



# Biogenic carbon accounting method for upstream forest & end-of-life scenarios: A regional approach

Applied Research Consortium Meeting 05.19.2022  
Chuou Zhang



Jacob Dunn  
Marty Brennan

# Agenda

01  
RECAP



*Regional EOL & Design Decisions*

02  
END-OF-LIFE



*Bay Model Case Studies & EOL  
Emission Variations*

03  
NEXT STEPS



*A0 Update & Next Steps*

# 01

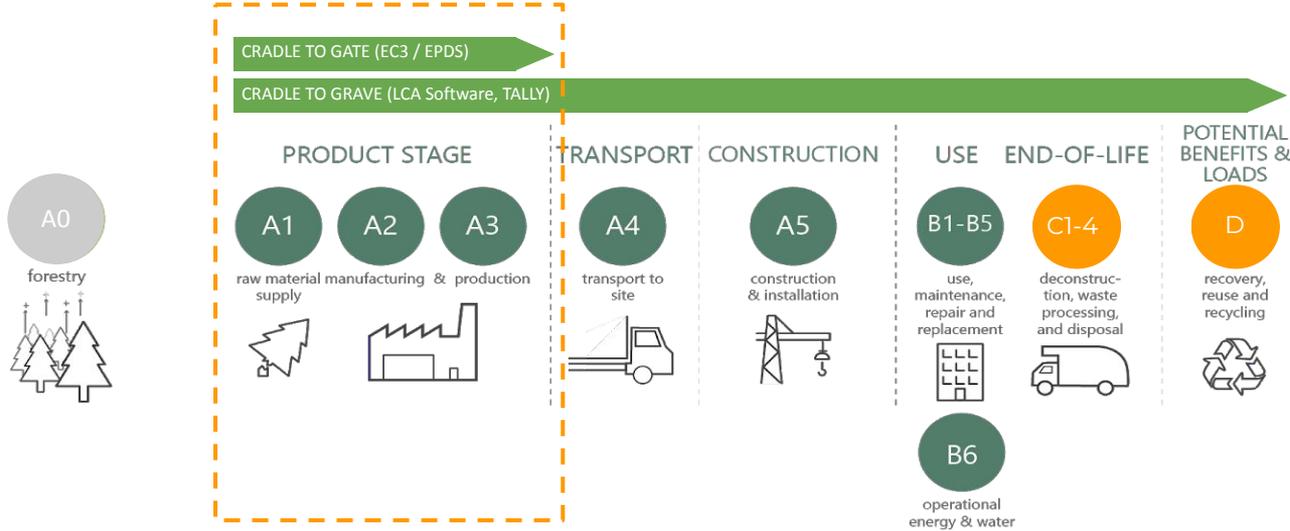
Recap

## ARC 2.0 Fall & Winter Quarter

### Fall Q Specified Forest Operation Factors

Manufacturing

- Harvest Intensity
- Transportations



### Winter Q

End of life

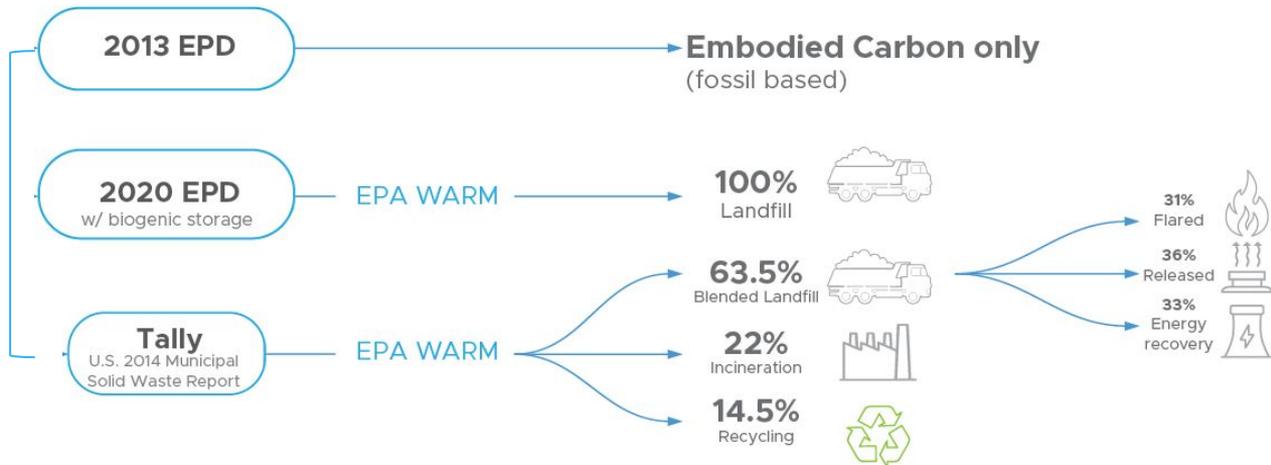
- Custom End of Life Scenarios (ARC 1.0) +
- Municipal/County data
- Design decision on reusabilities (ARC 2.0)

# 01

Recap

## Regional Wood Waste Diversions

### Lv 1 - National Average



### Lv 2 - County Level



### Lv 3 - Design Decisions



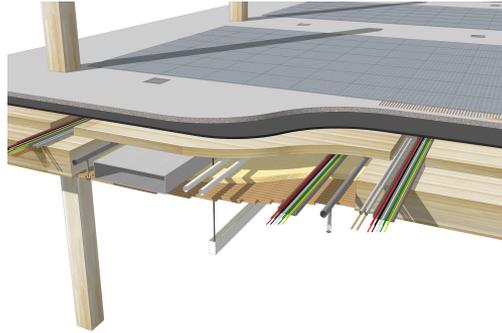
# 02

End-of-life

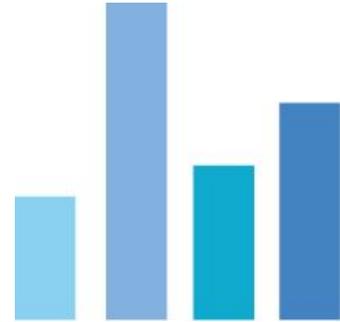
## Spring Quarter Scope



**Regional Waste Diversions**



**Deconstruction Potential in Common Practice**

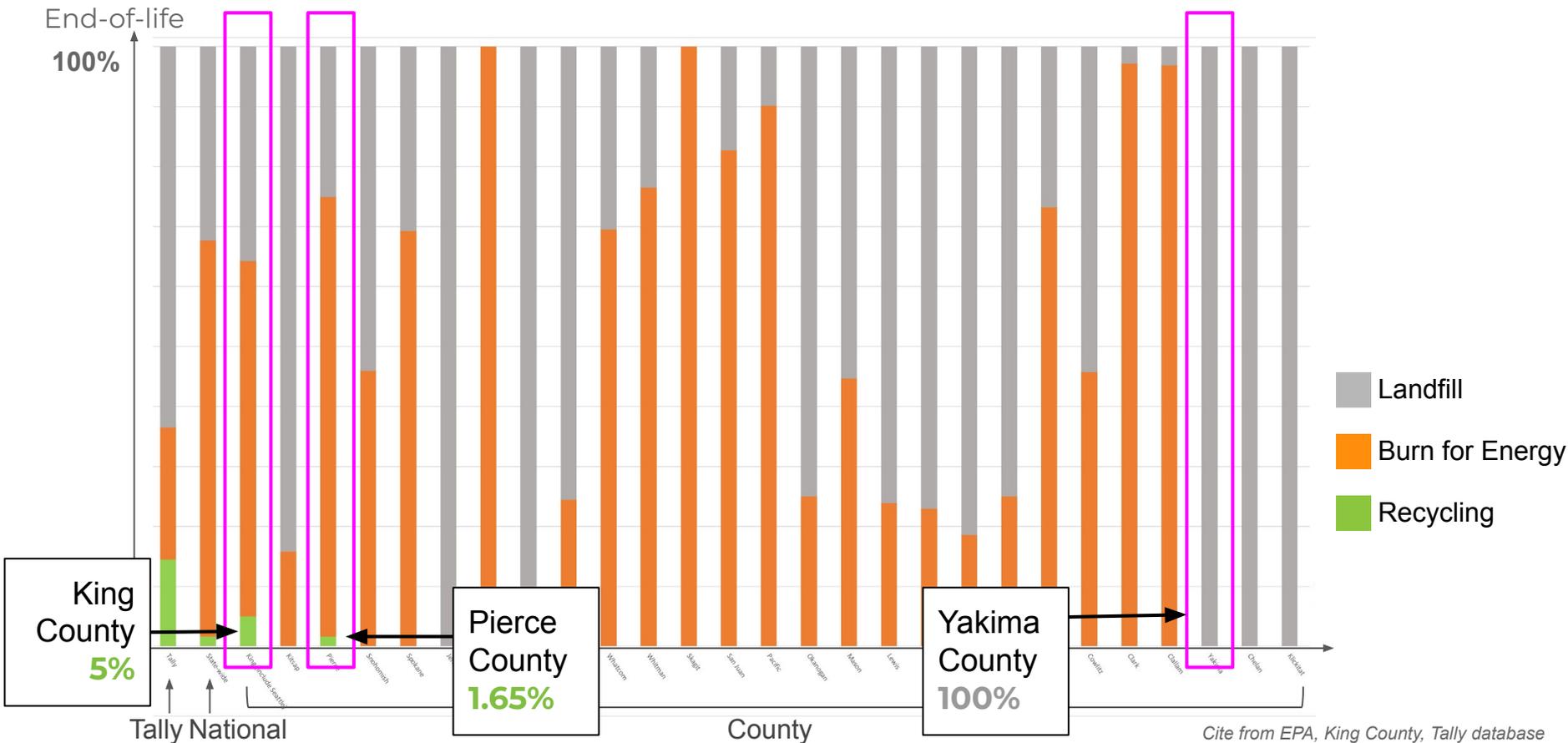


**Regional End of Life Emissions**

# 02

## Wood Waste Data Diversions

End-of-life  
100%



Cite from EPA, King County, Tally database

# 02

# Structural & Deconstruction Workshop

End-of-life

**Bay 1**

Grid 30'x30'

steel carbon range

- Gravity: glulam beam and column
- Lateral: CLT + topping slab with composite action (Concrete and CLT tied together with Lag bolts, steel plates-shear connector)
- Acoustics and vibration: topping slab

PAE Floor Assembly

HYBRID BEAM TO COLUMN CONNECTION

Notes:
 

- Steel plate-shear connector (1/2" x 1/4" x 12")
- Lag bolts (1/2" dia x 12")
- Concrete (4" thick)
- CLT (1 1/2" thick)
- Topping slab (4" thick)

## End of Life Discussion Meeting Series:

Chuou Zhang, Research fellow with University of Washington Applied Research Consortium

Tomás Mendez Echenagucia, Ph.D., Assistant Professor, University of Washington

Jacob Dunn, ZGF

Marty Brennan, ZGF

## Waste Specialists

Kinley Deller, King County Solid Waste Division

Alex Erzen, King County Solid Waste Division

Katie Kennedy: Waste Diversion Lead at Seattle Public Utilities

Theresa Blaine: Sustainable Materials Management Specialist at US EPA Region 10

Timonie Hood, Zero Waste & Green Building Coordinator, U.S. EPA Region 9

Christina Bjarvin, Master's student at UW Environmental & Forest Sciences

## Structural Engineering

Amie E. Sullivan, PE, SE, Principal, KPFF

Shana Kelley, PE, SE, Seattle Office Director of Sustainable Design, KPFF

Donald W. Davies, PE, SE, President, Magnusson Klemencic Associates

Morgan Brun, Design Engineer, Magnusson Klemencic Associates

Denis Blount, Associate Principal, Acoustics, Audiovisual, Theatre Consulting, CTS-D, Arup

## Construction Specialists

Marc Chen, Skanska, Sustainability Manager

Laura Soma, GLY Sustainability Specialist

## Deconstruction Specialists

David Bennick, Reuse Consulting Director of Building Deconstruction Institute, Owner of Re-Use Consulting

Noel Stout, Owner of Dedicated Deconstruction

**Bay 2**

- Gravity: Glulam beam and column
- Lateral: CLT
- Acoustics and vibration - topping slab (and fire)
  - Option 1: with topping slab - no composite action
  - Option 2: panelized acoustic system (dry)

48" PSYC & RIC FLOOR ASSEMBLY

Notes:
 

- PSYC (4" thick)
- RIC (4" thick)
- Acoustic insulation (4" thick)
- CLT (1 1/2" thick)
- Topping slab (4" thick)

**Bay 3**

- Gravity: steel beam, glulam or hybrid, glulam column
- Lateral: topping slab coupled to steel beam
- Acoustics and vibration - topping slab

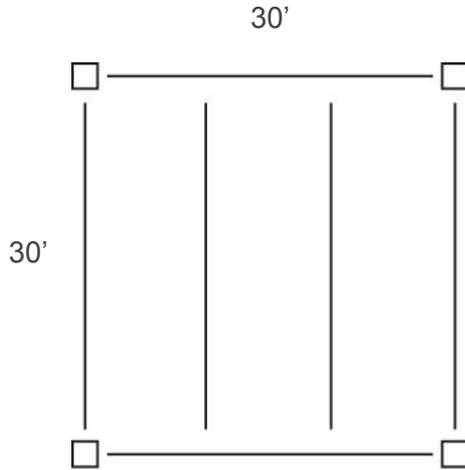
Notes:
 

- Steel plate-shear connector (1/2" x 1/4" x 12")
- Lag bolts (1/2" dia x 12")
- Concrete (4" thick)
- CLT (1 1/2" thick)
- Topping slab (4" thick)

# 02

End-of-life

## Floor Assembly Bay Model Study



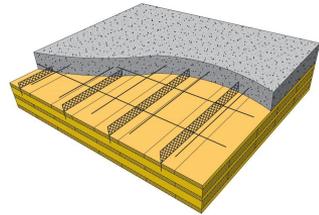
### Assumptions:

- Location: Seattle
- Code: WA 2018 IBC
- Type: Office- B Occupancy
- Construction type: IV B, Fully Sprinklered
- 10 Floors @ 13'-6" Height
- Fire Rating: 2 HR. Primary Structural Frame & Floor; Design to Char
- Grid Size: 30' x 30'
- 50 PSF Superimposed Dead Load
- 100 PSF Live Load

# 02

End-of-life

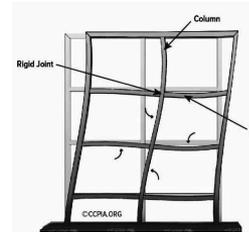
## Factors Impact on De-constructability



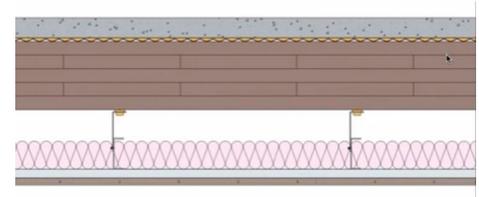
**Composite action**



**Fastener choice**  
(I.e. Screw / Bolt)



**Seismic/ Lateral system**



**Acoustic & Fireproofing system**

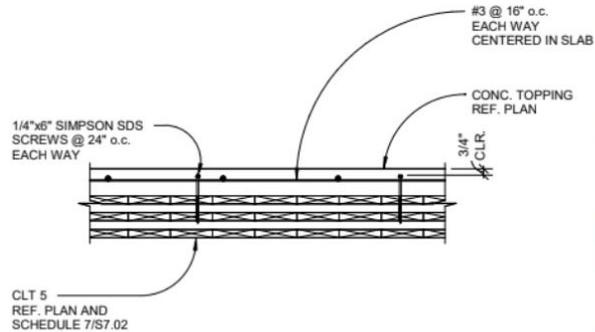
# 02

End-of-life

## Common Mass Timber Floor Assembly Designs

### Bay 1

- Gravity: Glulam beam & Column
- Lateral: CLT & topping slab with composite action
- Acoustic & Vibration: Topping slab



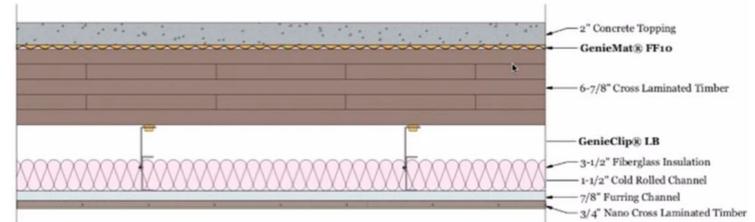
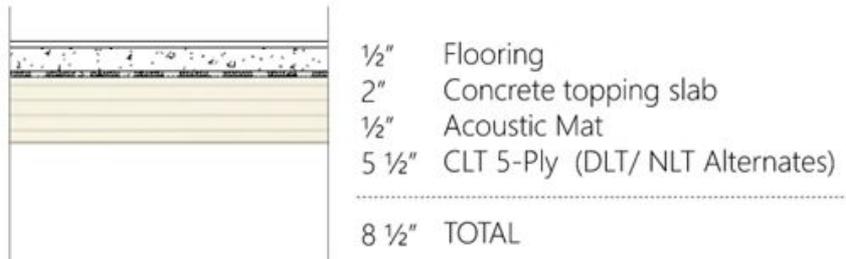
# 02

End-of-life

## Common Mass Timber Floor Assembly Designs

### Bay 2

- **Gravity: Glulam beam & Column**
- **Lateral: CLT**
- **Acoustics & Vibration: Topping slab (w/o composite action)**



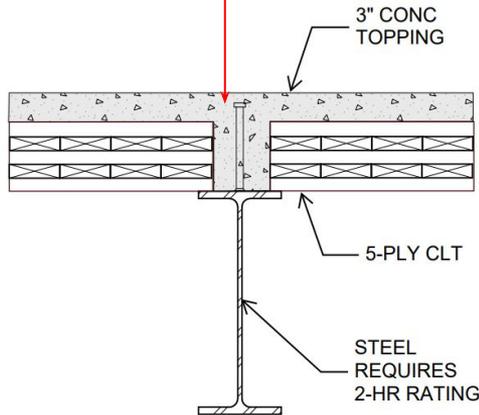
# 02

End-of-life

## Common Mass Timber Floor Assembly Designs

### Bay 3

- **Gravity:** Steel beam (2-HR rating), 5-ply CLT
- **Lateral:** Concrete topping coupled to steel beam
- **Acoustic & Vibration:** Topping slab



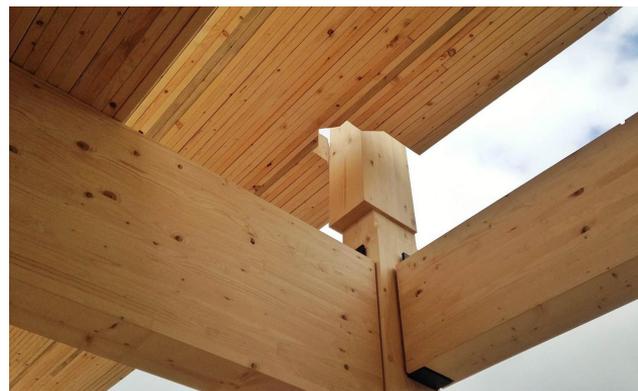
# 02

End-of-life

## Common Mass Timber Floor Assembly Designs

### Bay 4

- **Gravity:** Glulam beam, column
- **Lateral:** NLT/DLT, concrete w/ composite action
- **Acoustic & Vibration:** Topping slab



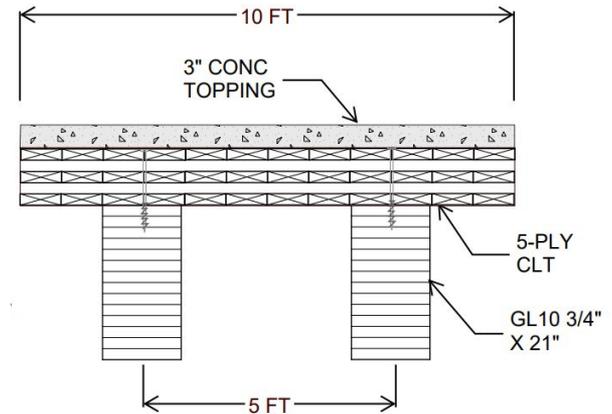
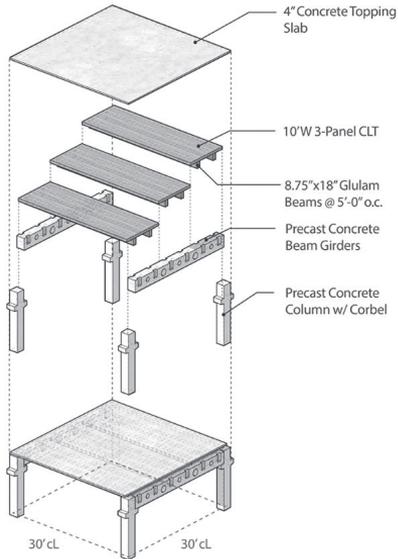
# 02

End-of-life

## Common Mass Timber Floor Assembly Designs

### Bay 5

- **Gravity:** Composite double T Glulam & 5-ply CLT & precast concrete girders
- **Lateral:** Concrete slab / plywood
- **Acoustic & Vibration:** Topping slab (w/o composite action)



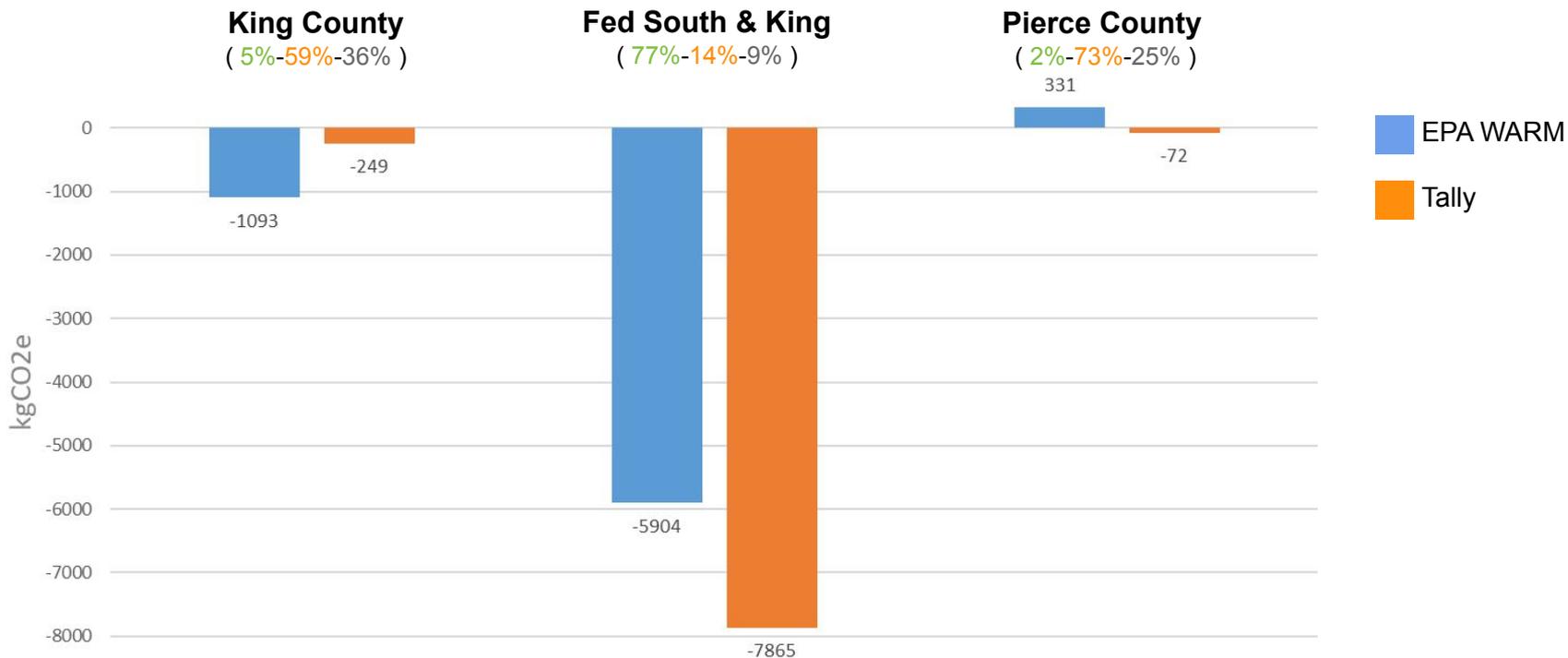
Cite from Amie E. Sullivan, KPFF

# 02

End-of-life

## Bay 2 Regional End of Life Comparisons

(CLT Floor - 515.63 ft<sup>3</sup>)



# 03

SUMMARY

## Main Takeaway



- ✓ **Design Decisions**
- ✓ **Data Set**
- ✓ **Wood End-of-Life**

# 03

## NEXT STEPS



UpStream  
Forestry Carbon & LCA Tool



### Fall quarter

- Forest Harvest Intensities
- Transportation Factors

### Winter quarter

- Municipal/ County waste diversion data
- Design decision impact on deconstruction and reuse
- Interviews with demo contractors
- UpStream Tool update

### Spring quarter

- Regional waste diversions
- Bay model sensitivity studies
- CLF Forestry carbon methodology review
- Building Transparency openIMPACT development
- Final report

Thank you



# Common Mass Timber Floor Assembly

	Bay 1: Typical Concrete composite	Bay 2: Non-Composite	Bay 3: Steel & Mass Timber Hybrid	Bay 4: DLT/NLT w/ Concrete	Bay 5: Double T Glulam Beams
Connection Details					
Gravity	Glulam beam, column	Glulam beam, column	Steel beam (2-HR rating), 5-ply CLT	Glulam beam, column	Composite double T Glulam & 5-ply CLT, precast concrete girders
Lateral	CLT & topping slab with composite action	CLT	Concrete topping coupled to steel beam	NLT/DLT, concrete w/ composite action	Concrete slab /plywood
Acoustic & Vibration	3" Topping slab	3" Topping slab (w/o composite action)	3" Topping slab	3" Topping slab	3" Topping slab (w/o composite action)