forest Manufacturing Associations (WV, OH, PA, NY, MD, etc.) need to come together and initiate a program to **encourage the acceptance of hardwood CLT panels** for commercial construction by building code standard organizations, like the International Building Code (IBC).
- Simultaneously, **mechanical testing on Yellow-poplar and Soft Maple (**and other species) CLT lay-ups should be ramped up and test results submitted to the ANSI PRG 320 Standards Review Panel for inclusion in the ANSI/APA - CLT standards.

OVERCOMING THE CURRENT PRG HARDWOOD NON-INCLUSION?

- **While ANSI/APA PRG 320 does not specify the use of hardwoods, it may be possible to get certification under "Custom Grades"**
- **Would be for that specific lay-up pattern only**



Questions, Comments, Discussion?