Key Concepts for Biogenic CO² Assessment

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EPA Stakeholder Workshop:
Fostering Constructive Dialogue on the Role of Biomass in Stationary Source Carbon Strategies
April 7, 2016

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OUTLINE

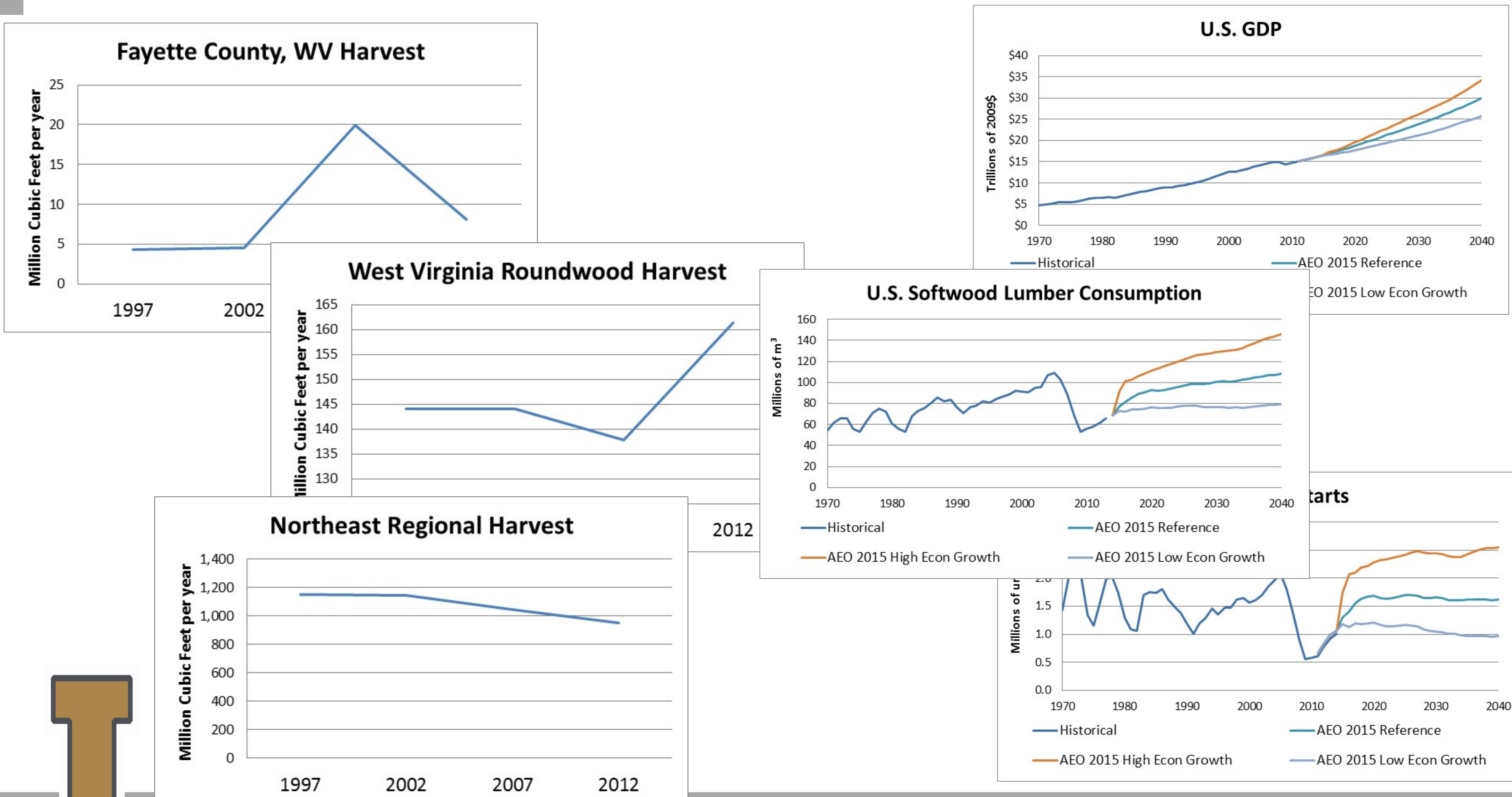
- Baselines
  - Why have them?
  - Are they Important?
- Forest Sector Modeling Example
  - What they are?
  - And how they work
  - Forest and Agricultural Sector Optimization Model example analysis that focuses on:
    1. Time Frame of Impacts
       - Does it matter when these impacts occur?
    2. Feedstock Designation
       - Should all biogenic feedstocks be treated equal?
    3. Scale of Feedstock Use
       - Does the amount of feedstock use affect its GHG impacts?
  - Example comparing multiple models
- Conclusion

BASELINES – WHY HAVE THEM?

- What we need to know is what is the change in emissions due to biogenic feedstock use for energy is
- Since we can't know what the impacts of using the biomass vs not using it will be, we need to get creative
- One thing we do know is that this impact is the result of biomass use and biomass availability

Variation regionally and in potential

PAST HARVESTING AND FUTURE DRIVERS



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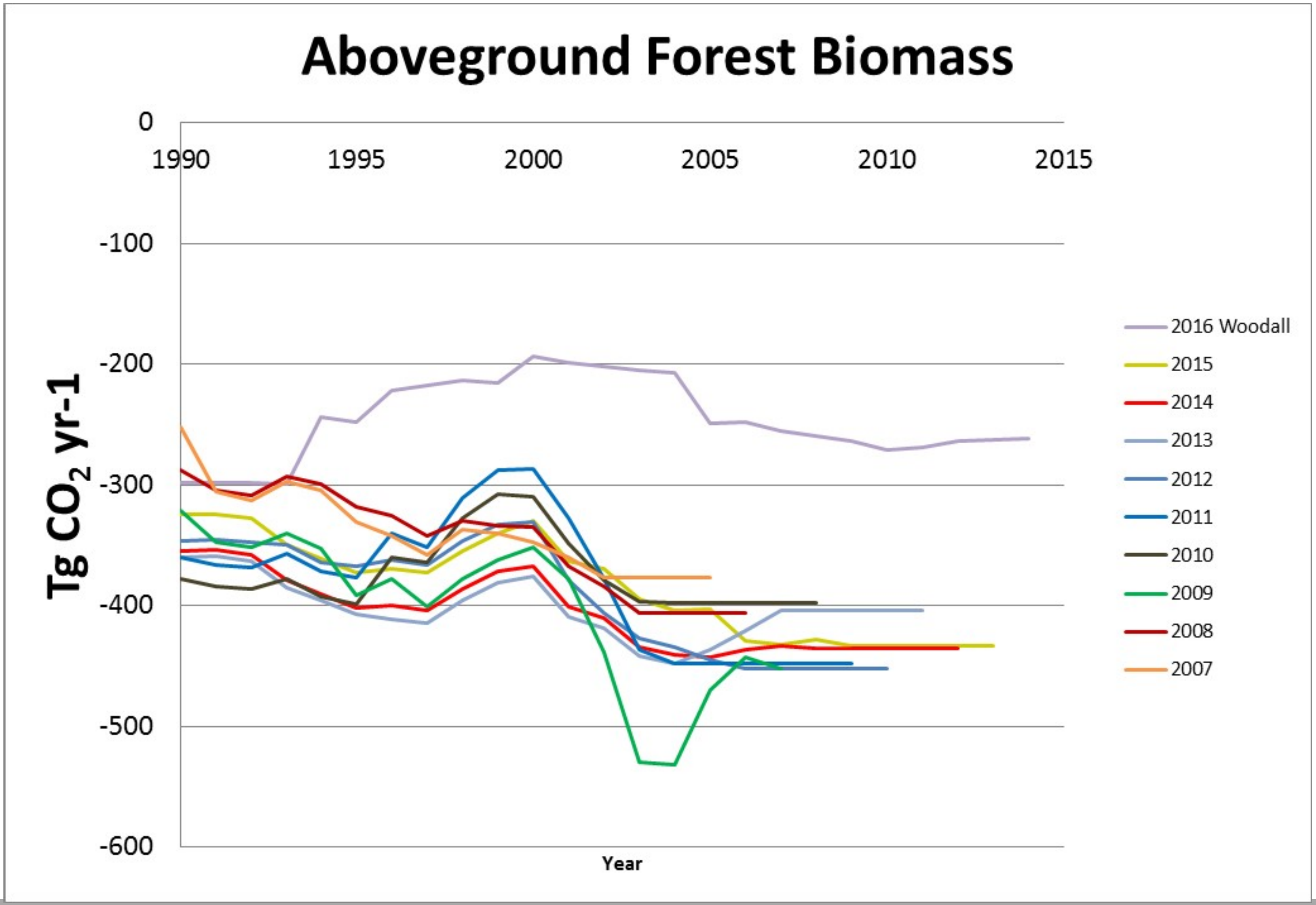
Variation in estimates of past growth

HISTORICAL CARBON SEQUESTRATION IN TREES



USEPA. 2015. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2013. U.S. Environmental Protection Agency, Office of Atmospheric Programs, EPA 430-R-14-003 , Washington, D.C.

Woodall, Christopher W.; Coulston, John W.; Domke, Grant M.; Walters, Brian F.; Wear, David N.; Smith, James E.; Andersen, Hans-Erik; Clough, Brian J.; Cohen, Warren B.; Griffith, Douglas M.; Hagen, Stephen C.; Hanou, Ian S.; Nichols, Michael C.; Perry, Charles H. (Hobie); Russell, Matthew B.; Westfall, Jim; Wilson, Barry T. (Ty). 2015. The U.S. forest carbon accounting framework: stocks and stock change, 1990-2016. Gen. Tech. Rep. NRS-154. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 49 p.

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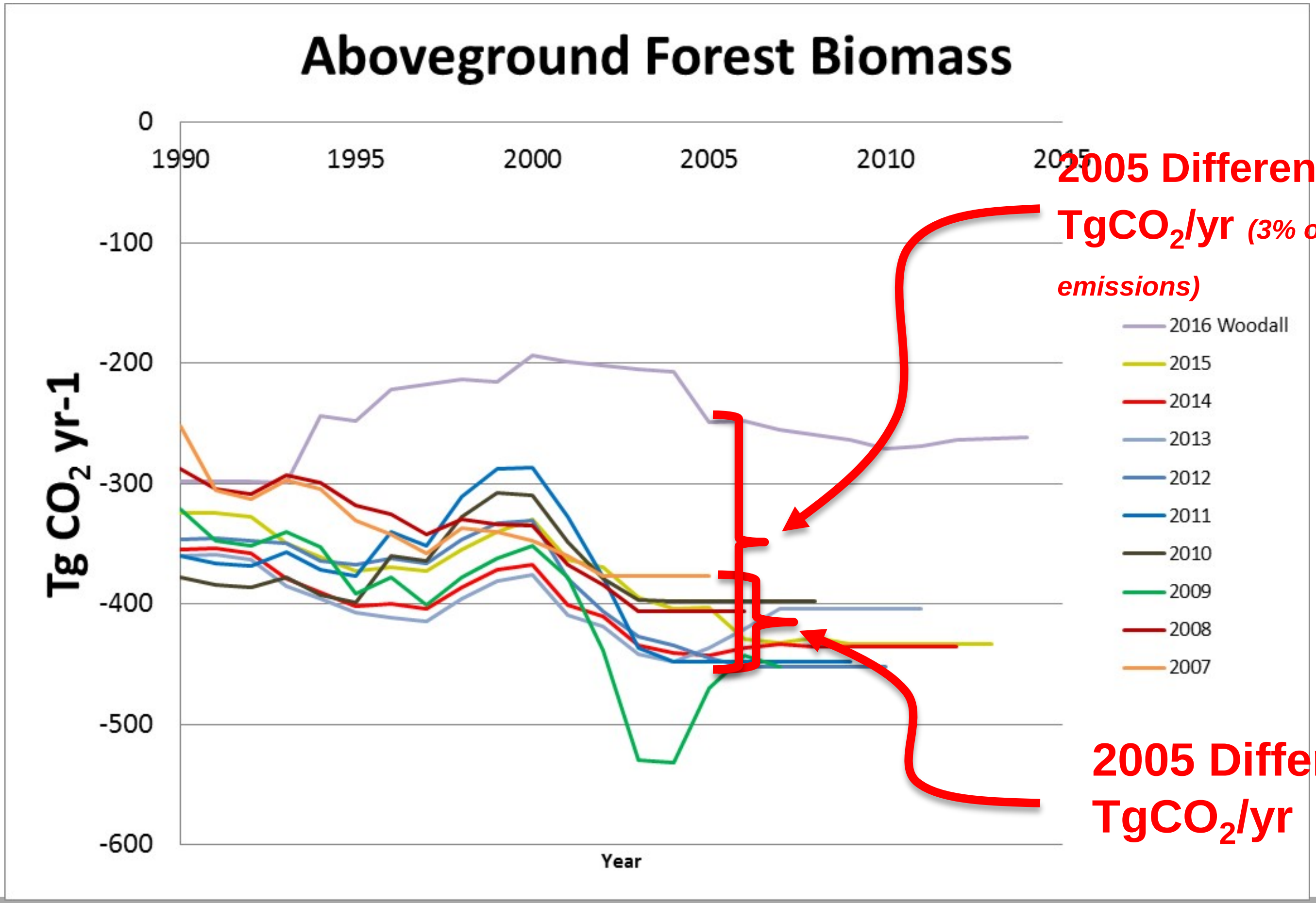


2005 Difference of 221 $TgCO_2$/yr ***(3% of gross US GHG emissions)***

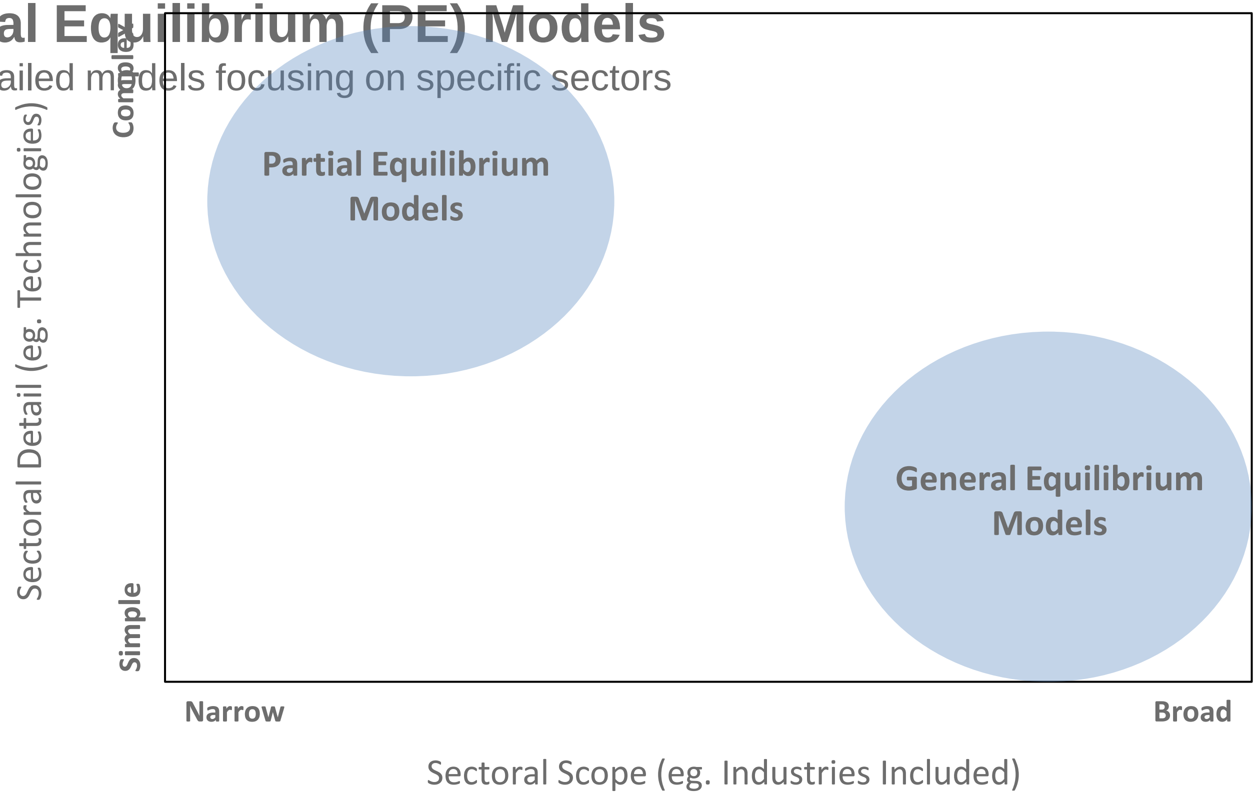
2005 Difference of 93 $TgCO_2$/yr

BASELINES – WHY HAVE THEM?

- What we need to know is what is the change in emissions due to biogenic feedstock use for energy is
- Since we can't know what the impacts of using the biomass vs not using it will be, we need to get creative
- Modeling is one way to approach it
- One way to structure such a model would be to simulate the markets in which the biomass exists
  - Largely because biomass is 1) an emerging market (yes, I know we have been using biomass as fuel for a long time, but not to the potential scale we are talking about here) and 2) is driven by primary markets for either forest products and/or crops

MARKET MODELS

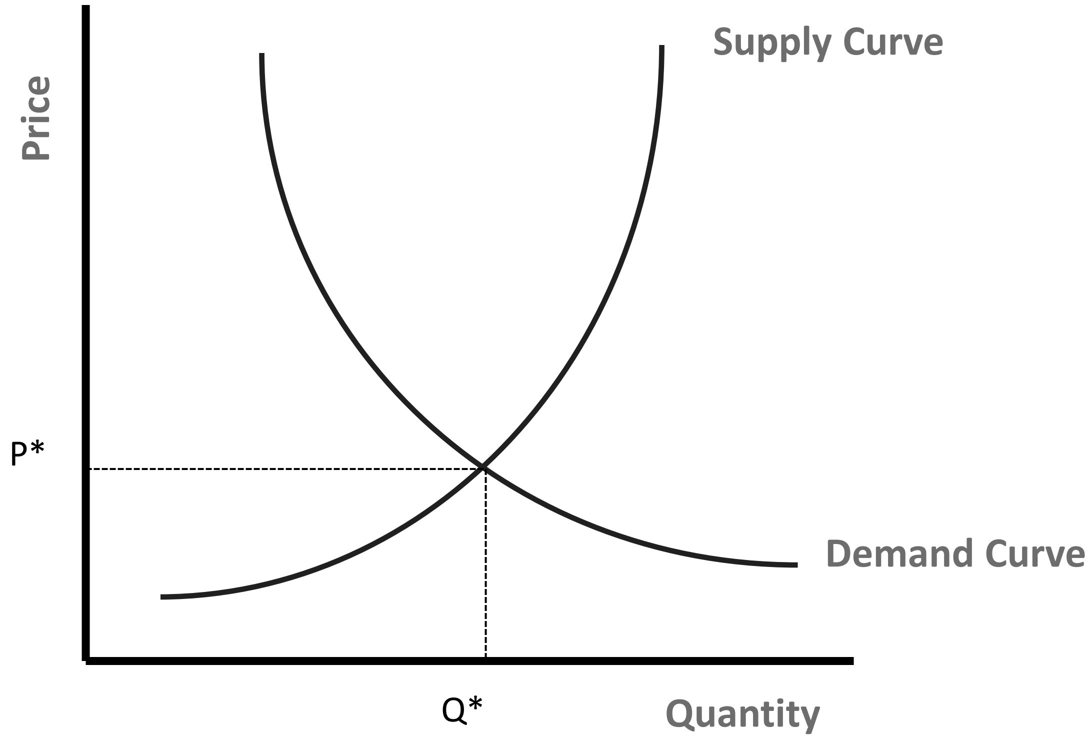
- **Computable General Equilibrium (CGE) Models**
  - Broad all inclusive models including many industries (sectors)
- **Partial Equilibrium (PE) Models**
  - Detailed models focusing on specific sectors



•Partial Equilibrium (PE) Models
• Detailed models focusing on specific sectors
•Computable General Equilibrium (CGE) Models
• Broad all inclusive models including many industries (sectors)

WHAT IS A FOREST SECTOR MODEL?

- **Partial equilibrium (PE) model**
    - Price endogenous (one to many regions, one to many products)

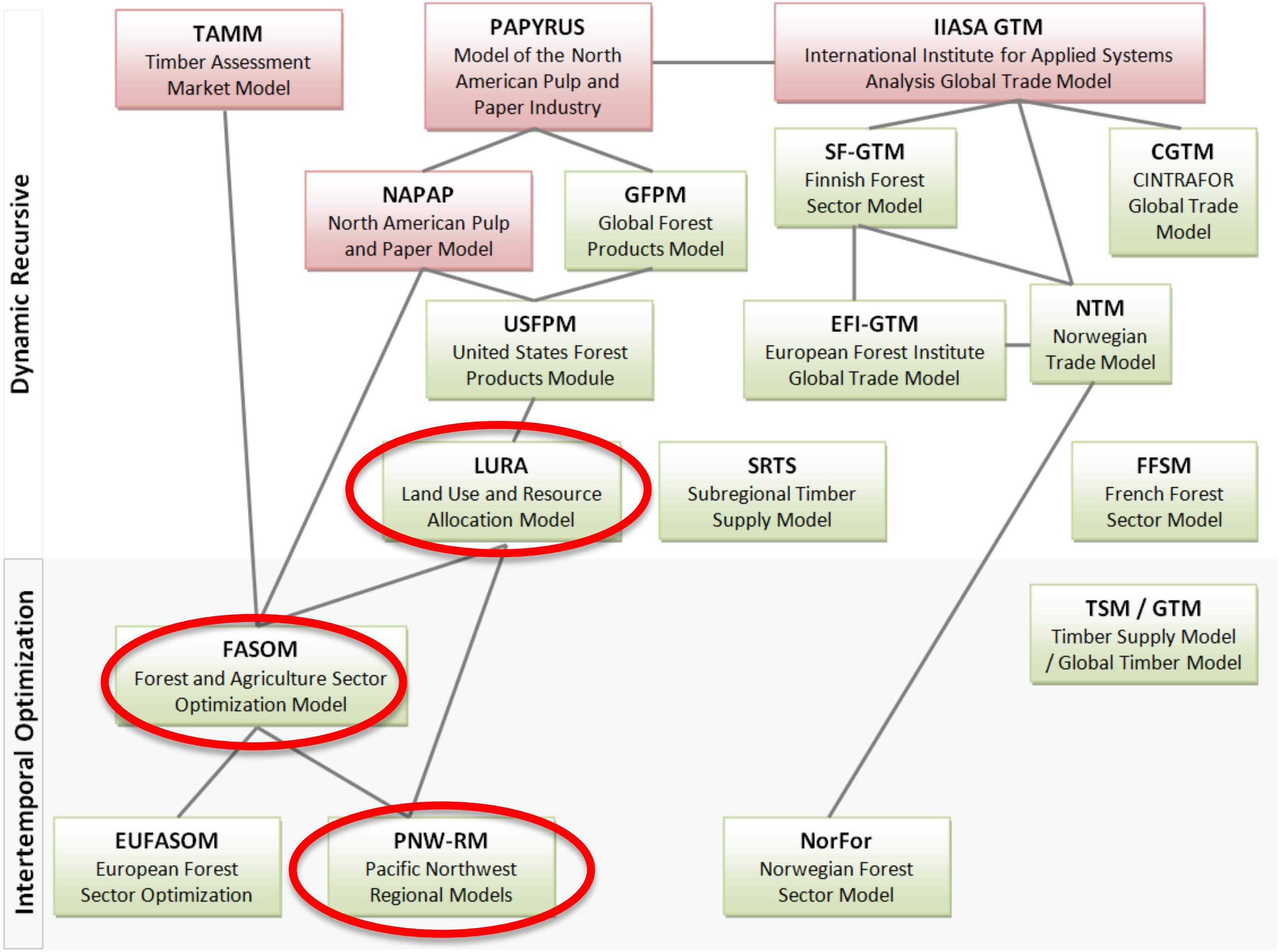


FOREST SECTOR MODEL SOLUTION TECHNIQUE

- **Dynamic Recursive**
  - Solves annual (typically) surplus, updates parameters, repeats
  - Shorter-term
  - Provides Most likely / Forecast type values
  - Mill Manager Perspective

- **Intertemporal Optimization**
  - Solves all time periods' surplus simultaneously
  - Longer-term
  - Provides Potential / Possible values
  - Forest Manager/Planner Perspective

FOREST PARTIAL EQUILIBRIUM MODELS



Adapted from:
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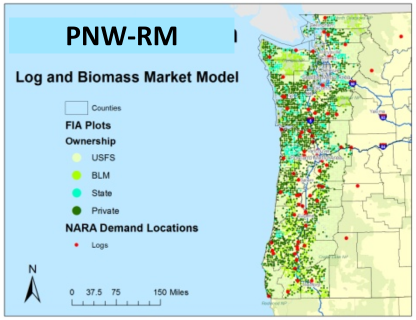
EVALUATING THREE MODELS

Less Complex

More Complex



Regional

Log Market

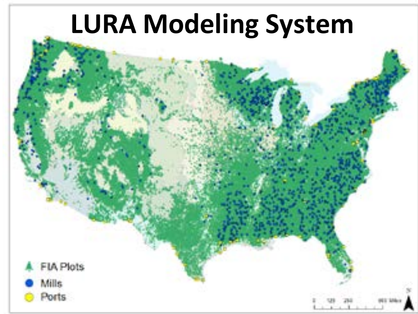
Can do sensitivity analyses for products but have to translate it to log demand

Individual tree growth

Can provide sensitivity linkages with detailed sustainability studies in C2P

Long-run optimal outlook

5-year periods for longer time frame to get optimal silviculture which drives the long-run log demand



National

Product Market

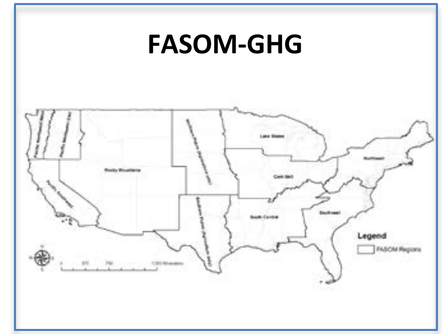
Can do sensitivity analyses for product demand based on AEO scenarios

Stand-level growth

Can provide carbon values, but little other detail for sustainability measures

Short-run "likely" outlook

1-year periods for shorter time frame with limited silviculture. Macroeconomic conditions drive demand.



National

Products and Ag. Market

Brings land use competition with agricultural uses and markets into the analysis

Stand-level growth

Can provide carbon values, but little other detail for sustainability measures

Long-run optimal outlook

5-year periods for longer time frame to get optimal silviculture which drives the long-run land use change

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EXAMPLE OF FOREST SECTOR MODEL USE

Latta, G.S. J.S. Baker, R.H. Beach, S.K. Rose, and B.A. McCarl. 2013. A multi-sector intertemporal optimization approach to assess the GHG implications of U.S. forest and agricultural biomass electricity expansion. *Journal of Forest Economics* 19(4): 361-383.

What:

- Evaluate the GHG emissions implications of increased utilization of specific biomass feedstocks as a result of an effort to increase biopower production

How:

- Utilize the Forest and Agriculture Sector Optimization Model with Greenhouse Gas (FASOM) with additional constraints on biopower production

A LITTLE ABOUT FASOM-GHG

Linked model of U.S. agriculture and forest sectors

Utilizes a intertemporal optimization approach to simulate markets for agriculture and forest products

Tracks a variety of agriculture and forestry resource conditions and management actions

Mitigation - four fundamental ways to mitigate emissions

1. Change land use
   - Afforestation, grassland conversion…
2. Alter management practices
   - Soil tillage practices, silviculture, extend timber rotations
3. Alter production levels and activity mix
   - More/less animals or a different mix of grass fed / feedlot
4. Bioenergy

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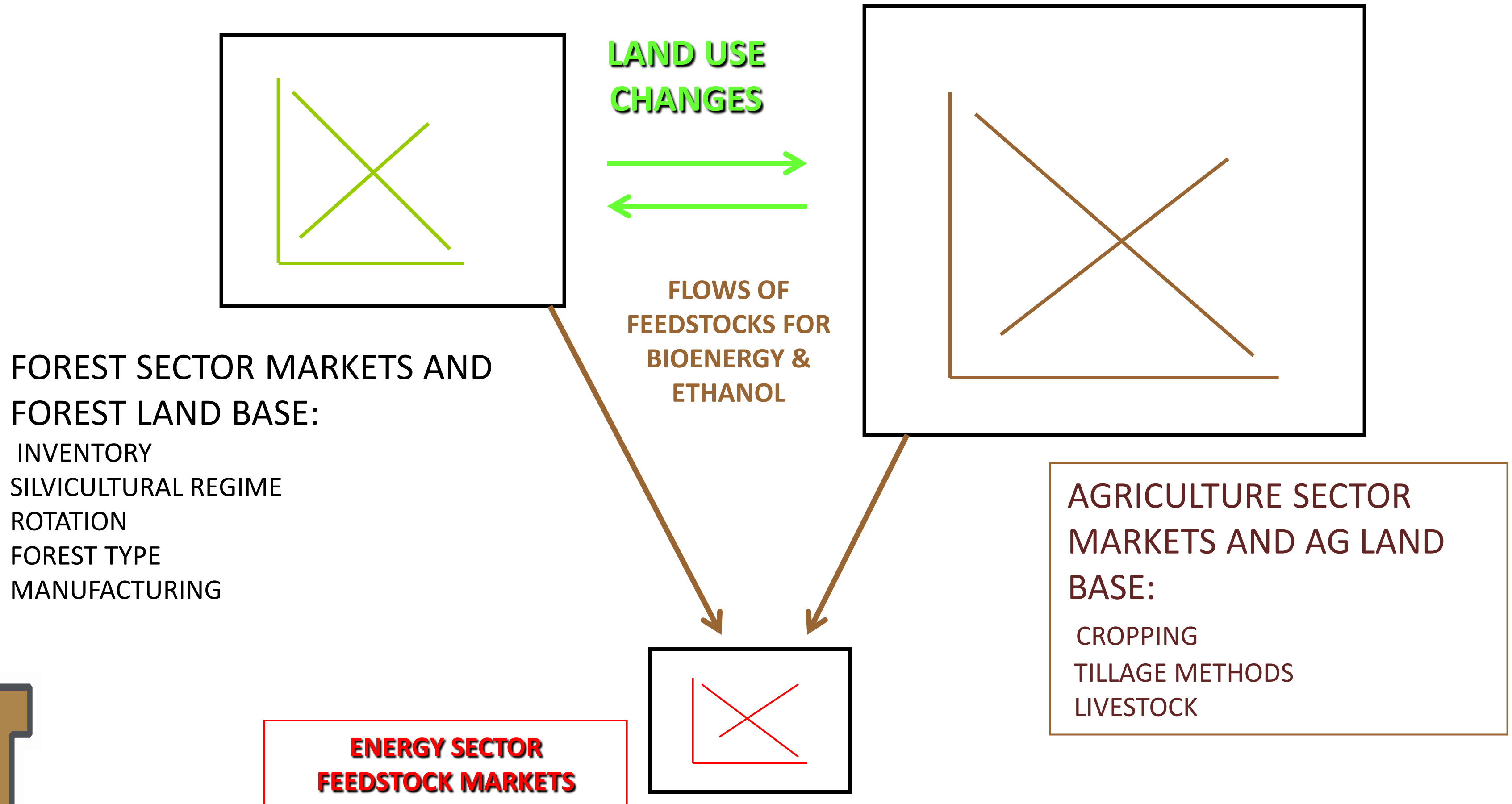
A LITTLE MORE ABOUT FASOM-GHG



Latta et al., 2013

SCENARIOS EVALUATED

Biopower Production Levels

- Base
- +**25**, 50, 75, **100**, 125, 150, 175, **200**, TWh's per year by 2030
  - Linear increase in production from 2010 – 2030

Biomass Feedstock Usage Scenarios

All Biomass Sources	all forest and agriculture feedstocks
All Agricultural Sources	only agricultural feedstocks
All Forestry Sources	only forest feedstocks
Roundwood Only	only roundwood
Residues Only	only forest logging and milling resides
Roundwood and Logging Residues	only roundwood and logging residues
All Biomass Sources No Sub	all forest and agriculture feedstocks , no substitution
All Agricultural Sources No Sub	only agricultural feedstocks, no substitutions
All Forestry Sources No Sub	only forest feedstocks, no substitution

Latta et al., 2013

TABLE 6: ANNUAL AVERAGE GHG EMISSIONS ASSOCIATED WITH PRODUCING BIOMASS TO MEET SIMULATED RES TARGETS FOR EACH OF THE FEEDSTOCK GROUPS

The 100 TWh by 2030 scenario displaces 38 Mt coal CO_2 annually in the Short-term (2010-2025 average)

	Agriculture			Afforestation			Forestry			Total		
	25	100	200	25	100	200	25	100	200	25	100	200
	additional emissions in million metric tonnes per year											
Short-term (2010-2025)												
average annual avoided fossil fuel emissions										10	38	76
All Biomass Sources	7	12	10	(2)	7	7	(3)	5	(7)	1	24	10
All Agricultural Sources	(0)	7	14	0	(2)	31	7	7	11	7	12	55
All Forestry Sources	0	16	55	(3)	(8)	(96)	12	48	71	12	55	30
Roundwood Only	2	15	113	(1)	(8)	(133)	(2)	21	77	(1)	28	57
Residues Only	4	98	160	(7)	(166)	(391)	13	68	725	11	(0)	494
Roundwood and Logging Residues	(1)	(11)	43	2	33	(56)	(3)	25	53	(1)	47	40
All Biomass Sources No Sub	9	11	17	0	0	0	8	6	13	16	17	31
All Agricultural Sources No Sub	2	13	8	0	(0)	(0)	2	5	10	4	18	18
All Forestry Sources No Sub	1	2	1	(0)	0	(1)	3	76	224	4	78	224
Longer-term (2025-2040)												
average annual avoided fossil fuel emissions										22	89	178
All Biomass Sources	0	12	3	(5)	3	14	11	11	29	6	25	45
All Agricultural Sources	(1)	1	16	(2)	(4)	(5)	8	6	7	4	3	18
All Forestry Sources	2	20	94	(3)	(19)	(190)	14	78	257	12	78	158
Roundwood Only	9	35	2	(25)	(42)	(199)	17	17	335	2	10	136
Residues Only	0	(4)	(14)	(1)	(90)	(346)	(2)	158	(135)	(3)	64	(498)
Roundwood and Logging Residues	15	24	49	(4)	(25)	(127)	21	62	297	32	60	215
All Biomass Sources No Sub	(2)	26	11	0	0	(0)	(2)	(7)	(17)	(4)	19	3
All Agricultural Sources No Sub	(47)	(48)	(25)	0	5	3	1	8	(1)	(45)	(34)	(20)
All Forestry Sources No Sub	6	8	8	(0)	(14)	39	18	142	271	24	137	318

Remember our key concepts:

Time Frame Consideration

Feedstock Consideration

Scale of Use Consideration

Latta et al., 2013 - TIME FRAME CONSIDERATION

ALL BIOMASS SOURCES – 25 TWH

Time Frame	Scenario	Agriculture	Afforestation	Forestry	Total
		------------- *additional emissions in million metric tonnes per year* -------------			
Short-term (2010-2025)	All Biomass Sources	7	(2)	(3)	1
Longer-term (2025-2040)	All Biomass Sources	0	(5)	11	6

	Short-term	Longer-term
Feedstock Use	*Mt / yr*	
Energy Crop	4.6	3.8
Crop Residues	1.8	6.8
Short Rot. Woody Crop		5.2
Mill Residues	0.5	0.6
Land Use	*1000 ha / yr*	
Afforestation	(12)	42
Commodity Substitution	*Mt / yr*	
Pulp Fiber from Ag Land	(0.3)	0.3
Harvest	*million M^3 / yr*	
	2.4	(0.7)
Tree Carbon	*Mt CO_2 / yr*	
Flux	(1)	(2)

Note that in our baseline of no biomass use there was **296**

Note that in our baseline of no biomass use there was **2.6**

Note that in our baseline of no biomass use there was **379**

This is on an average baseline carbon stock of **26,529** Mt CO_2 in the short run and **26,096** Mt CO_2 in the longer run

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Latta et al., 2013

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Latta et al., 2013 - FEEDSTOCK DESIGNATION

ONLY FORESTRY SOURCES – 25 TWH

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Short-term (2010-2025)	All Biomass Sources	7	(2)	(3)	1
Short-term (2010-2025)	All Forestry Sources	0	(3)	12	12

	All Biomass	Only Forestry
Feedstock Use	*Mt / yr*	
Energy Crop	4.6	
Crop Residues	1.8	
Logging Residues		3.4
Mill Residues	0.5	2.7
Roundwood		2.7
Land Use	*1000 ha / yr*	
Afforestation	(12)	3
Commodity Substitution	*Mt / yr*	
Pulp Fiber from Ag Land	(0.3)	(0.8)
Harvest	*million M^3 / yr*	
	2.4	4.6
Tree Carbon	*Mt CO_2 / yr*	
Flux	(1)	(9)

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Latta et al., 2013

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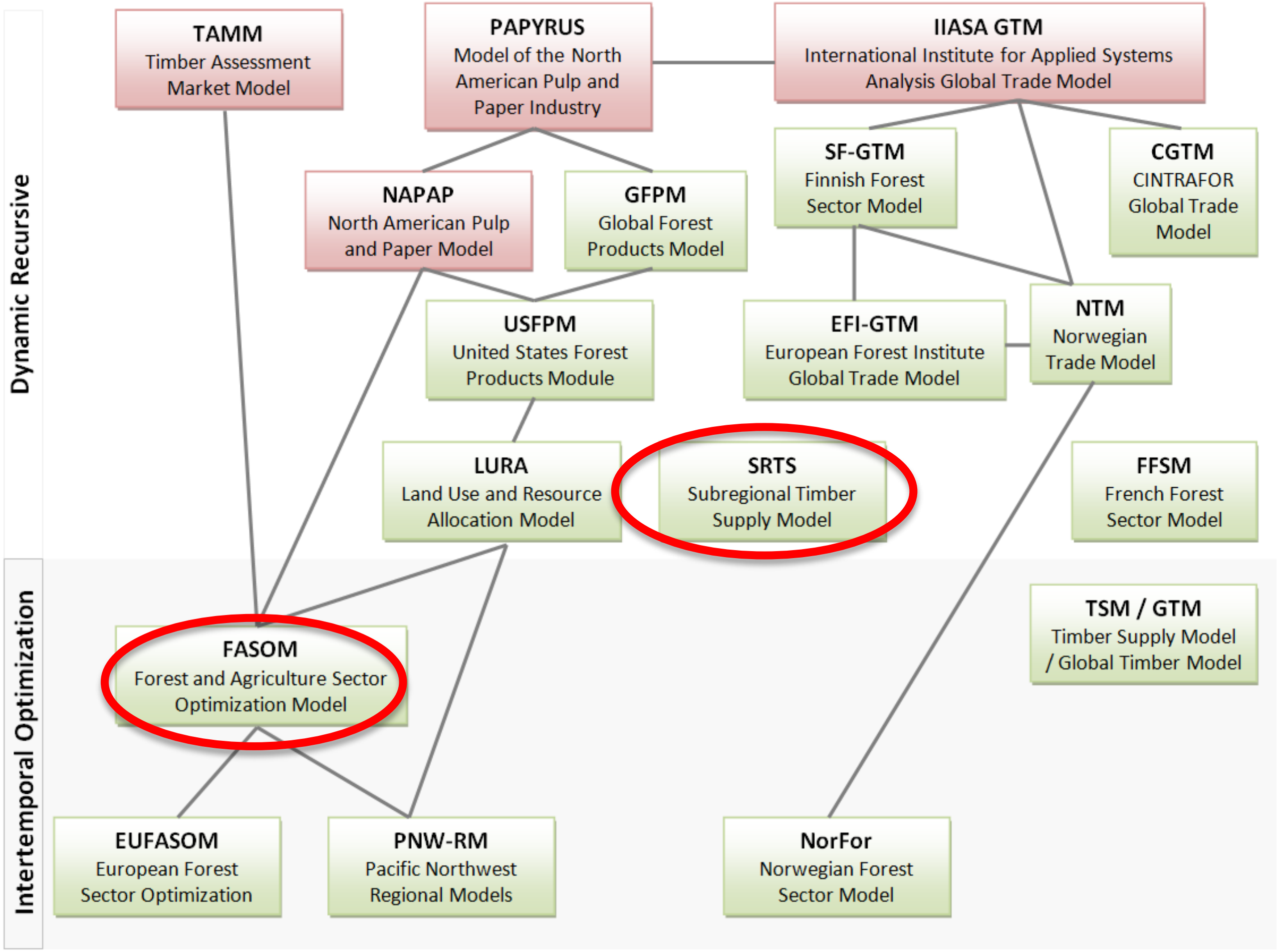
Latta et al., 2013 - SCALE OF USE

ONLY FORESTRY SOURCES – 100 TWH

Time Frame	Scenario	Agriculture	Afforestation	Forestry	Total
		------------- *additional emissions in million metric tonnes per year* -------------			
Short-term (2010-2025)	Forestry Sources @ 25 TWH	0	(3)	12	12
Short-term (2010-2025)	Forestry Sources @ 100 TWH	16	(8)	48	55

	25 TWH	100 TWH
Feedstock Use	*Mt / yr*	
Logging Residues	3.4	14.0
Mill Residues	2.7	8.0
Roundwood	2.7	14.5
Land Use	*1000 ha / yr*	
Afforestation	3	12
Commodity Substitution	*Mt / yr*	
Pulp Fiber from Ag Land	(0.8)	6.4
Harvest	*million M^3 / yr*	
	4.6	17.9
Tree Carbon	*Mt CO_2 / yr*	
Flux	(9)	(39)

FOREST PARTIAL EQUILIBRIUM MODELS



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MARKET MODELS

- Partial Equilibrium (PE) Models
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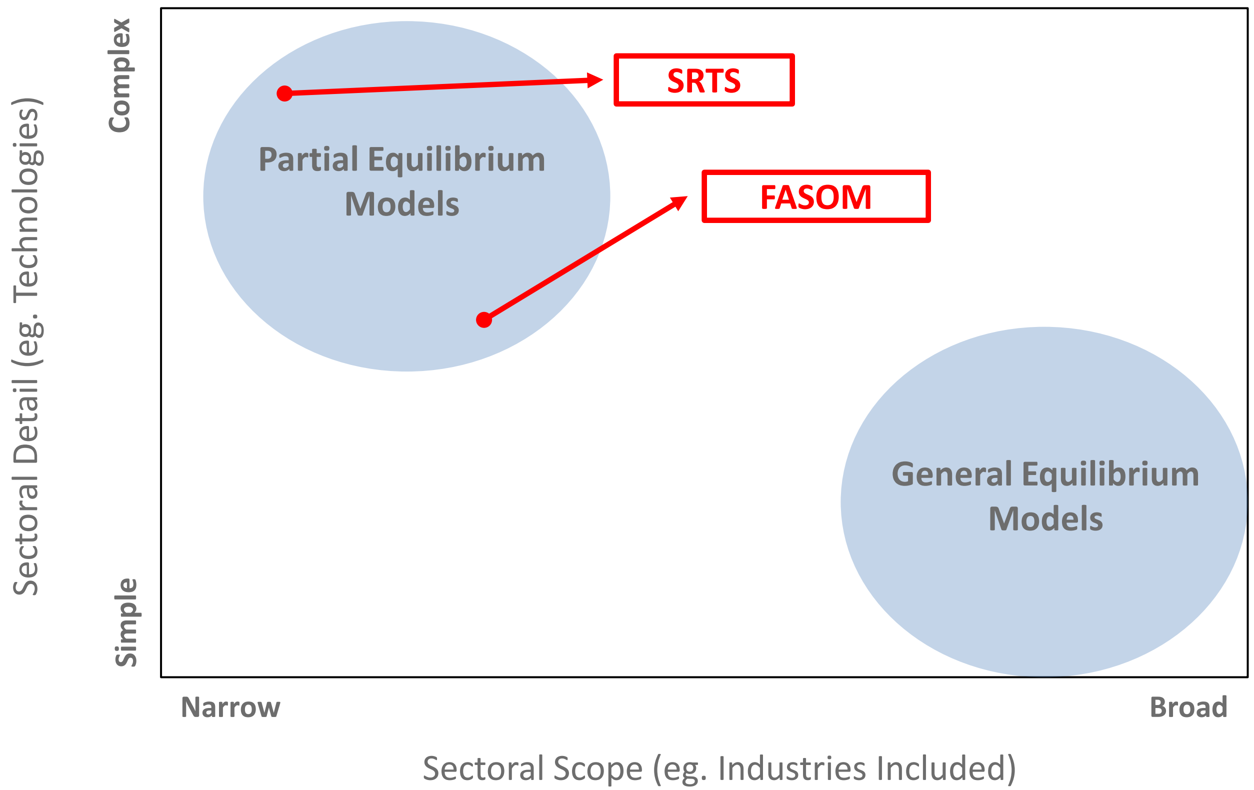

- Computable General Equilibrium (CGE) Models
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FASOM SRTS Example

COMPARING MODEL RESPONSES

Both models have been used for bioenergy policy analysis

Both models are well represented in the academic literature – (*ie: hopefully vetted*)

Because of how different they are, they complement each other

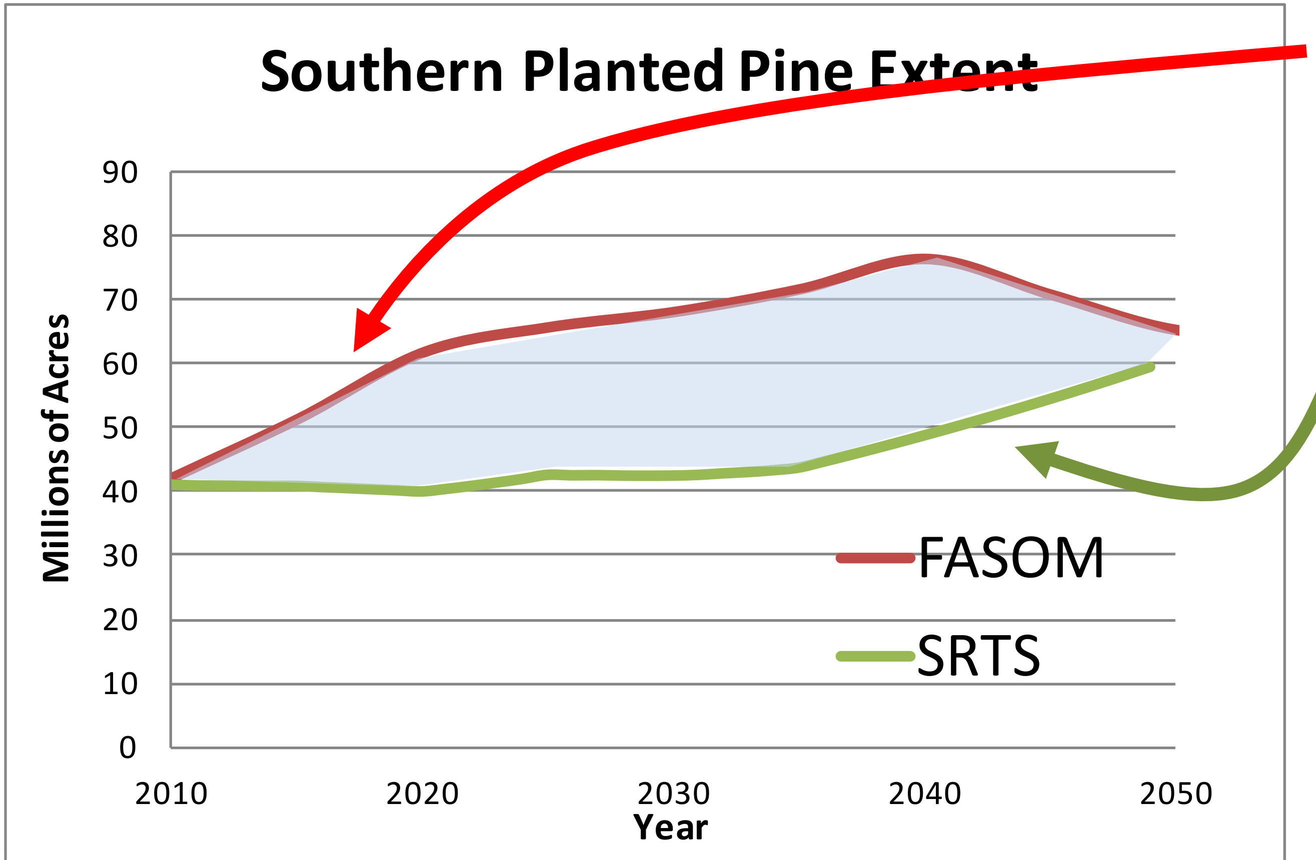
Geographic scale
- FASOM provides the interregional perspective
- SRTS provides subregional – local perspective

Temporal scale
- FASOM identifies long term supply potential impacts
- SRTS identifies short-term resource distributional impacts

Sectoral scale
- FASOM identifies tradeoffs between agricultural and forest biomass
- SRTS identifies log grade differentiated tradeoffs

FASOM SRTS Example

FOREST MANAGEMENT RESPONSE TO RPS



- FASOM perfect foresight leads to early response to RPS with boost in planted pine acreage
- SRTS increases planted pine acreage later in response to price signal
- Reality most likely is somewhere inbetween

Adapted From:

Galik, C.S., R.C. Abt, G. Latta, and T. Vegh. 2015. The environmental and economic effects of regional bioenergy policy in the southeastern US. *Energy Policy*. 85(2015): 335-346.

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CONCLUSION

- Baselines are important
  - What you've considered (product detail, region, markets, etc.) is important as well as how you've considered it (what degree of foresight did you assume)
- Market models are a great TOOL for these types of analyses
- They internally handle the very complex interactions within an incredibly complex forest resource and manufacturing situation
  - But you must be an intelligent consumer
    - *The model solution is only the beginning of the analysis*
    - *Why did the model return the solution it did?*
    - *And what does it mean?*
  - Multiple models and well designed scenarios can help with this