Carbon Power from Research or Mythology:

Life Cycle Analysis of the Forest Products Industry – No Longer an Option

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and
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Consortium for Research on Renewable Industrial Materials

CORRIM

A non-profit research corporation formed by 15 research institutions to develop life cycle environmental measures for all wood-use stages of processing (from cradle to grave)

Is carbon the change agent of the century?

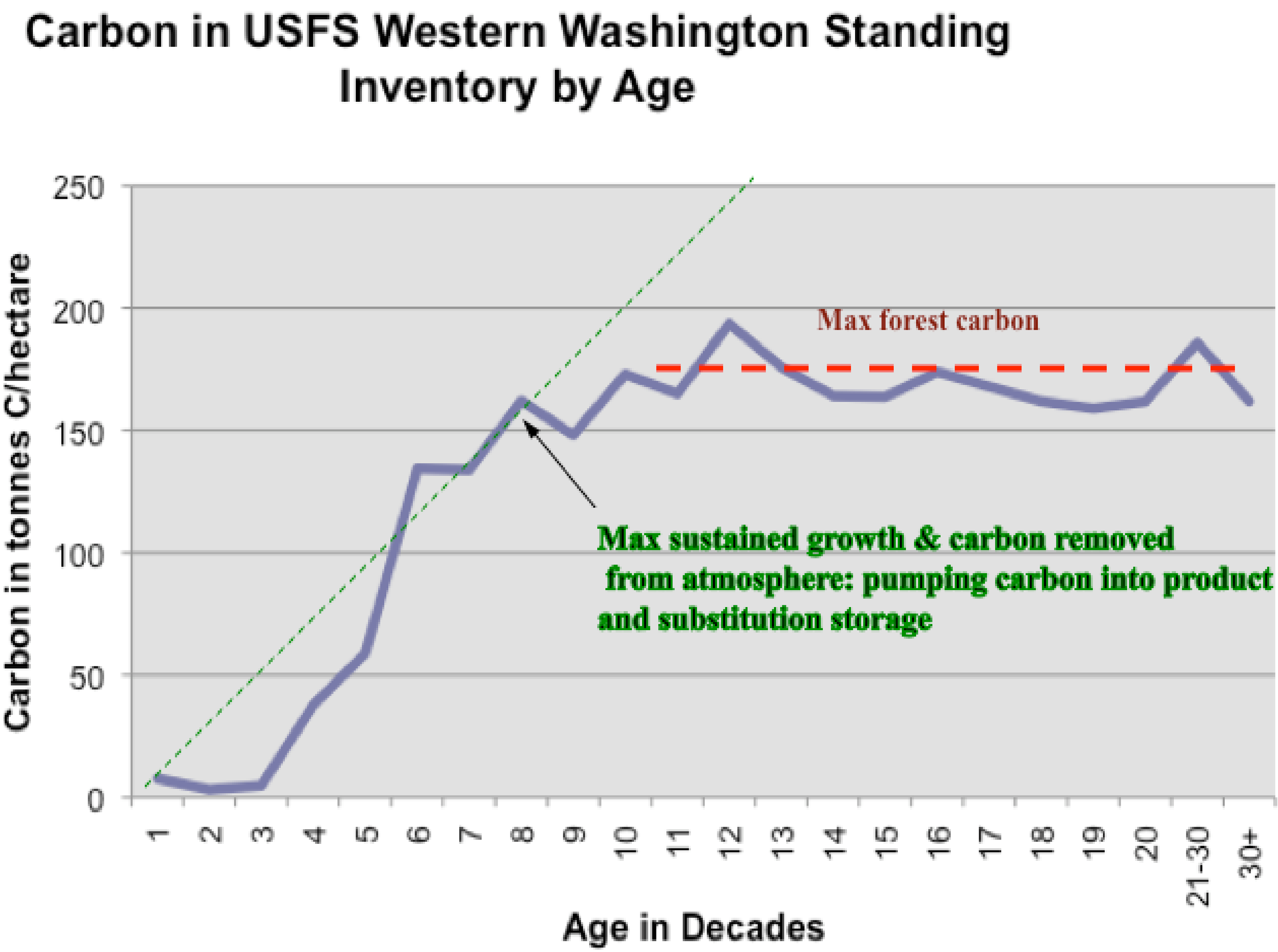
- Carbon is the sustainability metric of our time characterized more by myth than fact.
- Understanding carbon will be critical to effective mitigation policy
- Carbon is not a toxin you can bottle and hide
  - -every living thing and every manufacturing process modifies carbon
  - -there are millions of linked carbon pools

The CORRIM Research Based Carbon Story

Carbon Sequestration ‘in, or by using’ Forests?

- Options: store carbon in the forest or sustainably pump it into buildings and substitutes for fossil intensive materials

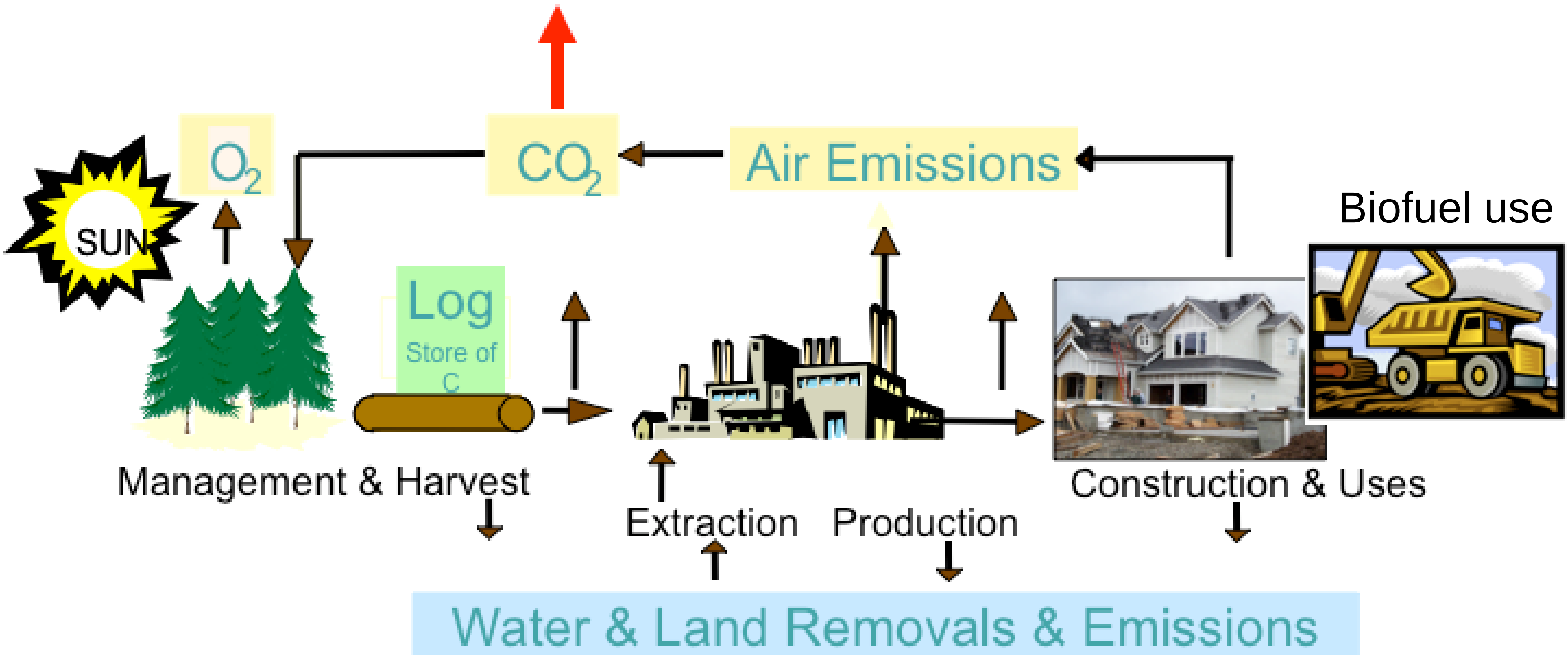
- What we know
- What we don’t know
- What’s not working



Carbon in USFS Western Washington Standing Inventory by Age
Carbon in tonnes C/hectare
250
200
150
100
50
0
Max forest carbon
Max sustained growth & carbon removed from atmosphere: pumping carbon into product and substitution storage
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21-30
30+
Age in Decades

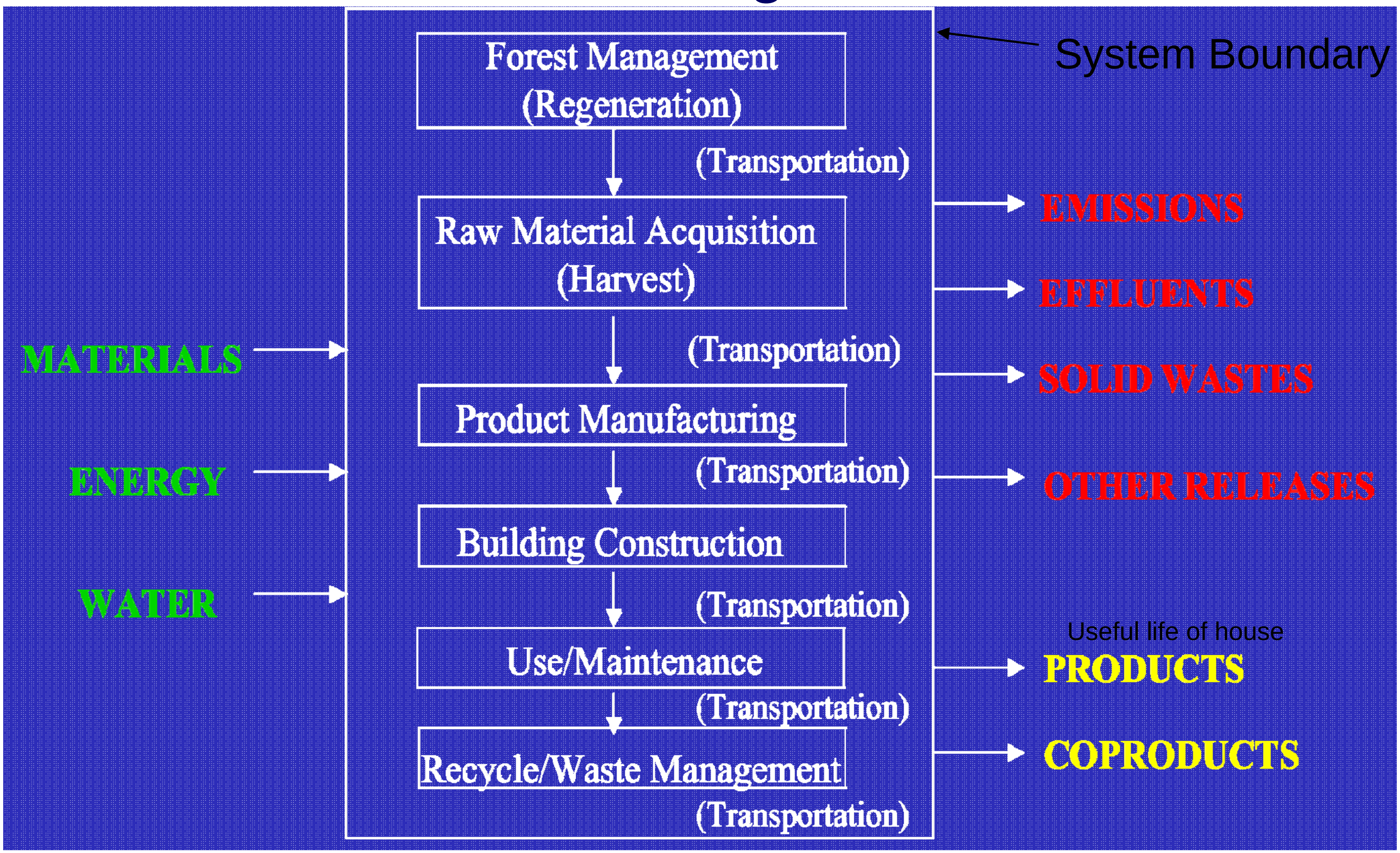
Life Cycle Inventories & Assessment
of Products & Buildings & Biofuels

measures of all the inputs and outputs for every stage of processing



Life Cycle Inventory Analysis

‘cradle to grave”



LCI/LCA is the ~~accepted~~ method

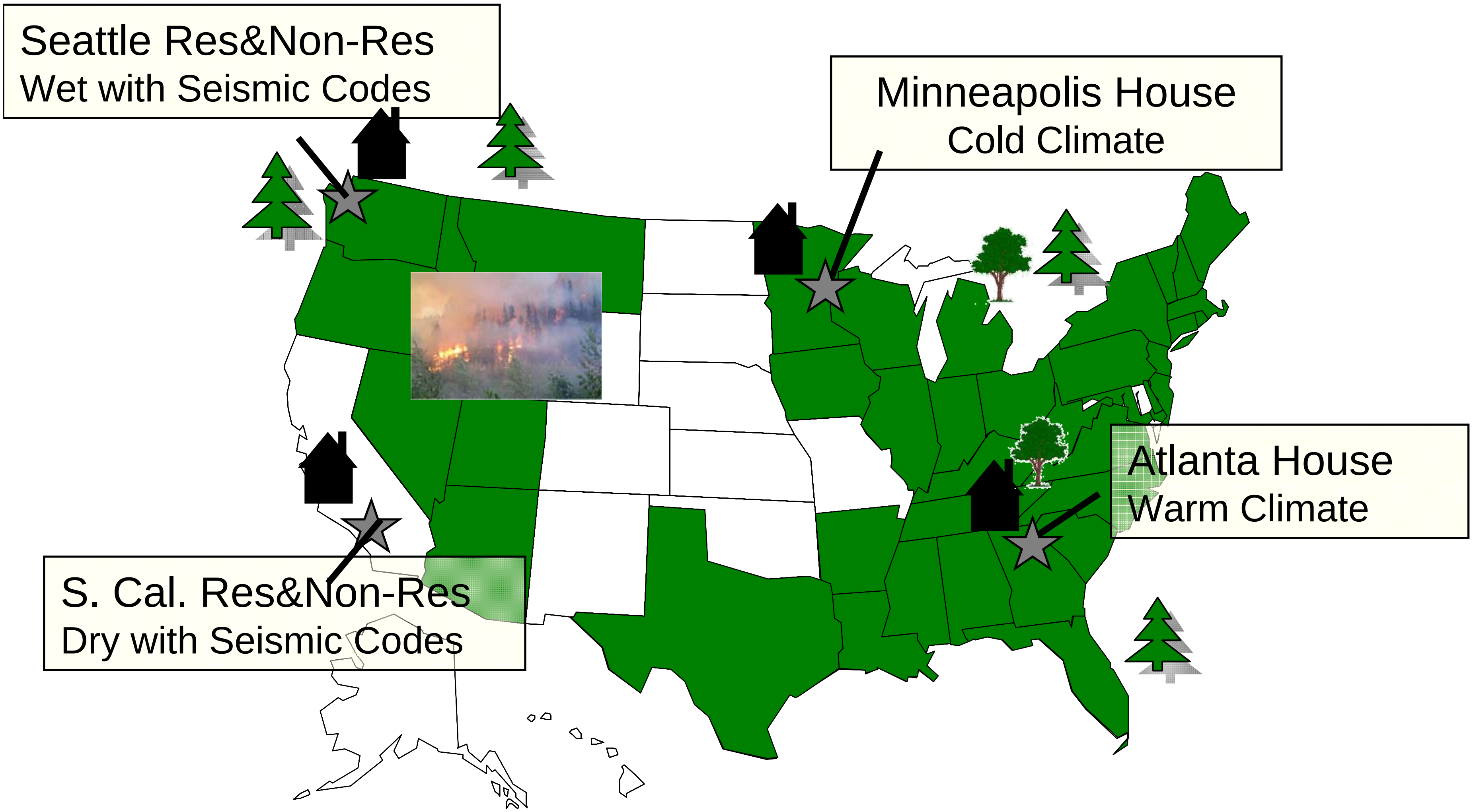
- US EISA 2007 sets GHG thresholds for biofuels requiring LCA – a Congressional mandate

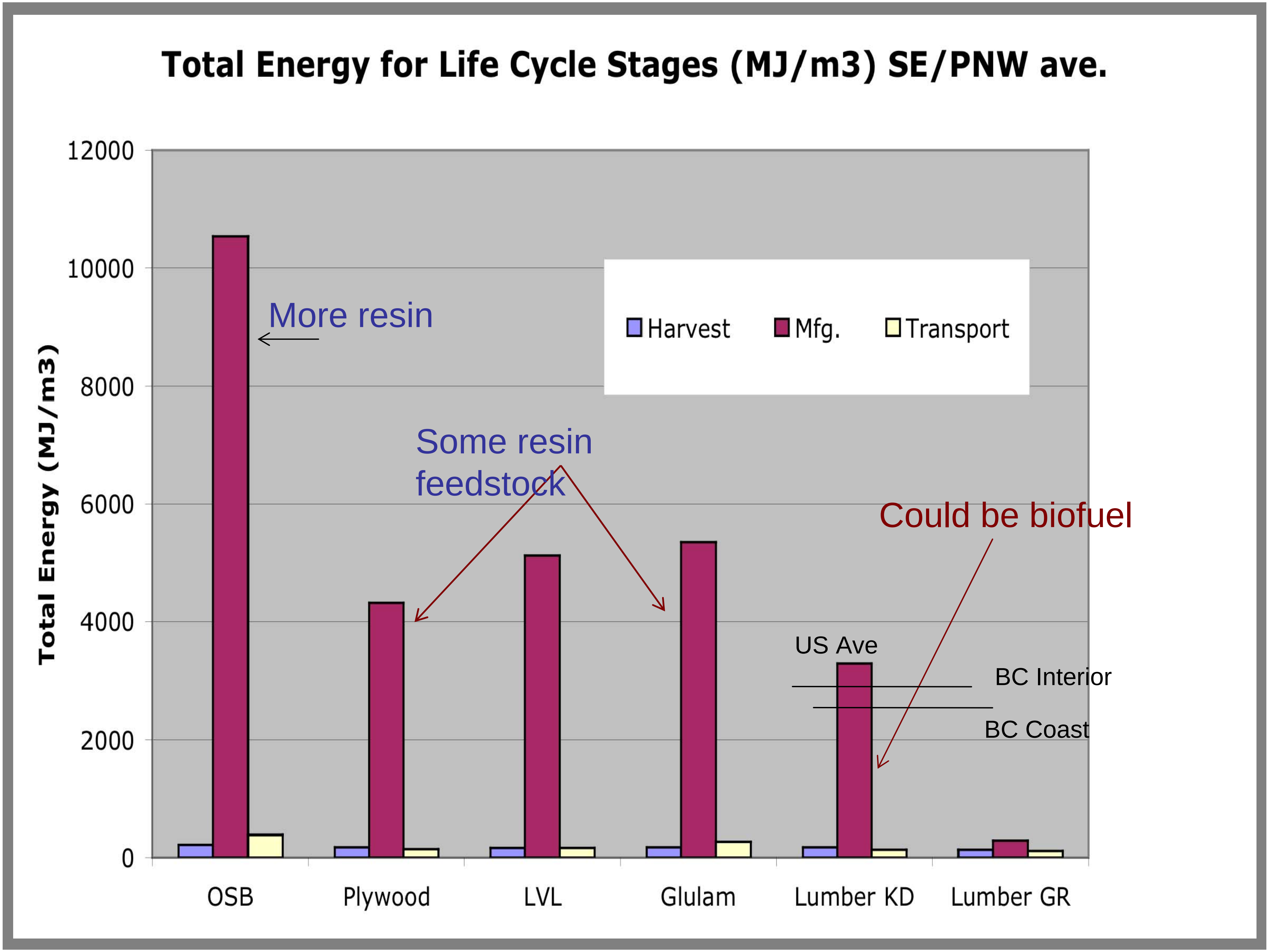
  - Congress's $.51/gal ethanol tax credit
    - Takes 5 gal corn-ethanol to displace CO2 of 1 gal gasoline

      $2.60/19lbs CO2 or $295/mtCO2 (metric-ton)
  - CCX: $2, ECX: $13, Congress: $295 /mt

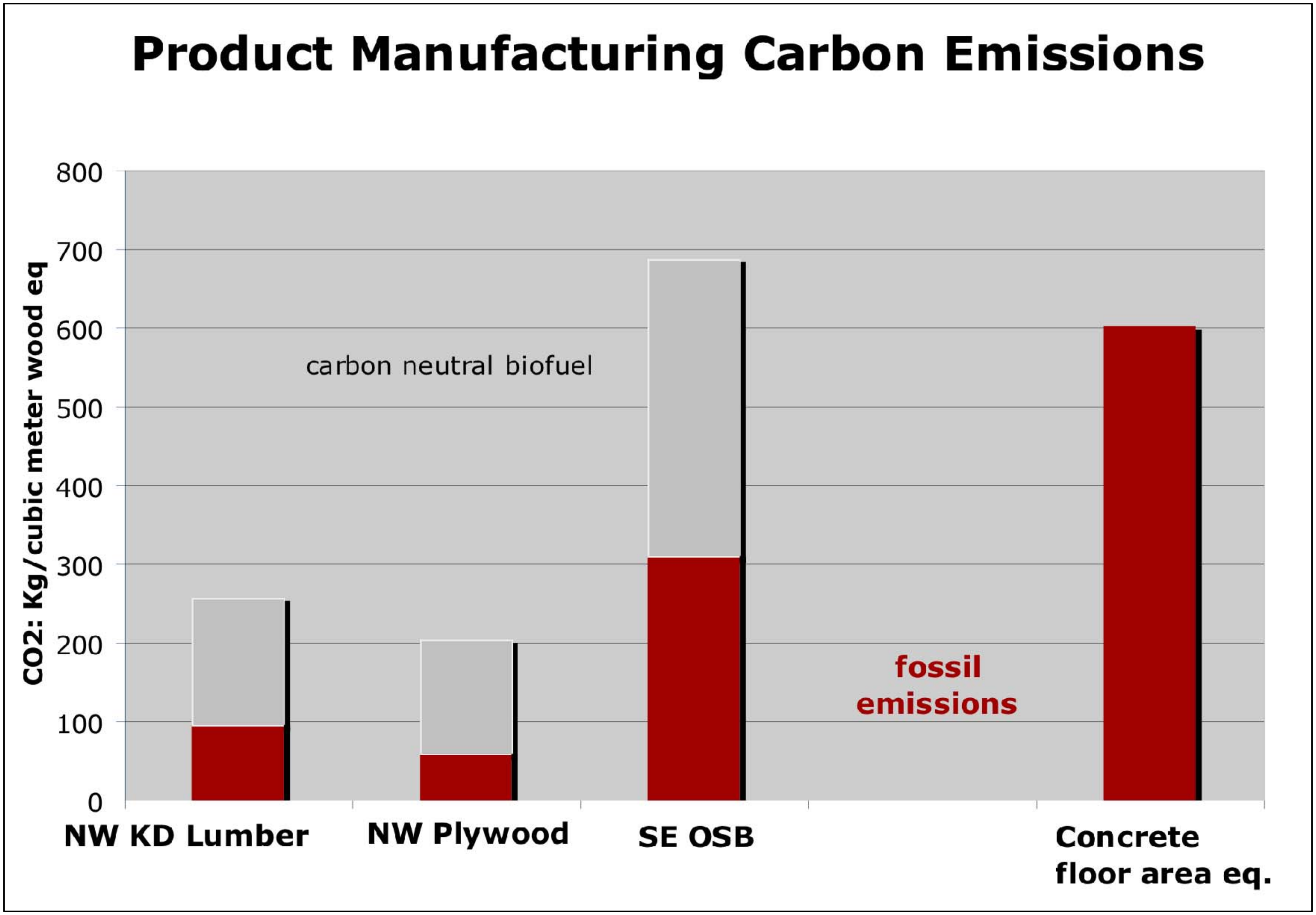
- $244 billion/yr to offset gasoline from imported oil
- While stealing feedstocks from carbon saving uses

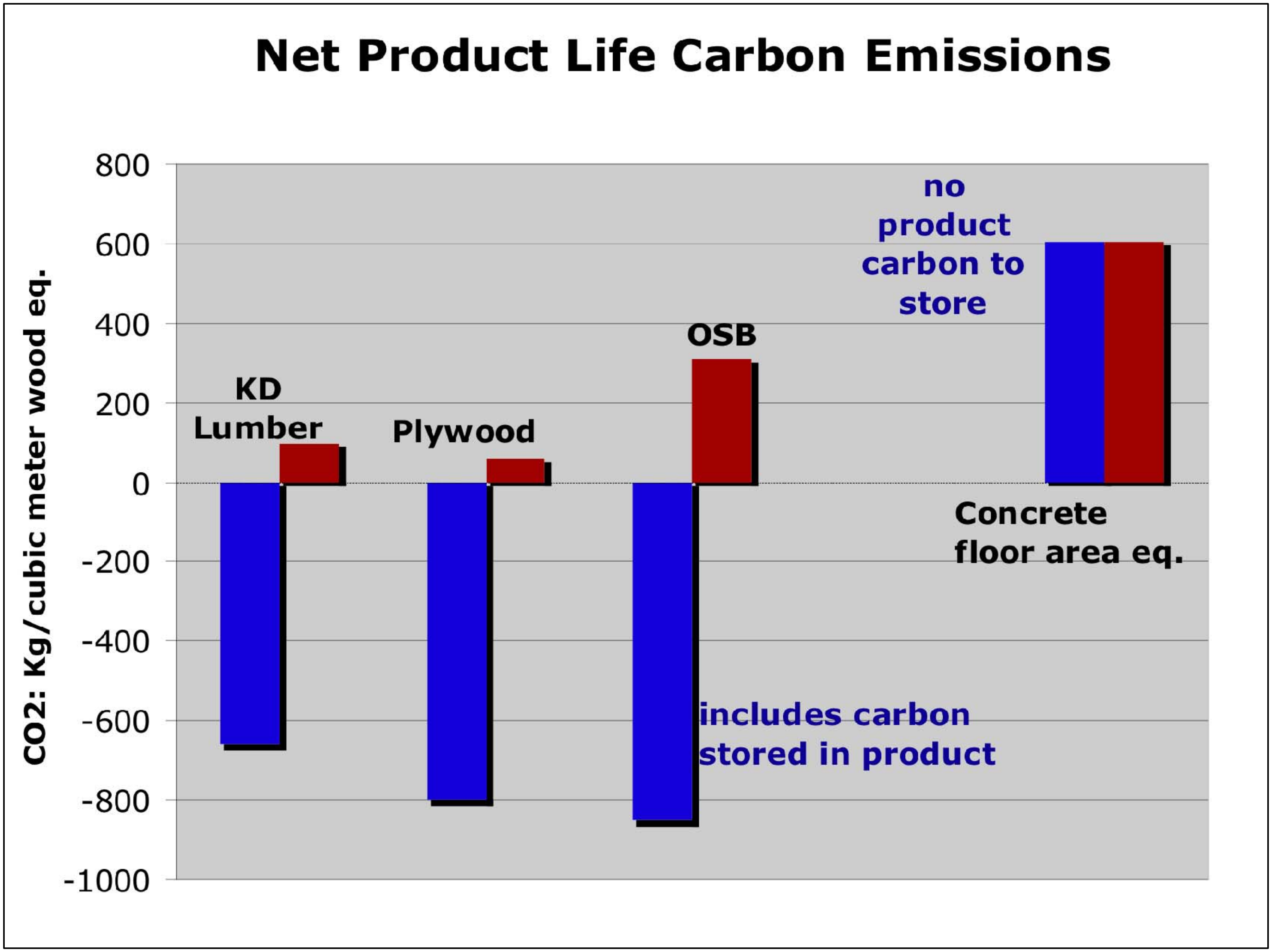
Phase1&2: 4 Forest Supply Regions, 9 Products, and 4 Construction Sites





Total Energy for Life Cycle Stages (MJ/m3) SE/PNW ave.
Total Energy (MJ/m3)
12000
10000
8000
6000
4000
2000
0
Harvest
Mfg.
Transport
More resin
Some resin
feedstock
Could be biofuel
US Ave
BC Interior
BC Coast
OSB
Plywood
LVL
Glulam
Lumber KD
Lumber GR


Product Manufacturing Carbon Emissions
CO2: Kg/cubic meter wood eq
800
700
600
500
400
300
200
100
0
carbon neutral biofuel
fossil emissions
NW KD Lumber
NW Plywood
SE OSB
Concrete floor area eq.



Net Product Life Carbon Emissions
CO2: Kg/cubic meter wood eq.
800
600
400
200
0
-200
-400
-600
-800
-1000
KD Lumber
Plywood
OSB
no product carbon to store
Concrete floor area eq.
includes carbon stored in product

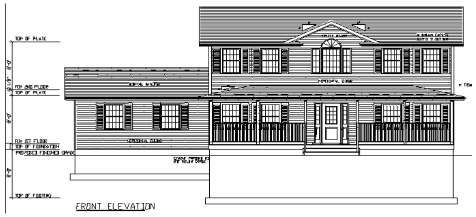
Life Cycle Assessment (LCA) In Terms of Performance Indices

- Embodied & Fossil Energy
- Global Warming Potential (GHG)
- Air Emissions
- Water Emissions
- Solid Waste
- Ecosystem Impacts

CORRIM

Houses Designed to Local Code:
LCA comparisons

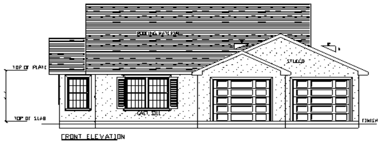
Minneapolis House
Cold Climate



Wood vs. steel *framed* house designed to same R code.

Concrete basement, sheetrock, insulation, wood trusses, vinyl windows, vinyl siding and asphalt roofing.

Atlanta House
Warm Climate



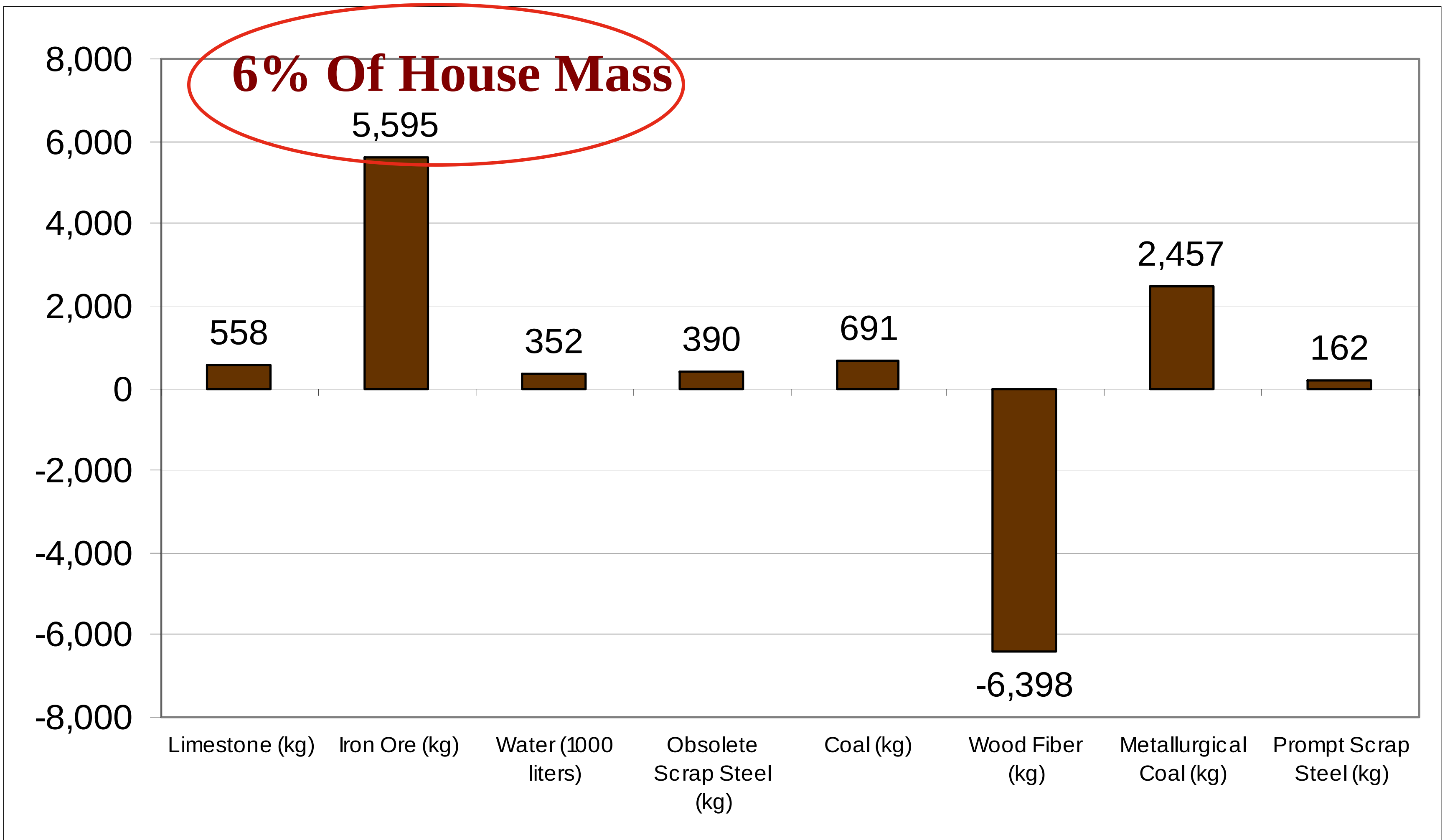
Wood *framed* vs. concrete block exterior walls designed to same R code.

Slab on grade, sheetrock, insulation, wood trusses, vinyl windows, stucco/vinyl siding and asphalt roofing.

Design Differences: Minneapolis

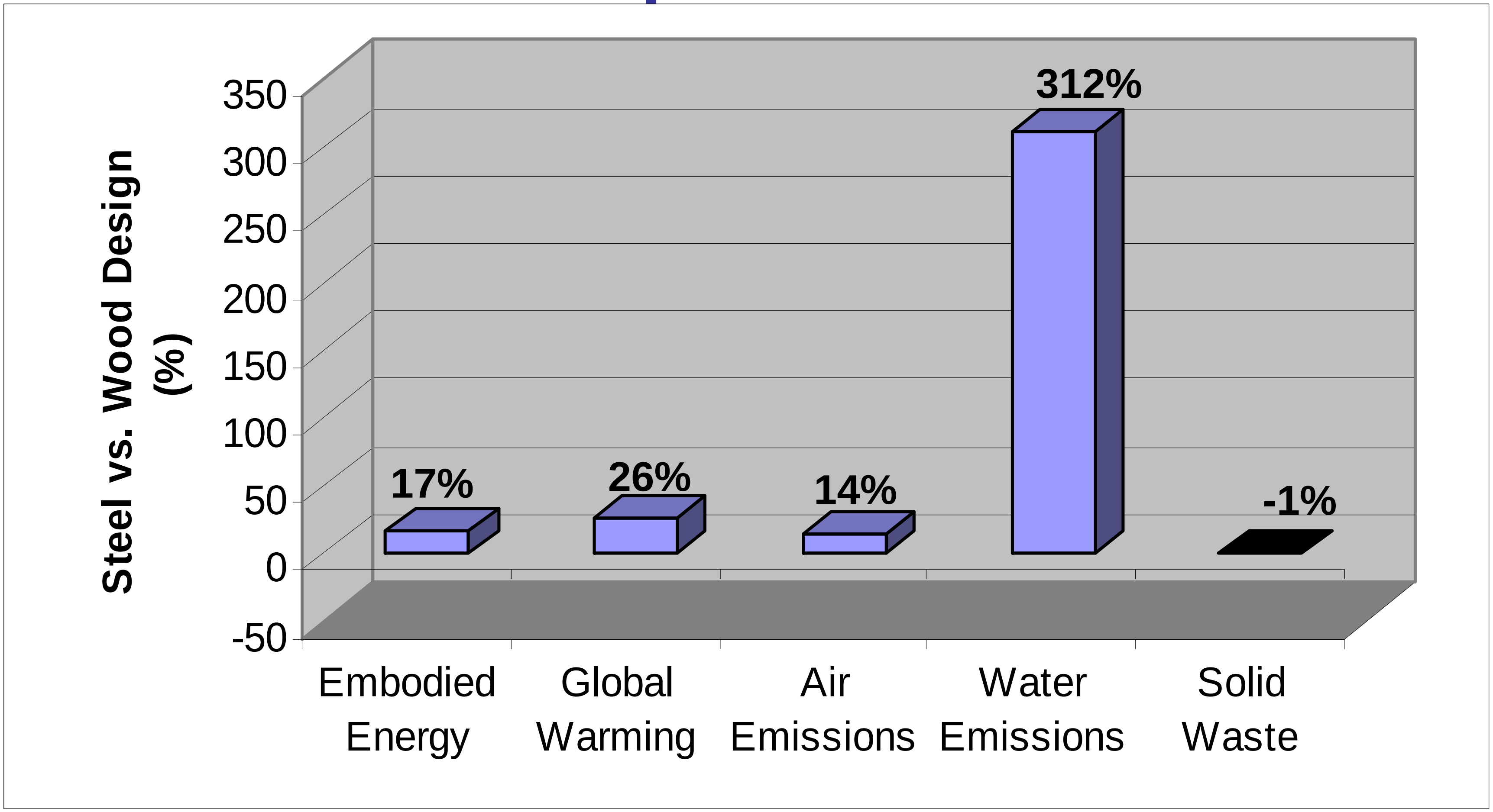
Steel Frame minus Wood Frame

Extraction (primary materials in kg)



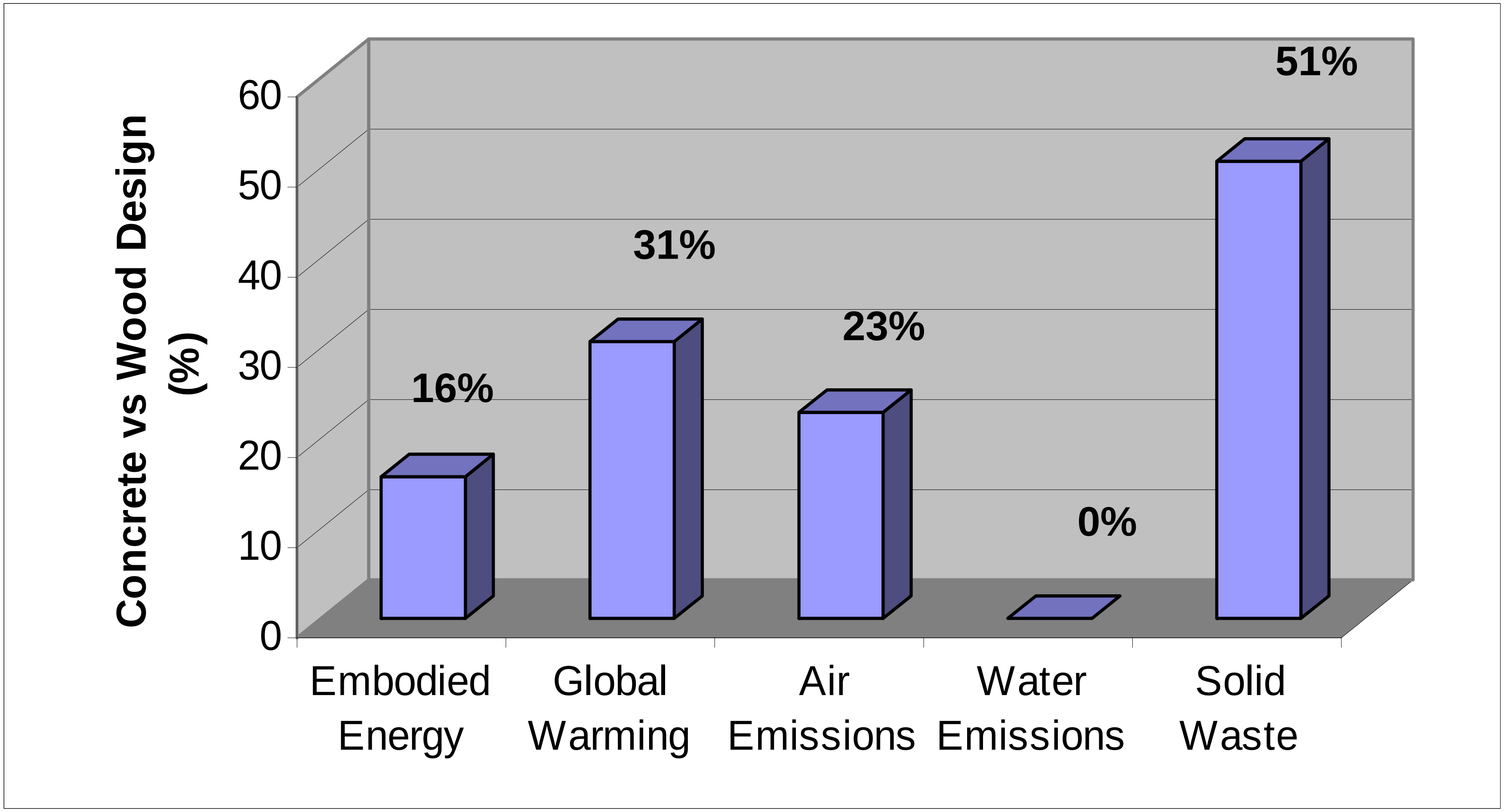
Summary Performance Indices

Life Cycle Assessment (LCA) for Minneapolis House

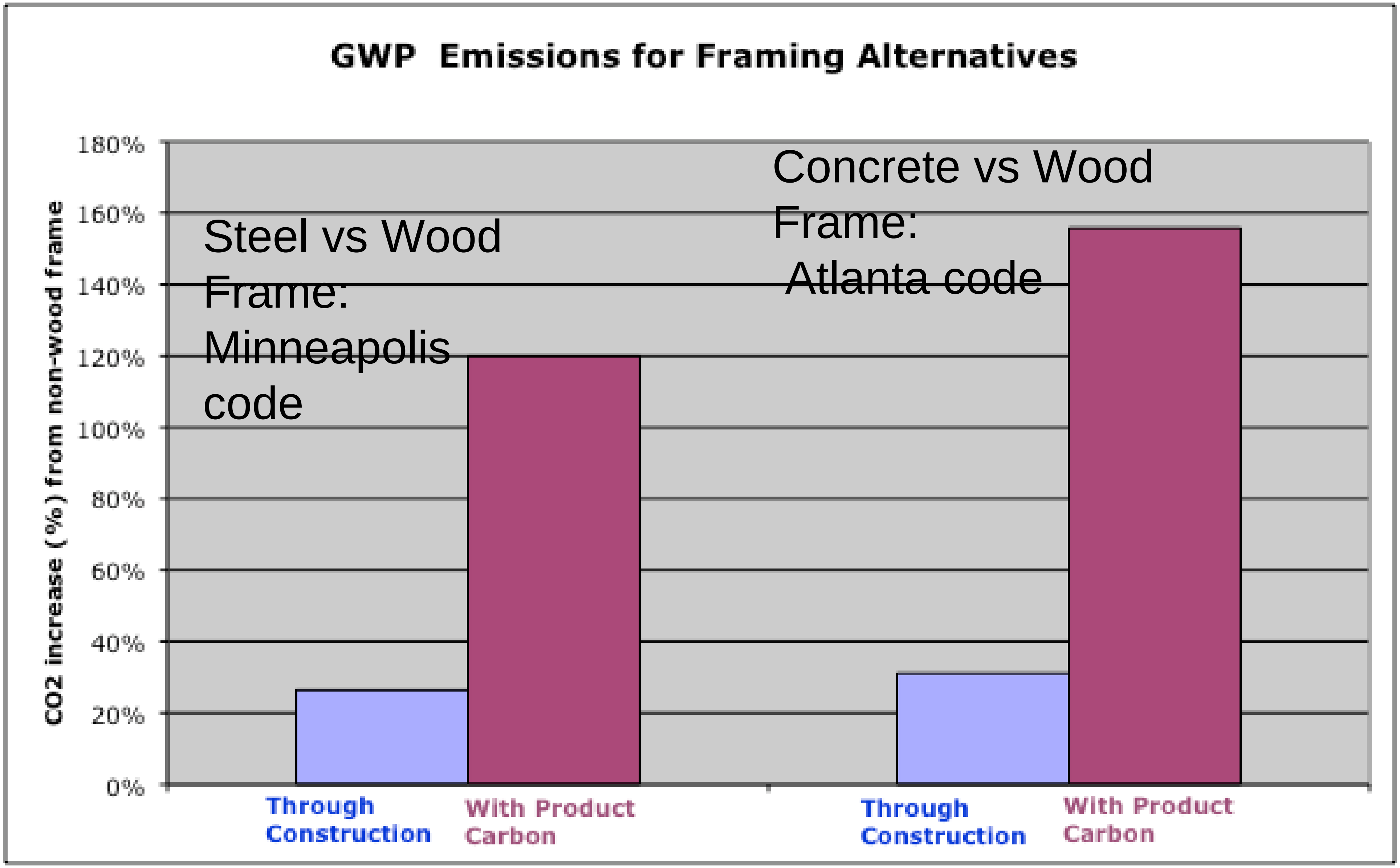


Summary Performance Indices:

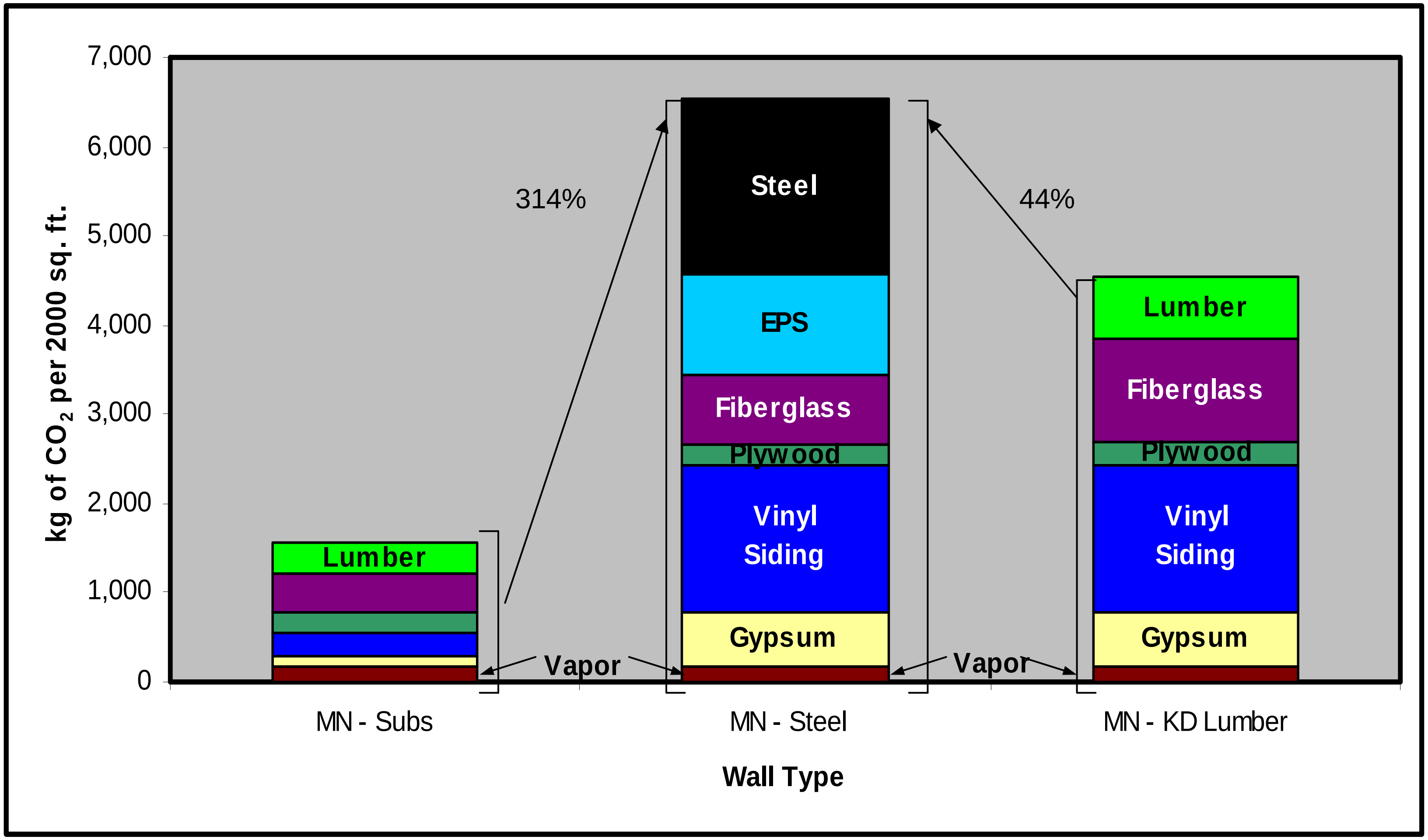
Life Cycle Assessment (LCA) for Atlanta House



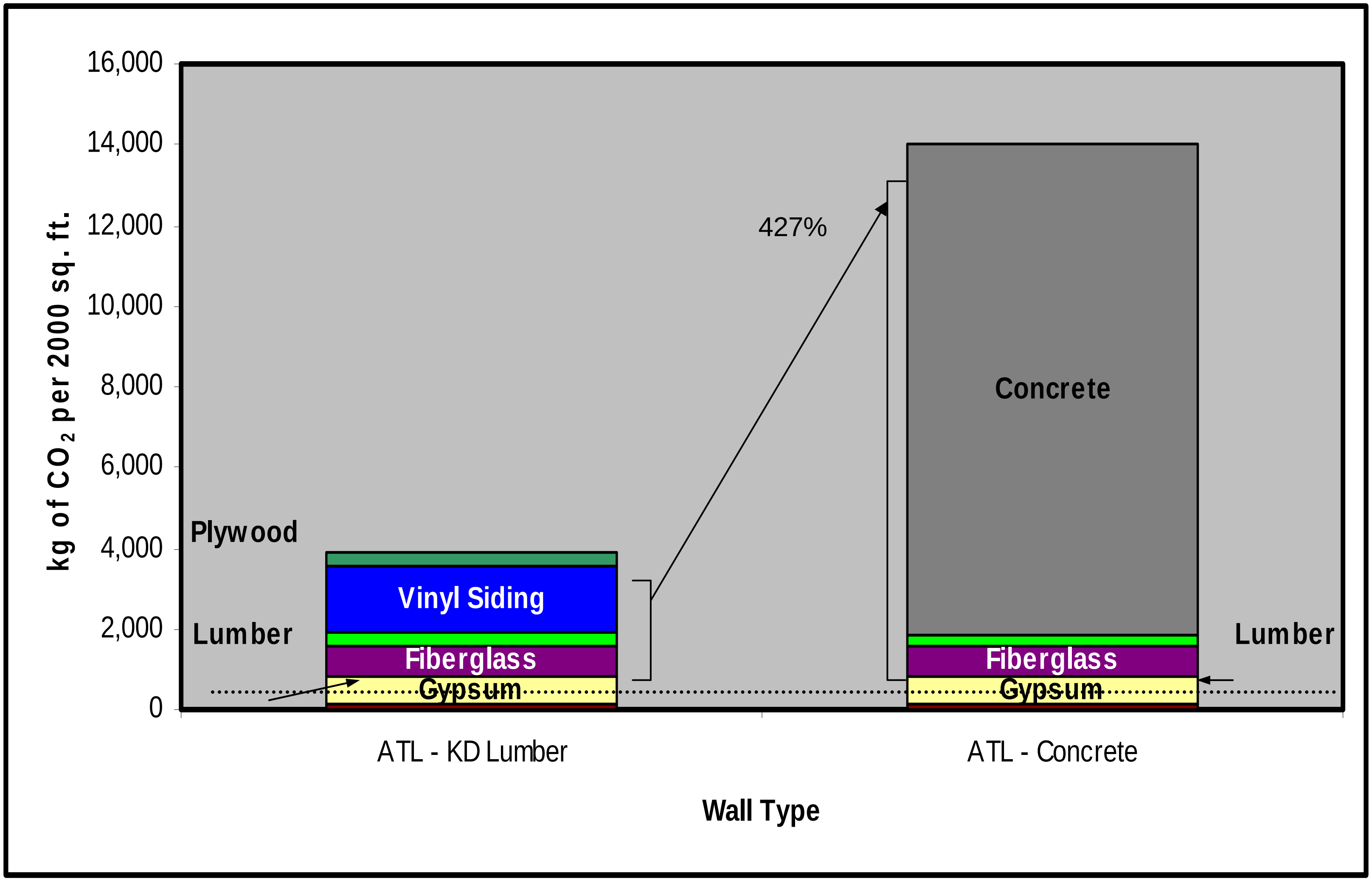
With Carbon in Products



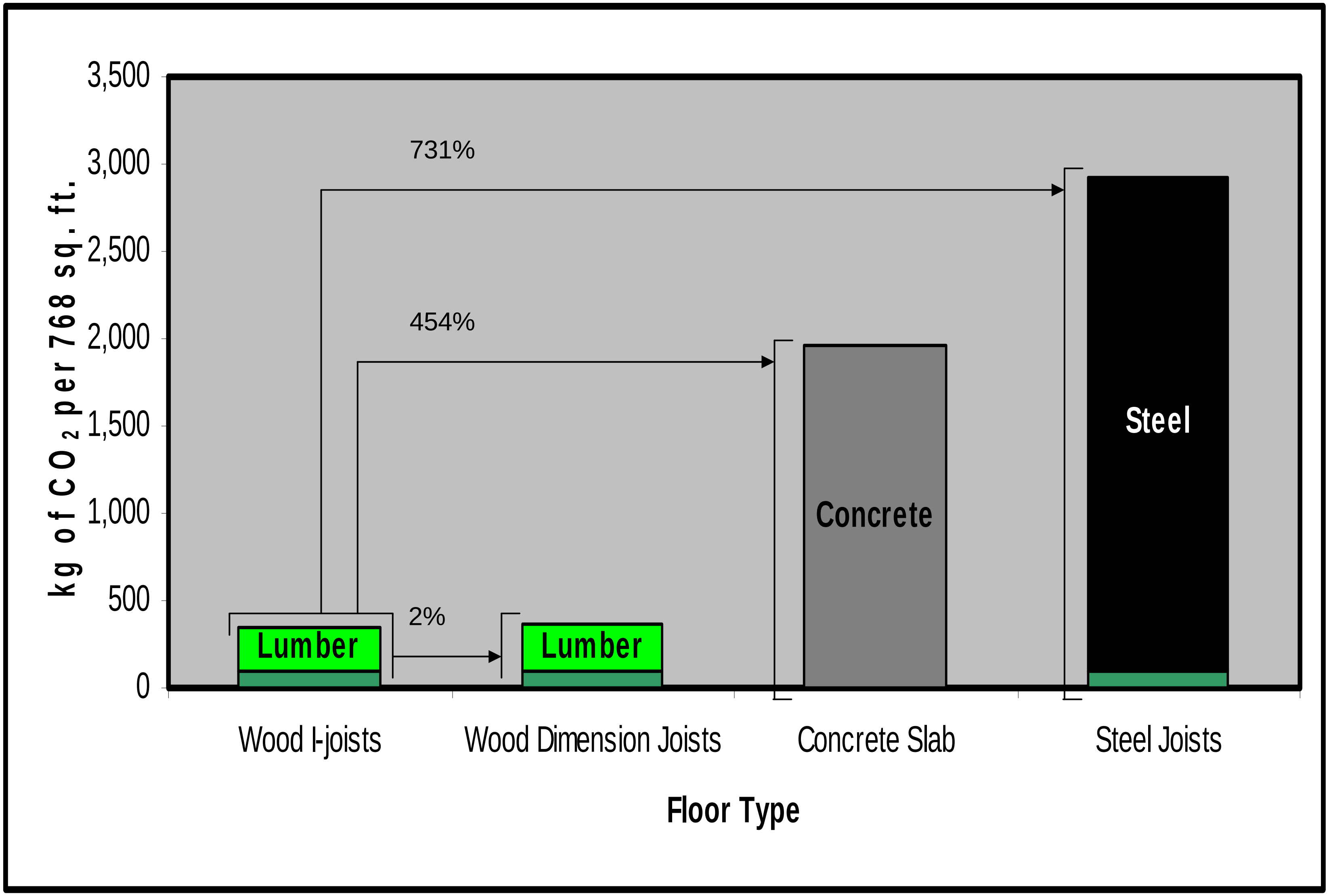
Minneapolis Walls: GWP (GHG) by component



Atlanta Walls: Global Warming Potential: GWP by component



Floors: GWP by component



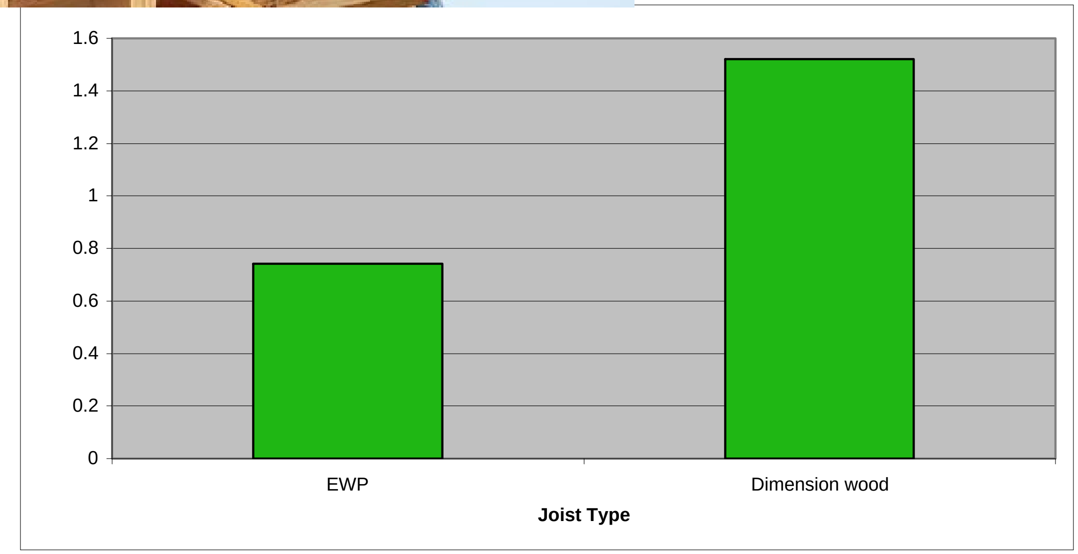
I-joist uses ½ the fiber of a dimension joist:

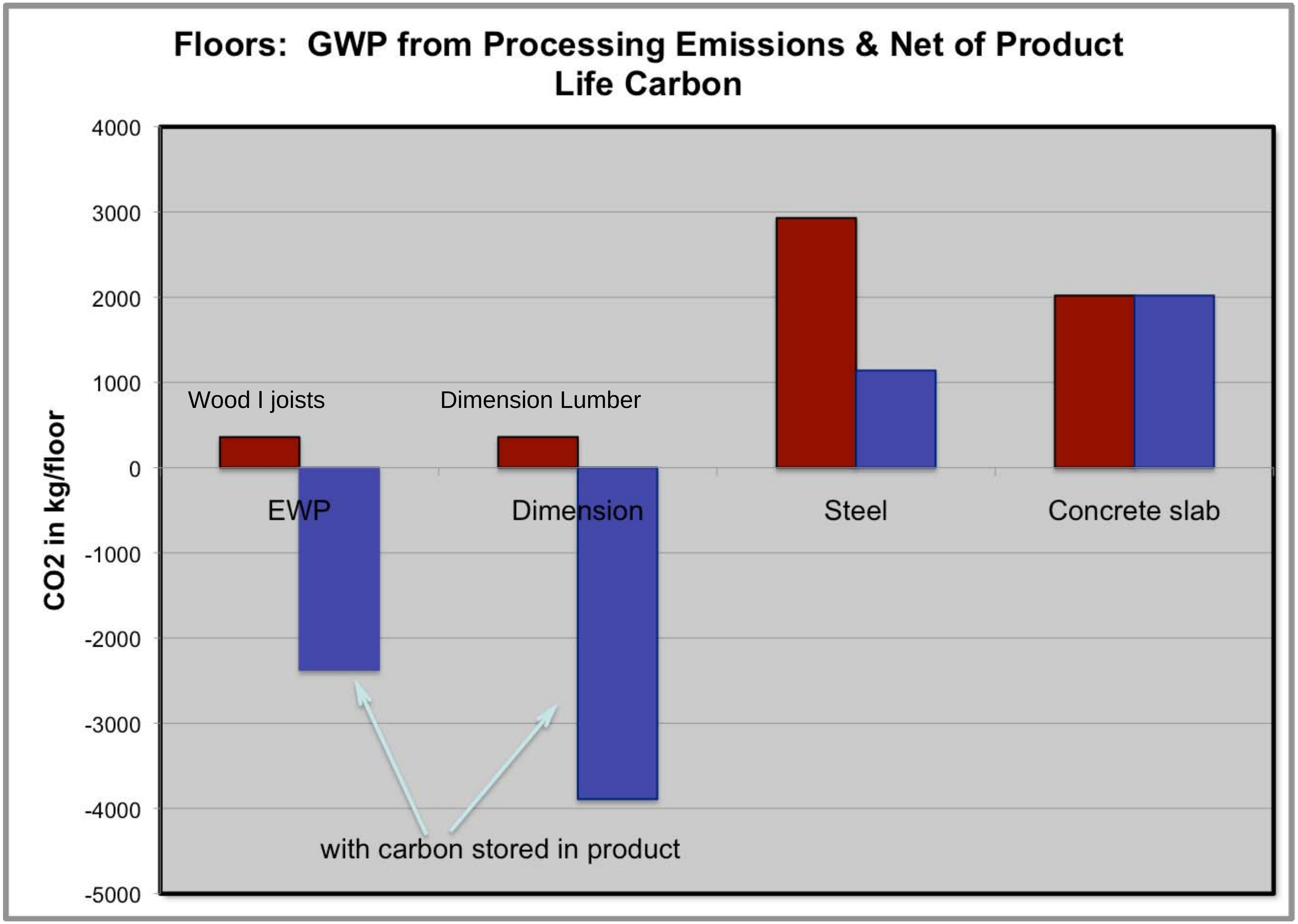
-reduced profile & stiffer

-cut to length with less waste

-underutilized species

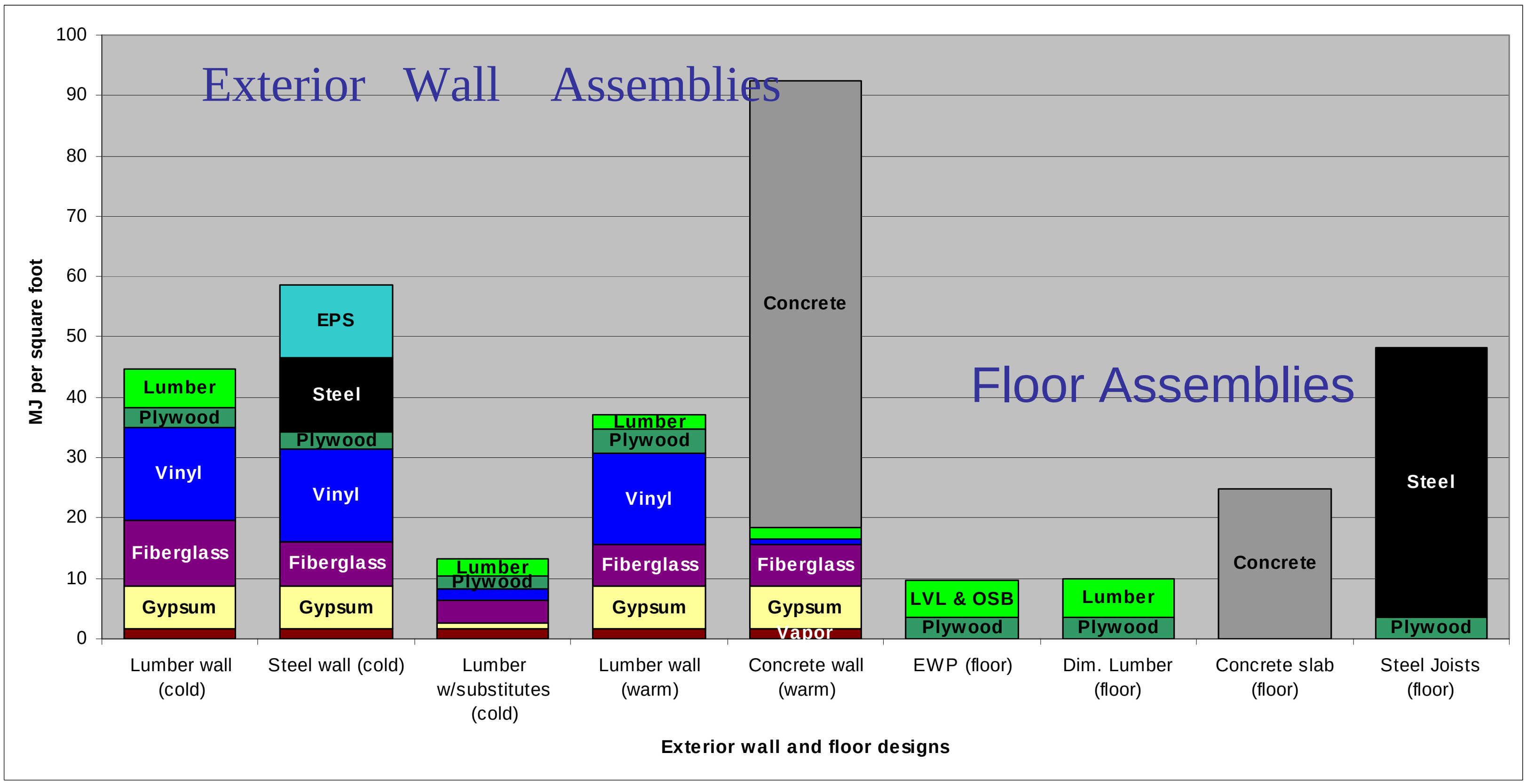
-doubling resource use efficiency




Floors: GWP from Processing Emissions & Net of Product Life Carbon
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-5000
CO2 in kg/floor
Wood I joists
Dimension Lumber
EWP
Dimension
Steel
Concrete slab
with carbon stored in product

Many Alternatives Can Improve Performance:

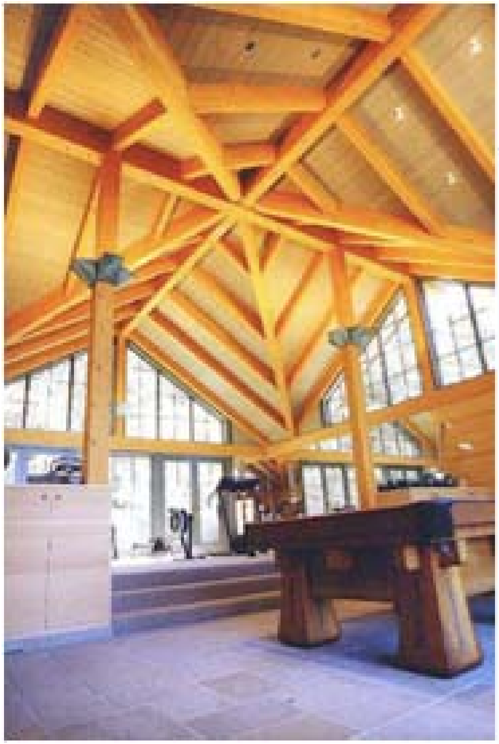
materials, product development, design, process



More Direct Substitution

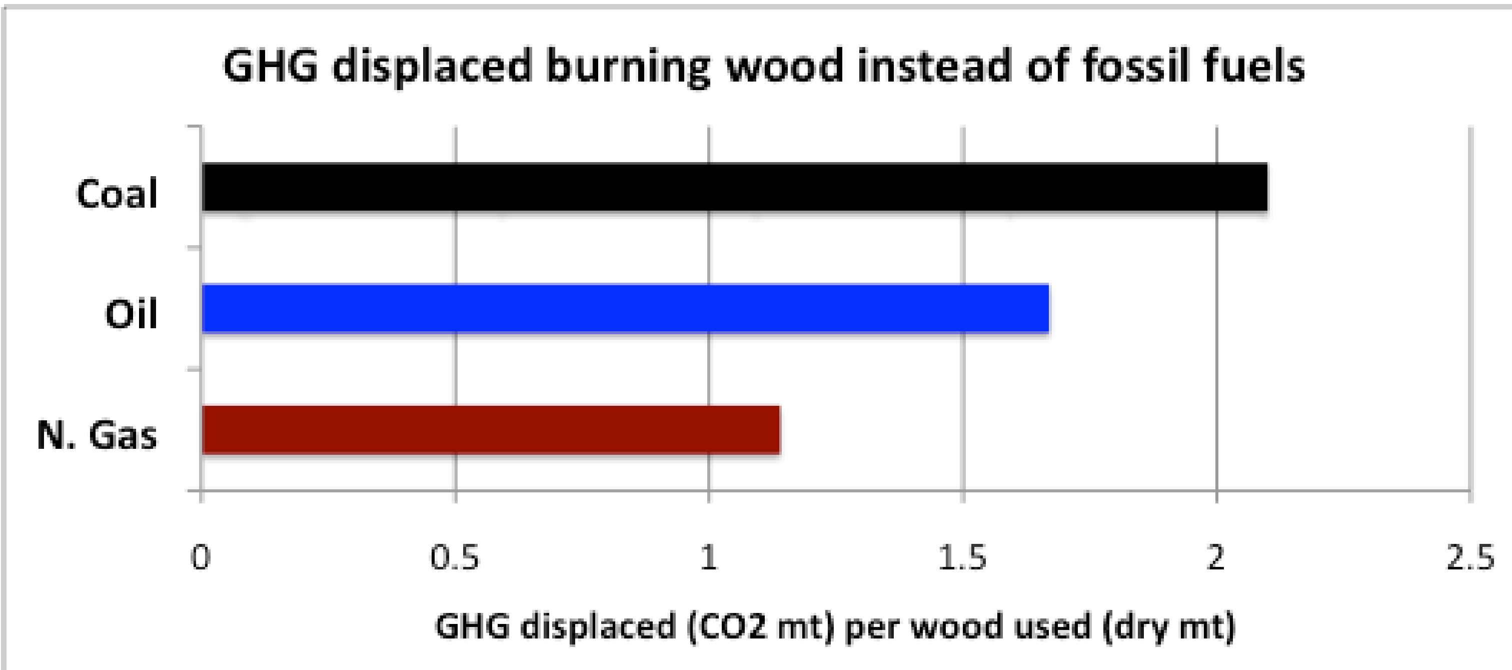

LCA driven opportunities

No limits on potential design: *even from reclaimed wood*



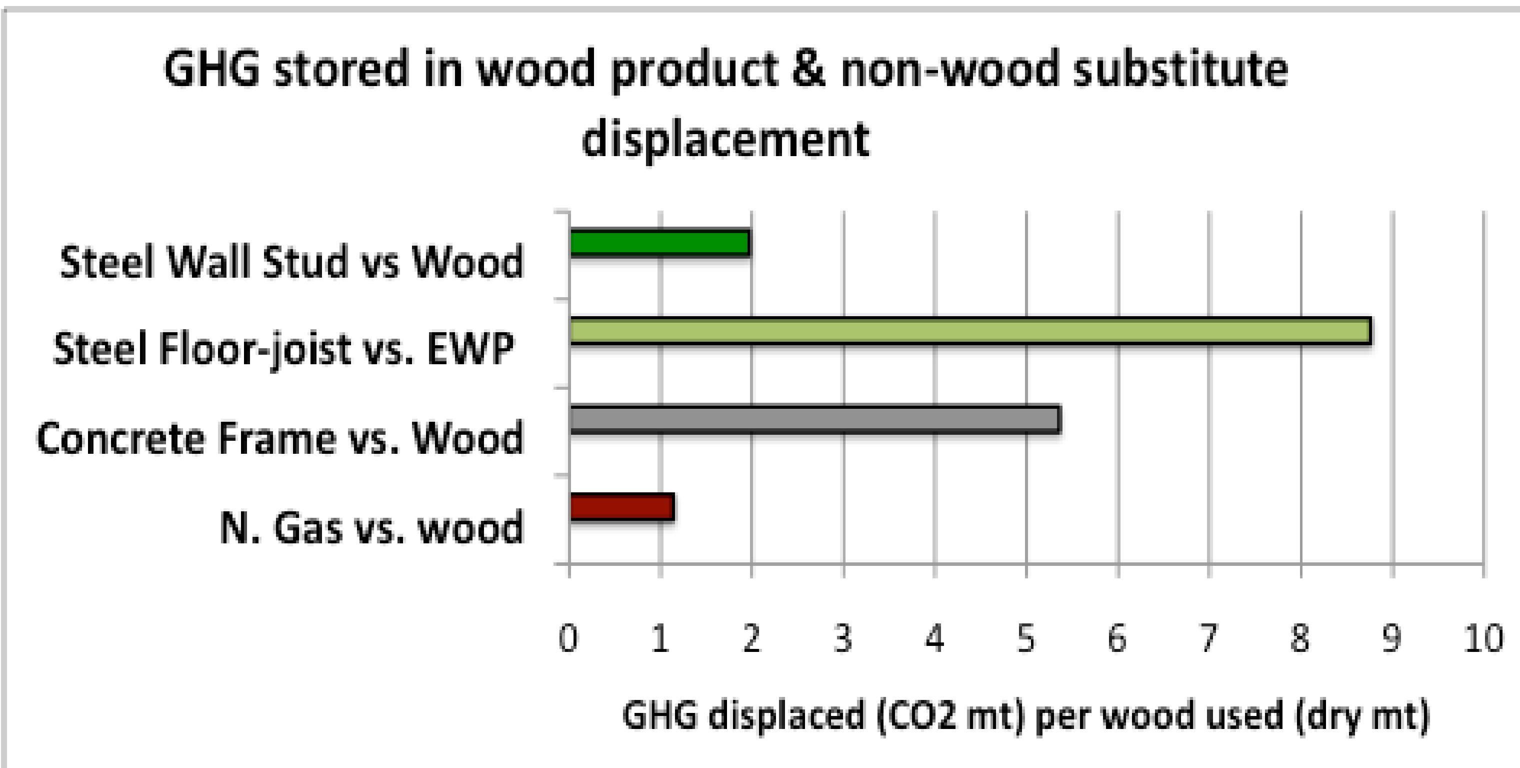
Displacing Carbon Emissions

Burning wood for energy permanently displaces fossil fuel carbon emissions: as important as storing carbon



Displacing Carbon Emissions

Substituting wood for energy intensive materials can be more effective



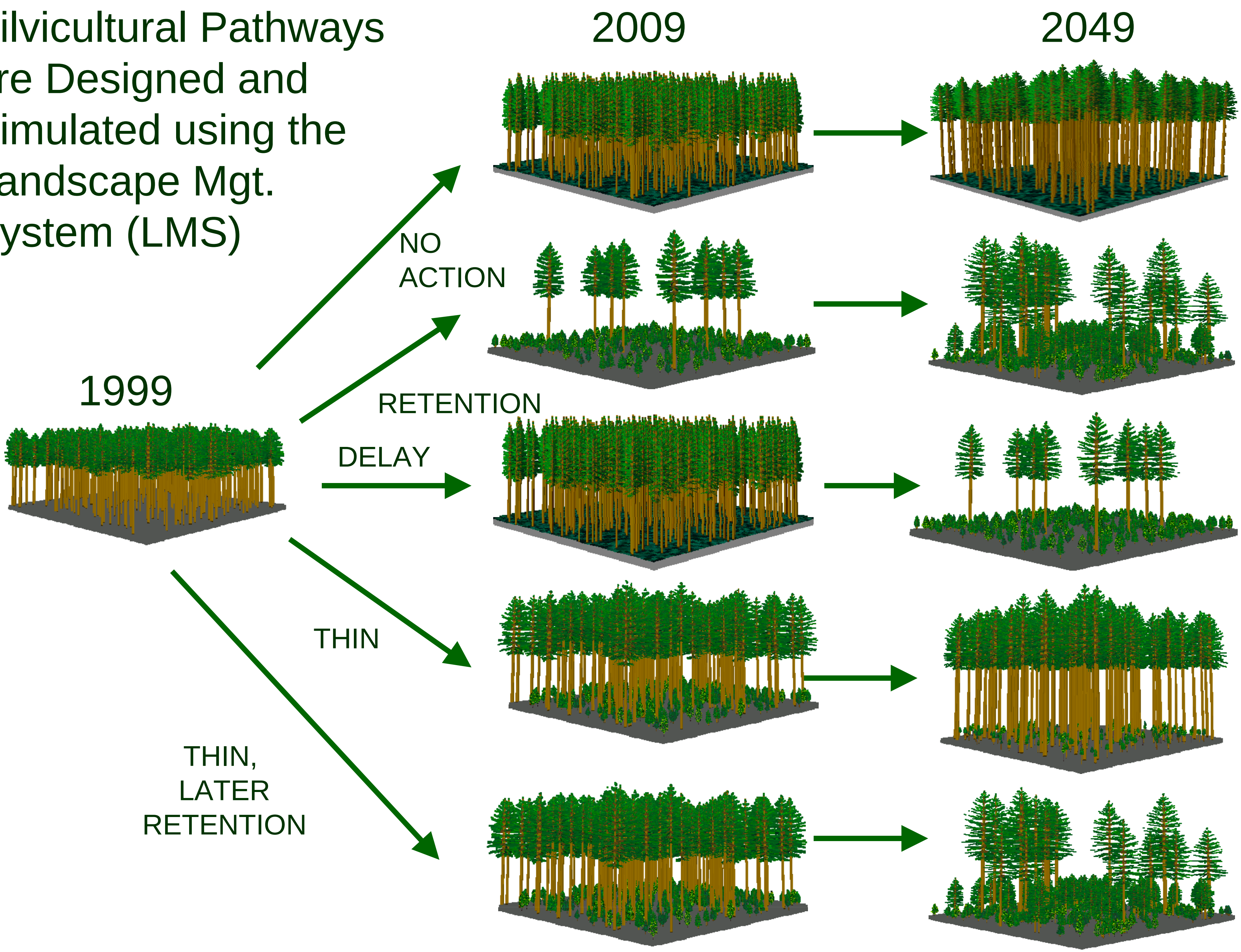
Linking all product life cycle pools to the forest: tracking carbon from forests to uses

- ✓ LCI provides a cross section of every stage of processing at a point in time

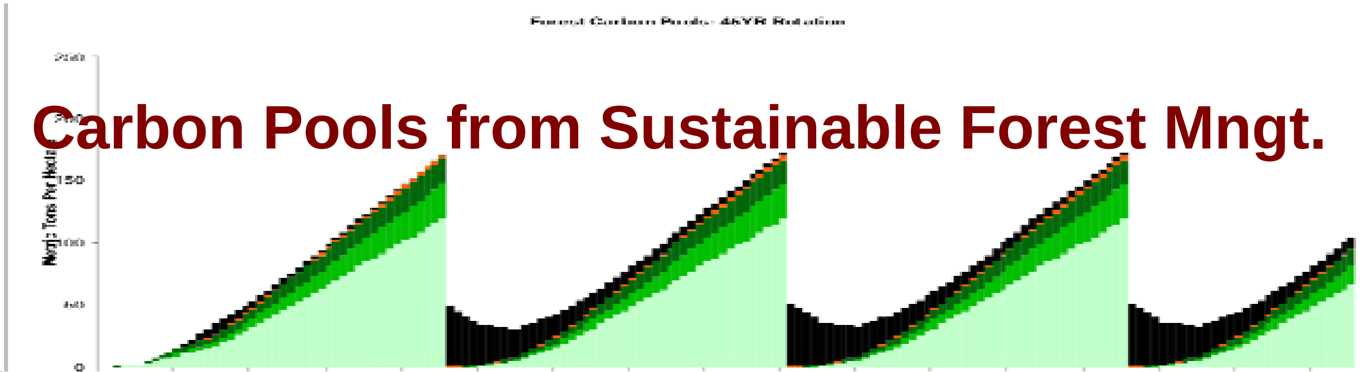
- ✓ *Tracking carbon pools over time*: attach each current process to their time event (current processes, not predicted technology change)

- ✓ Simulate forest carbon with growth models linked to product & substitution impacts

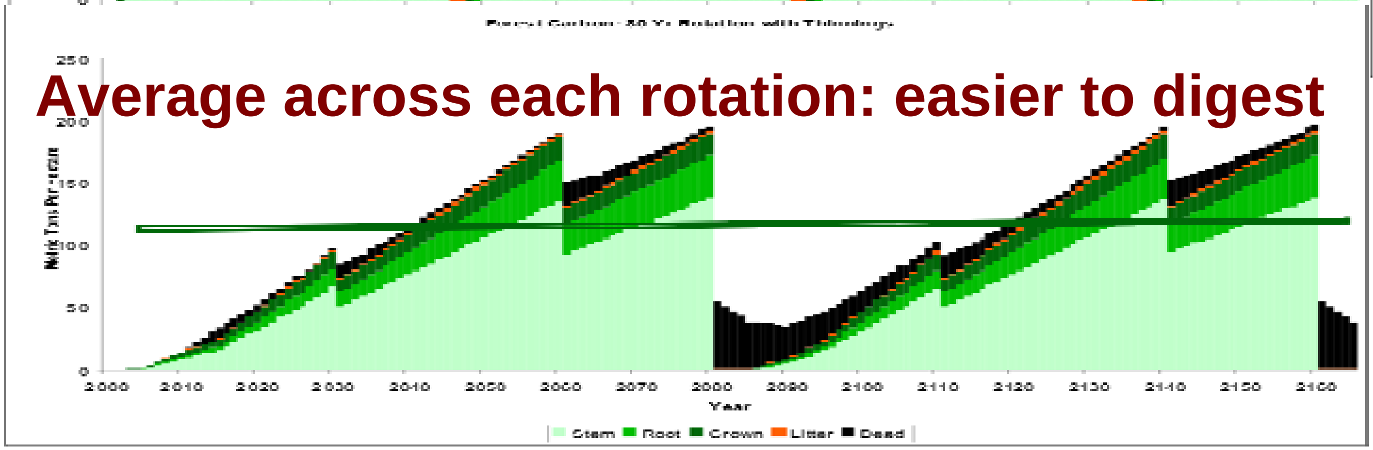
Silvicultural Pathways are Designed and Simulated using the Landscape Mgt. System (LMS)

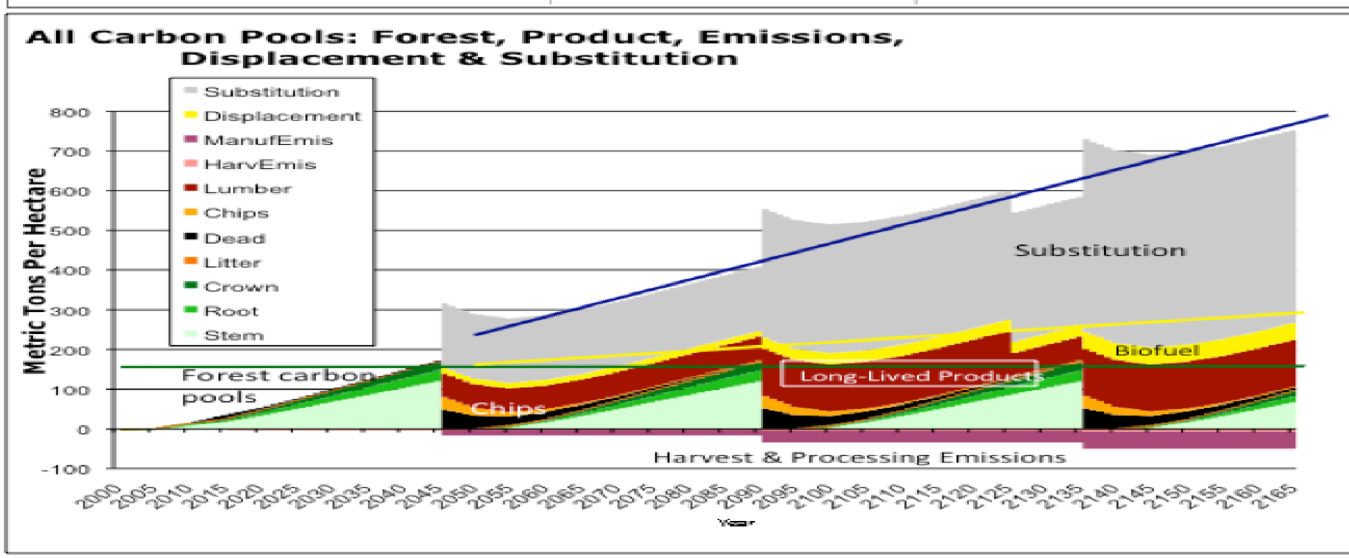


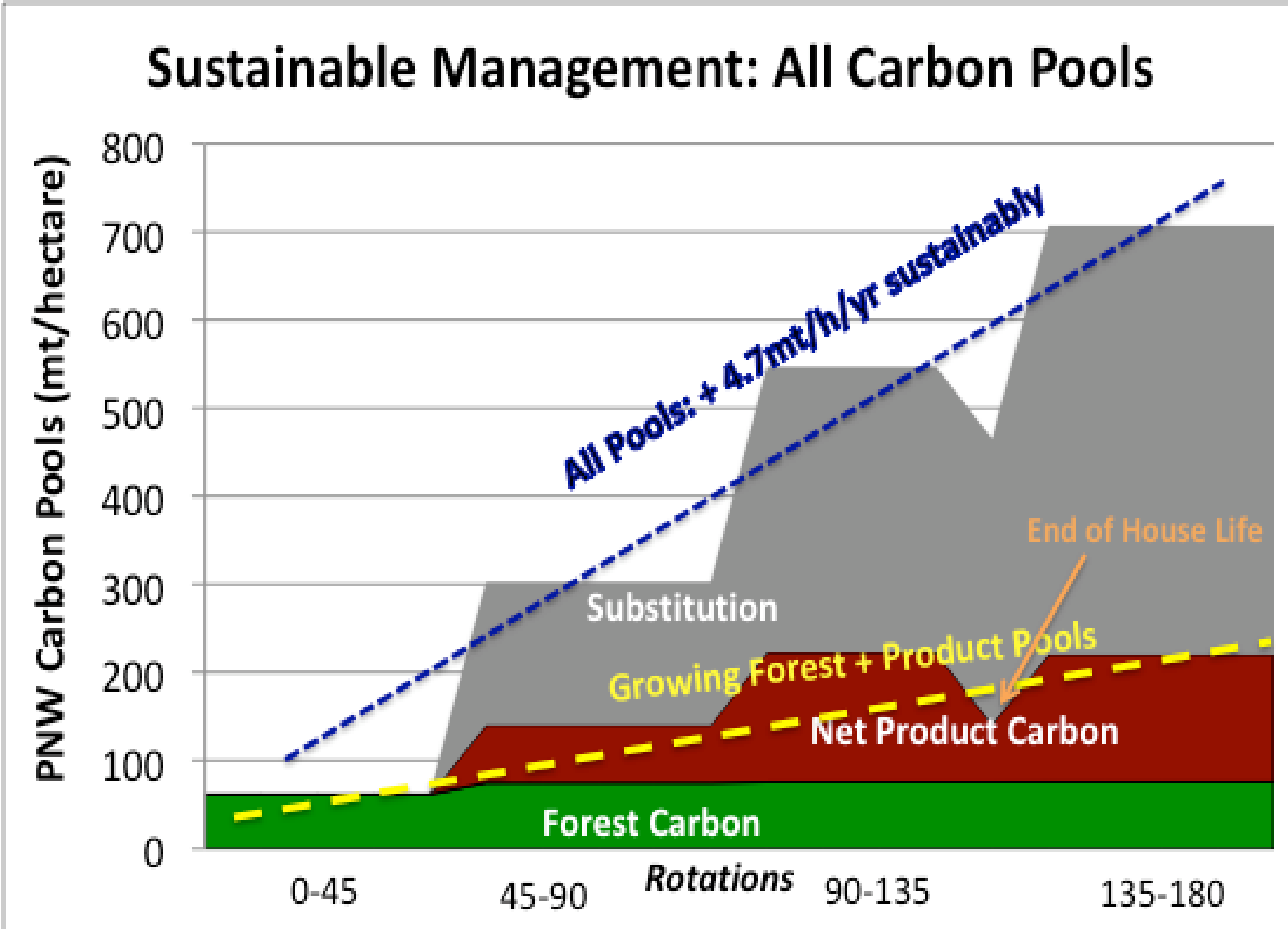
Carbon Pools from Sustainable Forest Mngt.

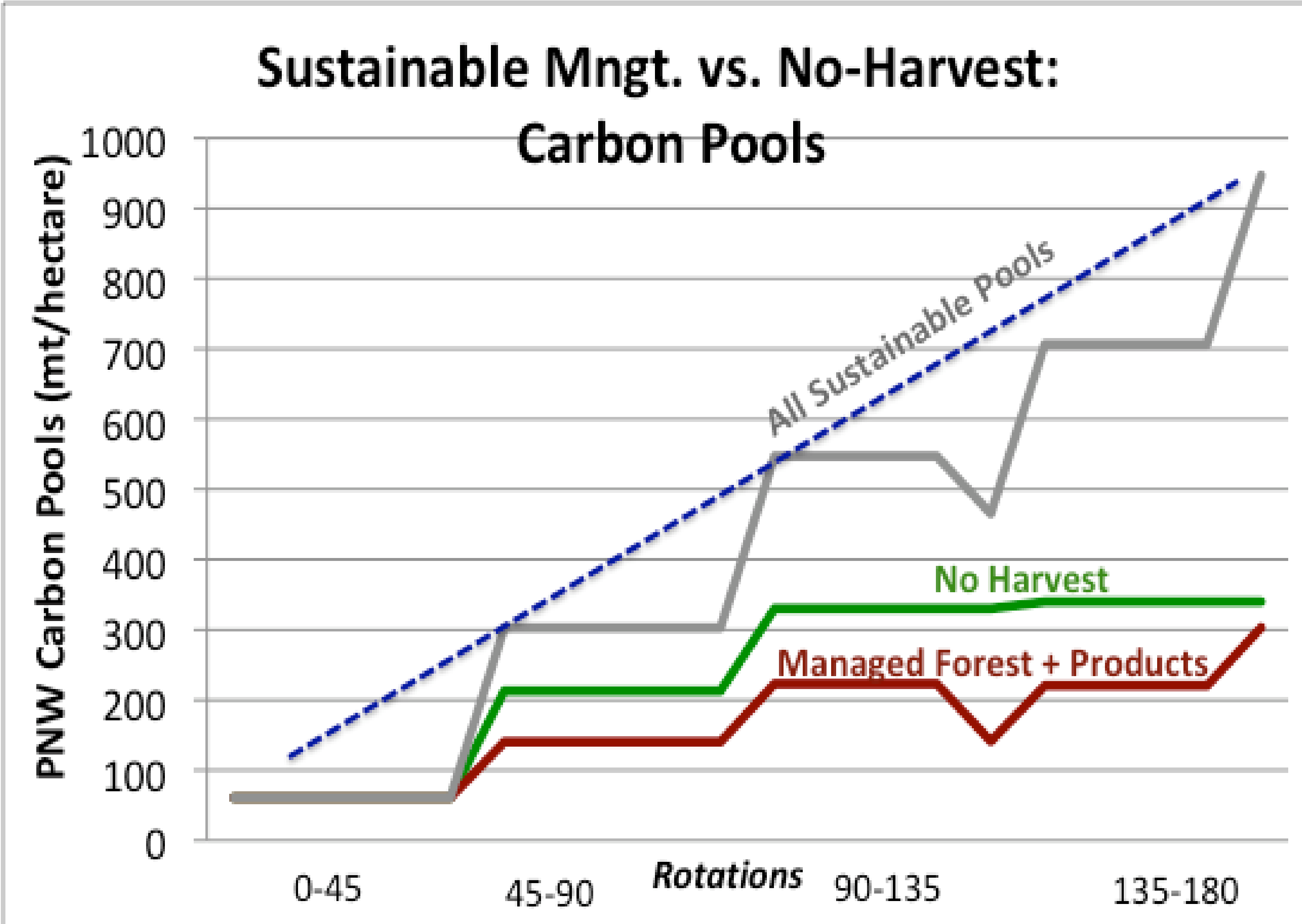


Average across each rotation: easier to digest



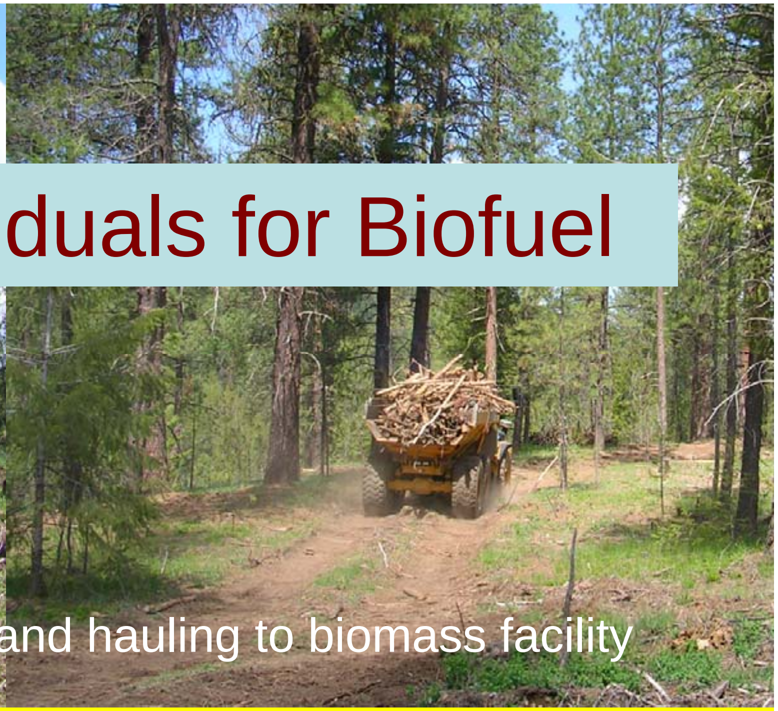



Sustainable Management: All Carbon Pools
PNW Carbon Pools (mt/hectare)
800
700
600
500
400
300
200
100
0
All Pools: + 4.7mt/h/yr sustainably
End of House Life
Substitution
Growing Forest + Product Pools
Net Product Carbon
Forest Carbon
Rotations
0-45
45-90
90-135
135-180



Sustainable Mngt. vs. No-Harvest:
Carbon Pools
PNW Carbon Pools (mt/hectare)
1000
900
800
700
600
500
400
300
200
100
0
All Sustainable Pools
No Harvest
Managed Forest + Products
Rotations
0-45
45-90
90-135
135-180

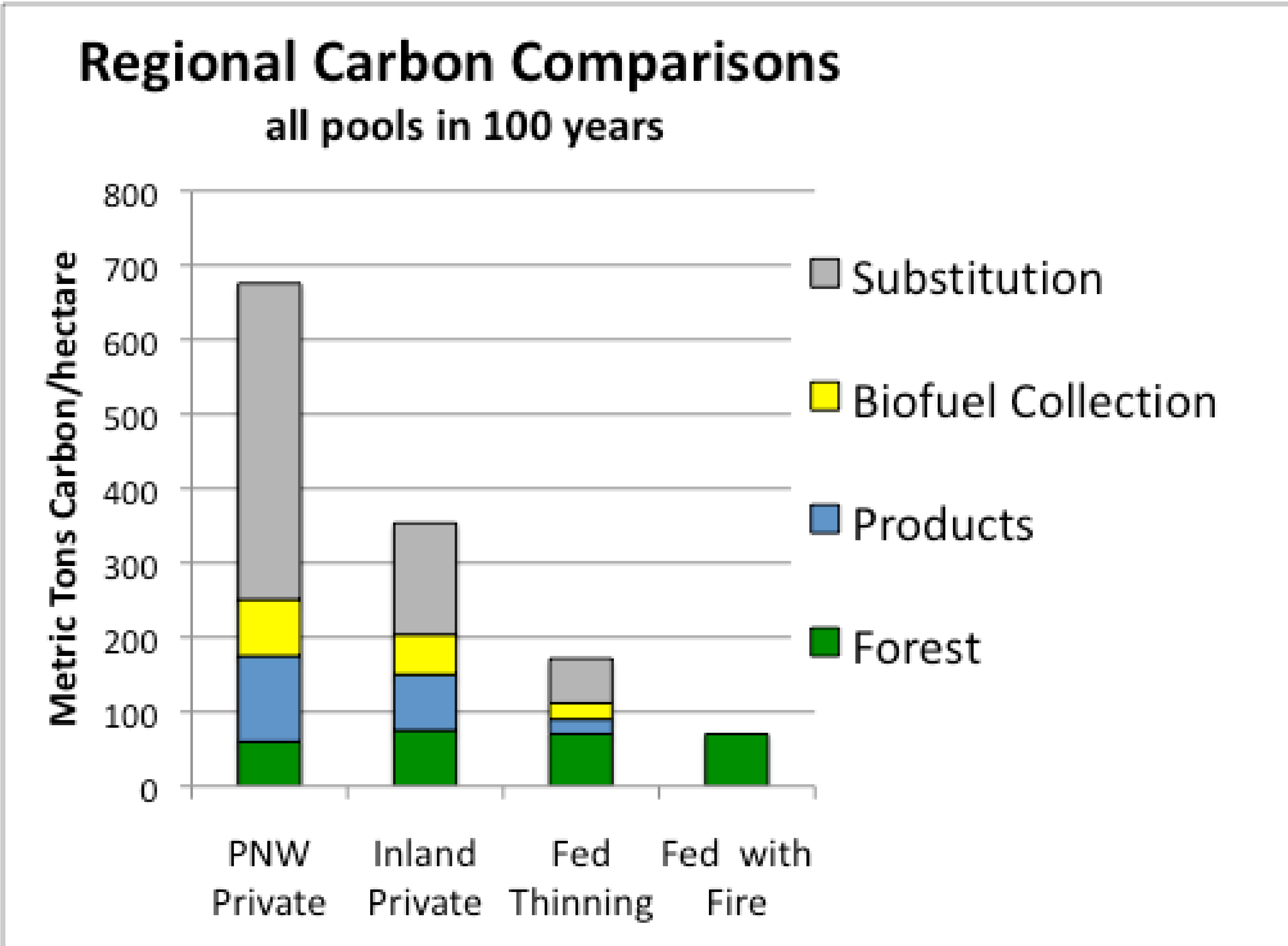
Residuals for Biofuel



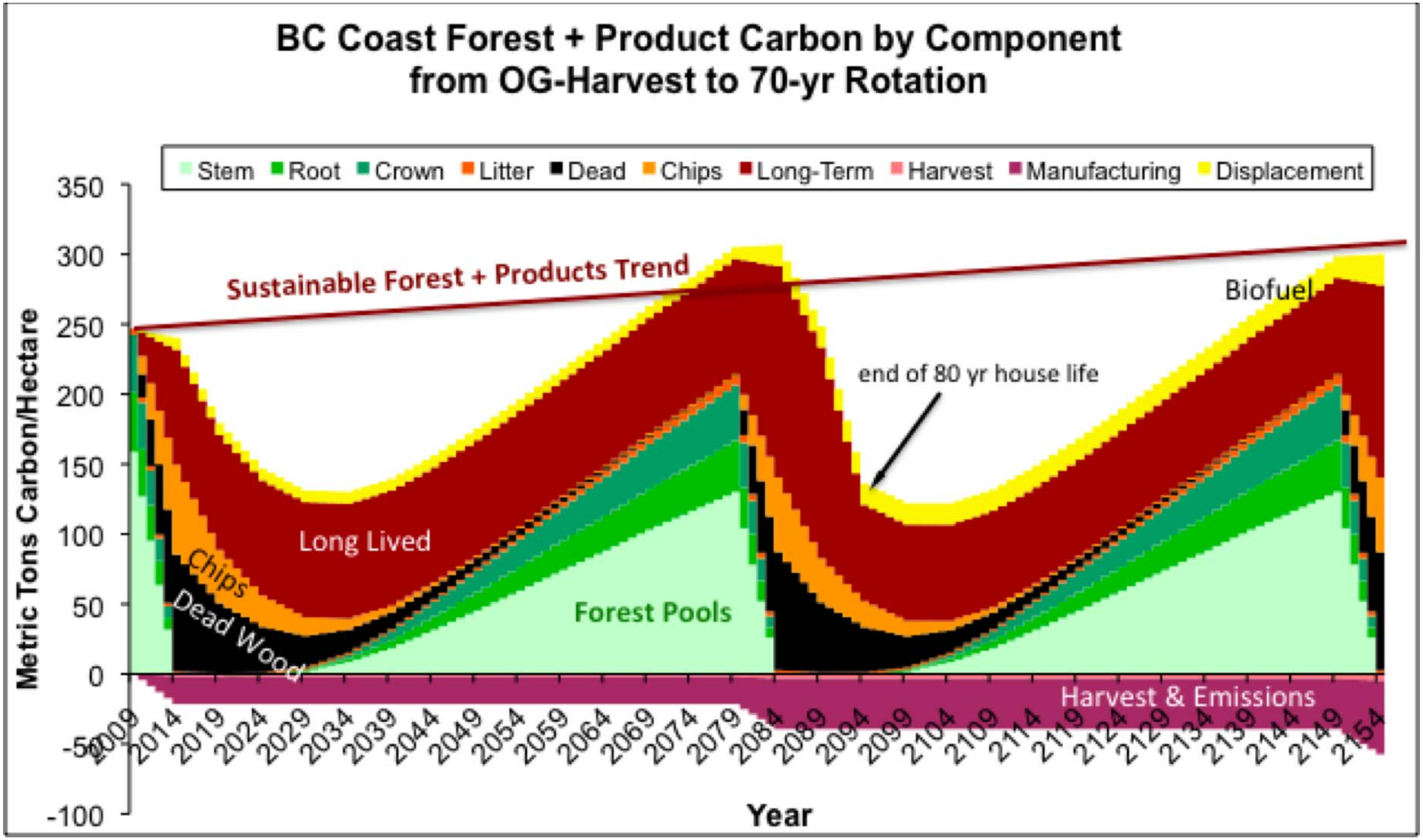
Load of forest residuals and hauling to biomass facility

Ground Slash Feedstock = 50% of merch logs

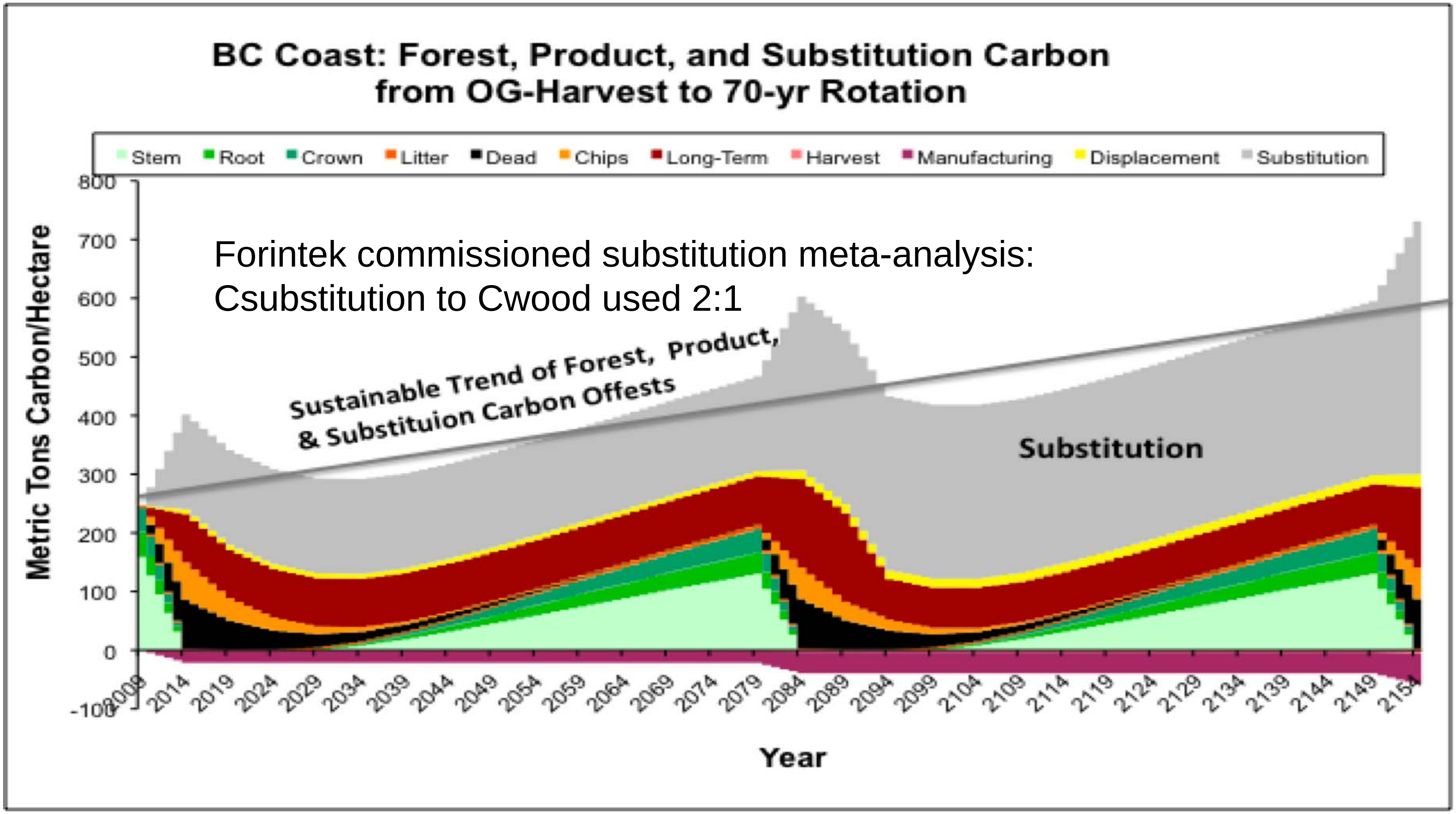
Residuals piles at processing yard



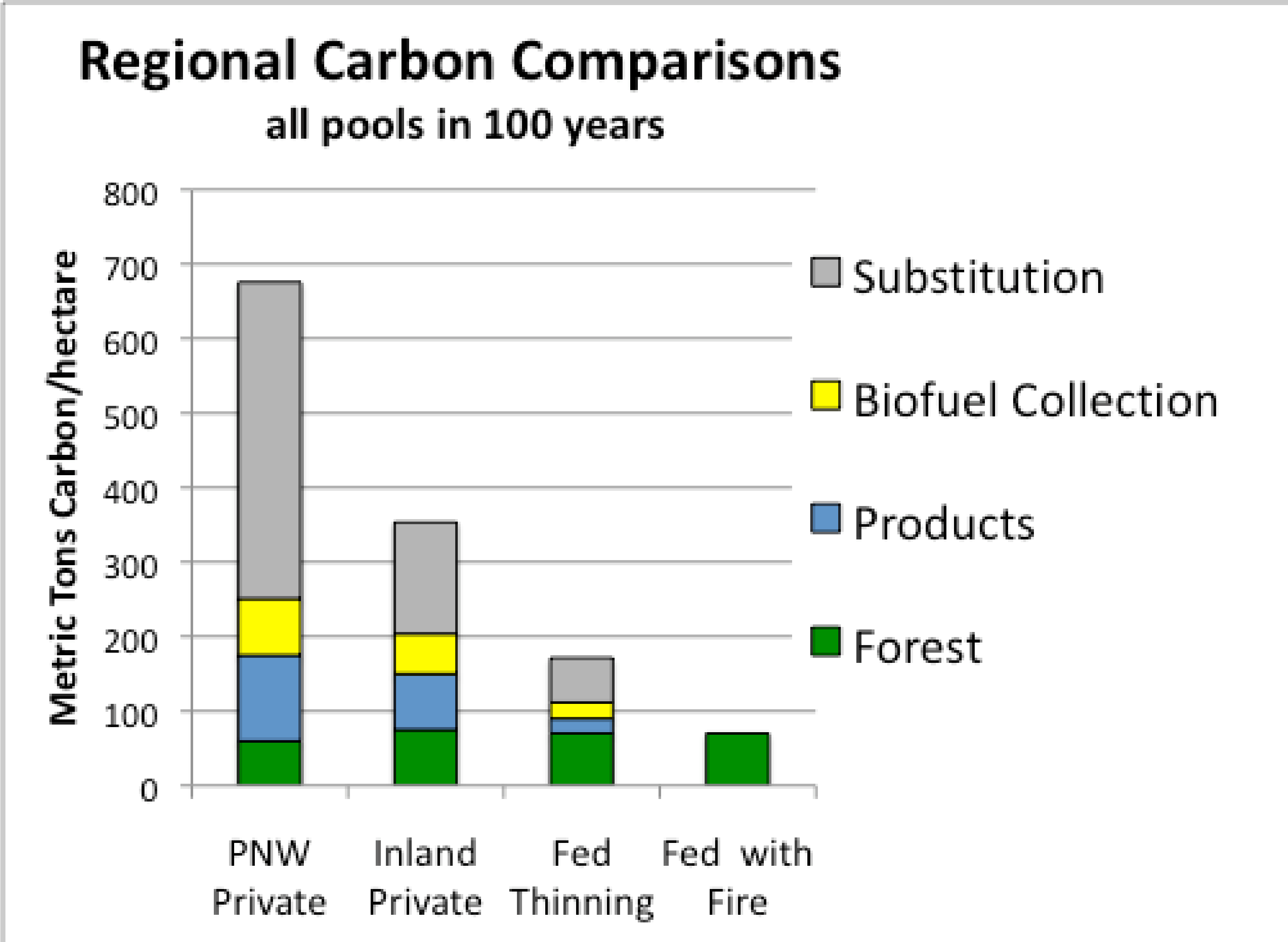
Regional Carbon Comparisons
all pools in 100 years
Metric Tons Carbon/hectare
0
100
200
300
400
500
600
700
800
Substitution
Biofuel Collection
Products
Forest
PNW Private
Inland Private
Fed Thinning
Fed with Fire



- ✓ Forest + Product pools demonstrate sustainable trend although falling below initial forest carbon as short lived pools decompose
- ✓ Long-lived product pool increases with each rotation with longer house life



- ✓ Substitution at first harvest more than offsets dead wood & short lived product carbon losses



Regional Carbon Comparisons
all pools in 100 years
Metric Tons Carbon/hectare
800
700
600
500
400
300
200
100
0
Substitution
Biofuel Collection
Products
Forest
PNW Private
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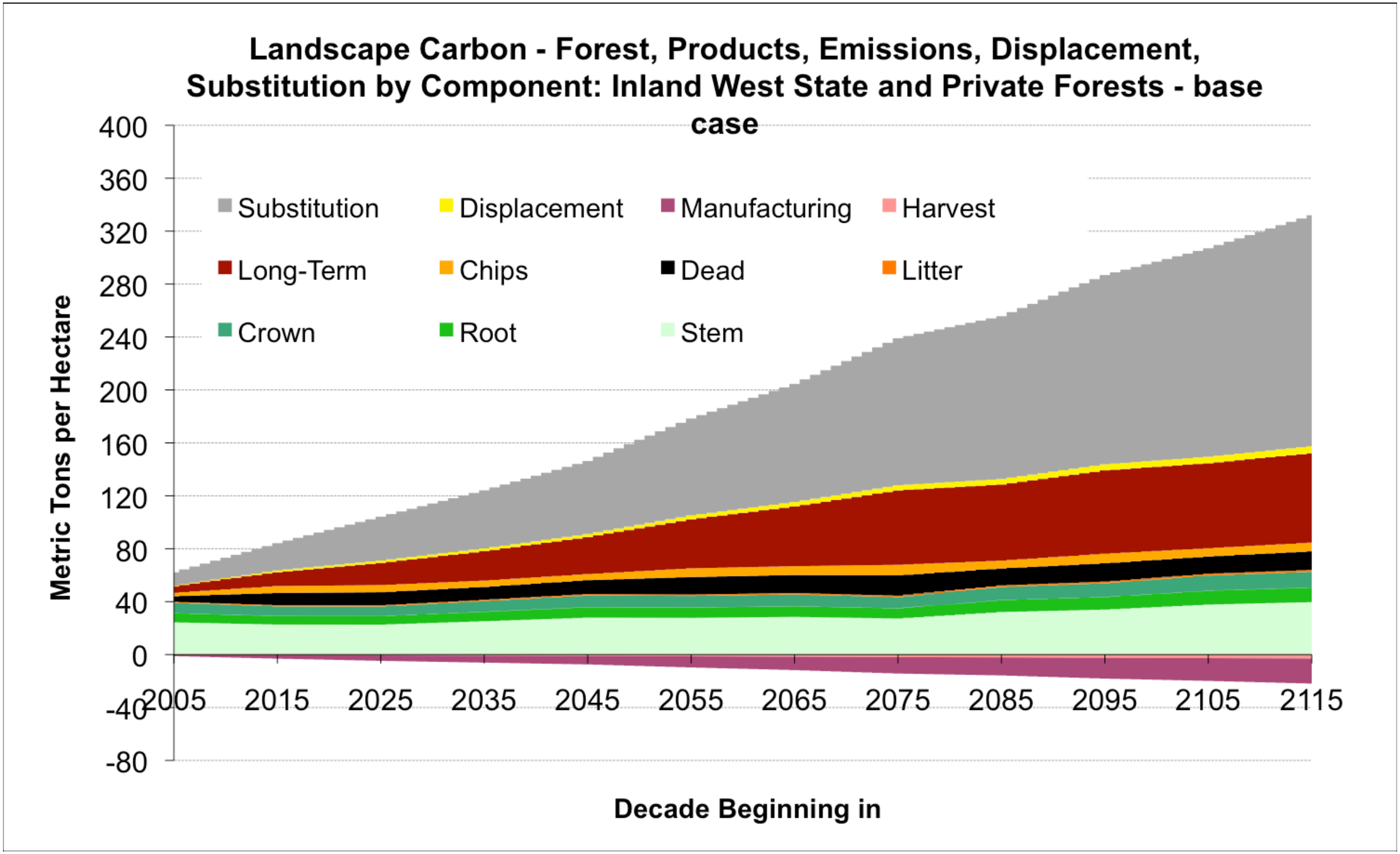
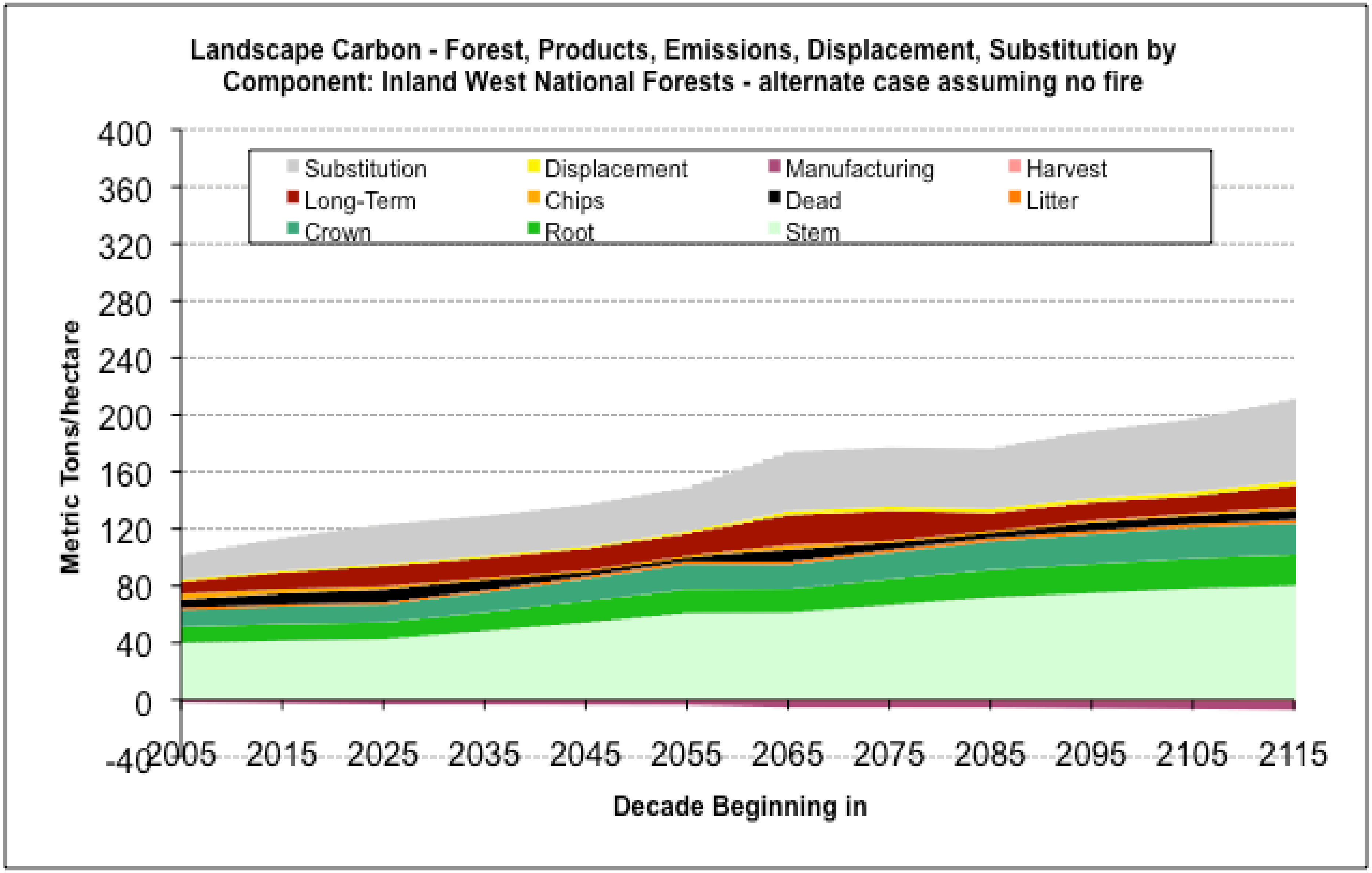
Fed Thinning
Fed with Fire

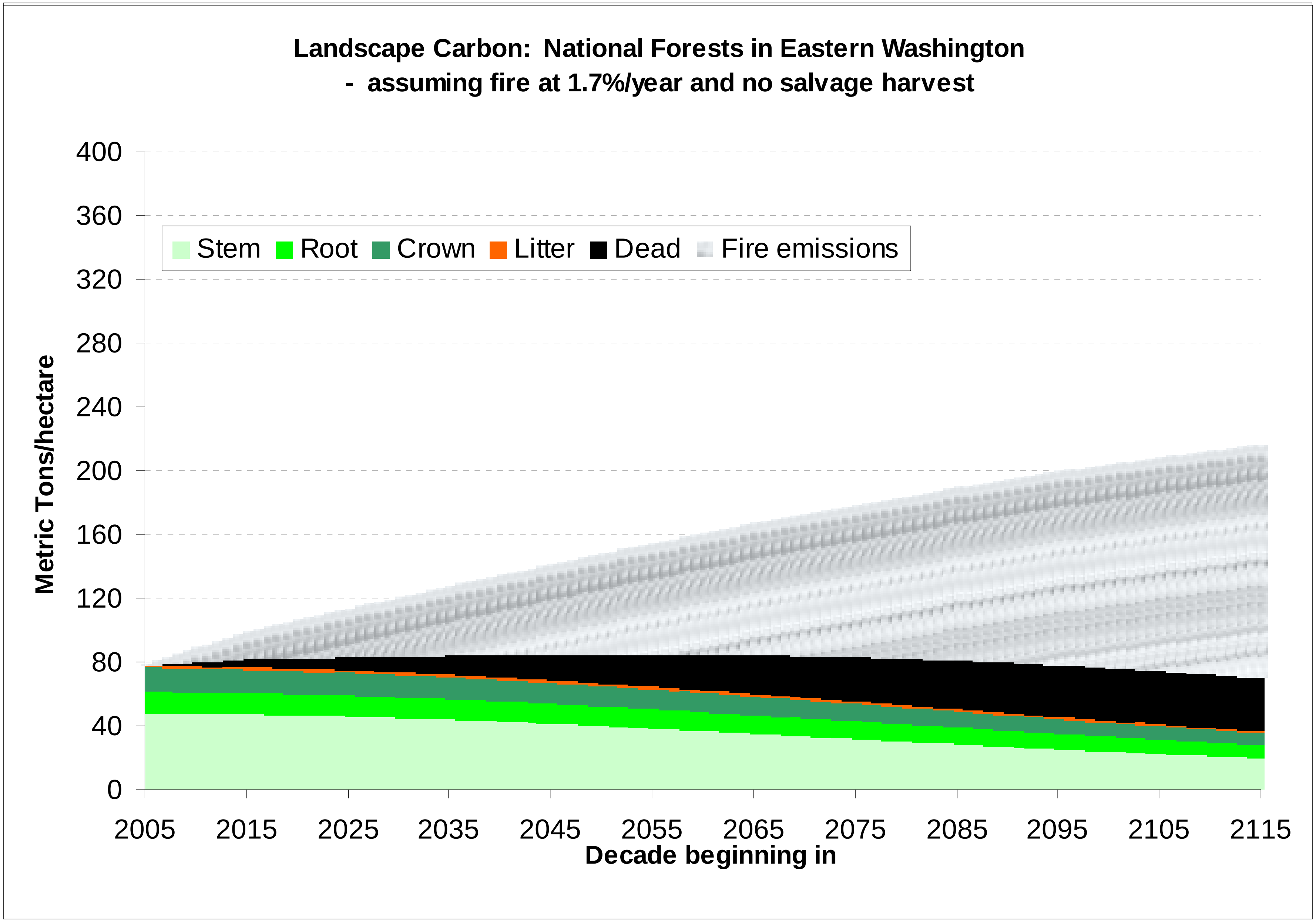
Carbon Pools across State & Private Inland West

(per hectare average)

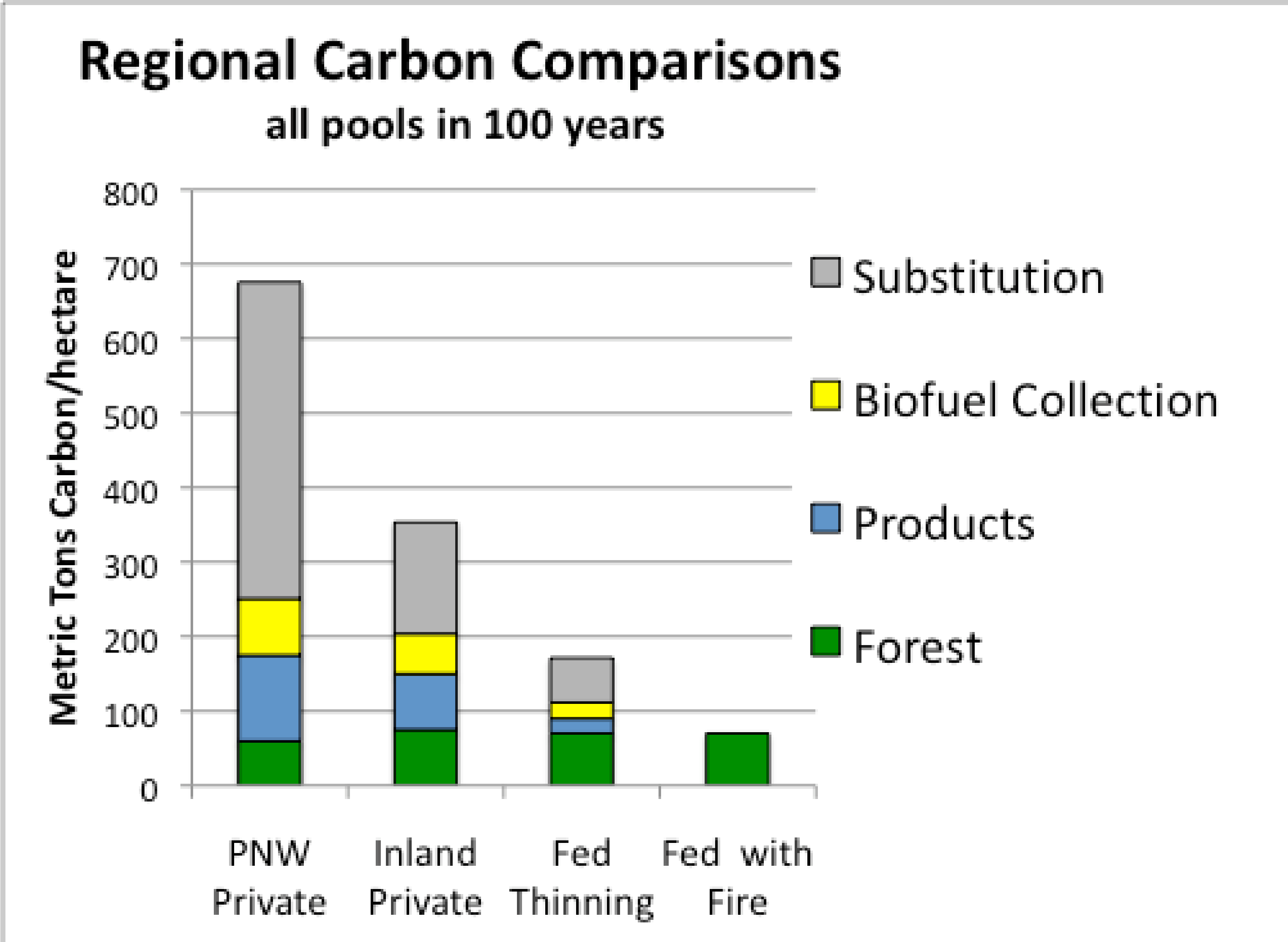


If increased Forest Service thinnings were fast enough to avoid fire





Landscape Carbon: National Forests in Eastern Washington
- assuming fire at 1.7%/year and no salvage harvest
Stem
Root
Crown
Litter
Dead
Fire emissions
Metric Tons/hectare
0
40
80
120
160
200
240
280
320
360
400
2005
2015
2025
2035
2045
2055
2065
2075
2085
2095
2105
2115
Decade beginning in


Regional Carbon Comparisons
all pools in 100 years
Metric Tons Carbon/hectare
800
700
600
500
400
300
200
100
0
PNW Private
Inland Private
Fed Thinning
Fed with Fire
Substitution
Biofuel Collection
Products
Forest

Biofuel use provides a major new opportunity

- Remove residuals & thinnings to reduce fire and insect risk
  - Capturing the product and displacement carbon rather than burning forest residuals & wildfire
  - Improves forest resiliency to climate change
  - Need scale volumes inclusive of federal thinnings for scale investments in regional ethanol processing
- Thinnings avoid the future social costs of "no-management"
  - cost of fighting fires, fatalities, facility losses, restoration costs, water lost, timber and habitat lost, community impacts of smoke, carbon lost

Uses of Life Cycle Carbon accounting

- track carbon across multiple carbon pools -

- Policy based on single carbon pools will likely be counterproductive.
- Incentives to deliver more carbon faster will increase carbon in all pools (although producing less old forest habitat).
- Credits for builders to displace fossil intensive products. *Given the high leverage from substitution, builders have the greatest opportunity to reduce emissions*
  - And bid the savings back through the resource supply chain motivating increased investments to reduce emissions.

Uses of Life Cycle Carbon accounting

- Incentives to remove forest residuals to increase biofuels *can be productive*;

  - Not if the incentive diverts wood feedstocks from higher valued uses like fiberboards that substitute for fossil intensive products.
  - Incentives for the end product ethanol will steal feedstock before collecting residuals

Uses of Life Cycle Carbon accounting

- Arbitrary rules such as requiring permanency in the product to 100 years ignore life cycle assessments
  - Wood uses from the acre are better than permanent, ***growing*** sustainably

- Incentives that recognize the losses in carbon from fires and the costs of fighting fires would encourage below cost thinnings to reduce fire & insect risk.
  - Reducing carbon emissions from fires also increases, feedstocks for biofuels & substitution
  - Improves forest resiliency to climate change but we need more *site-specific* (by forest type) research on how much to thin.

Some Conclusions

- Fossil energy is too cheap and will out-compete wood markets in every downturn until the fossil fuel cost structure is increased.
- We have a long way to go to get the rules consistent with good science so they are not counterproductive.
- Incentives can too easily be counterproductive
  - Incentives for ethanol will bid away existing feedstocks before they pay for the increased cost to collect forest residuals and thinnings
  - Incentives for small scale production like renewal energy standards (targets) will proliferate small scale incremental uses of biofuels preempting the supply needed for scale ethanol plants
  - Incentives for forest carbon will delay harvest & increase fossil fuels use.
  - Be careful what you ask for?

Impact of Higher Fossil Fuel/Carbon Prices
- an optimistic future -

- ✓ Pay to collect forest residuals & waste
- ✓ Pay to use more wood in construction or other fossil substitutes (furniture etc.)
  - Where the carbon displacement leverage is highest
- ✓ Use more biofuels (*but solid wood prices must rise more than biofuel feedstock to avoid counter productive result)*
- ✓ Pay to grow it faster & use it sooner, not grow it longer

What we don't yet know

- Product substitution parameters
  - Structural change over time
    - losing share for decades
    - where less direct vs more (higher leverage)
  - Elasticities of substitution
  - Furniture, cabinets, trim, hybrids
  - Other uses of mill residuals: paper, plastic composites
- Recycling (especially for more than energy)
- Environmental product development

What we don’t yet know

- Biofuel feedstock & processing LCIs
  - A current Phase I project & Phase II proposals
    - Many different collection settings: regional differentiation
    - Many processing alternatives limited to process models
    - Policy conflicts & unintended consequences

- Science informed strategy needed
  - Value added market/incentive conflicts

What’s not working

- Building & Regulatory Standards not consistent with LCA
- Education: university, CE, policy, public, even scientists & the choir (education without political advocacy?)
- Environmental product development
- A more strategic response, from whom?

The “forest woodlot”: carbon storage or a pump to stores?

- If your back yard wood-lot is left to grow, once it reaches its carrying capacity it no longer takes carbon out of the air.
- If you cut the dying wood each year to burn in your stove, you can sustainably (forever) avoid freezing while displacing the emissions from energy alternatives you would otherwise need.
- If you cut the wood before the tree growth slows down you may have enough for your neighbor as well,
- Or use that wood to build your growing family’s next house displacing even more emissions from the fossil intensive products you will not need, and for their family’s after that.
- With more good wood lots <u>pumping</u> carbon you can serve a big part of the nation’s housing & energy need, reducing carbon emissions.

Support Acknowledgements

- CORRIM- Consortium for Research on Renewable Industrial Materials
  - 15 research institutions and 23 authors
  - DOE & 5 companies funded the Research Plan
  - USFS/FPL, 10 companies & 8 institutions funded Phase I
- USFS, 10 companies & 6 institutions currently funding Phase 2
- Many product manufactures surveyed

The Details

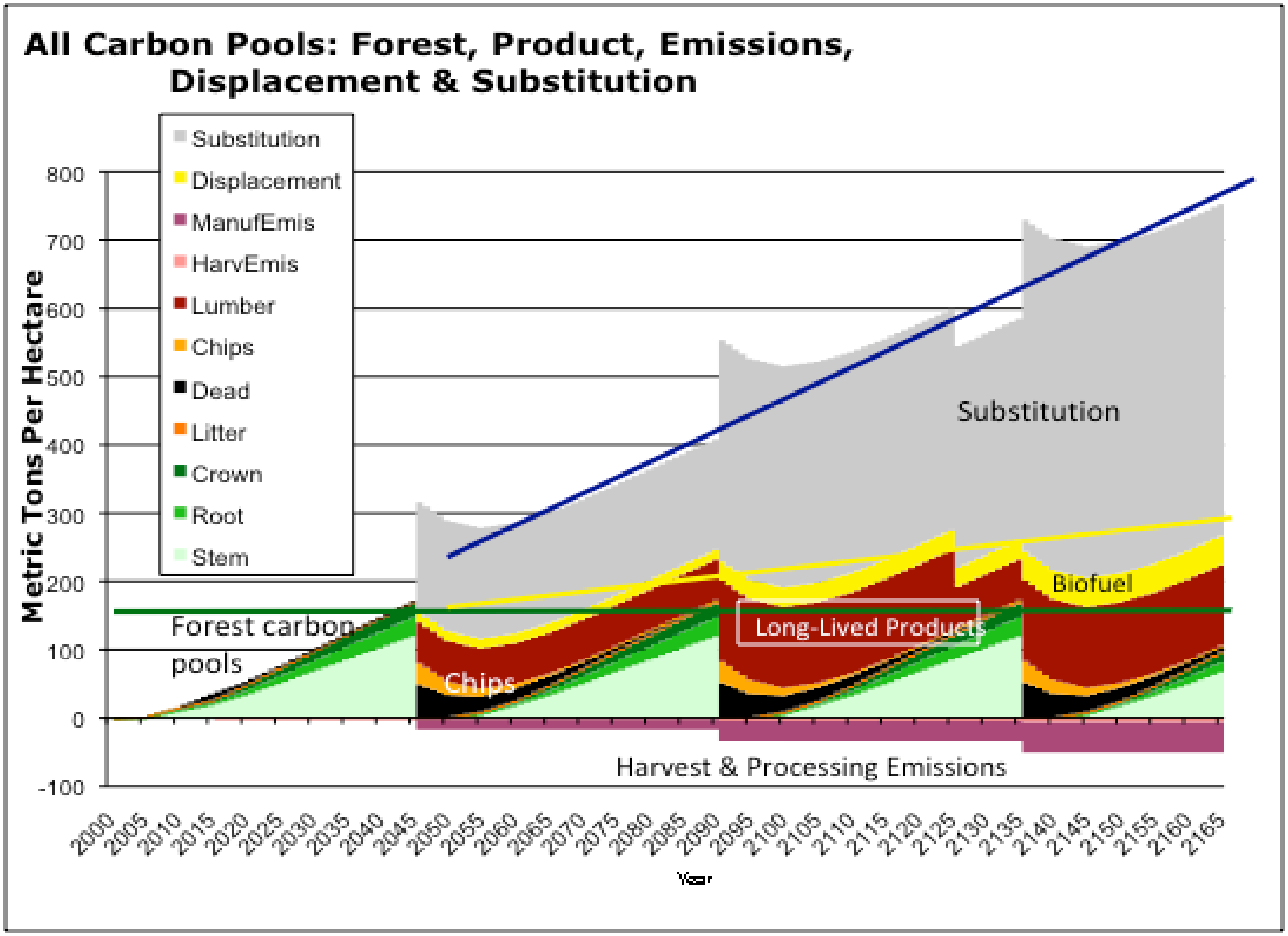
CORRIM: **www.CORRIM.ORG**

Athena: **www.athenaSMI.ca**

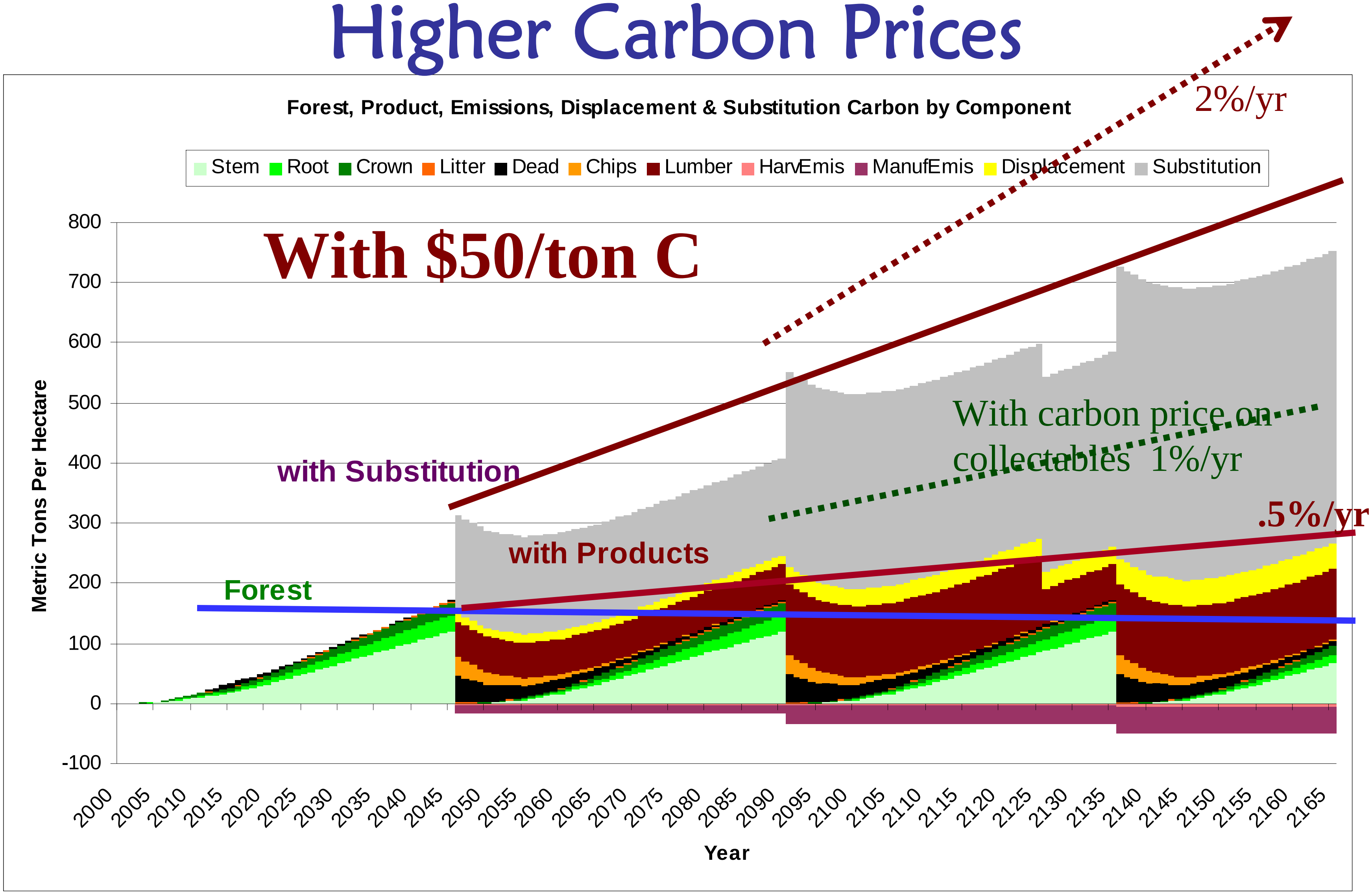
LMS: **http://LMS.cfr.washington.edu**

USLCI database: **www.nrel.gov/lci**

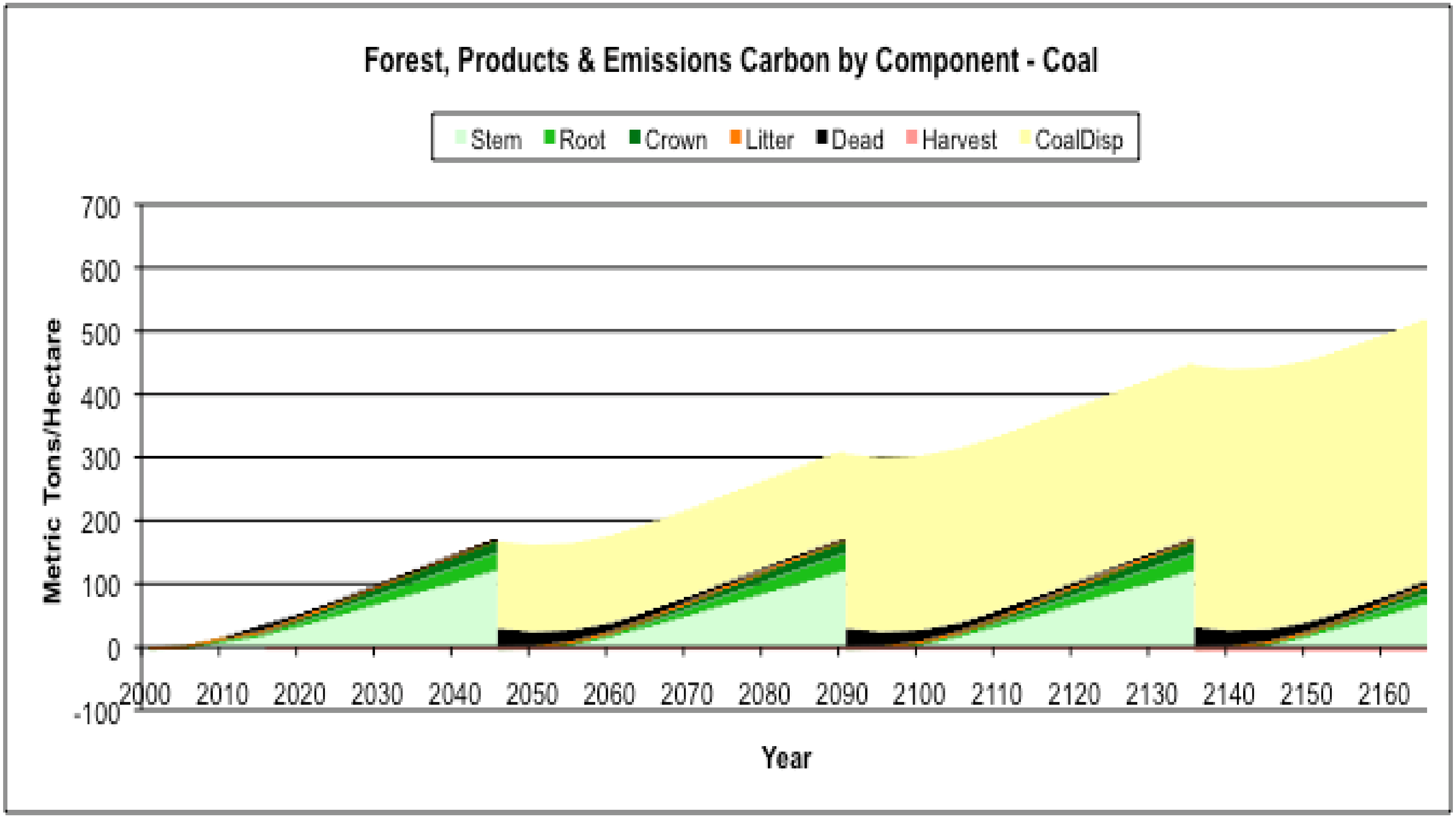
Carbon Pools from Sustainable Forest Management

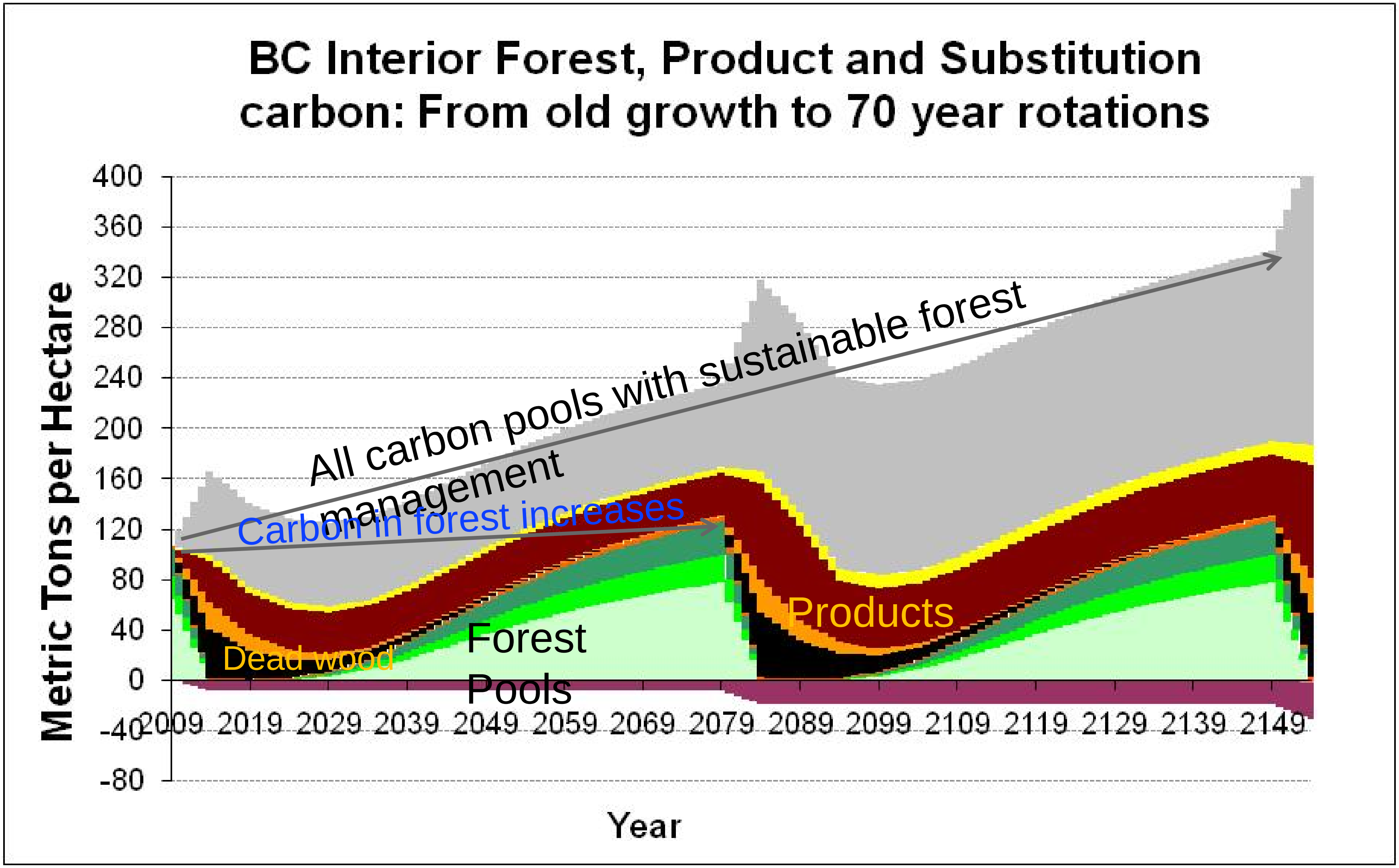


Forest, Product and Substitution Pools with Higher Carbon Prices



Carbon from Forest & Biofuel Displacement of Coal (not reviewed)





- ✓ Starting with net merchantable volume from current inventory and projecting average future expected yields generates a positive trend in forest, product, and substitution pools.

Biomass Collection & Processing LCI/LCA