The Economic Tradeoffs in Timber Products Under Various Carbon Management Strategies for Maryland and Pennsylvania

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FOREST SERVICE US DEPARTMENT OF AGRICULTURE

DCNR pennsylvania DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

MARYLAND DEPARTMENT OF NATURAL RESOURCES

2/1/2023

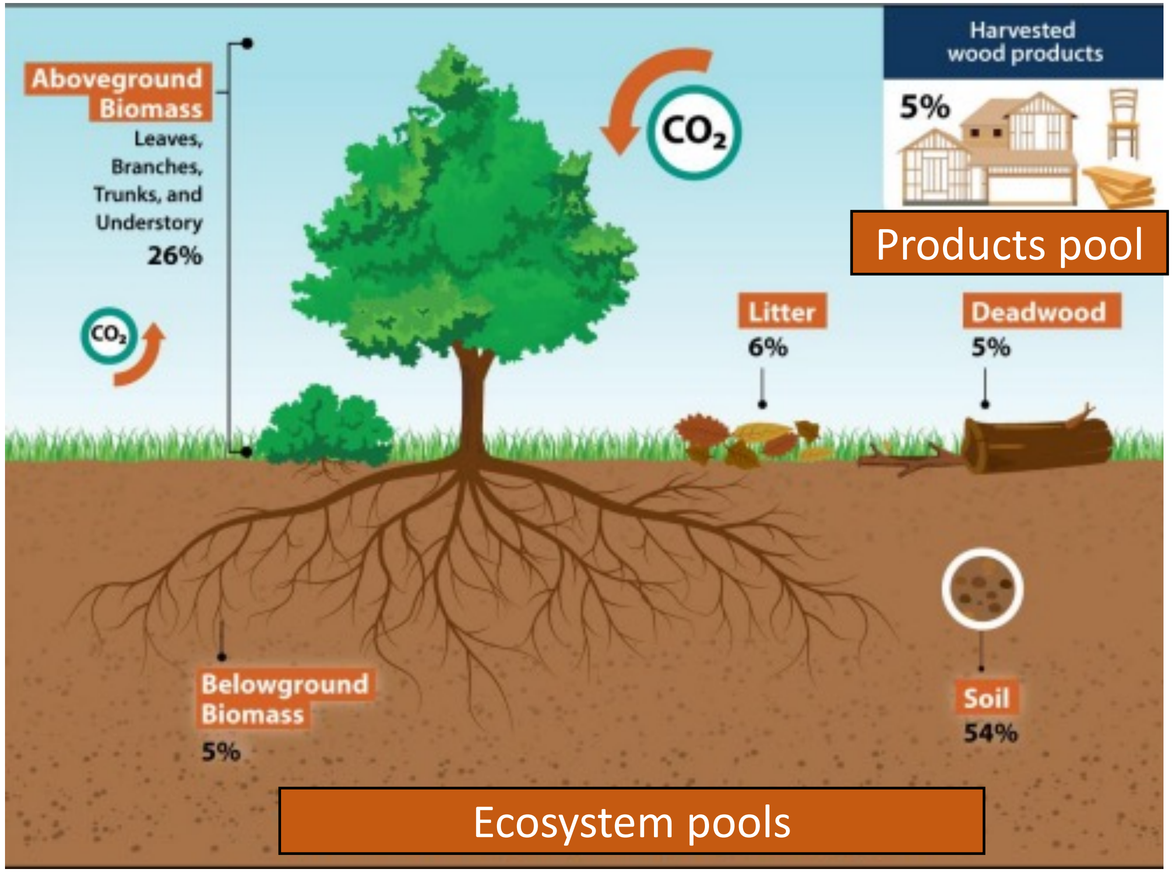
Outline

- Background
- Objectives
- Scenarios
- Methods
- Findings

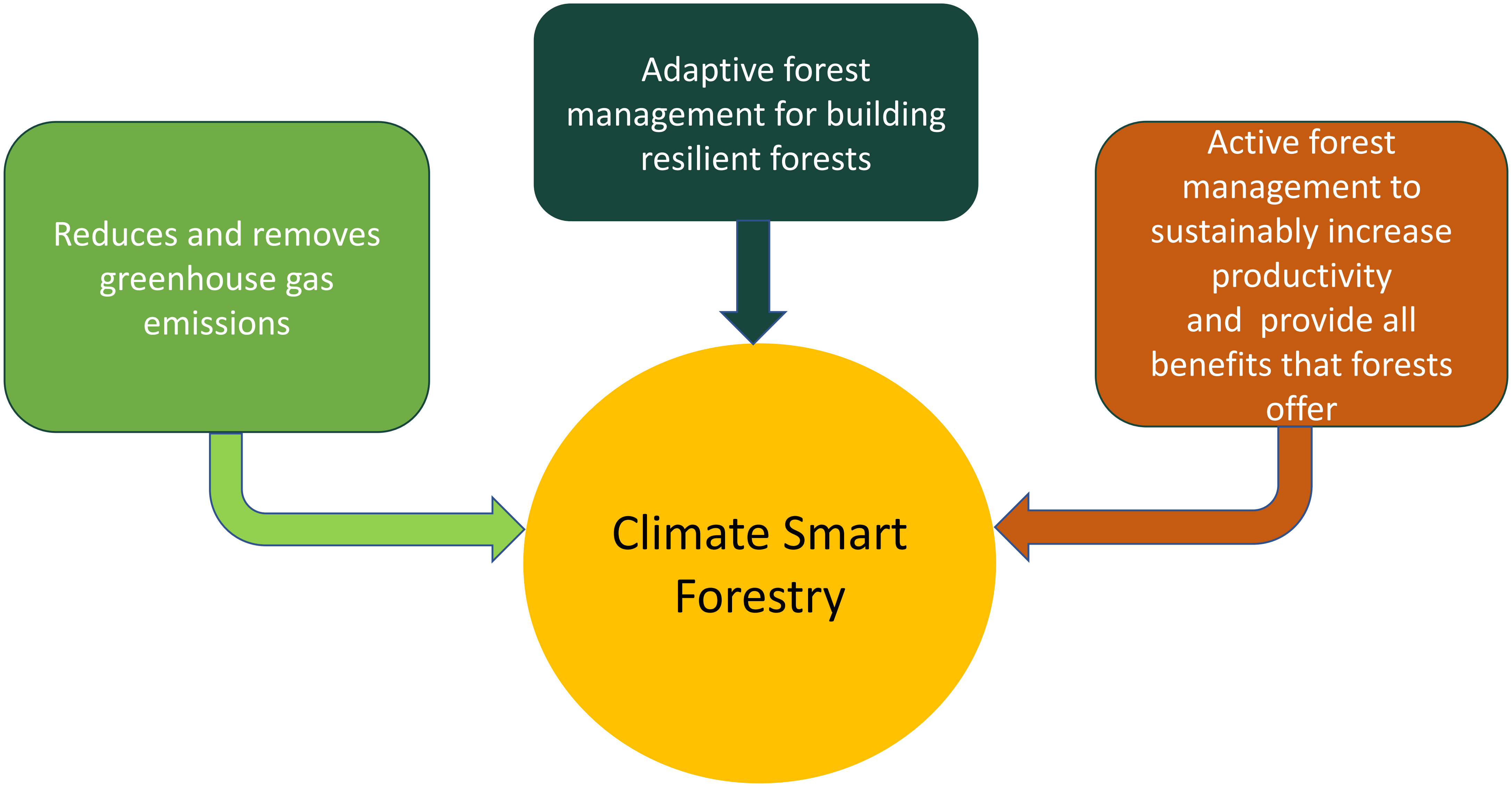
Photo: https://www.psu.edu/news/campus-life/story/professor-pennsylvanias-forest-cover-remains-stable-59-percent/

Background

- Forests play an important role in mitigating the effects of climate change
- In 2020, U.S. Forests sequestered 767 MMT CO_2 equivalent (offset of 13% gross GHG emissions) (Hoover and Riddle 2022)
- Growing recognition of forest's role in climate change has spurred interest to understand how such benefits from forests can be bolstered in the future



Source: Hoover and Riddle (2020)



A framework of climate smart forestry

Background

The Department of Natural Resources in Maryland and Pennsylvania contracted with Michigan State University Forest Carbon and Climate Program (MSU FCCP)

I. Understand the impact of existing forests and mgmt. practices on emissions level at present and forest's health and climate benefits in the future

II. Understand how different carbon mgmt. scenarios would perform in terms of carbon sequestration in the future

Penn Soil RC&D contracted with MSU to further look at the economic tradeoffs of the modeled forest management actions resulting from the earlier project

Objective

To quantify financial tradeoffs of carbon and timber products resulting from the CBM-CFS management scenarios for increasing carbon compared to the business as usual (BAU) scenario.

Management Scenarios in CBM-CFS

1. Business-as-usual (BAU) Scenario:

   -Represents continuation of current management practices (harvests, thinning, and prescribed burn). Projection starts from 2020 till 2170.

   -Basis for comparison to alternative scenarios

- 2. Alternative Management Scenarios

  -Created by changing BAU parameters beginning in 2020 representing potential changes in future management decisions or disturbance events.

  -Scenarios relate to one specific practice or objective, where only one BAU practice is changed and the rest of the BAU remains the same.

Alternative Management Scenarios

I. Extending Rotations : (Increase average harvest age of stands)

Extended Rotation(+ 30 years on all HWs and SWs and –10 years on Aspen stands until 2170 in PA)

Extended Rotation(+ 30 years on all HWs and +20 years on Loblolly Pine in MD until 2170)

Extended Rotation Alt.(+ 30 years on all HWs and +40 years on Loblolly Pine in MD until 2170)

II. Increasing Afforestation (Four scenarios):

afGGRA2030 (+2,376 acres/yr until 2030; then return to BAU in PA) (+350ac/yr till 2030 in MD)

afGGRA2050 (+2,376 acres/year until 2050; then return to BAU rate) (+350ac/yr till 2050 in MD)

afSU2030 (+23,760 acres/year until 2030; then return to BAU rate)(+3500ac/yr till 2030 in MD)

afSU2050 (+23,760 acres/year until 2050; then return to BAU rate)(+3500ac/yr till 2050 in MD)

Alternative Management Scenarios

III. Increasing Restocking (Increase supplemental planting to restock understocked stands):

Restock (Annual restocking rate + 4,508 acres/year until 2170 in PA)

(+2,500 acres/year till 2030 then return to baseline rate in MD)

Restock Alt. (Annual restocking rate + 2,500 acres/year until 2050 then return to baseline rate in MD)

IV. Increasing Timber Stand Improvements (TSI):

TSI (Annual thinning rate + 14,892 acres/year until 2170 in PA)(+5,500 acres/year in MD)

(Annual prescribed burn rate + 25,000 acres/year until 2170 in PA) (+500 acres/year in MD)

V. Reduced Deforestation (Decrease rate of permanent forest loss):

Reduced Def (Annual deforestation rate -5,149 acres/year until 2170 in PA)(-800 acres/year in MD)

Alternative Management Scenarios

VI. Reduced Diameter Limit Cuts (Eliminate high grading on private lands):

Reduced DLC (Annual DLC removals - 30,559 mt C/year (15% of DLCs in baseline) until DLCs=0 in 2027; DLCs stay at 0 until 2170 in PA)

(Annual DLC removals - 2,384 mt C/year (10% of DLCs in baseline) until DLCs=0 in 2030; DLCs stay at 0 until 2170 in MD)

VII. Control Deer Browse (Increase rates of successful deer browse control i.e. fencing):

Control DB (Annual browse control rate +14,459 acres/year until 2170 in PA) (+2000 acres/year in MD)

VIII. Silvopasture (Increase silvopasture adoption through low density planting of trees in pastureland):

Silvopasture (Annual Silvopasture planting rate +15,250 acres/year until 2170 in PA) (+3,115 acres/year in MD)

Alternative Management Scenarios

IX. No Harvest Activities (Reduce all harvest and thinning activities on all lands):

No Harvest (Annual harvest rate -100% acres/year until 2170)

(Annual thinning rate -100% acres/year until 2170)

(Annual DLC rate -100% acres/year until 2170)

Data and Methods

I. Estimation of timber products generated under business as usual (BAU) and alternative carbon management scenarios from the Harvested Wood Products (HWP) model was obtained using the following formula:

$$Volume = \frac{(Carbon * 2)}{Specific\ Gravity}$$

State-specific weighted specific gravities were used for conversion of softwood/hardwood component of forest types in each state

Maryland:

	Volume (MCF)	
softwood	9424.09737	*29.87%*
hardwood	22130.8831	*70.13%*
	31554.98	
total		

Weighted Specific Gravity	
softwood	0.5075104
hardwood	0.51647761

Pennsylvania:

	Volume (MCF)	
softwood	13573.2432	*5.38%*
hardwood	238539.78	*94.62%*
total	*252113.02*	

Weighted Specific Gravity	
softwood	0.39312572
hardwood	0.57964335

Estimation of Timber Products

Data obtained from HWPs model in different product stream categories

Variable	Product – General	Product – Specific	For Export?	Unit
ex.roundwood.MBF	Roundwood	Roundwood - for export	Y	MBF
ex_saw.MBF	Sawnwood	Sawnwood - for export	Y	MBF
D.saw.MBF	Sawnwood	Sawnwood logs, new domestic	N	MBF
R.saw.MBF	Sawnwood	Sawnwood, recycled	N	MBF
ex_veneer.MBF	Veneer	Veneer logs - for export	Y	MBF
D.veneer.MBF	Veneer	Veneer logs, new domestic	N	MBF
ex_D.pulp.tons	Pulp	Pulp - for export	Y	tons
ex_M.pulp.tons	Pulp	Pulp from mill residue - for export	Y	tons
ex_RS.pulp.tons	Pulp	Pulp, recycled - for export	Y	tons
D.pulp.tons	Pulp	Pulp	N	tons
M.pulp.tons	Pulp	Pulp from mill residue	N	tons
R.pulp.tons	Pulp	Pulp, recycled	N	tons
ex_D.CP.MCF	Composite panels	Composite panels - for export	Y	MCF
ex_M.CP.MCF	Composite panels	Composite panels from mill residue - for export	Y	MCF
D.CP.MCF	Composite panels	Composite panels	N	MCF
M.CP.MCF	Composite panels	Composite panels from mill residue	N	MCF
D.OI.MCF	Other industrial	Other industrial	N	MCF
M.bioenergy.tons	Bioenergy	Bioenergy from mill residue	N	tons
D.PPP.MBF	Poles, posts, pilings	Poles, posts, pilings	N	MBF

Economic Tradeoffs of Carbon and Timber Products Estimation

To quantify financial tradeoffs of carbon and timber products resulting from the CBM-CFS management scenarios, Net Present Value for each modeled scenario were estimated and compared to BAU scenario.

$$NPV = \sum \frac{R}{(1+i)^t} - \sum \frac{C}{(1+i)^t}$$

R is the revenue generated from the harvested wood products and/or carbon credits under each management scenario for a certain duration [Short term (2023 to 2032), Medium term (2023 to 2050), Medium-long term (2023 to 2070) and Long term (2023 to 2100)]

C is the costs associated with implementing each modeled management scenario including BAU for the same duration

i is the minimum acceptable real rate of return (RoR) and

t is the time in years during the period considered.

Revenue Estimation

Revenue from timber products estimated as:

$$Revenue\ TP = (Vol. Harvested * Stumpage\ Price)$$

Revenue from carbon credits estimated as:

$$Revenue\ CC = (CO_2\,equivalent * Price\ of\ carbon)$$

where,

$$CO_2\,equivalent = \{(Vol. Harvested\ BAU - Vol\ Harvest\ Modeled\ Scenario)/2\} * 3.67$$

(3.67 is the conversion factor used for converting carbon into CO_2 equivalent)

Stumpage Price for Revenue Estimation

Average stumpage price (2016 to 2021) in Pennsylvania

Product Type	Stumpage Price	Unit
Hardwood		
Logs	253.9	$/Mbf
Pulp	3.6	$/ton
Poles, post, pilings	253.9	$/ton
Softwood		
Logs	94.1	$/Mbf
Pulp	3.7	$/ton
Poles, post, pilings	94.1	$/ton

Average stumpage price (2010 to 2021) in Maryland

Product Type	Stumpage Price	Unit
Hardwood		
Logs	270	$/Mbf
Pulp	3	$/ton
Poles, post, pilings	270	$/ton
Softwood		
Logs	156	$/Mbf
Pulp	4	$/ton
Poles, post, pilings	156	$/ton

Starting year 2023, stumpage prices were increased by 3% every year for HWs and 2.5% per year for SWs.

Starting year 2023, stumpage prices were increased by 3% every year for HWs and 1% per year for SWs till 2032 and 2.5% starting 2033.

Percentages chosen based upon historical timber price trends in PA from 2007 to 2017 as per Jacobson (2022)

Forest Management Practices Costs Data for Cost Estimation

Data obtained from Environmental Quality Incentives Program's (EQIP) payment schedule 2022

Forest Practices Costs in Pennsylvania

Type of Forest Management Practice	EQIP Code	Per unit cost of implementing the management practice
Thinning	666	$327.2/acre
Prescribed fire	338	$75.95/acre
Site preparation cost in clearcut areas	490	$221.74/acre
Stand establishment cost in clearcut areas	612	$813.70/acre for HW species and $390.67/acre for SW species
Afforestation cost	612	$813.70/acre
Restocking cost	612	$636.20/acre
Fencing cost	382	$387/acre
Silvopasture planting cost	381	$128/acre

Forest Practices Costs in Maryland

Type of Forest Management Practice	EQIP Code	Per unit cost of implementing the management practice
Thinning	666	$317.98/acre
Prescribed fire	338	$68.18/acre
Site preparation cost in clearcut areas	490	$200.85/acre
Stand establishment cost in clearcut areas	612	$797.73/acre for HW species and $380.97/acre for SW species
Afforestation cost	612	$696.02/acre
Restocking cost	612	$380.97/acre
Fencing cost	382	$393/acre
Silvopasture planting cost	381	$128/acre

Starting year 2023, all forest practices costs were increased by 1.69% per year to account for inflation.

Carbon Price

- Price per ton of CO_2 equivalent used for financial analysis was $8.29 dollars for year 2022
  (as accessed in Oct 6,2022).

- Transaction cost of carbon was deducted from the market price to get the price of carbon used for financial analysis

- Transaction cost of carbon was estimated using the formula proposed by Pearson et al. (2013).

$$TC = 1 + 0.23 * P^c$$

where TC is the transaction cost of carbon,
1 represents the fixed cost of carbon ($1 per ton) and $0.23 * P^c$ represents the variable cost of carbon which is assumed to be 23% of the market price of carbon.

Starting year 2023, carbon price was assumed to increase by 2% every year

Live Carbon Prices Today

CarbonCredits.com Live Carbon Prices	Last	Change	YTD
Compliance Markets			
European Union	€78.67	0.00 %	−1.93 %
California	$30.83		−3.72 %
Australia (AUD)	$28.00	0.00 %	−45.10 %
New Zealand (NZD)	$80.30	0.00 %	+17.31 %
South Korea	$14.24	0.00 %	−43.12 %
Voluntary Markets			
Aviation Industry Offset	$2.98	0.00 %	−62.75 %
Nature Based Offset	$7.40	0.00 %	−47.44 %
Tech Based Offset	$2.37	0.00 %	−53.35 %

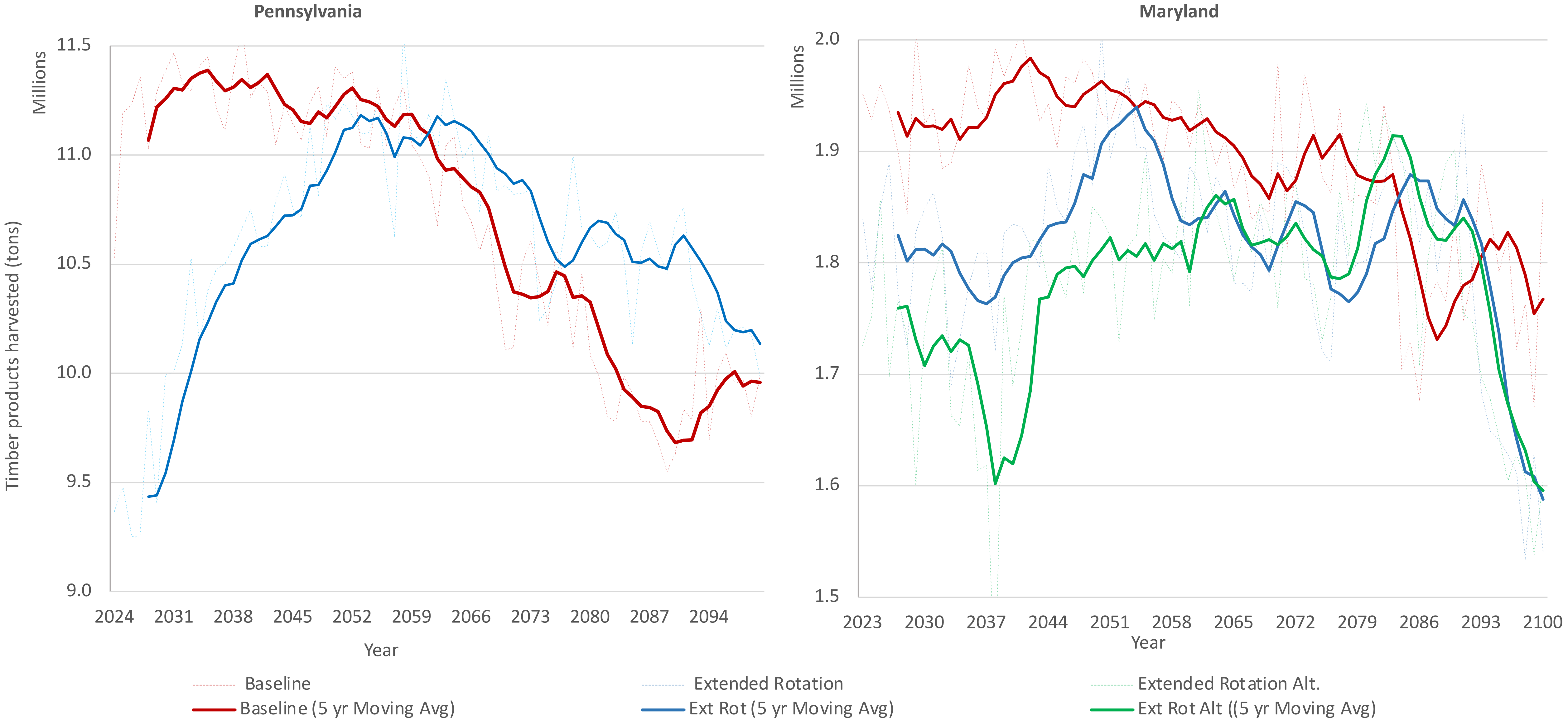
CarbonCredits.com Real-time Pricing (Updates Every 5 Mins)

Click here to learn how carbon credits are priced.

https://carboncredits.com/carbon-prices-today/?sl=cc-google-ads&gclid=Cj0KCQjw852XBhC6ARIsAJsFPN2FVsJRnxzxC42TZMKSM-Ue3wo7hVTTiOkz1eaJdi_sqLdghAJ853gaAkTdEALw_wcB

Findings

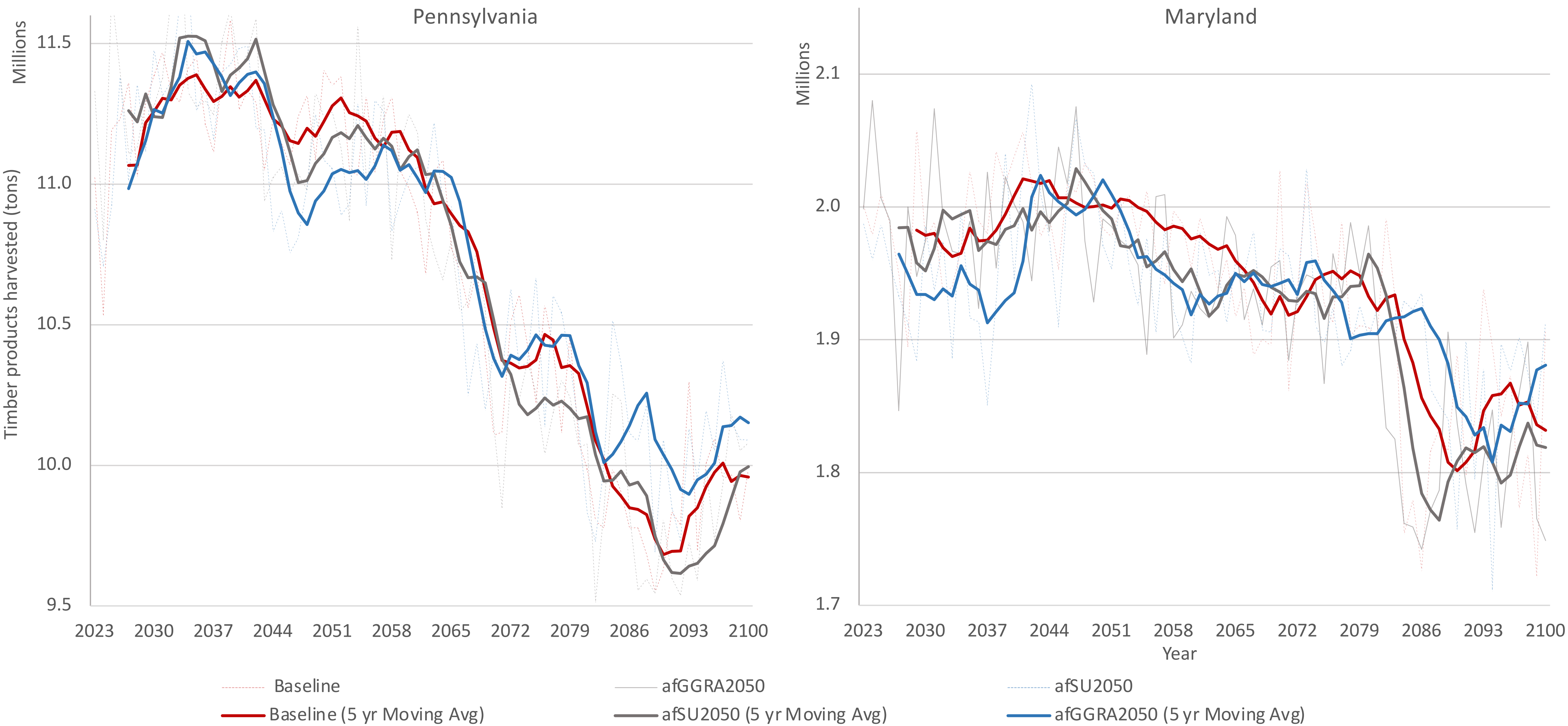
BAU Vs Extended Rotation



Extended Rotation= Increasing average harvest age of stands (+30 years on H/SWs; -10 years on Aspen in PA) (+30 years on HWs and +20 years on loblolly pine till 2170 in MD)

Extended Rotation Alt.= Increasing average harvest age of stands (+30 years on HWs and +40 years on loblolly pine till 2170 in MD)

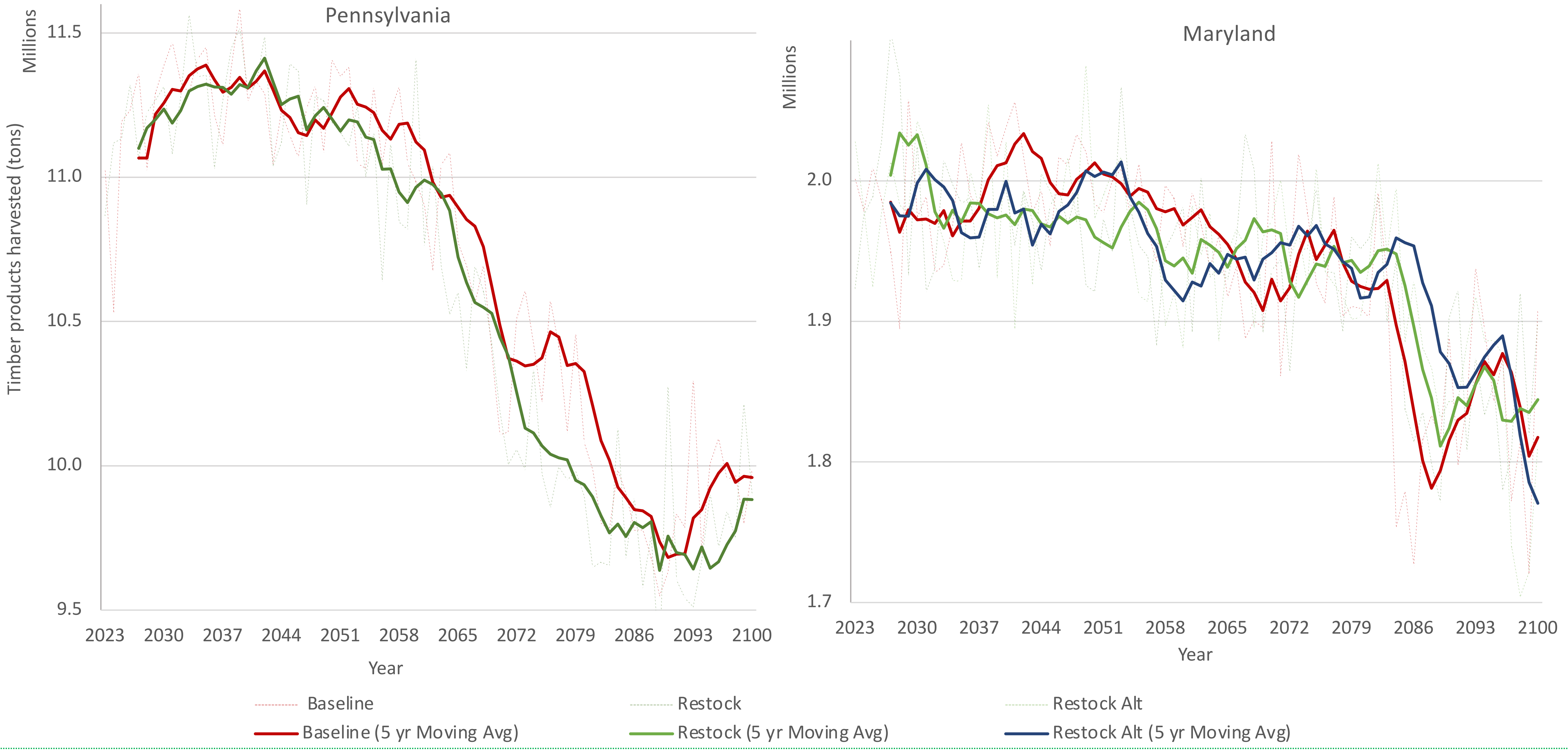
BAU Vs Afforestation



afGGRA2050 = Increasing afforestation (+2,376 acres/year till 2050 in PA; +350 acres/ year in MD)

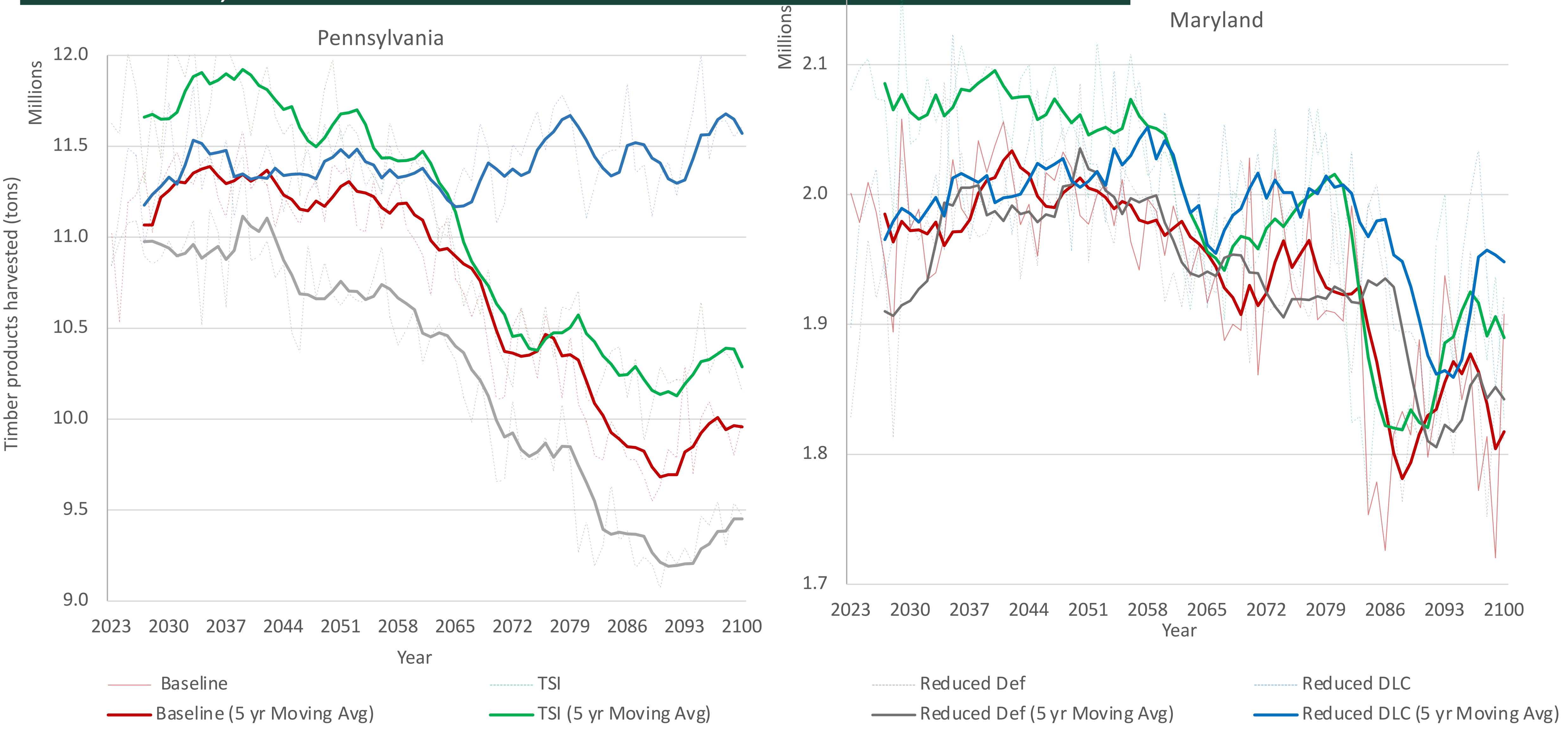
afSU2050 = Increasing afforestation scale up (+23,760 acres/year till 2050 in PA; +3500 acres/year in MD)

BAU Vs Restocking



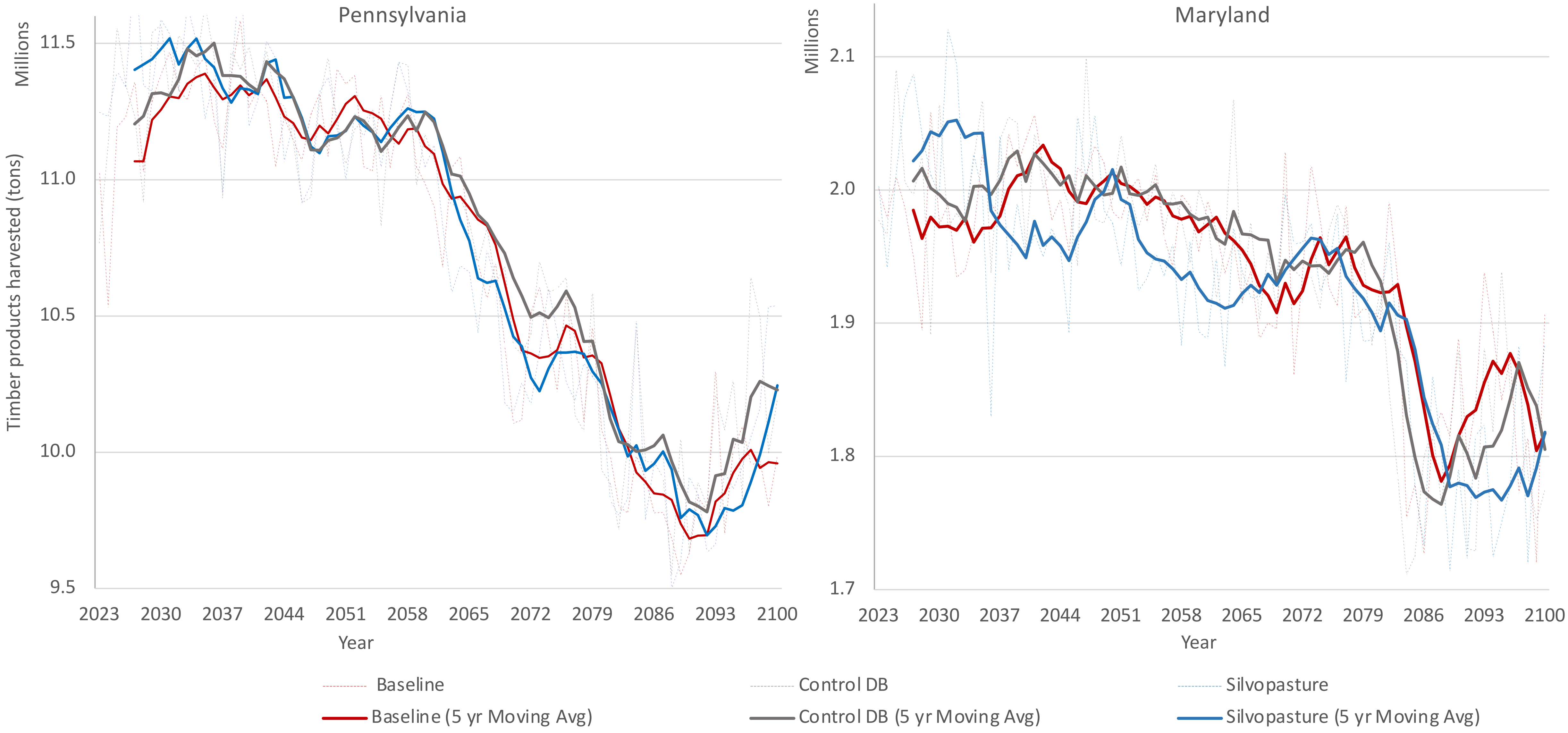
Restock = Increasing supplemental planting (+4,508 acres/year till 2170 in PA; +2500 acres/year till 2030 in MD), Restock Alt = Increasing supplemental planting (+2500 acres/year till 2050)

BAU Vs TSI, Reduced DLC and Reduced Deforestation Scenarios



TSI = Annual thinning rate (+14,892 acres/year till 2170 in PA; +5500 acres/year in MD); Annual prescribed burn rate (+25,000 acres/year till 2170 in PA; +500 acres/year in MD)
Reduced DLC = (-30,559 mt C/year until DLC = 0 in 2027; DLCs stay at 0 until 2170 in PA) (-2384 mt C/year until DLC = 0 in 2030; DLCs stay at 0 until 2170 in MD)
Reduced Deforestation = (-5,149 acres/year until 2170 in PA) (-800 acres/year until 2030; then return to baseline in MD)

BAU Vs Controlled Deer Browse and Silvopasture Scenarios



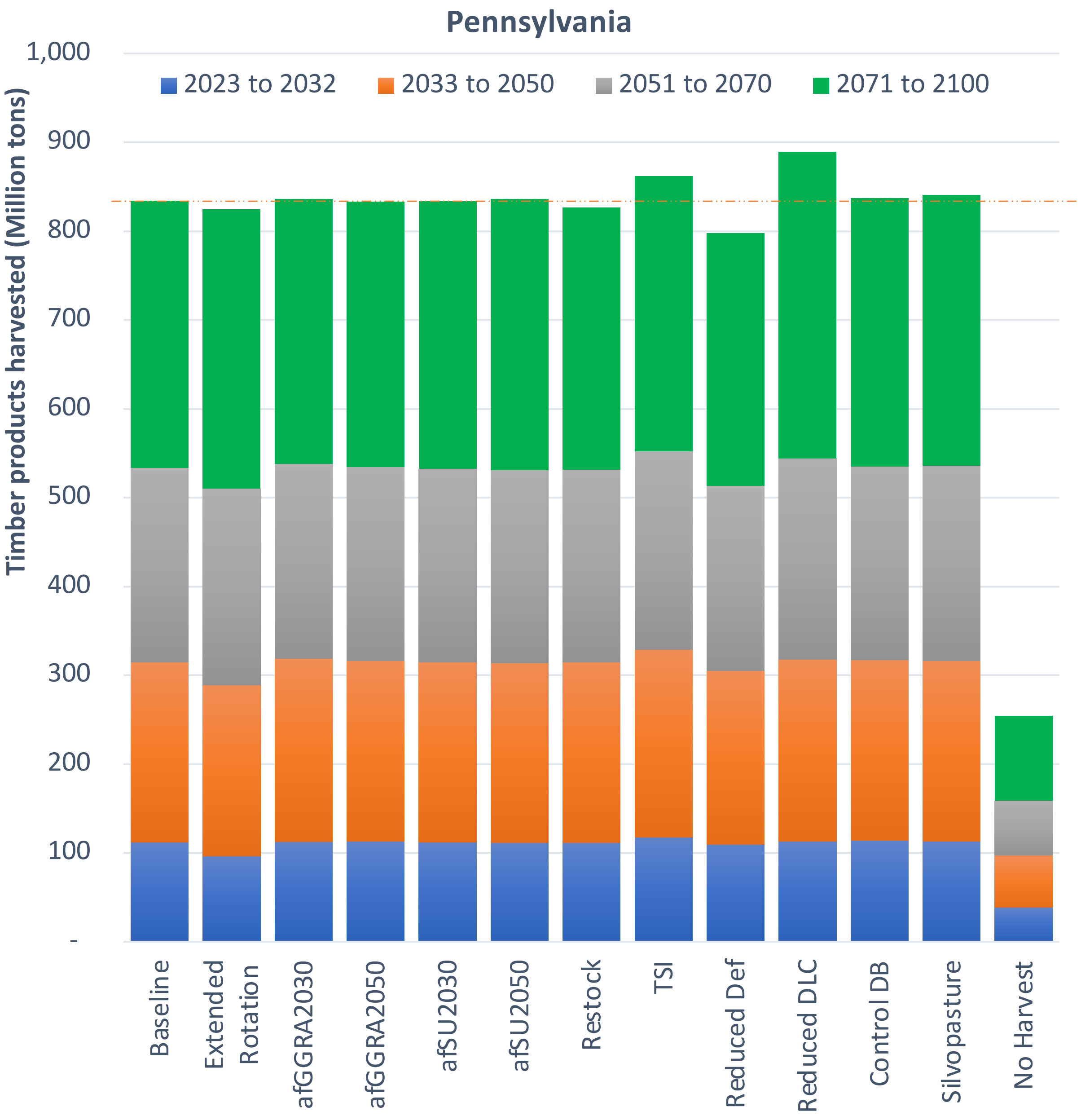
Controlled Deer browse = Annual browse control rate (+14,459 acres/year until 2170 in PA) (+2,000 acres/year until 2170 in MD)

Silvopasture = Annual Silvopasture planting rate {+15,250 acres/year (0.5% of eligible acres) until 2170 in PA} (+3,511 acres/year until 2170 in MD)

Pennsylvania: Timber Products Harvested

Scenarios	Harvested timber products (in million tons) at the specified time frame			
	Short Term	Medium Term	Medium-long Term	Long Term
Baseline	112	315	533	834
Extended Rotation	96	289	510	825
afGGRA2030	113	319	538	836
afGGRA2050	113	316	534	833
afSU2030	112	315	532	833
afSU2050	112	313	531	836
Restock	112	315	531	826
TSI	117	329	552	862
Reduced Def	109	305	513	798
Reduced DLC	113	318	544	889
Control DB	114	317	535	837
Silvopasture	113	316	536	841
No Harvest	39	97	159	254

Pulp: 49%
Sawlogs: 38.5%
Composite panels: 7.5%
Bioenergy: 4.6%
Poles, posts and pilings: 0.25%

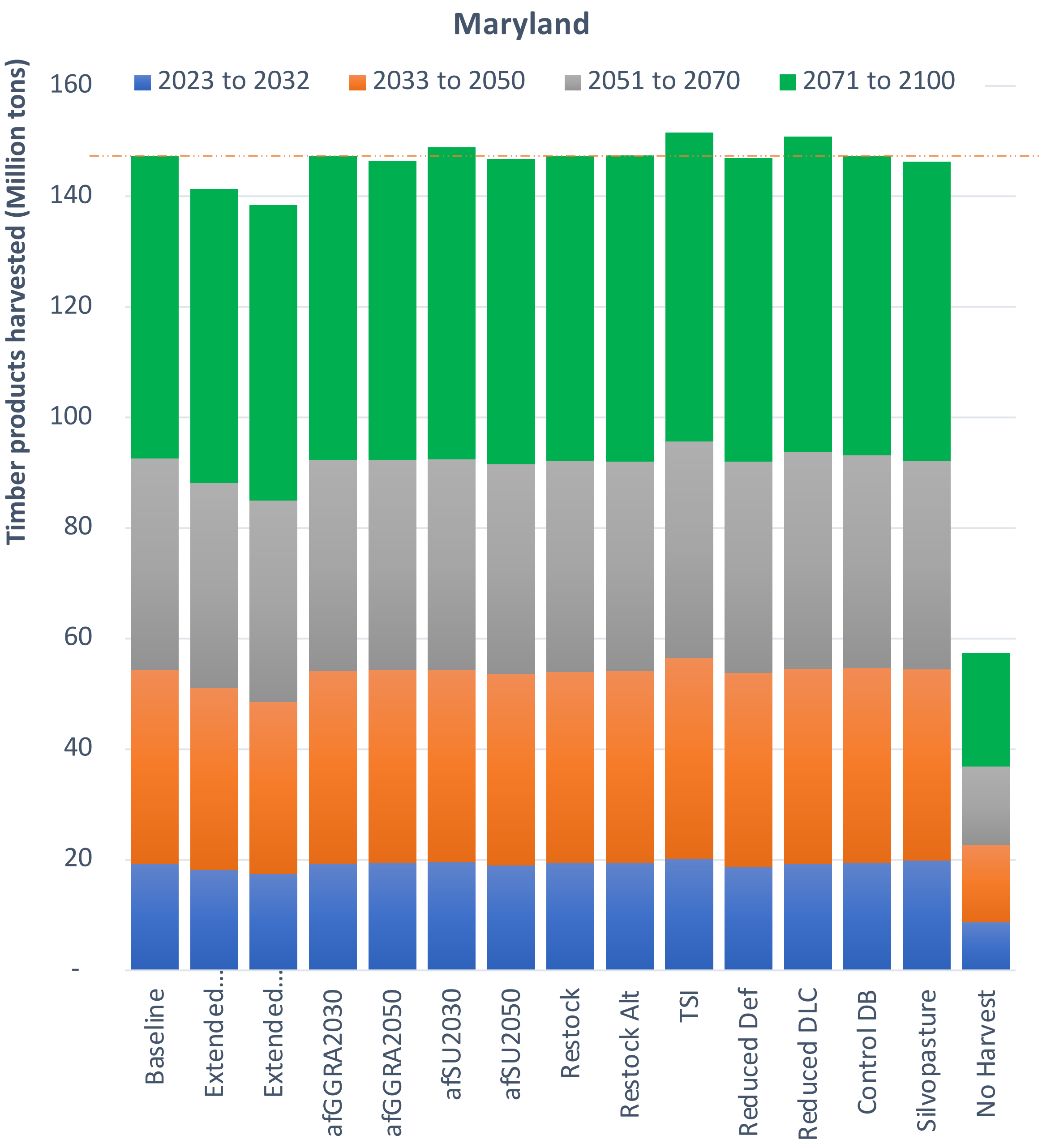


Cumulative timber products harvested

Maryland: Timber Products Harvested

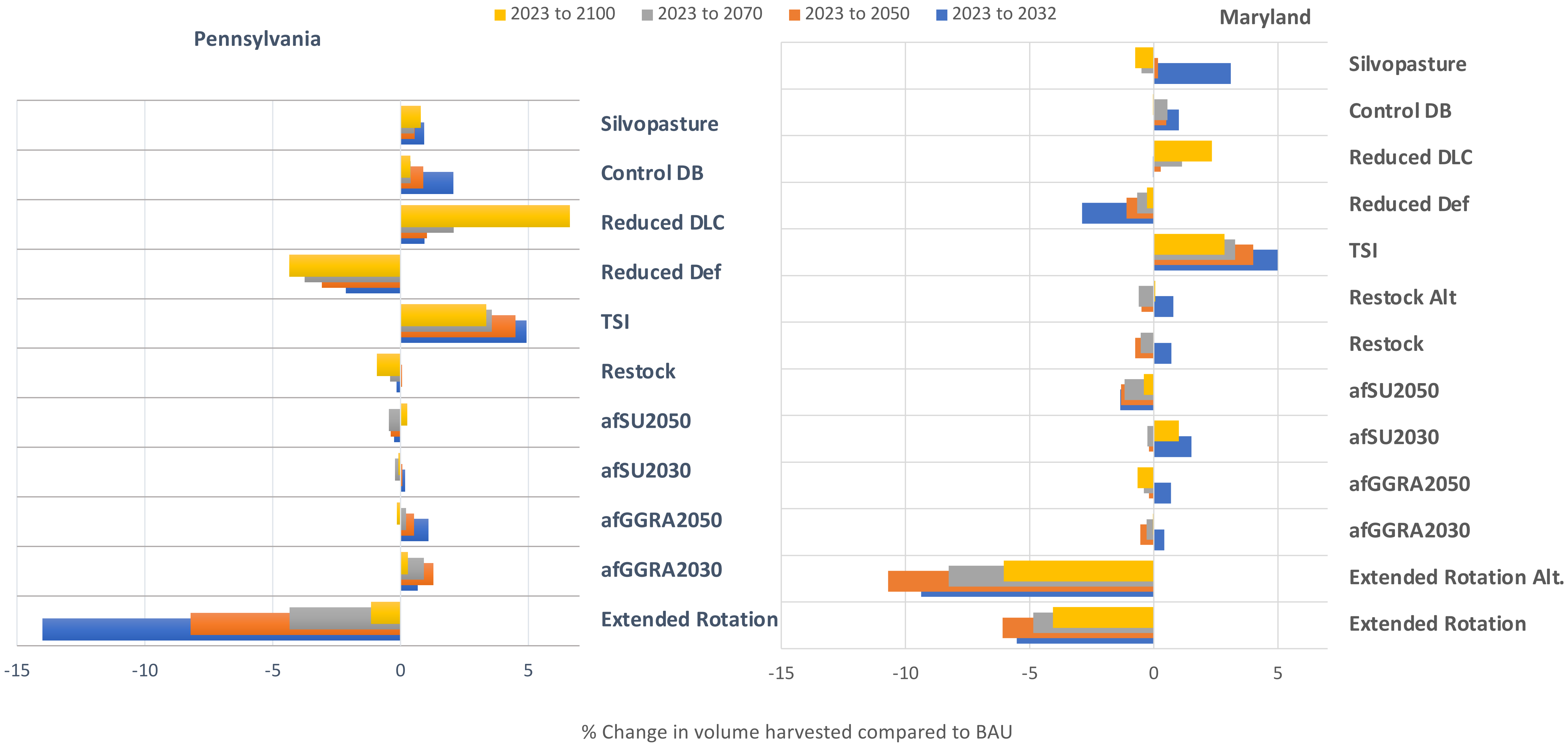
Scenarios	Harvested timber products (in million tons) at the specified time frame			
	2023 to 2032	2023 to 2050	2023 to 2070	2023 to 2100
Baseline	19	54	93	147
Extended Rotation	18	51	88	141
Extended Rotation Alt.	17	49	85	138
afGGRA2030	19	54	92	147
afGGRA2050	19	54	92	146
afSU2030	20	54	92	149
afSU2050	19	54	92	147
Restock	19	54	92	147
Restock Alt	19	54	92	147
TSI	20	57	96	152
Reduced Def	19	54	92	147
Reduced DLC	19	55	94	151
Control DB	19	55	93	147
Silvopasture	20	55	92	146
No Harvest	9	23	37	57

Pulp: 68%
Sawlogs: 25%
Composite panels: 4%
Bioenergy: 2%
Poles, posts and pilings: 1%

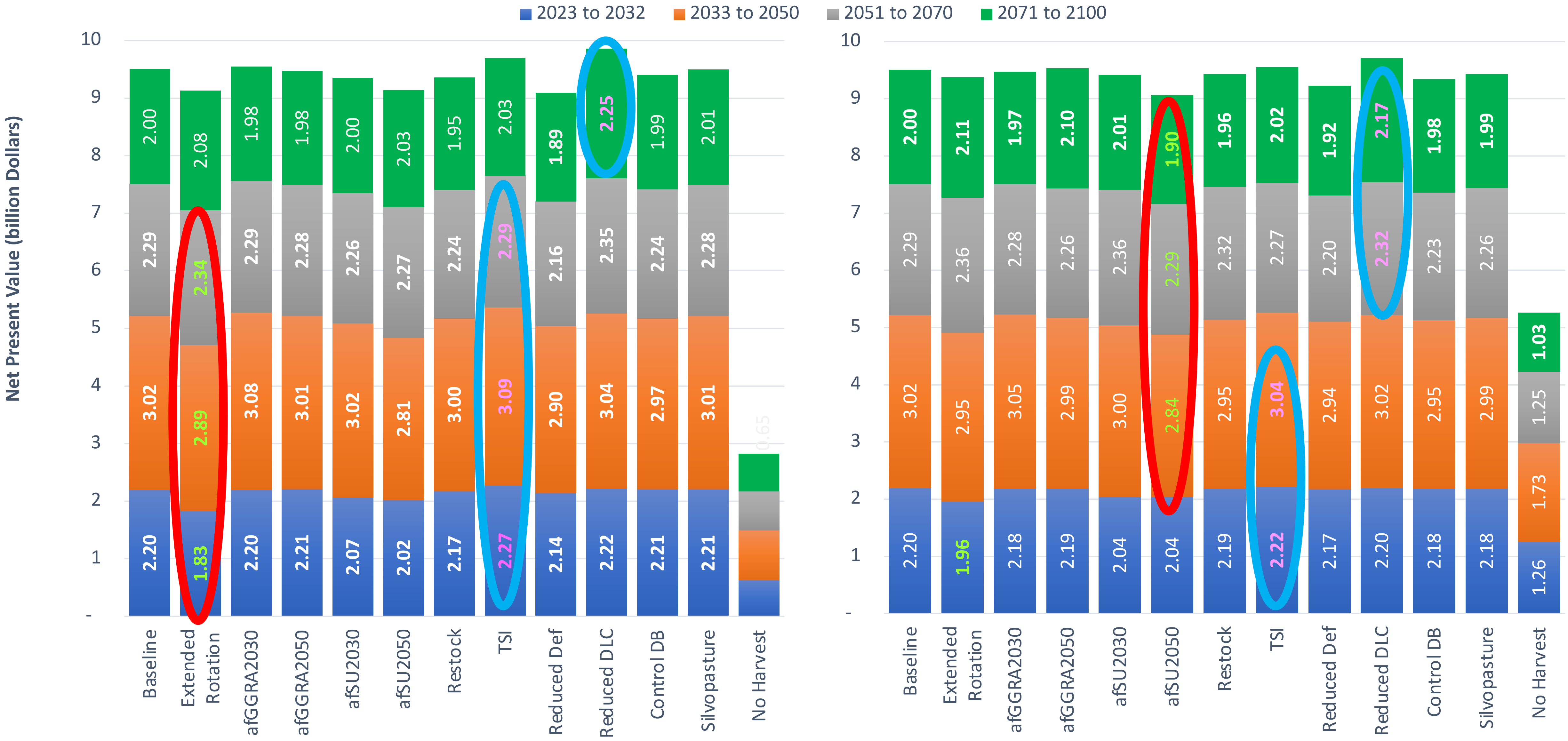


Cumulative timber products harvested

Change in timber products harvested compared to BAU (%)



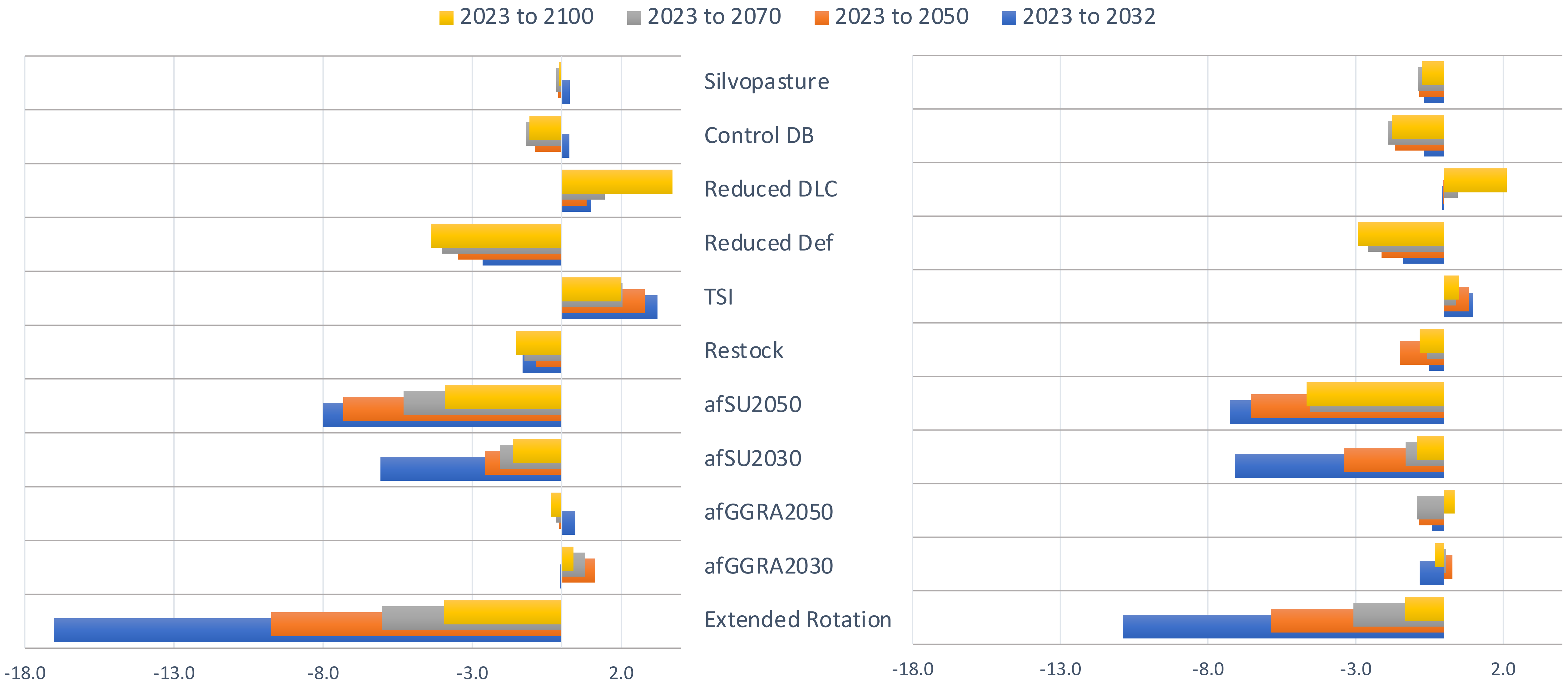
Pennsylvania: Net Present Value (NPV)



Cumulative NPV <u>without</u> carbon credits

Cumulative NPV with carbon

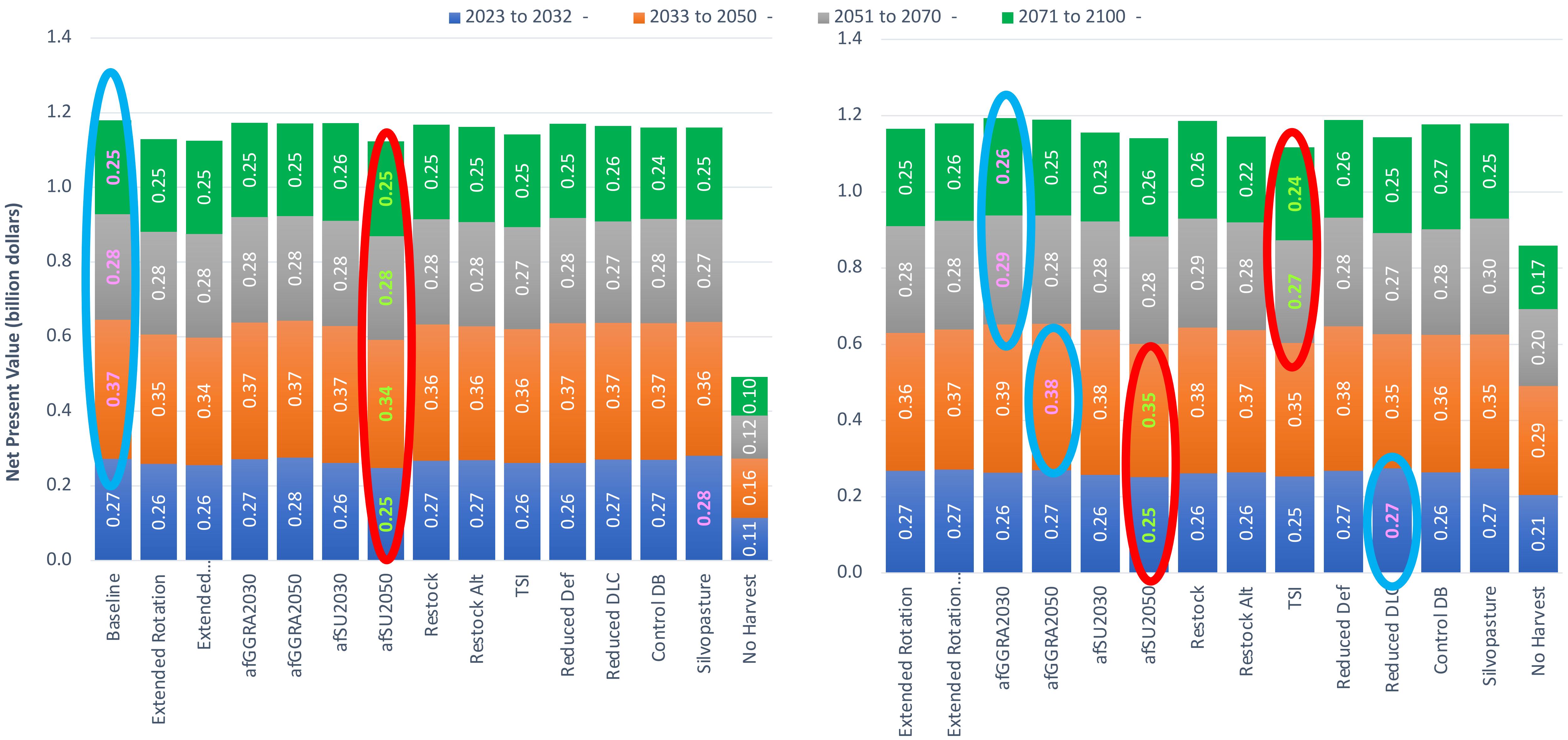
Pennsylvania: % Change in NPV



% Change in NPV <u>without Carbon</u> credits compared to BAU

% Change in NPV with carbon compared to BAU

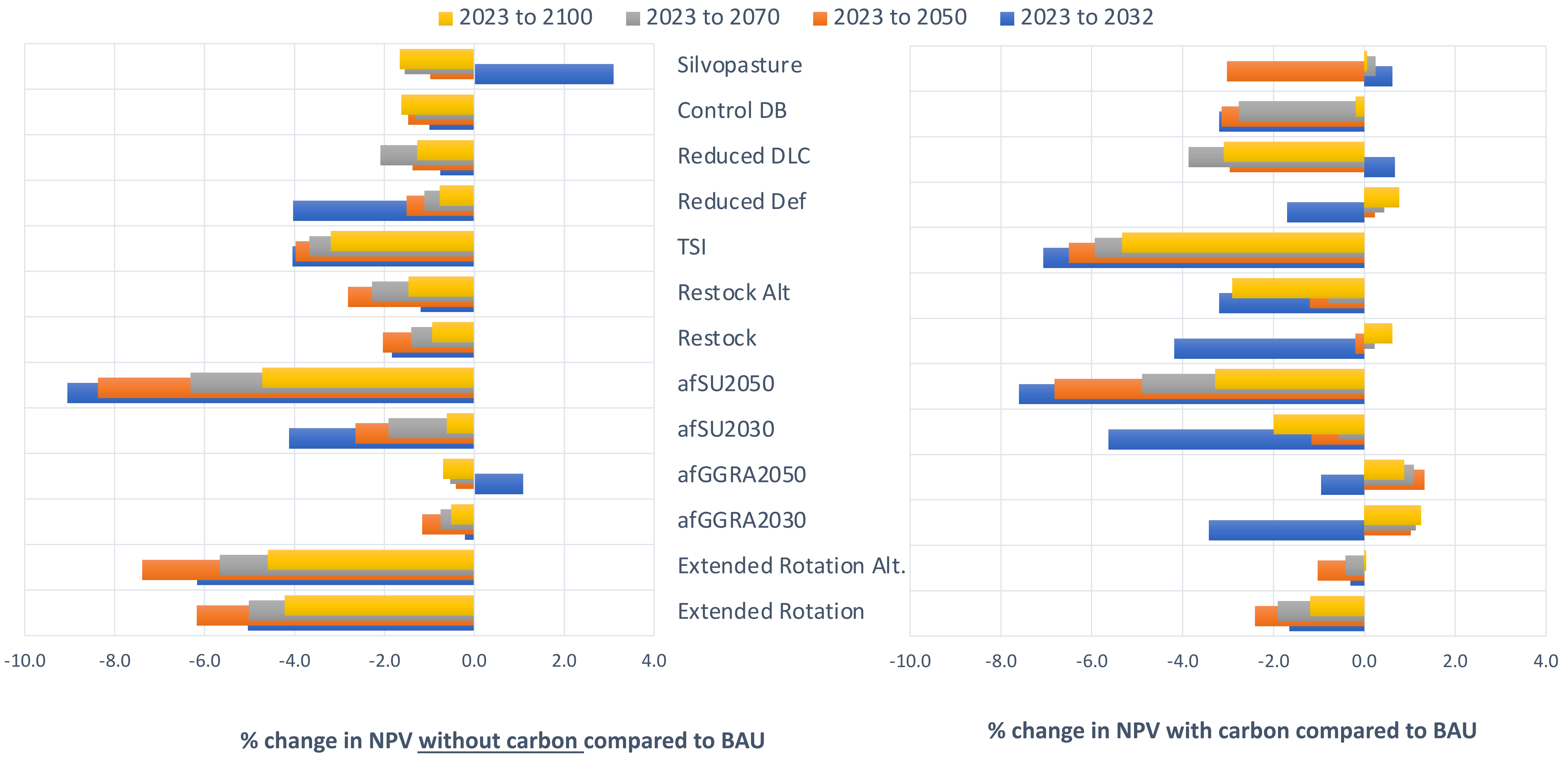
Maryland: Net Present Value (NPV)



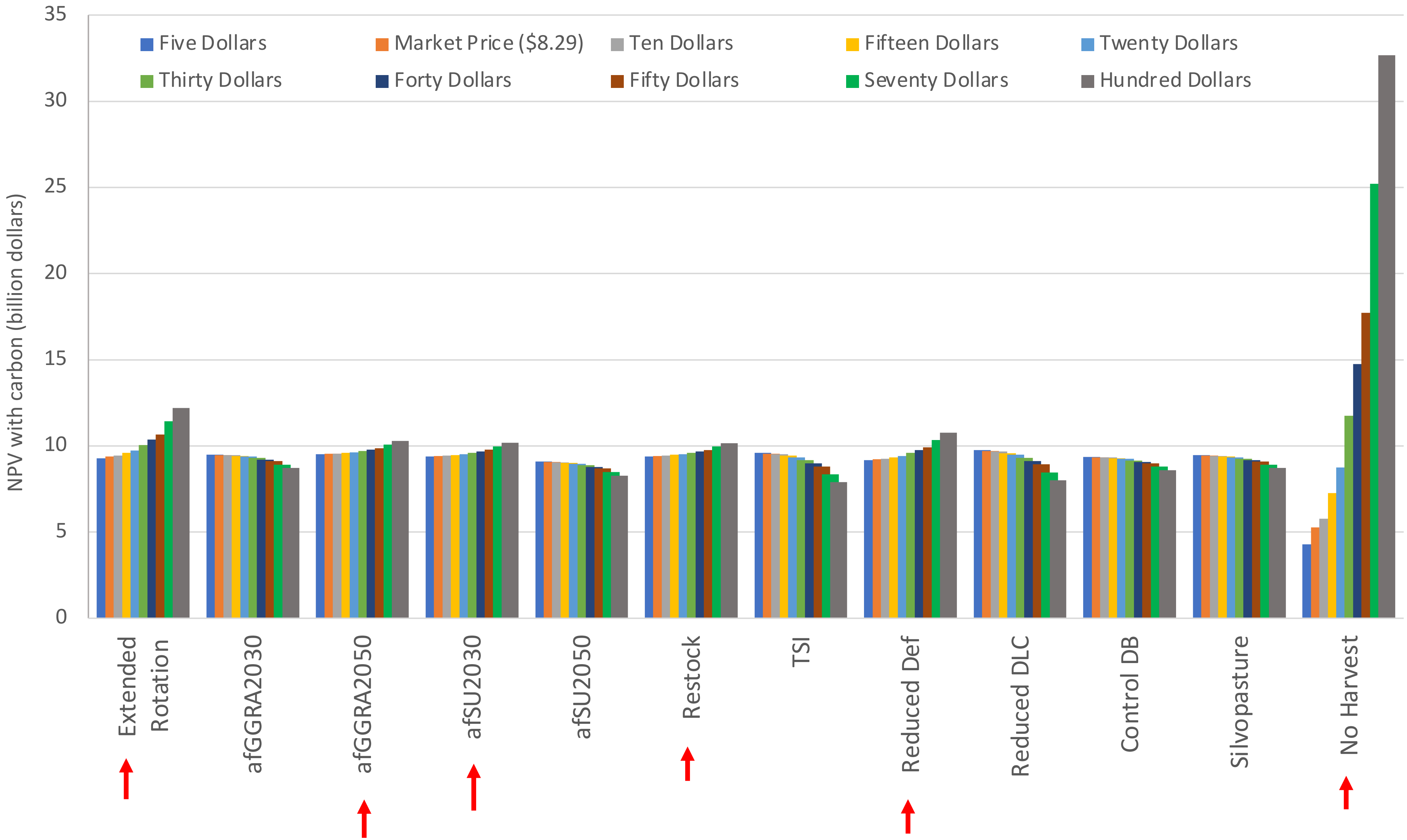
Cumulative NPV <u>without</u> carbon credits

Cumulative NPV with carbon

Maryland: % Change in NPV



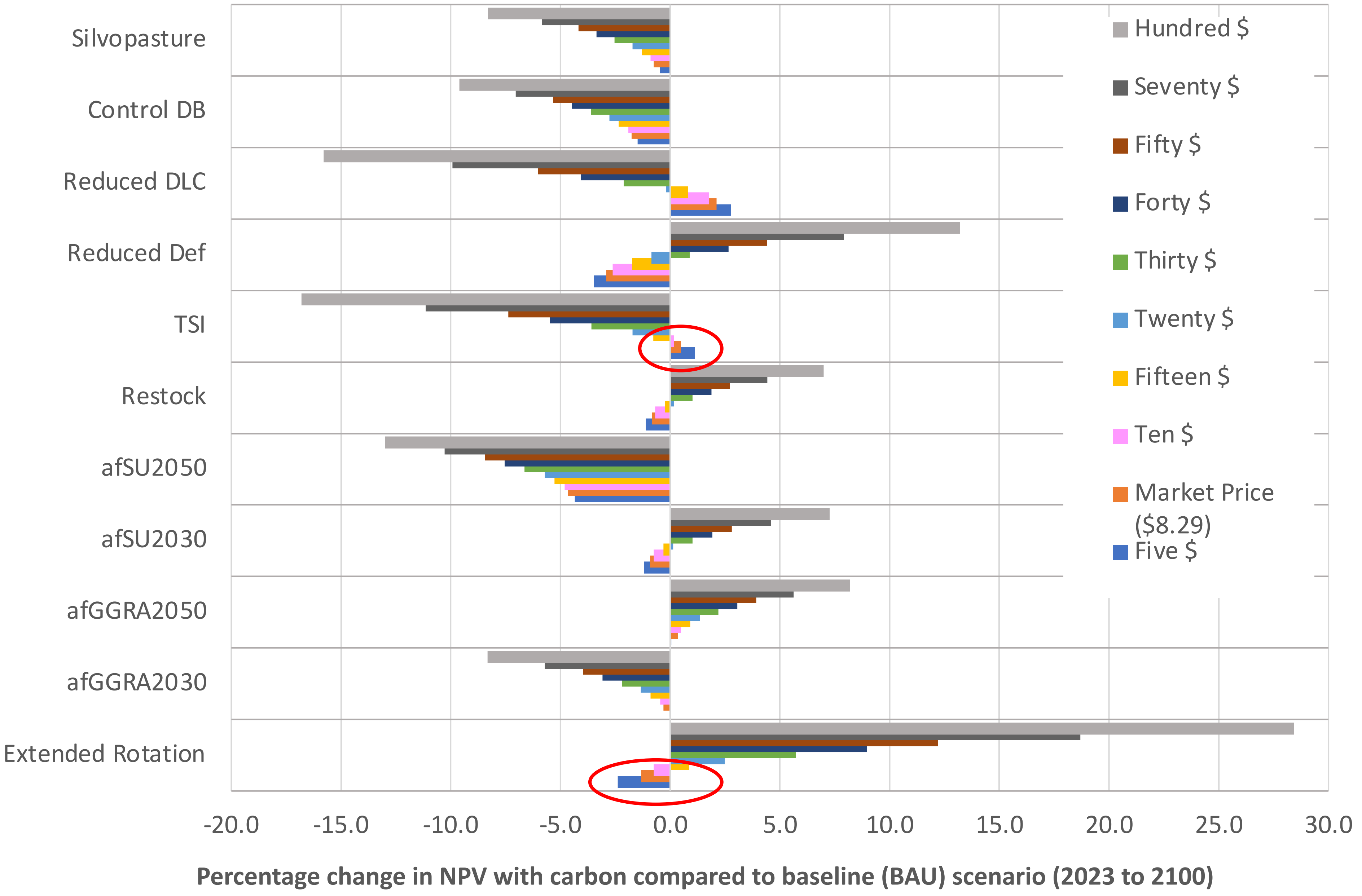
Sensitivity Analysis (Change in Carbon Price)



- With the increase in price of carbon, NPV increases in scenarios that accumulate more biomass and harvest less volume such as no harvest, extended rotation and reduced deforestation scenarios
- NPV decreases with increasing carbon price in scenarios that harvest more volume such as TSI and Reduced DLC

NPV under different carbon management scenarios at varying carbon prices in the Pennsylvania (2023 to 2100)

Sensitivity Analysis (Change in Carbon Price)



- If the market price of carbon exceeds $15/t CO_2e, NPV in extended rotation in more than BAU while NPV in TSI and reduced DLC drops below BAU.
- With increasing price of carbon, NPV increases in scenarios that accumulate more biomass and harvest less volume (Extended rotation, Reduced deforestation)

Key Takeaways

- NPV is positive under all scenarios considered meaning that economically all scenarios are feasible to undertake without incurring a loss in investment.

- However, TSI is the only scenario in Pennsylvania that consistently yields NPV higher than that under BAU at all timeframes considered with or without carbon benefits

- For scenarios like extended rotation or no harvest to yield higher NPV compared to BAU scenario, market price of carbon needs to be higher than what it is at present (at least $15 assuming that all unharvested volume is enrolled in carbon program).

- In Maryland, though volume harvested under alternative management scenarios such as TSI and controlled deer browse were greater than that under BAU, the costs incurred were also higher compared to BAU and so yielded lower NPV. When carbon credits were considered, scenarios that accumulate more biomass with reasonable management costs such as afforestation 2030 and 2050, restocking, and reduced deforestation scenarios yielded higher NPV compared to baseline in Maryland.

- For TSI and reduced DLC scenarios to yield higher NPV compared to BAU scenario in Maryland, stumpage price needs to be higher than the current stumpage price.

Thank you !

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