University of Idaho
College of Natural Resources

CONSIDERATIONS IN MODELING HARVESTED WOOD PRODUCT MITIGATION STRATEGIES

Greg Latta

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Presented at the: Western Forest Economists Meeting
May 16, 2025

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Greg Latta[1] and Chat GPT[2]

[1] Associate Research Professor, Department of Natural Resources and Society, University of Idaho
[2] The Internet

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HWP MITIGATION CONSIDERATIONS

- **Understanding Harvested Wood Products**
  - You first have to know what you are looking at
- **Carbon Storage in Harvested Wood Products**
  - And how it is modeled
- **Strategies for Maximizing Carbon Benefits**
  - This is the actual modeling part
- **Challenges and Considerations**
  - And the part where we reflect on the modeling
- **Conclusion**

UNDERSTANDING HARVESTED WOOD PRODUCTS

- Harvested wood products encompass a wide range of wood-based materials, including lumber, plywood, paper, and furniture, that are derived from harvested trees.

ChatGPT off to a good start

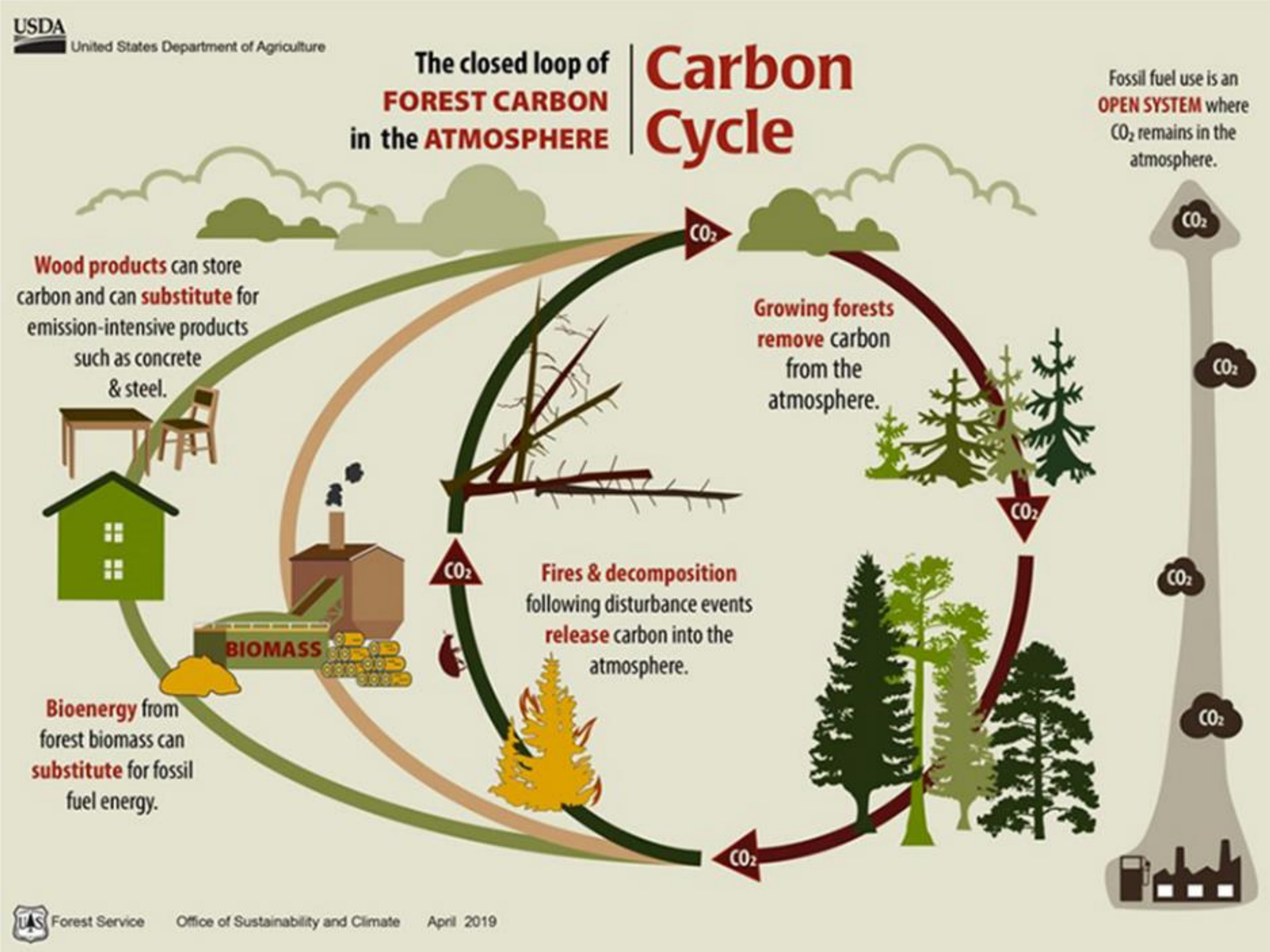
- Unlike standing forests, which continue to sequester carbon for a finite period, HWPs retain carbon for longer durations, thereby extending the carbon storage lifespan and mitigating carbon emissions.

And then again maybe not

CARBON 101 TERMINOLOGY

- 2 Important Terms

1. **Carbon Stocks** – the amount of carbon in a pool (*or account*). The pictures in the figure to the right
2. **Carbon Flux** – or difference in carbon stocks over a specified time period (*or stock change*). The



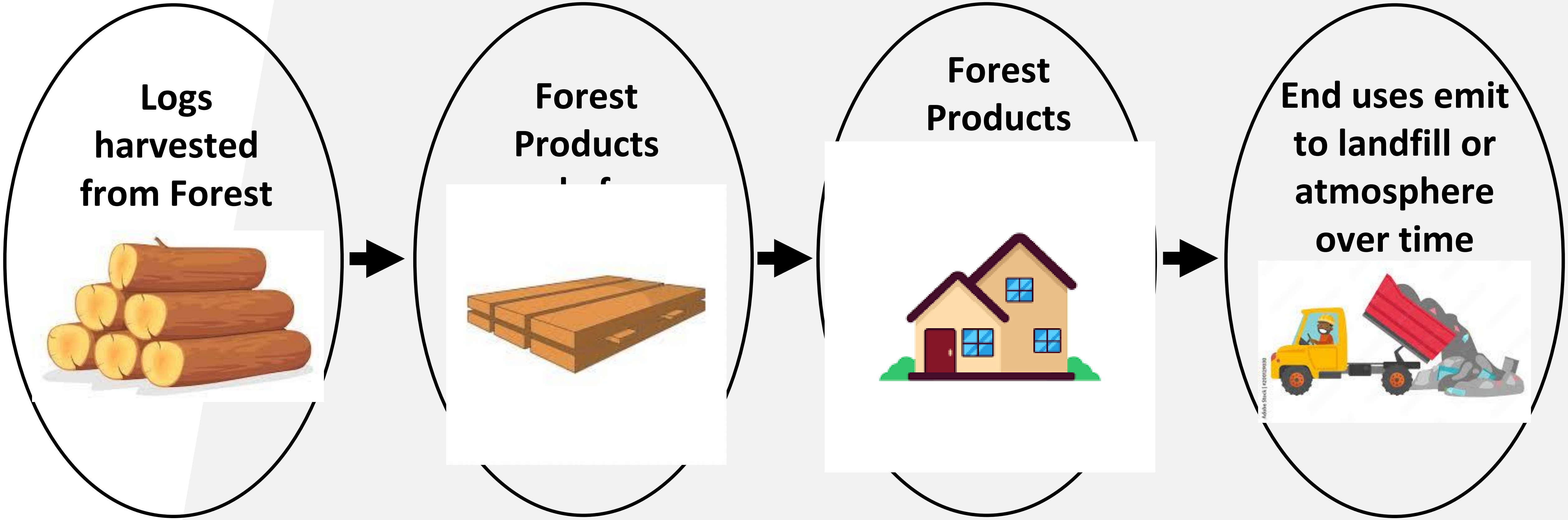
CARBON STORAGE IN HARVESTED WOOD PRODUCTS

- The carbon stored in harvested wood products originates from atmospheric carbon dioxide absorbed by trees during photosynthesis.

- When harvested, this carbon is captured within wood-based products, where it can remain stored for years, decades, or even centuries, depending on the product's lifespan and disposal practices.

ACCOUNTING FOR CARBON IN HWP

- **Pretty much everybody uses the same sort of approach**



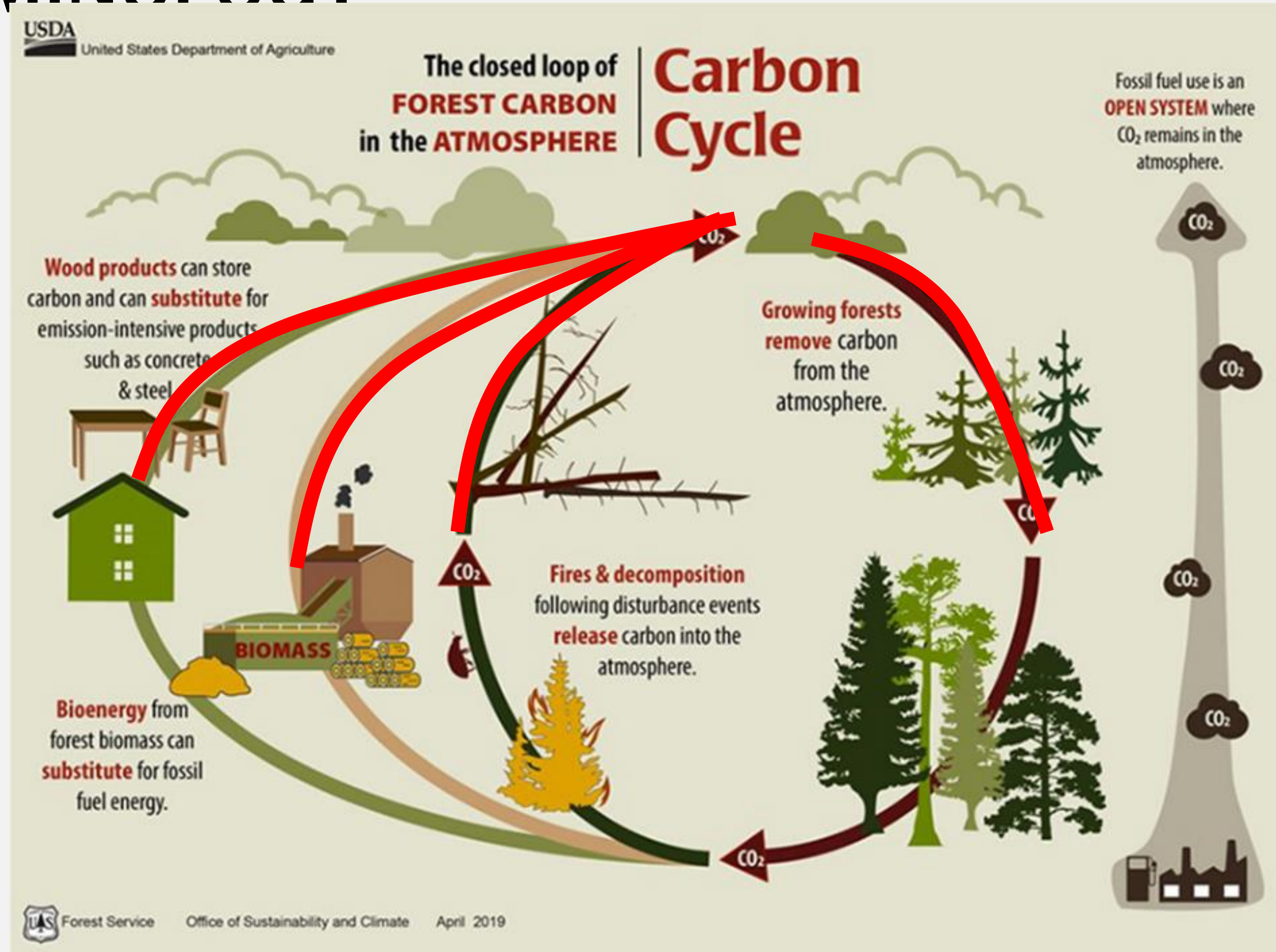
Skog, K.E. 2008. Sequestration of carbon in harvested wood products for the United States. *Forest Products Journal*. 58(6):56-72

CARBON 101 TERMINOLOGY

- 2 Important Terms

1. **Carbon Stocks** – the amount of carbon in a pool (*or account*). The pictures in the figure to the right
2. **Carbon Flux** – or difference in carbon stocks over a specified time period (*or stock change*). The arrows in the figure to the right

Stocks don't matter, only the flux (and in particular the stock change between terrestrial pools and the atmosphere)



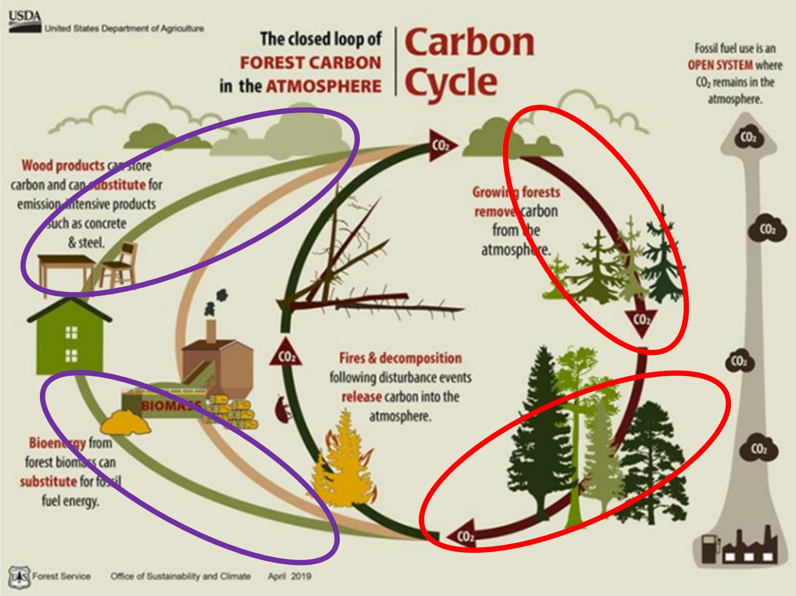
WHAT DO THESE FLUXES (STOCK CHANGES I KNOW) LOOK LIKE?

Table 6-8: Net CO_2 Flux from Forest Ecosystem Pools in Forest Land Remaining Forest Land and Harvested Wood Pools (MMT CO_2 Eq.)

Carbon Pool	1990	2005	2017	2018	2019	2020	2021
Forest Ecosystem	**(697.7)**	**(608.2)**	**(610.4)**	**(610.5)**	**(559.8)**	**(610.8)**	**(592.5)**
Aboveground Biomass	(499.1)	(443.8)	(425.9)	(428.0)	(410.8)	(419.0)	(409.1)
Belowground Biomass	(101.8)	(89.8)	(84.5)	(85.1)	(81.6)	(83.1)	(81.1)
Dead Wood	(100.8)	(97.9)	(100.0)	(102.7)	(98.2)	(102.3)	(101.1)
Litter	0.9	22.5	(2.0)	1.6	30.4	(1.9)	1.9
Soil (Mineral)	3.2	0.5	(0.1)	0.6	0.7	(5.4)	(4.0)
Soil (Organic)	(0.8)	(0.4)	1.4	2.3	(1.1)	0.1	0.1
Drained Organic Soil[a]	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Harvested Wood	**(123.8)**	**(106.0)**	**(100.3)**	**(94.0)**	**(89.6)**	**(96.6)**	**(102.8)**
Products in Use	(54.8)	(42.6)	(34.9)	(28.9)	(25.1)	(32.0)	(37.8)
SWDS	(69.0)	(63.4)	(65.3)	(65.1)	(64.5)	(64.6)	(65.1)
Total Net Flux	**(821.4)**	**(714.2)**	**(710.7)**	**(704.4)**	**(649.3)**	**(707.4)**	**(695.4)**

[a] These estimates include C stock changes from drained organic soils from both Forest Land Remaining Forest Land and Land Converted to Forest Land. See the section below on CO_2, CH_4, and N_2O Emissions from Drained Organic Soils for the methodology used to estimate the CO_2 emissions from drained organic soils. Also, Table 6-20 and 6-21 for non-CO_2 emissions from drainage of organic soils from both Forest Land Remaining Forest Land and Land Converted to Forest Land.

Notes: Forest ecosystem C stock changes do not include forest stocks in U.S. Territories because managed



WHAT DO THESE FLUXES

(STOCK CHANGES I KNOW)

LOOK LIKE?

Table 6-8: Net CO_2 Flux from Forest Ecosystem Pools in Forest Land Remaining Forest Land and Harvested Wood Pools (MMT CO_2 Eq.)

Carbon Pool	1990		2005		2017	2018	2019	2020	2021
Forest Ecosystem	**(697.7)**		**(608.2)**		**(610.4)**	**(610.5)**	**(559.8)**	**(610.8)**	**(592.5)**
Aboveground Biomass	(499.1)		(443.8)		(425.9)	(428.0)	(410.8)	(419.0)	(409.1)
Belowground Biomass	(101.8)		(89.8)		(84.5)	(85.1)	(81.6)	(83.1)	(81.1)
Dead Wood	(100.8)		(97.9)		(100.0)	(102.7)	(98.2)	(102.3)	(101.1)
Litter	0.9		22.5		(2.0)	1.6	30.4	(1.9)	1.9
Soil (Mineral)	3.2		0.5		(0.1)	0.6	0.7	(5.4)	(4.0)
Soil (Organic)	(0.8)		(0.4)		1.4	2.3	(1.1)	0.1	0.1
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Products in Use	(54.8)		(42.6)		(34.9)	(28.9)	(25.1)	(32.0)	(37.8)
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[a] These estima
Land and Lan
Organic Soils
6-20 and 6-2
Land and Lan
Notes: Forest

Table 6-8: Net CO_2 Flux from Forest Ecosystem Pools in *Forest L* and Harvested Wood Pools (MMT CO_2 Eq.)

Carbon Pool	1990		2005		2015	2016	2017	2018	2019
Forest Ecosystem	**(663.8)**		**(555.5)**		**(582.7)**	**(629.5)**	**(564.0)**	**(599.8)**	**(583.3)**
Aboveground Biomass	(456.4)		(401.3)		(414.2)	(421.3)	(395.1)	(402.4)	(394.0)
Belowground Biomass	(103.7)		(92.0)		(92.6)	(95.0)	(89.2)	(90.9)	(89.2)
Dead Wood	(97.3)		(93.5)		(98.7)	(105.1)	(97.1)	(101.7)	(99.3)
Litter	(8.1)		32.2		30.5	(3.2)	0.2	(2.3)	(0.5)
Soil (Mineral)	1.5		(1.5)		(7.3)	(6.8)	14.3	(4.5)	(2.4)
Soil (Organic)	(0.6)		(0.2)		(1.1)	1.2	2.1	1.2	1.2
Drained Organic Soil[a]	0.8		0.8		0.8	0.8	0.8	0.8	0.8
Harvested Wood	**(123.8)**		**(106.0)**		**(88.7)**	**(92.4)**	**(95.7)**	**(98.8)**	**(108.5)**
Products in Use	(54.8)		(42.6)		(24.6)	(27.8)	(30.3)	(31.5)	(39.2)
SWDS	(69.0)		(63.4)		(64.1)	(64.6)	(65.5)	(67.2)	(69.3)
Total Net Flux	**(787.6)**		**(661.5)**		**(671.4)**	**(721.9)**	**(659.7)**	**(698.6)**	**(691.8)**

Notes: Forest ecosystem C stock changes do not include forest stocks in U.S. Territories because managed forest land for U.S. Territories is not currently included in Section 6 Representation of the U.S. Land Base. The forest ecosystem C stock changes do not include Hawaii because there is not sufficient NFI data to support inclusion at this time. However, managed forest land area for Hawaii is included in Section 6 Representation of the U.S. Land Base so there are small differences in the forest land area estimates in this Section and Section 6. See Annex 3.13, Table A-214 for annual differences between the forest area

Table 6-8: Net CO_2 Flux from Forest Ecosystem Pools in Forest Land Remaining Forest Land and Harvested Wood Pools (MMT CO_2 Eq.)

Carbon Pool	1990	2005	2018	2019	2020	2021	2022
Forest Ecosystem	**(851.0)**	**(770.0)**	**(779.6)**	**(726.2)**	**(765.2)**	**(749.5)**	**(694.3)**
Aboveground Biomass	(600.9)	(550.8)	(536.7)	(516.3)	(522.8)	(513.0)	(491.7)
Belowground Biomass	(116.8)	(107.5)	(105.4)	(102.3)	(102.2)	(100.9)	(96.9)
Dead Wood	(132.0)	(131.2)	(138.0)	(133.4)	(136.2)	(135.3)	(131.4)
Litter	(2.4)	20.5	(1.5)	26.5	(3.4)	(0.1)	26.4
Soil (Mineral)	2.0	(0.8)	1.3	(1.3)	(1.3)	(0.9)	(1.2)
Soil (Organic)	(1.6)	(1.0)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
Drained Organic Soil[a]	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Harvested Wood	**(123.8)**	**(106.0)**	**(93.9)**	**(86.9)**	**(96.8)**	**(94.7)**	**(92.8)**
Products in Use	(54.8)	(42.6)	(28.8)	(22.6)	(32.3)	(30.4)	(28.8)
SWDS	(69.0)	(63.4)	(65.1)	(64.3)	(64.5)	(64.3)	(63.9)
Total Net Flux	**(974.8)**	**(876.0)**	**(873.5)**	**(813.2)**	**(862.0)**	**(844.2)**	**(787.0)**

STRATEGIES FOR MAXIMIZING CARBON BENEFITS

1. **Longer Product Lifespans**: Designing and constructing durable wood products with longer lifespans can maximize carbon storage over time. High-quality wood products, such as engineered wood and solid wood furniture, can withstand multiple uses and generations, thereby prolonging carbon sequestration.
2. **Recycling and Reuse**: Promoting recycling and reuse of wood-based materials can further extend their carbon storage lifespan. By salvaging wood from demolished structures or repurposing discarded furniture, carbon stored in HWPs can be preserved and reincorporated into new products, reducing the need for virgin materials and mitigating emissions from disposal.
3. **Bioenergy and Biomaterials**: Harnessing wood residues and byproducts for bioenergy production or the manufacturing of biomaterials offers additional opportunities to enhance carbon storage. Utilizing woody biomass for renewable energy generation displaces fossil fuel emissions, while substituting carbon-intensive materials with sustainable wood-based alternatives reduces overall carbon footprints.

THE MODELING PART

1. **Longer Product Lifespans**: Designing and constructing durable wood products with longer lifespans can maximize carbon storage over time. High-quality wood products, such as engineered wood and solid wood furniture, can withstand multiple uses and generations, thereby prolonging carbon sequestration.
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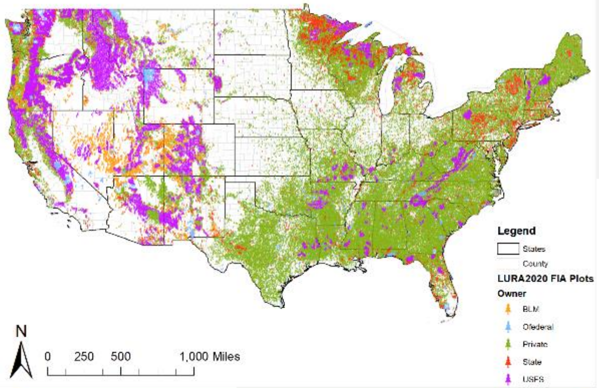
LURA MODEL BACKGROUND

Balance supply and demand with price sensitive demand

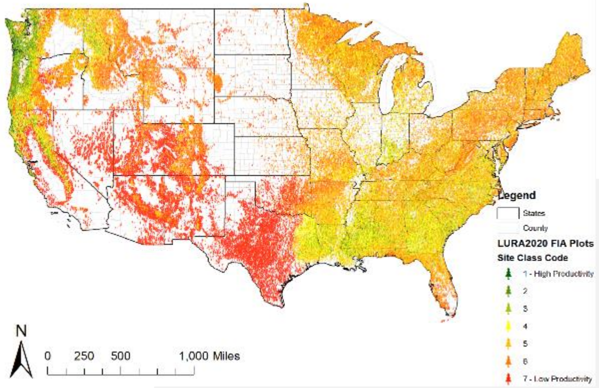
1. Which has a forest land base representation (164k plots)
2. And a forest products market representation (3.4k mills)

LURA Static Supply Forest Ownership

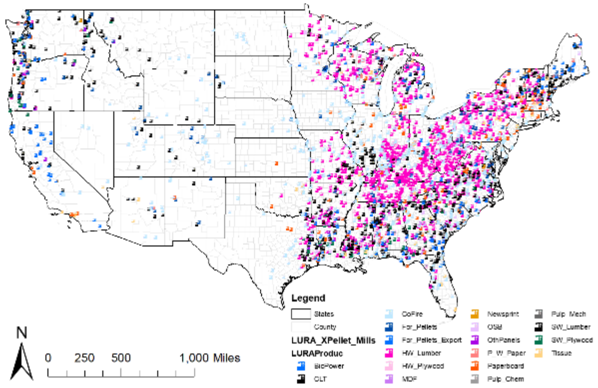


Owner	Acres	Percent
BLM	31,101,654	5%
Ofederal	20,505,041	3%
Private	427,520,906	63%
State	60,609,602	9%
USFS	136,510,772	20%
Total	676,247,974	100%

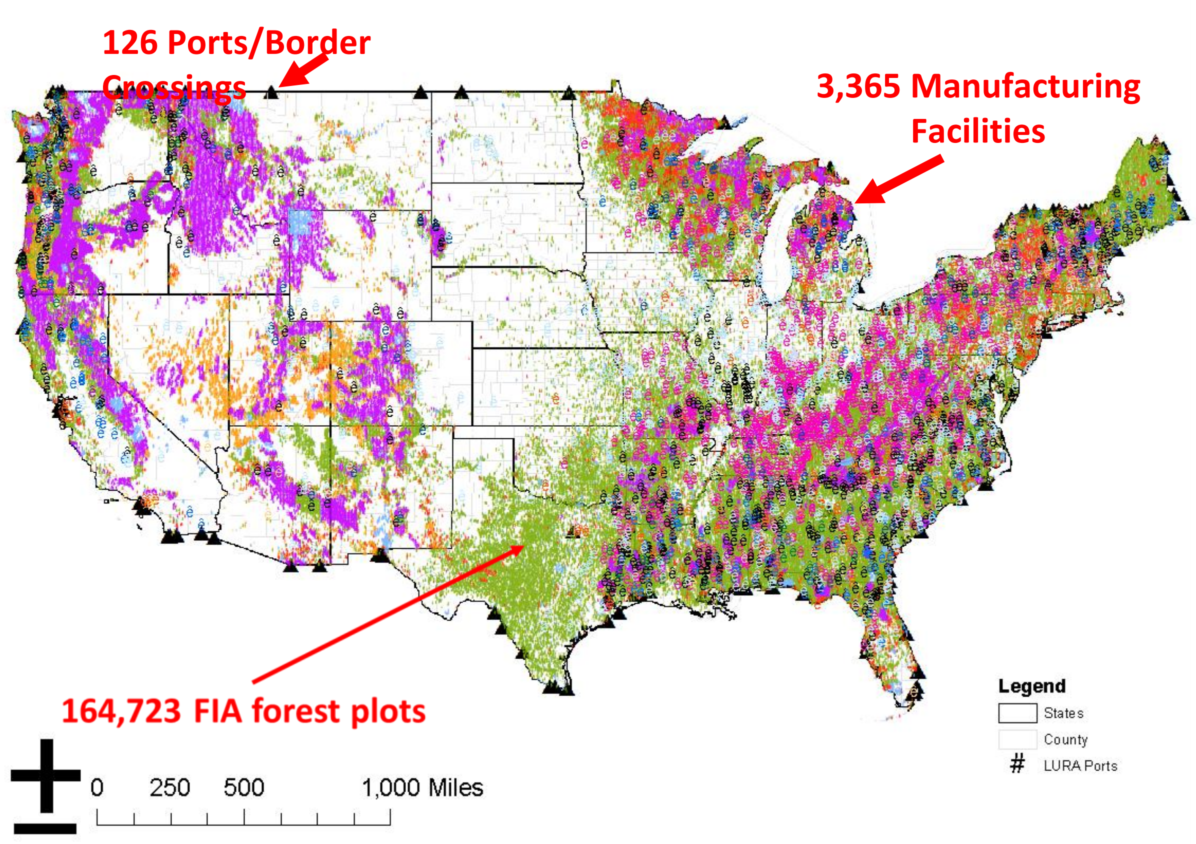
LURA Static Supply Forest Productivity



LURA Static Demand Mill Locations



LURA Combined Forest Sector

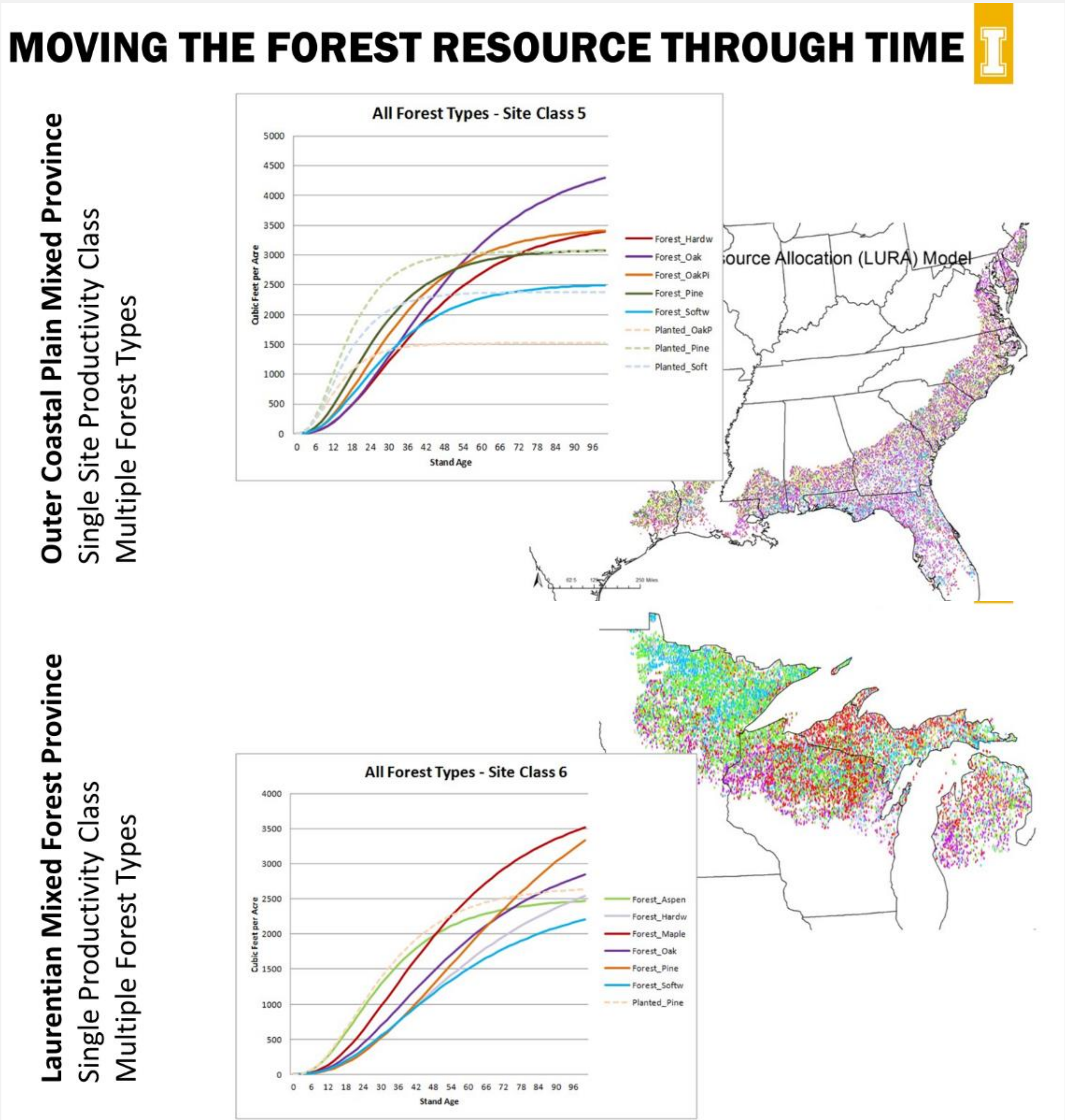


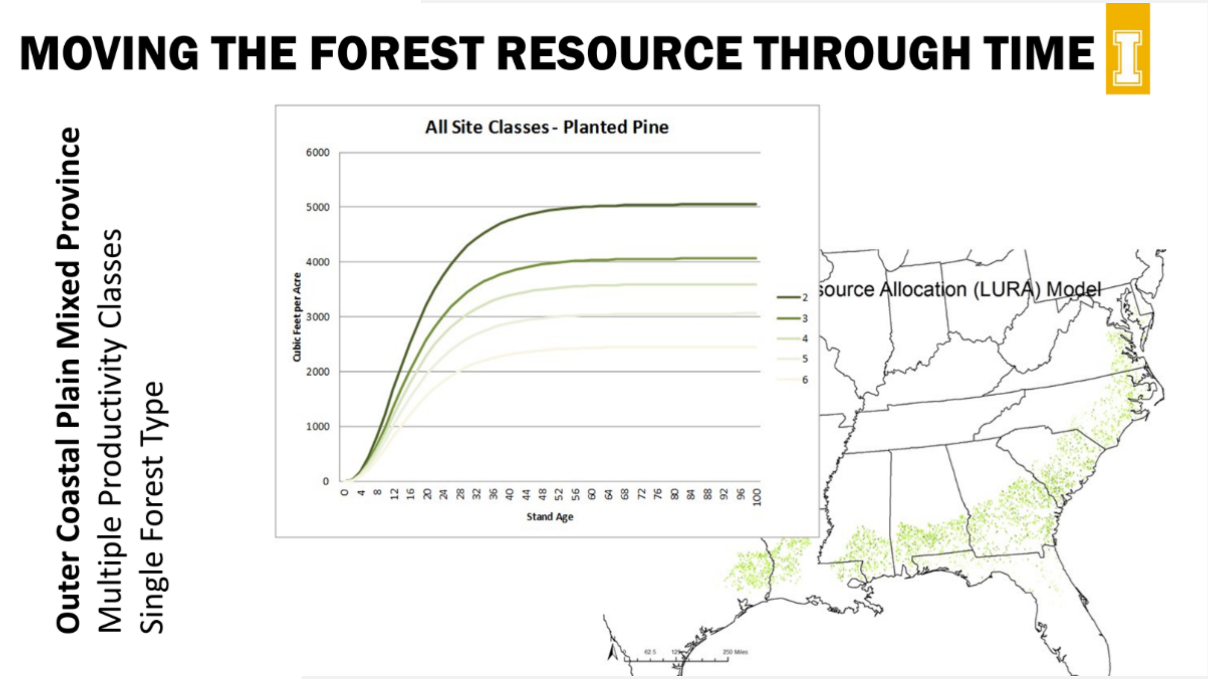
Latta, G., J. Baker and S. Ohrel. 2018. A land use and resource allocation (LURA) modeling system for projecting localized forest CO_2 effects of alternative macroeconomic futures. *Forest Policy and Economics* 87(2018):35-48.

LURA MODEL BACKGROUND *– DYNAMIC SUPPLY*

Balance supply and demand with price sensitive demand

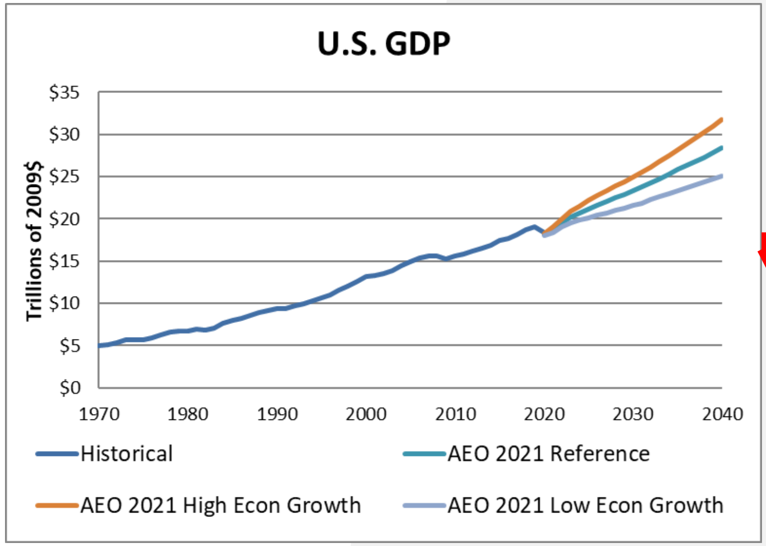
1. You need to move the resource through time
2. LURA uses yields specific to ecoregion, forest type and site productivity class

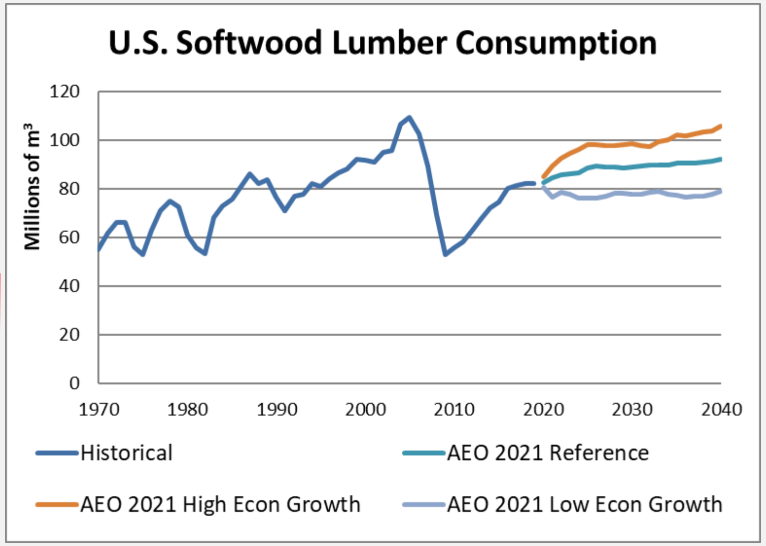


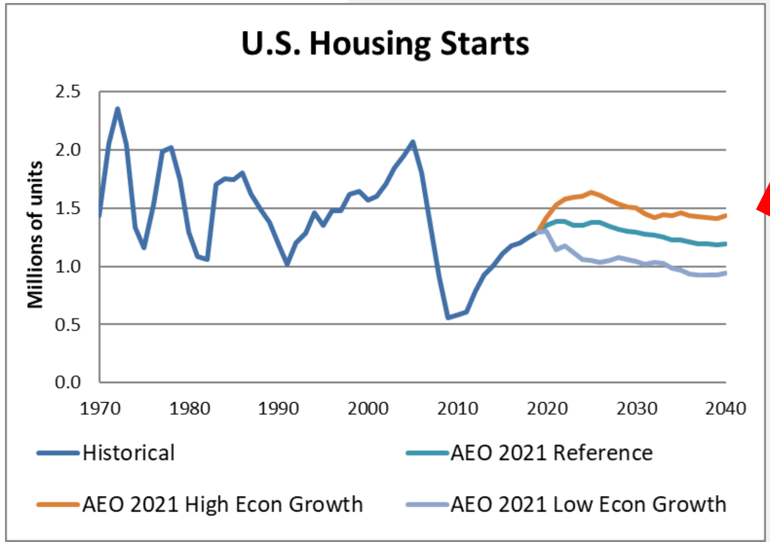


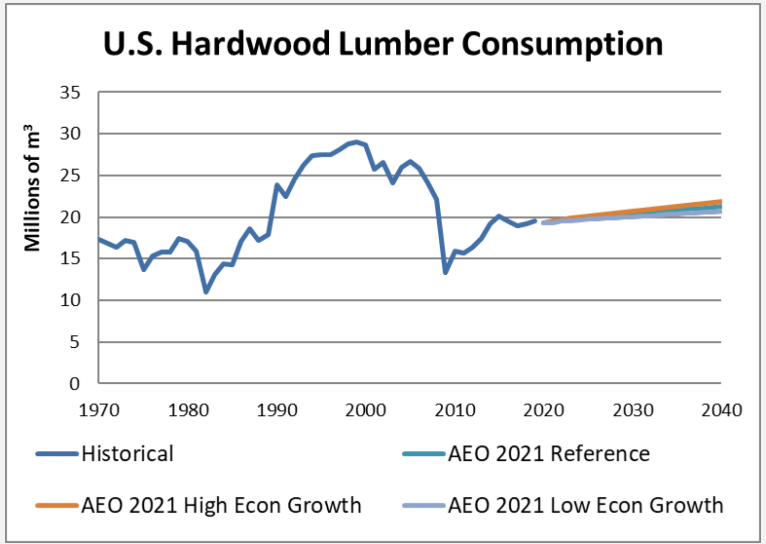
LURA MODEL BACKGROUND *– DYNAMIC DEMAND*

2) And move demand through time

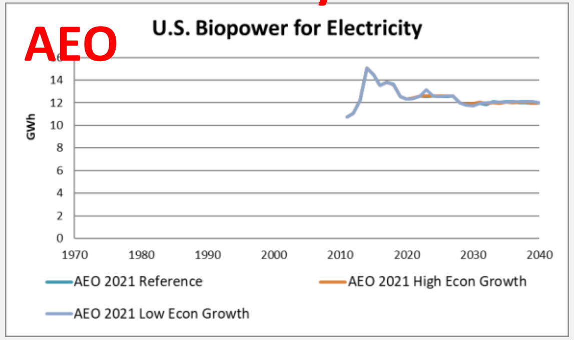






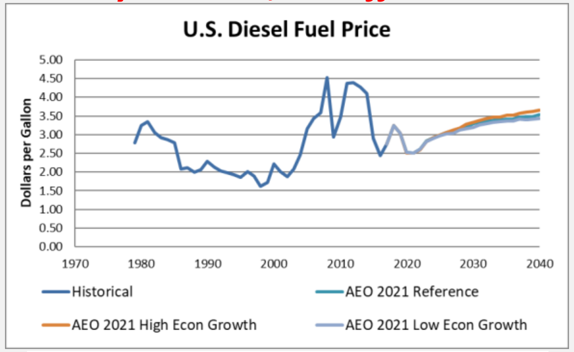


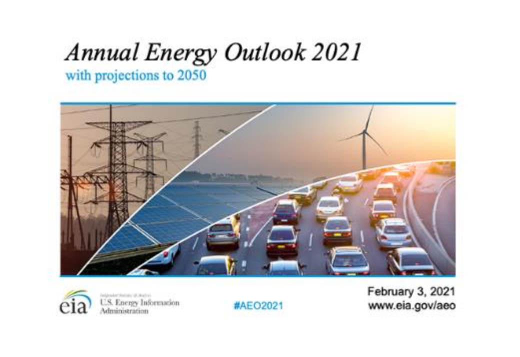
Taken directly from AEO



Taken directly from AEO

(not really demand, but affects demand)





https://www.eia.gov/outlooks/aeo/

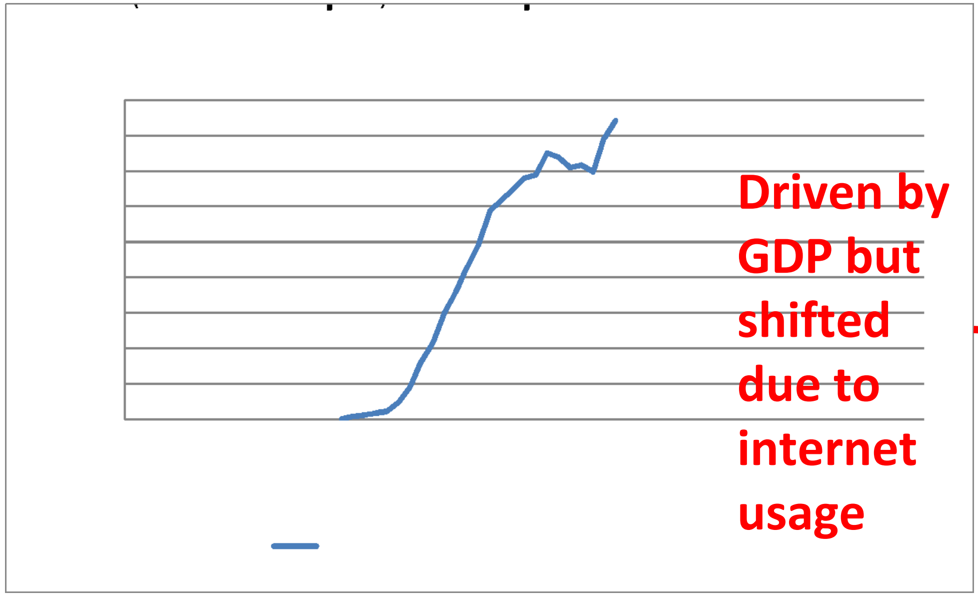
MOVING FOREST PRODUCTS THROUGH TIME

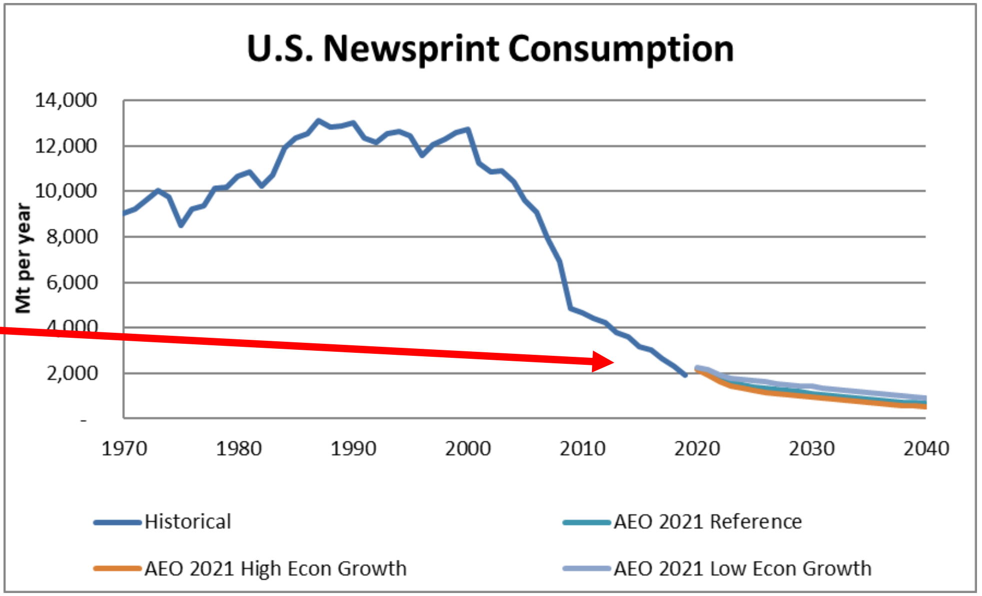
Pulp Market Demand Projections

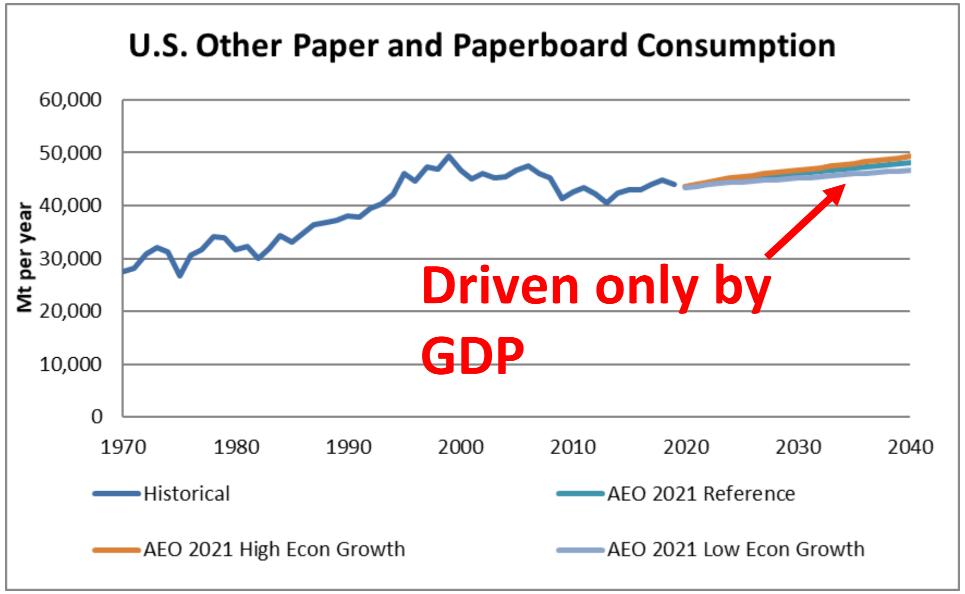
Multiple economic indicators

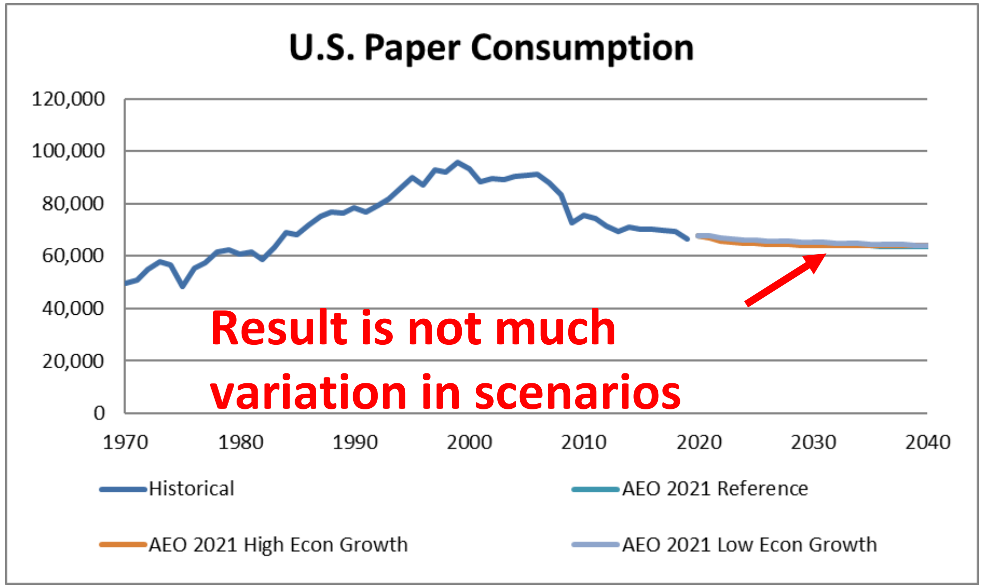
Multiple future economic scenarios

Latta, G., Plantinga, A., and M. Sloggy. 2016. The effects of Internet use on global demand for paper products. *Journal of Forestry* 114(4): 433-440.

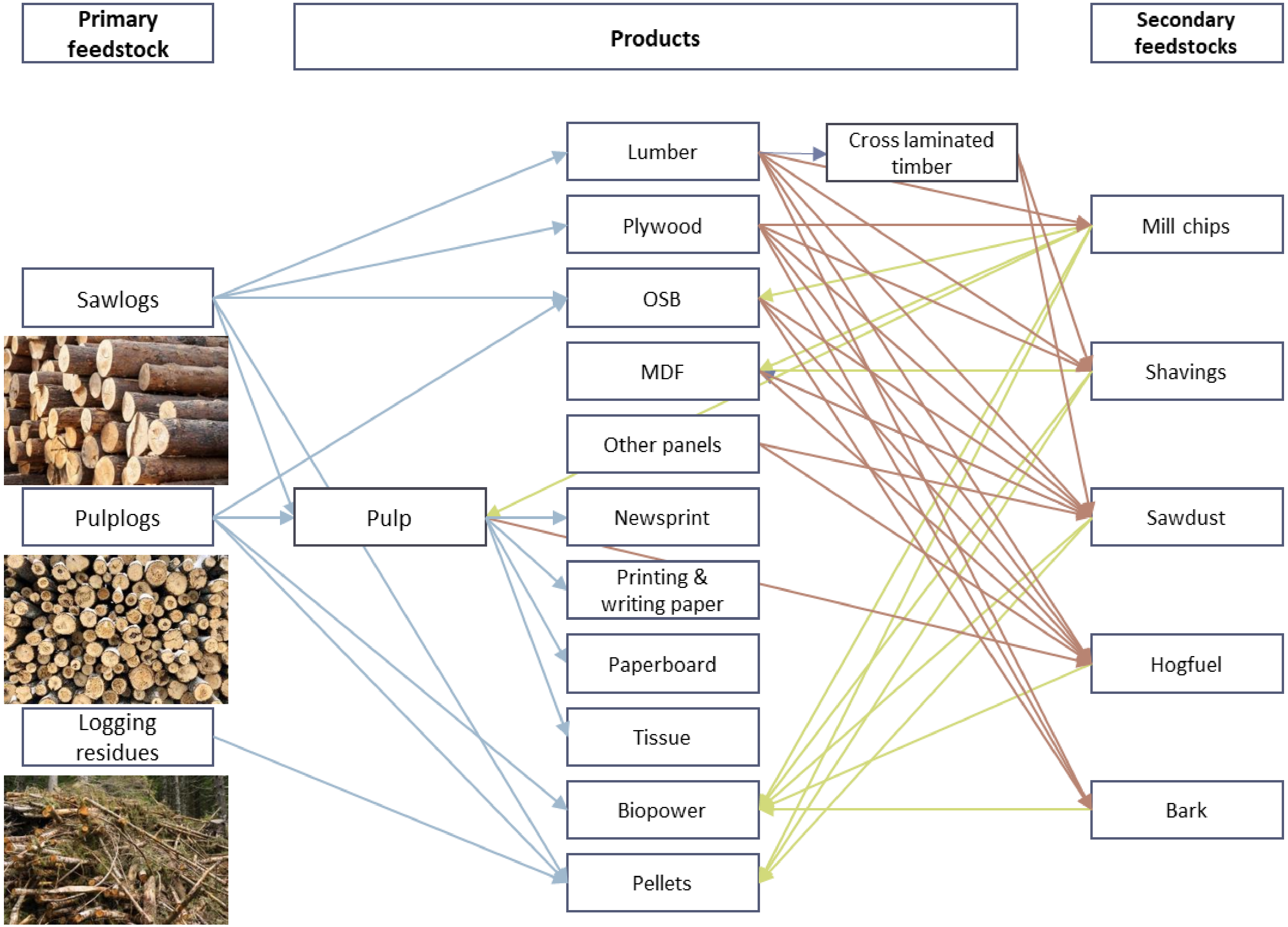








LURA CASCADING WOOD FLOW



Primary feedstocks used in wood products and energy

Residues generated in wood products production

Residues used in wood products and energy

BIOENERGY APPLICATIONS – CHOOSING SITES

- Logging residue supply for biorefinery siting

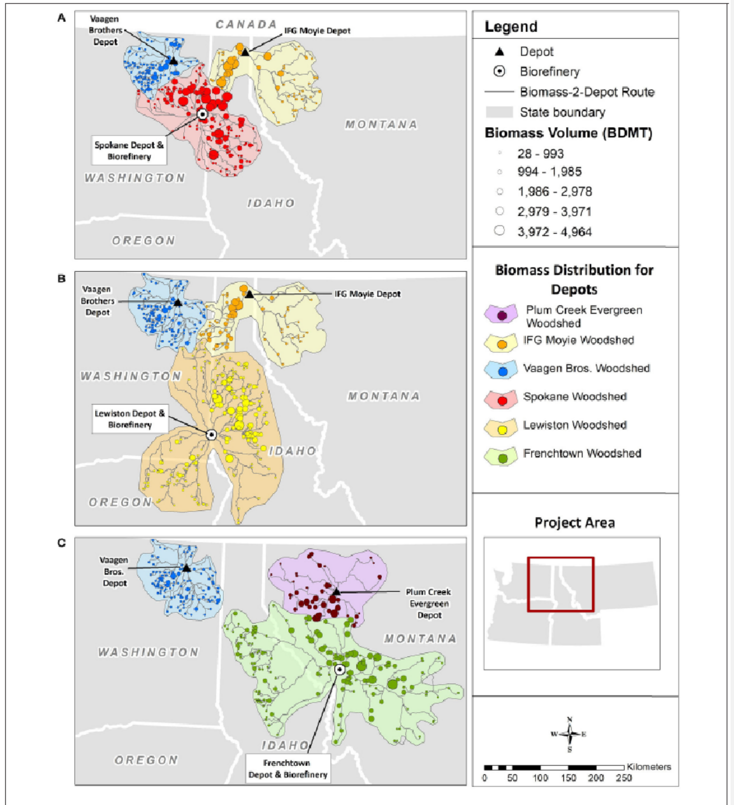
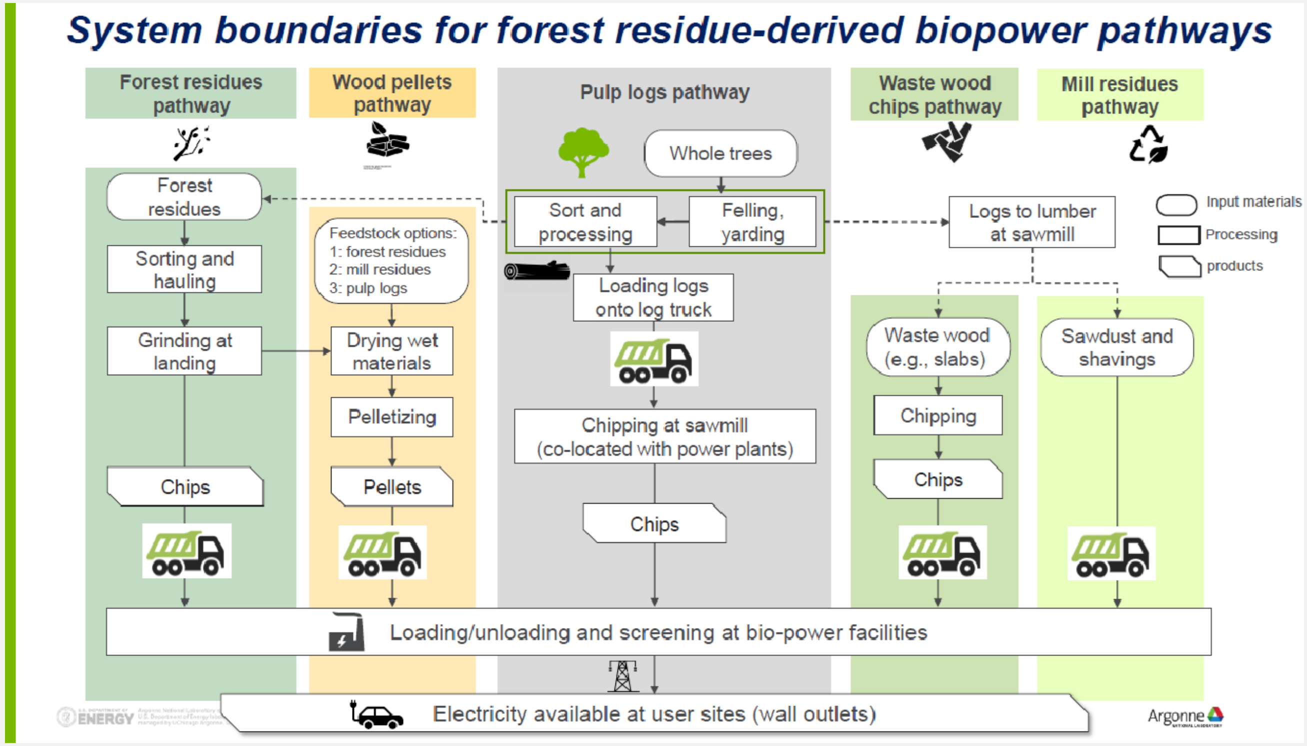


FIGURE 3 | Biomass source point distribution and depot "woodshed" service areas for the (A) Spokane, (B) Lewiston, and (C) Frenchtown biorefinery.

Martinkus, N., G. Latta, S.A.M Rijkhoff, D. Mueller, S. Hoard, D. Sasatani, F. Pierobon, and M. Wolcott. 2019. A Multi-Criteria Decision Support Tool for Biorefinery Siting: Using Economic, Environmental, and Social metrics for a Refined Siting Analysis. *Biomass and Bioenergy*. 128(2019):105330

- Argonne National Laboratory GREET model Biopower Module



Xu, H., G. Latta, U. Lee, J. Lewandrowski and M. Wang. 2021. Regionalized Life Cycle Greenhouse Gas Emissions of Forest Biomass Use for Electricity Generation in the United States. Environmental Science & Technology. https://doi.org/10.1021/acs.est.1c04301

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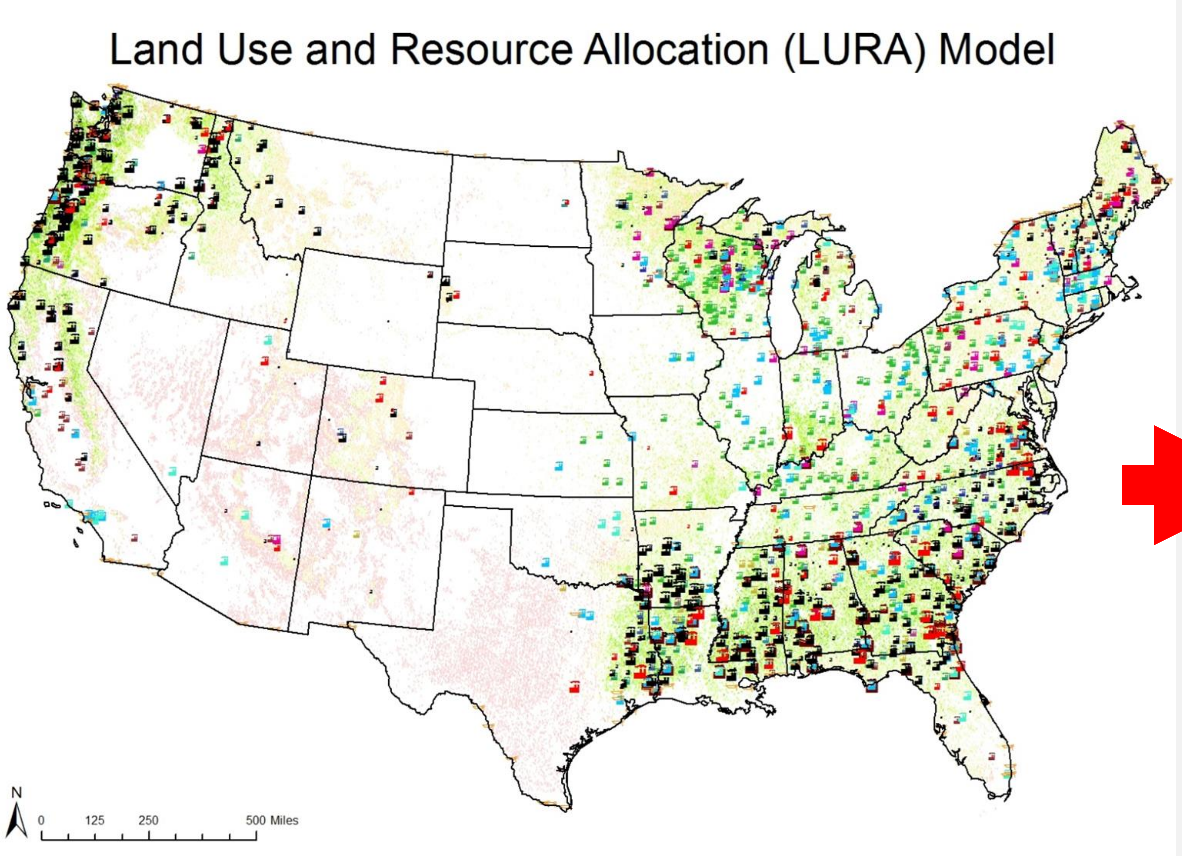
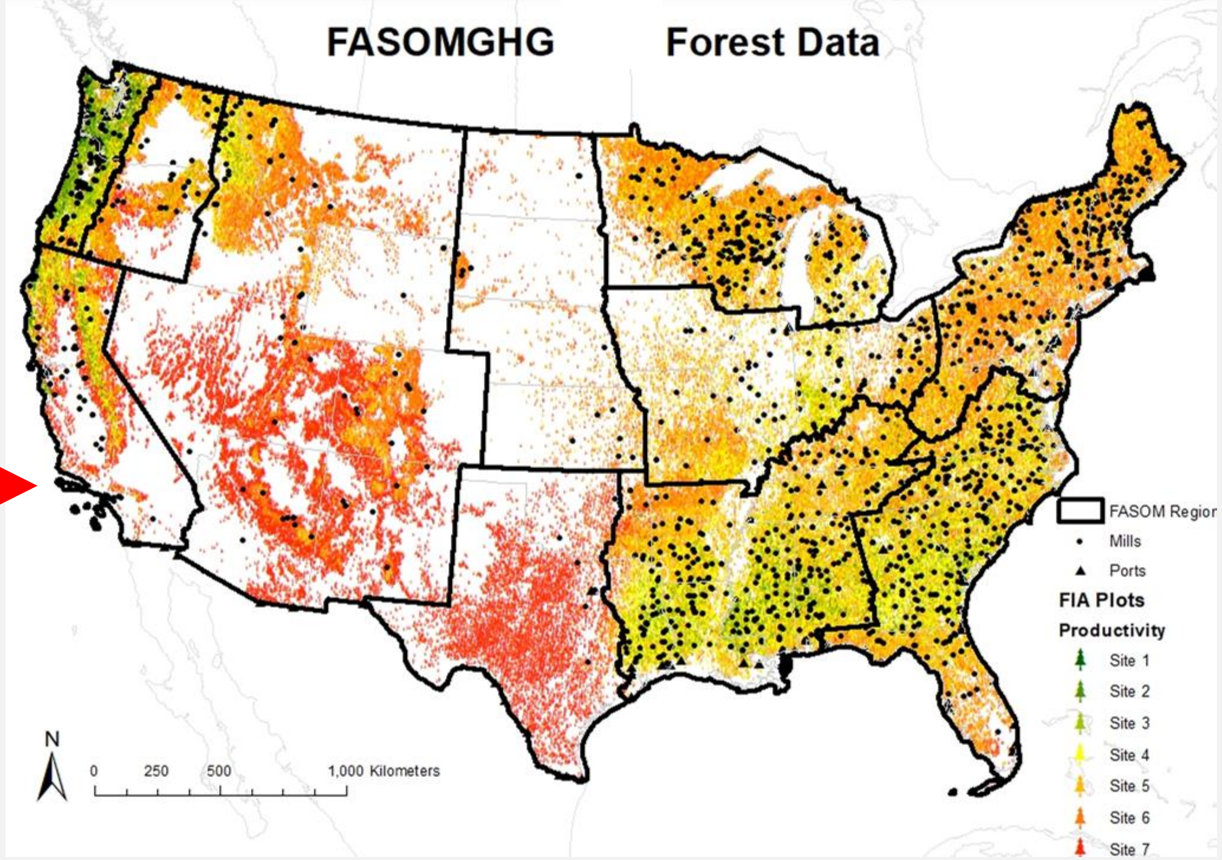
3. **Bioenergy and Biomaterials**: Harnessing wood residues and byproducts for bioenergy production or the manufacturing of biomaterials offers additional opportunities to enhance carbon storage. Utilizing woody biomass for renewable energy generation displaces fossil fuel emissions, while substituting carbon-intensive materials with sustainable wood-based alternatives reduces overall carbon footprints.
4. **Forest Management Practices**: Implementing sustainable forest management practices that prioritize carbon sequestration and wood utilization can amplify the carbon benefits of harvested wood products. Responsible harvesting techniques, afforestation efforts, and reforestation initiatives contribute to maintaining and enhancing forest carbon stocks, ensuring a continuous supply of wood resources for

LURA - FASOMGHG INTEGRATION

- LURA data was used to generate weighted averages for FASOMGHG Forest Supply and Demand replacing the existing FASOM forest model and moving the starting time period to 2015





FASOM-GHG

(THE FOREST AND AGRICULTURE SECTOR OPTIMIZATION MODEL WITH GREENHOUSE GASES)

Long history modeling carbon markets and forestry

For policy analysis

EPA analysis of **S 843** *(Clean Air Planning Act of 2003)*, **S 280** *(Climate Stewardship and Innovation Act of 2007)*, **S 1766** *(Low Carbon Economy Act of 2007)*, and **S 2191** *(Lieberman-Warner Climate Security Act of 2007)*, **HR 2454** *(American Clean Energy and Security Act of 2009)*, **S 1733** *(Clean Energy Jobs and American Power Act)*

And journal articles

Adams, R., Adams, D., Callaway, J., Chang, C., and McCarl. B.: **1993**, 'Sequestering Carbon on Agricultural Land: Social Cost and Impacts on Timber Markets', *Contemporary Policy Issues* XI (1), 76–87.

Adams, D., Alig, R., McCarl, B., Callaway, J., and Winnett. S.: **1999**, 'Minimum Cost Strategies for Sequestering Carbon in Forests', *Land Economics 75 (3), 360–374.*

R Alig, G. Latta, D. Adams, and B. McCarl. **2010**. Mitigating Greenhouse Gases: The Importance of Land Base Interactions Among Forests, Agriculture, and Residential Development in the Face of Changes in Bioenergy and Carbon Prices. *Forest Policy and Economics* 12(1): 67-75.

Latta, G., D. Adams, R. Alig and E. White. **2011**. Simulated effects of mandatory versus voluntary participation in private forest carbon offset markets in the United States. Journal of Forest Economics 17(2): 127-141.

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A LITTLE HWP MODELING EXPERIMENT

Using the forest side of FASOM (the Forest and Agriculture Sector Optimization Model with Greenhouse Gases)

Scenarios

1. Is HWP a mitigation strategy in and of itself
   - Only pay for HWP stock changes
2. What happens when you bring the rest of the US Forest Sector in
   - Pay for all forest sector stock changes
3. What about a regional HWP-only strategy
   - Pay for only Lake States HWP stock changes

A LITTLE HWP MODELING EXPERIMENT

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- **Apply C prices to specific C fluxes** (yes, I know it is a stock change)
  - This will drive the additional mitigation

1 IS HWP A MITIGATION STRATEGY IN AND OF ITSELF?

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1 IS HWP A MITIGATION STRATEGY IN AND OF ITSELF?

Marginal Abatement Cost Curve (MACC)

Steps:

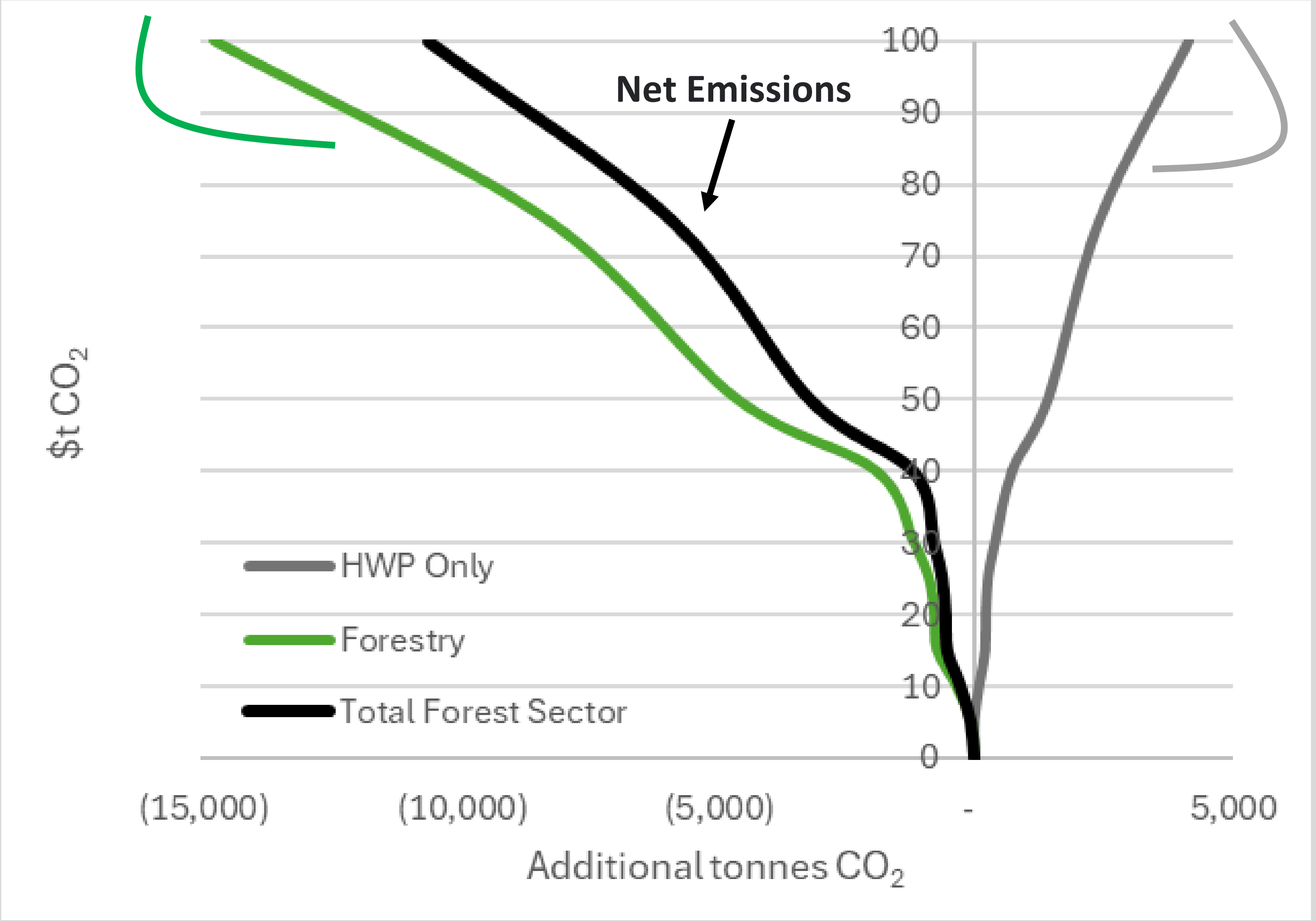
1. Run the Carbon Price Scenarios through 2090 in 5-year time periods
2. Calculate additional sequestration in each time period
3. Discount the additional carbon using 4% *(similar to Murray et al (2004))*
4. Calculate the annual annuity value that would equal the sum of the first 50 years of discounted additional carbon

$$V_0 = \frac{a*[(1+i)^t - 1]}{i*(1+i)^t}$$

V_0 is the sum of the discounted additional carbon over the first 40 years
i is the discount rate (here 4%)
t is the time period over which the annuity is calculated (here 40 years)
a is the annuity value (or a single value that could be applied annually for 40 year and give us the discounted sum of additional sequestration – it basically makes it so we have one value for each carbon price)

Forestry – additional emissions at each carbon price

HWP Benefits – additional sequestration at each carbon price



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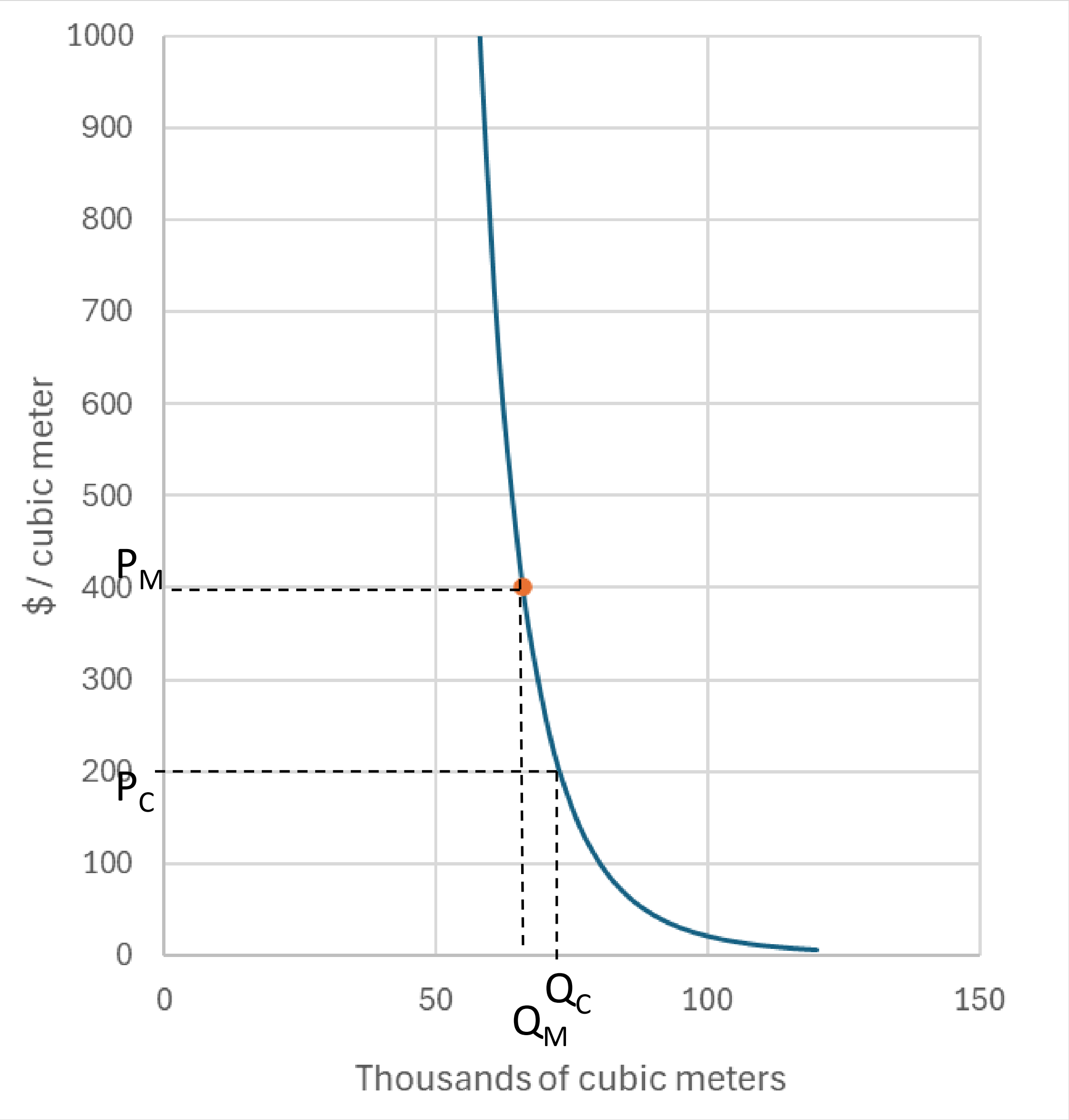
1 IS HWP A MITIGATION STRATEGY IN AND OF ITSELF?

This would be what the softwood lumber demand ***(note: this is a long-lived harvested wood product)*** looks like. It is:

- Defined by an exogenous point (the P_M and Q_M) and an elasticity
- It is inelastic e_d = -0.14
- So a small change in Q leads to big change in P



The demand curve limits the amount of mitigation

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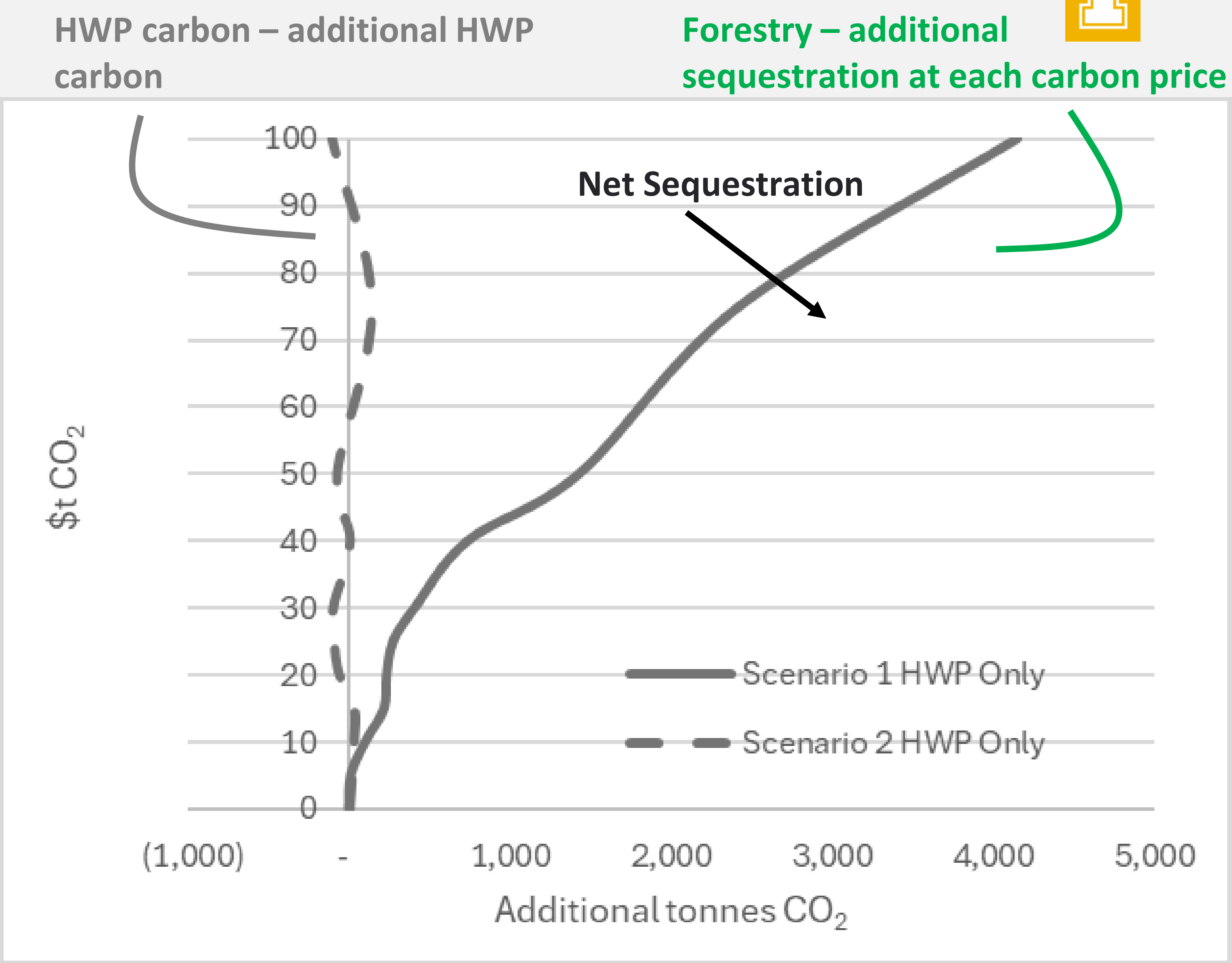
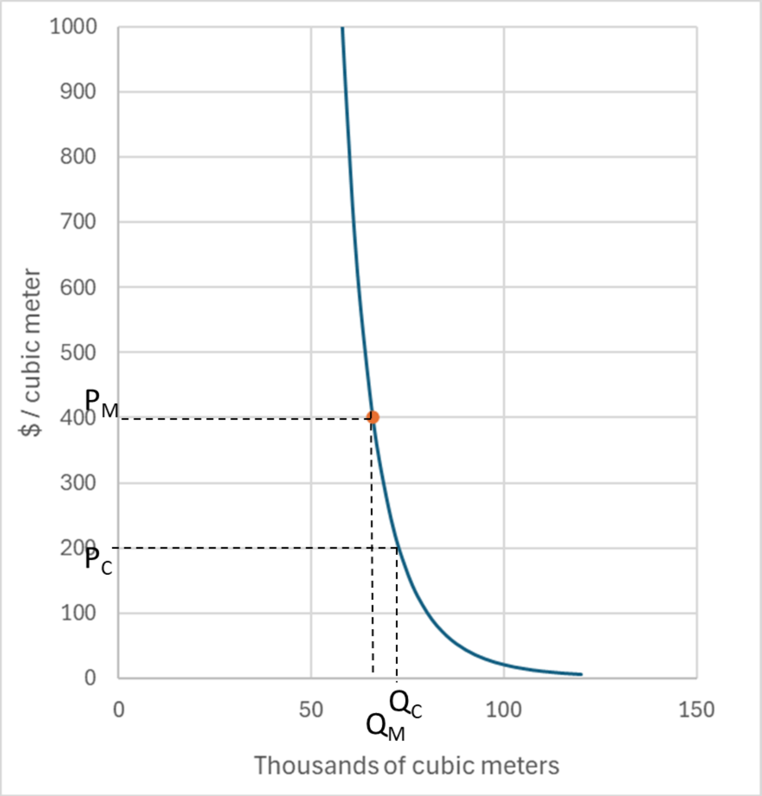
2 WHAT HAPPENS WHEN YOU BRING THE REST OF THE US FOREST SECTOR IN?

When we bring the forestry carbon into the payment scheme it dominates the mitigation



1 IS HWP A MITIGATION STRATEGY IN AND OF ITSELF?

with HWP production in commodities that tend to be inelastic which drops price which in turn disincentivizes more production



with forestry:

- An increase in forest growth does not have to lead to a reduction in product prices
- So you can do as much as you would want*
- And it can actually lead to an increase in production later on

3 WHAT ABOUT A REGIONAL HWP-ONLY STRATEGY?

Using the forest side of FASOM (the Forest and Agriculture Sector Optimization Model with Greenhouse Gases)

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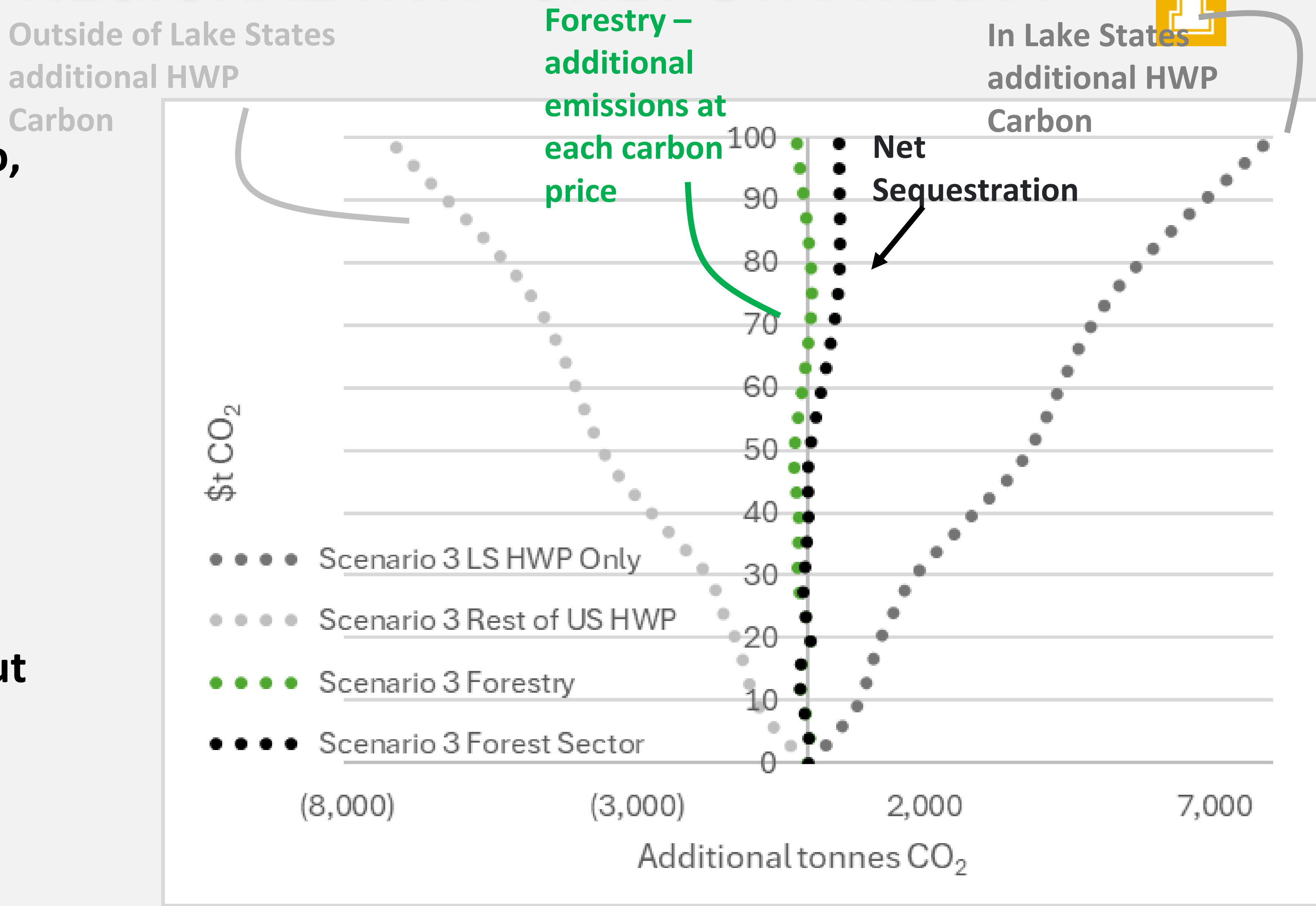
3 WHAT ABOUT A REGIONAL HWP-ONLY STRATEGY?

- In this particular scenario, the long-lived wood product of choice is Oriented Strandboard (OSB)
- And we actually see an increase in paperboard production - but using market pulp produced out of region
- Other regions might be different



CHALLENGES AND CONSIDERATIONS

1. **Market Demand and Consumer Preferences**: Shifting market demand and consumer preferences towards wood-based products requires education, awareness, and incentives to incentivize sustainable choices and practices.
2. **Lifecycle Assessments**: Conducting comprehensive lifecycle assessments to evaluate the carbon implications of different wood products and disposal pathways is essential for informing decision-making and optimizing carbon benefits.
3. **Policy and Regulation**: Developing supportive policies and regulations that recognize the carbon benefits of harvested wood products and incentivize sustainable forest management and wood utilization practices is crucial for scaling up adoption and investment.

I'LL WRITE MY OWN CONCLUSION

This was a very basic/simple evaluation of HWP mitigation strategies.

- ***Harvested Wood Products are not a strategy in and of themselves***
  - ***You need to look at the forestry effects as well***
  - ***Including market effects / elasticities is important***
    - ***Markets have a dampening effect on scale not present in forestry mitigation***
- ***Regional policies targeting a shift to longer lived wood products (with no change in demand) may result in 100% leakage***

- ***Because I'm in academia: More work is needed***
  - ***Elasticities are old and in need of updating***
  - ***As we expand mass timber and biofuels/biomaterials we should be careful in our accounting***

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