Optimal Set-Asides for Carbon Sequestration and Co-Benefits of Forestry

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- How much carbon available in forest sequestration?
- Relationship between conservation and carbon
- Global forest and land use model description
- Assessment of conservation options.

Forest actions for reducing net emissions?

- **Afforestation**
  - 0.2 – 2.0 Pg C/yr globally for $20-$300/t C over century.
  - Richards et al. (2004); Sohngen and Mendelsohn (2003,2007)
- **Reduced Deforestation**
  - 0.4-1.4 Pg C/yr globally for $20-$300/t C over next 30 years.
  - Kindermann et al. (2007); Sathaye et al. (2006), and Sohngen and Mendelsohn (2003,2006)
- **Forest Management**
  - Up to 0.6 Pg C/yr for $100/t C over century
  - Sohngen and Mendelsohn (2003,2006).
- **Set-asides/Bio-reserves**
  - Not assessed widely to date.

These potentially could reduce the costs of meeting a 550 ppmv stab. target by 40-50% (e.g., reduce carbon prices by 40-50%)
Tavoni et al. (2007)

Conservation Biologists suggest that up to 10% of each biome globally should be preserved.

- What is the optimal level of conservation in forests?
- Are “set-asides” consistent with carbon sequestration goals?
- What inefficiencies might arise with different types of policies aimed at biodiversity and carbon storage in forests?

Optimal conservation

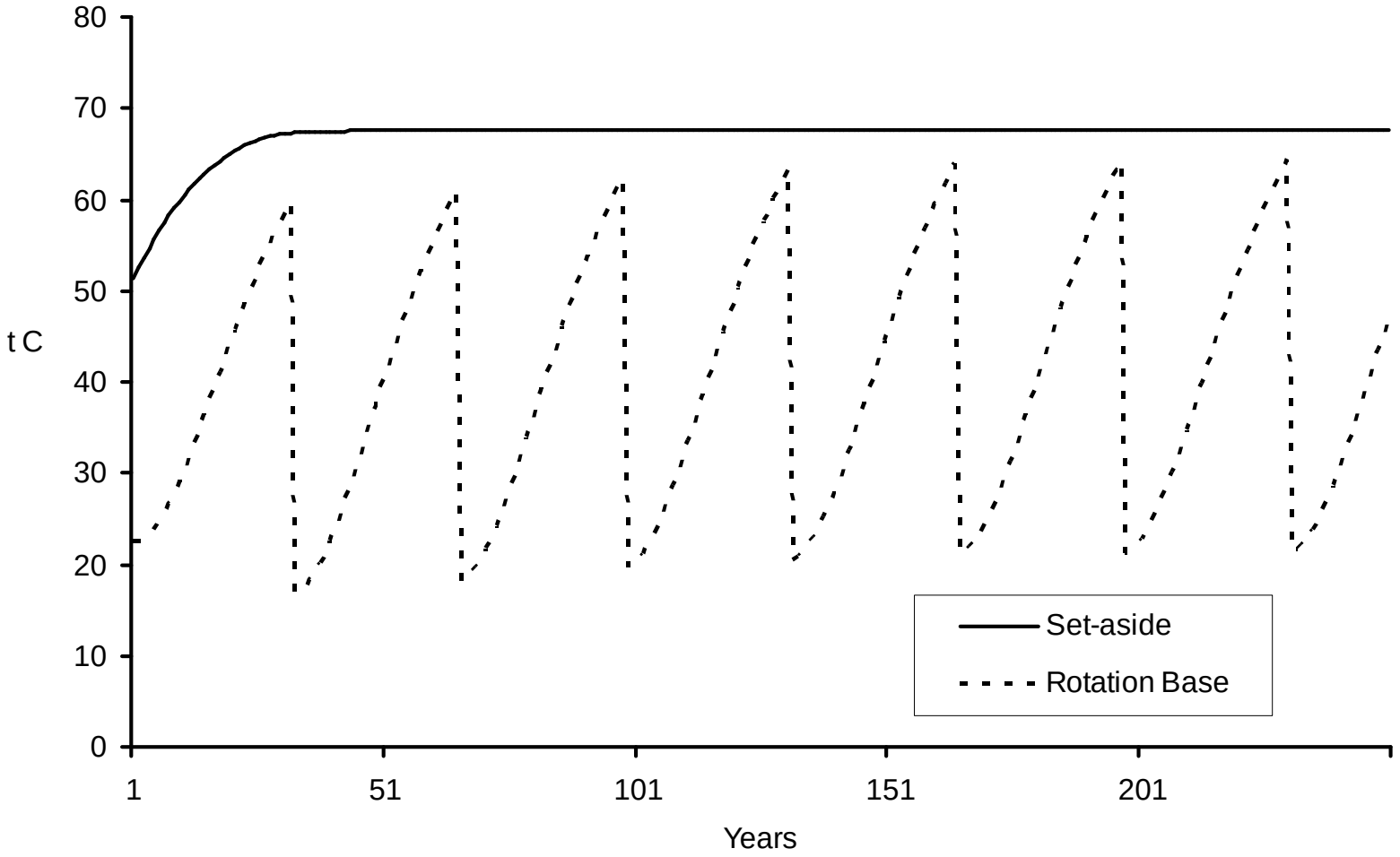
- Hartman (1976) recommends older rotations if non market values increase with biomass.
- Vincent and others have argued for partitioning forests (e.g. setting aside unique areas, and leaving others for production).
- Sedjo, Kauppi, etc. have argued that conservation results from improved technologies that reduce the derived demand for wood from natural sources (e.g., EKC for forest area)
- One problem with defining “optimality” is that the relationship between forest area, forest stock, forest structure, the distribution of forests globally AND human values ($, €) is complex…
- Not clear if any of these conservation measures lead to increased carbon storage in the atmosphere.

This study….

- Utilizes a Hartmann-like model of conservation values tied to carbon sequestration
  - Carbon in forests has value and is rented.
  - The value of carbon storage in forests increases as biomass increases.
- Assesses the potential role of set-asides in the context of global climate policy
  - Set-asides defined as removing land from availability for timber harvesting and land-use change.
- Assesses different policies for achieving set-asides.

Example of Set-aside

Carbon in set-aside vs. managed forests in a Southern U.S. Loblolly pine stand.



Analysis

- Adopt global forestry and land use model in Sohngen and Mendelsohn (2003, 2007), and assess set-aside potential with “optimal C prices.”
- Compare three set-aside policies/scenarios:

  (1) Pay only for C only in accessible set-aside forests.

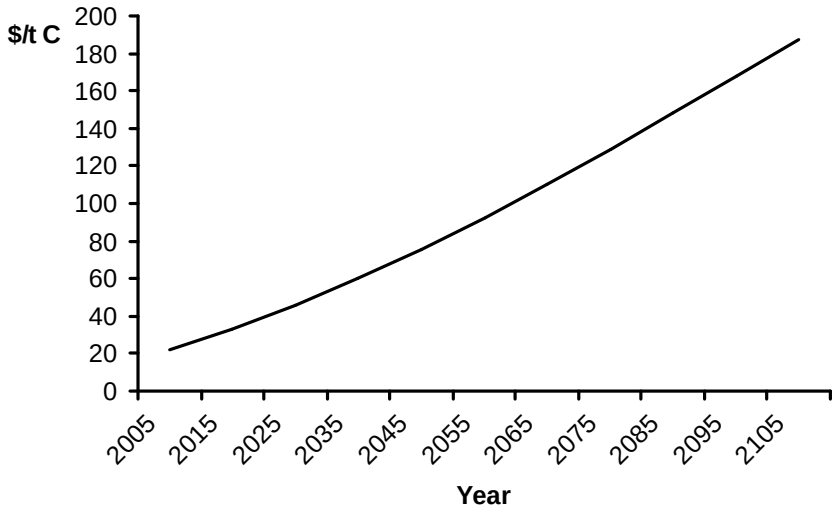
  (2) Pay only for C in accessible and remote set-aside forests.

  (3) Pay for C in all deviations from baseline, including set-asides.

  - “Efficient” policy

A little about the model…

- Max NPV(CS + PS + Annual Carbon Rent)
- Single Global Forest Log Demand Function.
- Series of land rental functions simulating demand for land from agriculture.
- Regions have different forest production functions, costs for managing, harvesting, and transporting logs and products to markets.
- Model optimizes
  - Land area (afforestation/deforestation), harvest age, management intensity, market product pool, and area set aside.
- Optimal C prices from Sohngen and Mendelsohn (2003).



Baseline carbon storage in 2005 and projected for 2105

	Total Carbon Storage - 2005		Total Carbon Storage - 2105 Baseline	
	Billion Tons C	%	Billion Tons C	Loss (Pg C)
Boreal/Temperate/Mid-Latitude				
North Am.	183	21%	183	-0.3
Europe	28	3%	30	2.1
Russia	256	28%	251	-5.2
China	27	3%	28	1.0
Oceania	25	4%	26	0.9
Subtotal	520	63%	518	-1.5
Tropical/Low-Latitude				
South Am.	223	19%	201	-21.6
Asia-Pacific	55	8%	36	-18.4
Africa	81	10%	59	-22.0
Subtotal	358	37%	296	-62.1
Global Total	878	100%	815	-63.5

Carbon gain under efficient policy

	Total Carbon Storage - 2105 Baseline		Total Carbon Storage - 2105 Efficient Policy	
	Billion Tons C	Loss (Pg C)	Billion Tons C	Gain comp. to Baseline (Pg C)
Boreal/Temperate/Mid-Latitude				
North Am.	183	-0.3	196	13.5 (+7%)
Europe	30	2.1	40	10.2 (+34%)
Russia	251	-5.2	258	7.8 (+3%)
China	28	1.0	42	13.6 (+48%)
Oceania	26	0.9	27	1.1 (+4%)
Subtotal	518	-1.5	564	46.3 (+9%)
Tropical/Low-Latitude				
South Am.	201	-21.6	225	23.6 (+12%)
Asia-Pacific	36	-18.4	72	35.5 (+98%)
Africa	59	-22.0	76	17.2 (+29%)
Subtotal	296	-62.1	373	76.3 (+26%)
Global Total	815	-63.5	937	122.6 (+15%)

Result 1: Large areas could be set-aside for carbon sequestration.

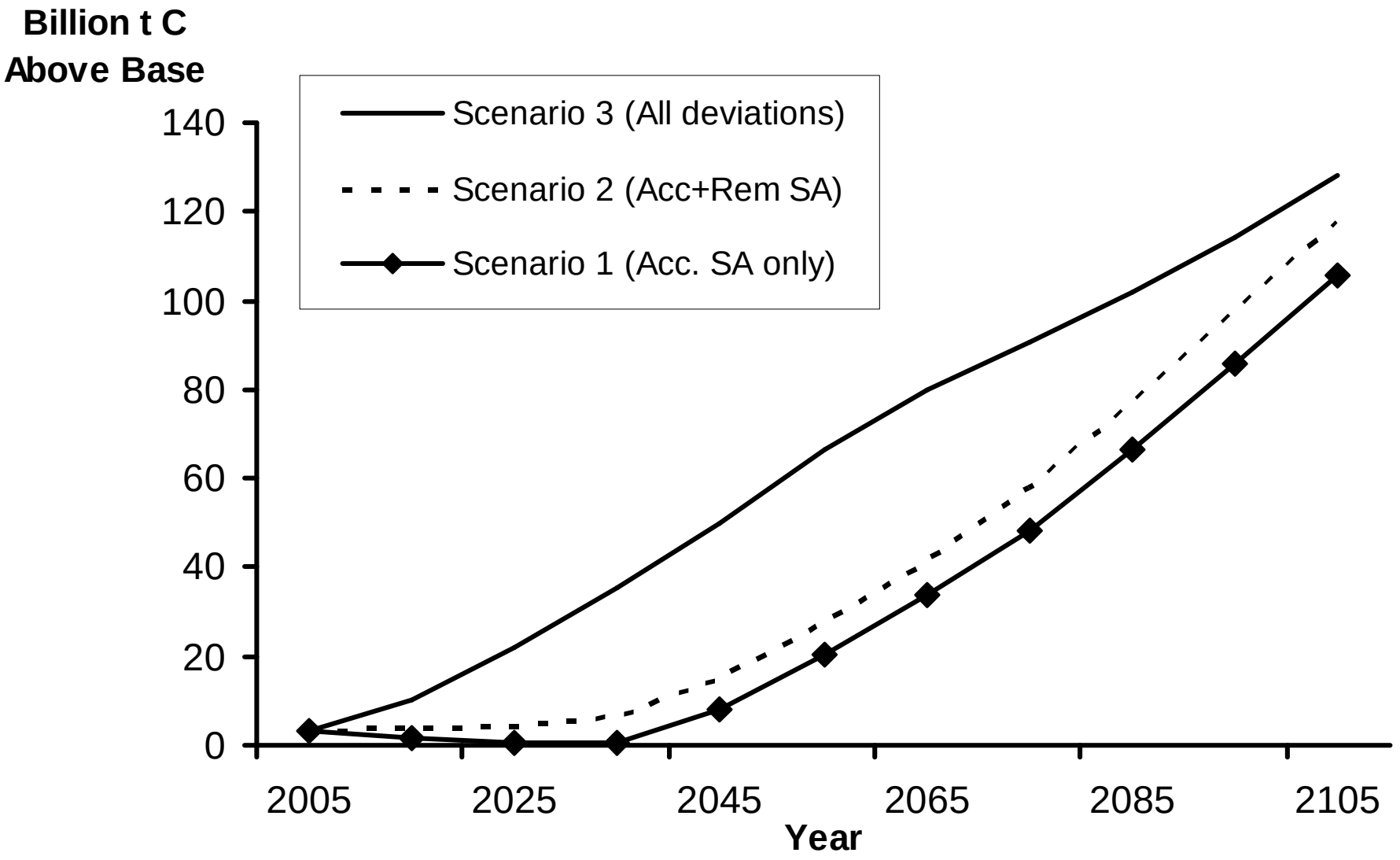
		2005	2025	2055	2105
Total Forest	Baseline	3,594	3,389	3,209	3,158
	Setaside	3,594	3,461	3,526	3,844
	"Efficient"	3,594	3,533	3,599	3,947
Forest Available for Harvesting	**Setaside**	**3,594**	**1,593**	**1,079**	**634**
	"Efficient"	3,594	3,350	3,399	3,648
Setaside	**Setaside**	**0**	**1,869**	**2,447**	**3,209**
	"Efficient"	0	183	200	299

When and where is land set aside?

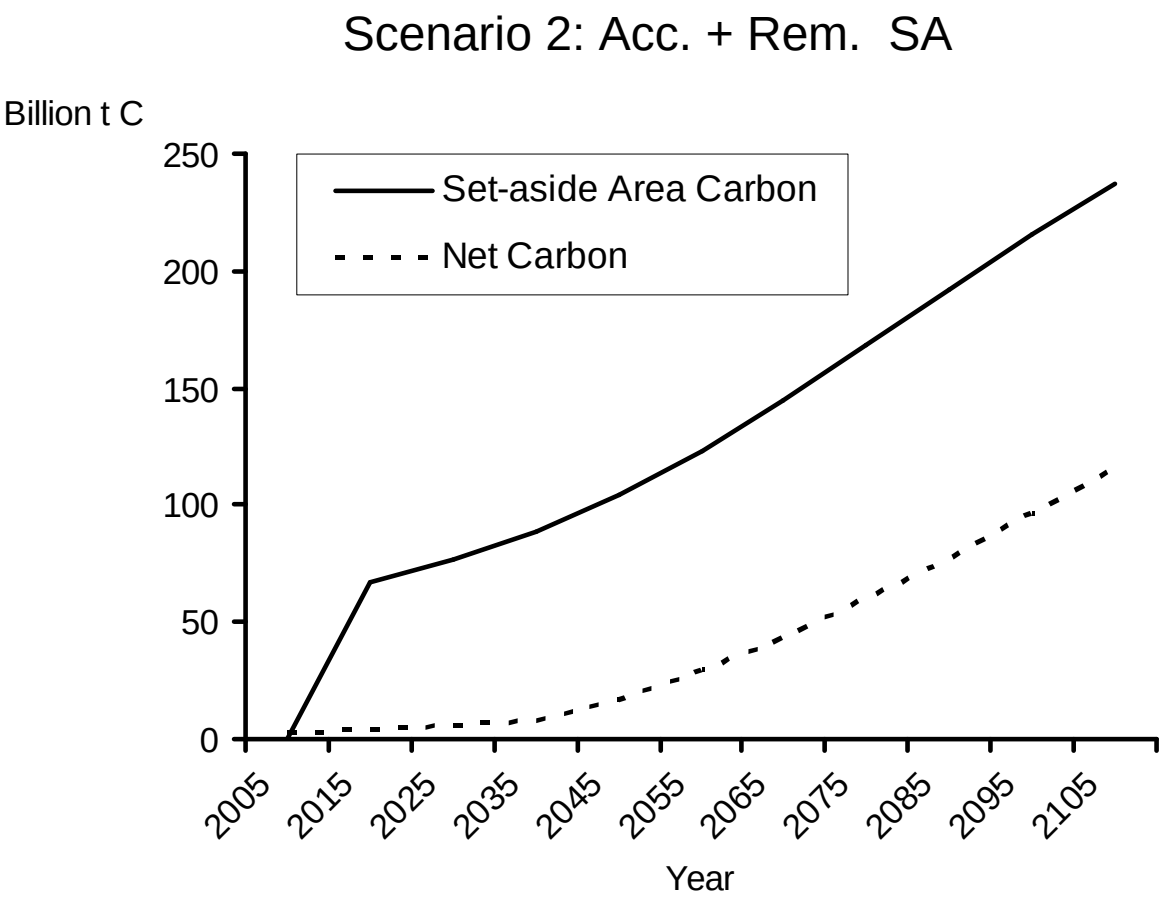
Scenario 2: Area set aside from productive forests

	Temperate Forests						
	US	Canada	Europe	Russia	China	Oceania	Japan
2025	53%	47%	50%	67%	78%	35%	7%
2055	77%	76%	65%	93%	96%	38%	66%
	Tropical Forests						
	South Amer	Cent. Amer.	India	SEA	Africa		**Global**
2025	21%	82%	82%	43%	7%		**32%**
2055	35%	92%	79%	77%	66%		**56%**

Result 2: Set-aside policies lead to large potential leakage in near term



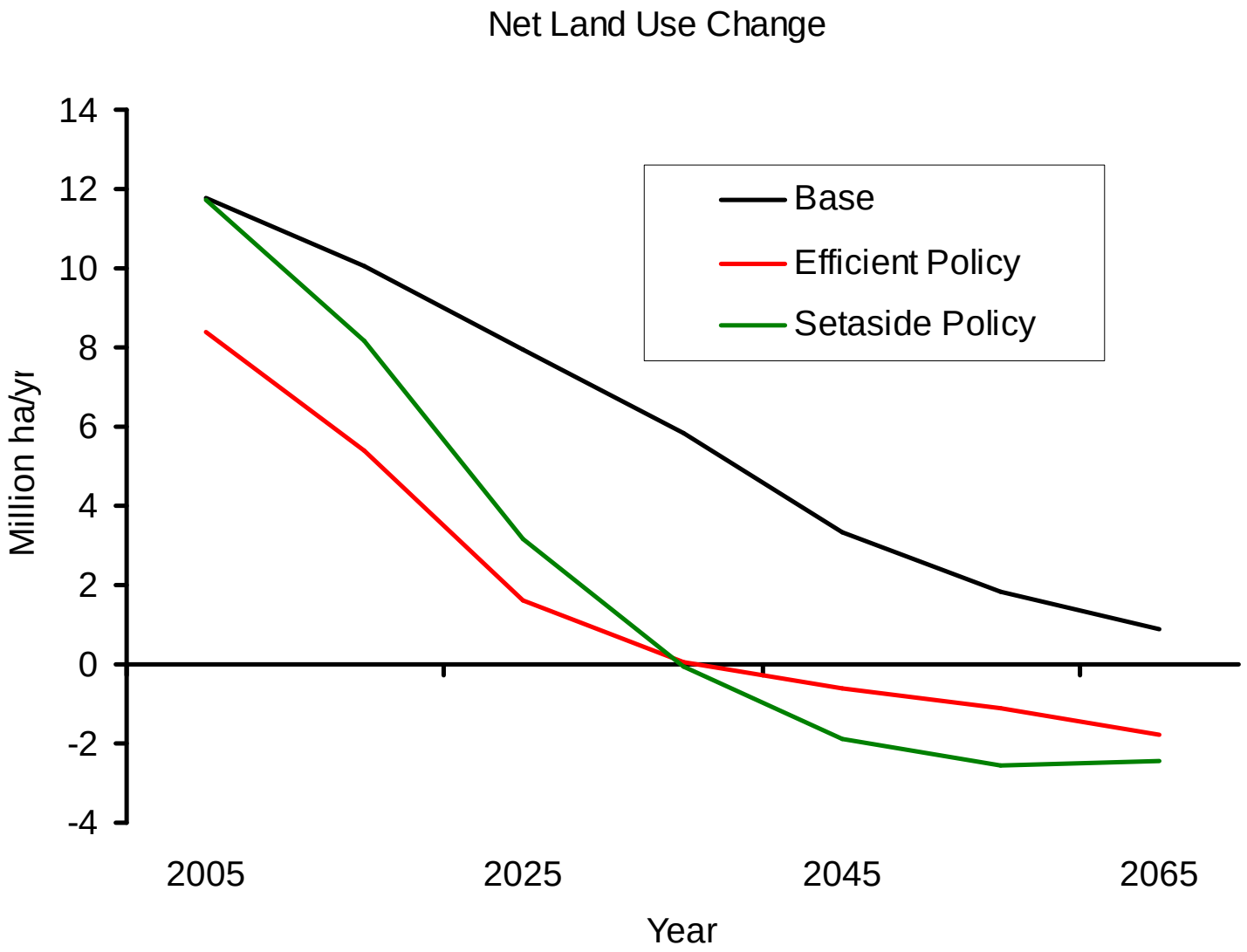
Carbon leakage



Global Leakage
Across Scenarios

Scen 1 = 47% (20-90)
Scen 2 = 52% (14-90)
Scen 3 = 0%

Net deforestation can be “eliminated” by 2040.

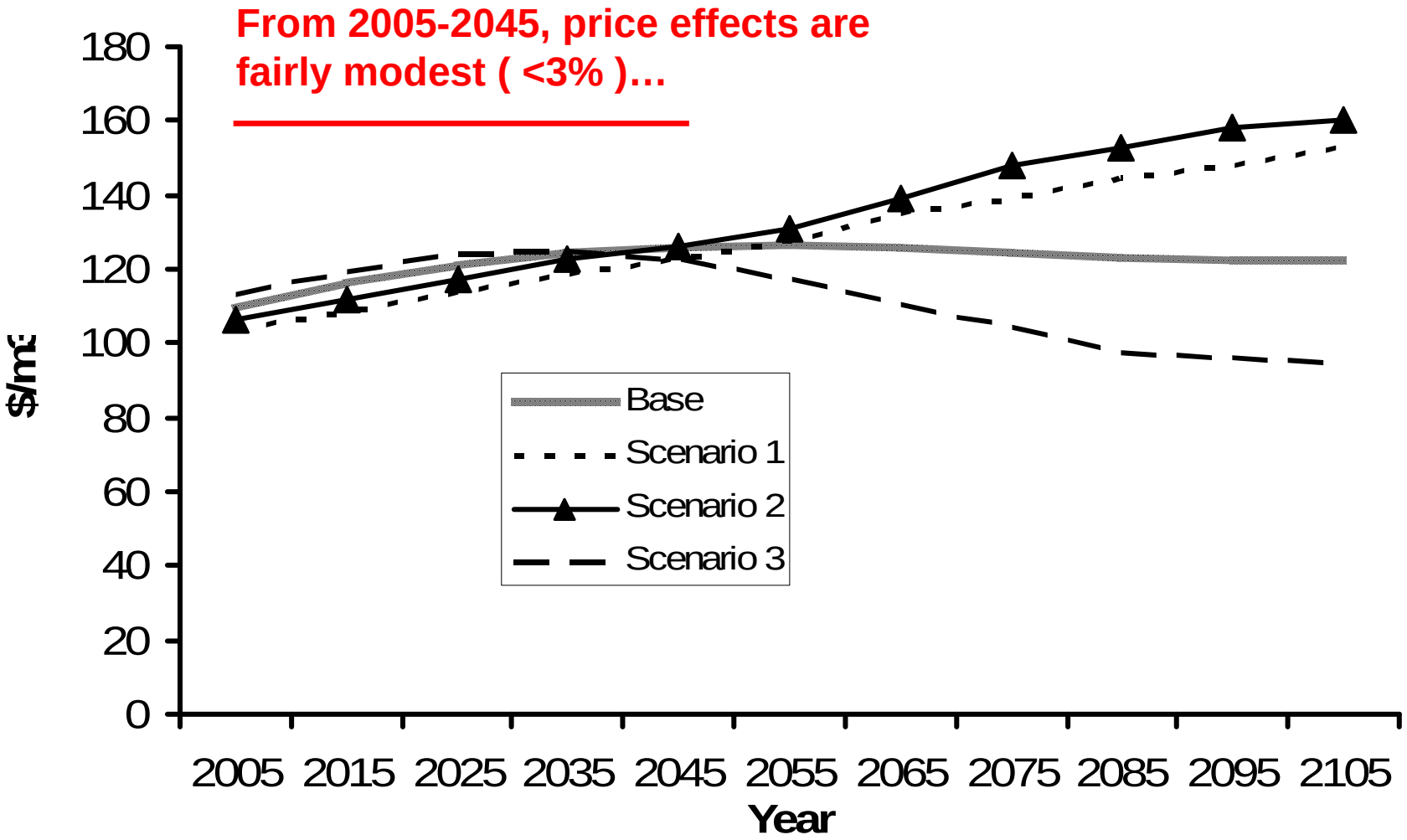


Result 3: Efficient policy sets aside far less land, but still provides ecological benefits by reducing intrusion

Proportion of productive forests harvested each year.

	2025						
	US	Canada	Europe	Russia	China	Oceania	Japan
Base	1.5%	0.6%	1.9%	0.2%	1.6%	0.4%	3.0%
Setaside	3.1%	2.1%	2.2%	1.4%	5.3%	0.6%	2.7%
Efficient	***1.6%***	***0.5%***	***1.1%***	***0.1%***	***1.2%***	***0.4%***	***3.1%***
	South Amer	Cent. Amer.	India	SEA	Africa		**Global**
Base	0.6%	2.7%	2.2%	2.0%	1.5%		**0.9%**
Setaside	0.9%	8.1%	7.0%	2.7%	2.3%		**1.8%**
Efficient	***0.4%***	***1.2%***	***1.7%***	***0.8%***	***0.4%***		***0.6%***
	2055						
	US	Canada	Europe	Russia	China	Oceania	Japan
Base	1.4%	0.4%	1.8%	0.3%	2.1%	0.4%	3.3%
Setaside	3.6%	1.1%	3.0%	5.2%	5.4%	0.9%	5.3%
Efficient	***1.3%***	***0.4%***	***1.1%***	***0.1%***	***1.2%***	***0.4%***	***1.5%***
	South Amer.	Cent. Amer.	India	SEA	Africa		**Global**
Base	0.5%	1.6%	3.3%	1.3%	1.3%		**0.8%**
Setaside	1.1%	7.0%	7.4%	4.4%	3.2%		**2.1%**
Efficient	***0.3%***	***0.8%***	***1.6%***	***0.5%***	***0.3%***		***0.5%***

Result 4: Price/Harvest effects relatively modest initially…



Result 5: How much do set-asides cost?

	Consumer Surplus Change[1]	Producer Surplus Change[1]	Carbon Payments	Total Cost of Carbon
	PV (Billions -- 2005 US $)			
Scenario 1	$211.7 (+22%)	-$420.5 (-18%)	$953.9	$1,162.7
Scenario 2	$86.1 (+9%)	-$320.3 (-14%)	$1,592.5	$1,826.8
Scenario 3	-$12.2 (-1%)	-$130.2 (-6%)	$871.9	$1,014.3

	Direct C Payments (Bil. 2005 $)	Hectares Preserved by 2105 (Million ha)	$/ha
Scenario 1	$954	2,095	$555
Scenario 2	$1,593	3,209	$569
Scenario 3	$145	299	$484

Conclusions

- If C prices rise from $20 to $187 per t C over the century
  - Forestry potential is roughly 122 Pg C over century, or 1.2 Pg/yr on average.
  - Up to 80% of the world's forests, or 3.2 billion hectares, could be set-aside for carbon sequestration.
    - This more than meets the goal set by conservation biologists/ecologists, but provides limited carbon advantages.
  - Market impacts in timber are relatively modest over next 50 years.
    - Why? Substantial "overhang" of mature timber provides a cushion for markets…
    - Increase in subtropical plantation forests.
  - *Average* cost of set-asides under these programs range from $480-$570/ha.
    - Smaller programs, would cost less (although not evaluated here)

Conclusions

- Large potential inefficiencies in the carbon market if policies focus only on set-asides.
  - Leakage is potentially large, >50% before 2050.
  - Market Price/Harvest effects become larger after 2050, but because more land has been preserved, leakage declines…
- Policy focus in land-use needs to be on designing efficient mechanisms.
  - How do we pay for deviations from the baseline – policy makers need to perfectly anticipate the future.