turning knowledge into practice

Modeling Economic Opportunities for Avoided Deforestation

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Presented at
Forestry and Agriculture Greenhouse Gas Modeling Forum
Workshop #4, March 2007
Sheperdstown, WV

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Acknowledgments

- Massimo Tavoni & Valentina Bosetti (FEEM)
- Michael Obersteiner (IIASA)
- Jayant Sathaye (LBNL)
- Brian Murray (Duke University)
- Ken Andrasko (US EPA)
- Sandra Brown (Winrock Int'l)
- Roger Sedjo (RFF)
- US Environmental Protection Agency (Climate Analysis Branch)
- US Department of Energy (Office of Biological and Environmental Research)

Issues Addressed

- How much Carbon is Possible from Avoided Deforestation (AD)?
  - "Virtually" stop deforestation for $100/t C ($27/t CO_2)
    - Costs $17 billion/yr
    - Provides 25 Pg C over 20 yrs, or 1250 million t C/yr
    - Payments would be ~$400 - $700/ha/yr
  - 10% reduction in deforestation has following effects over 20 years
    - Costs $430 million/yr
    - Provides 2.8 Pg C, or 140 million t C/yr
    - Payments would be ~$30/ha/yr
- How important Is Leakage?
  - Not surprisingly, a project based approach has substantial leakage in near-term.
- Forestry, including AD, is vital part of stabilization strategy
  - Could reduce carbon prices and economy-wide costs by 50%.
- Disclaimer: These are model results…

Global Timber Model

Model Framework (Most Recent)

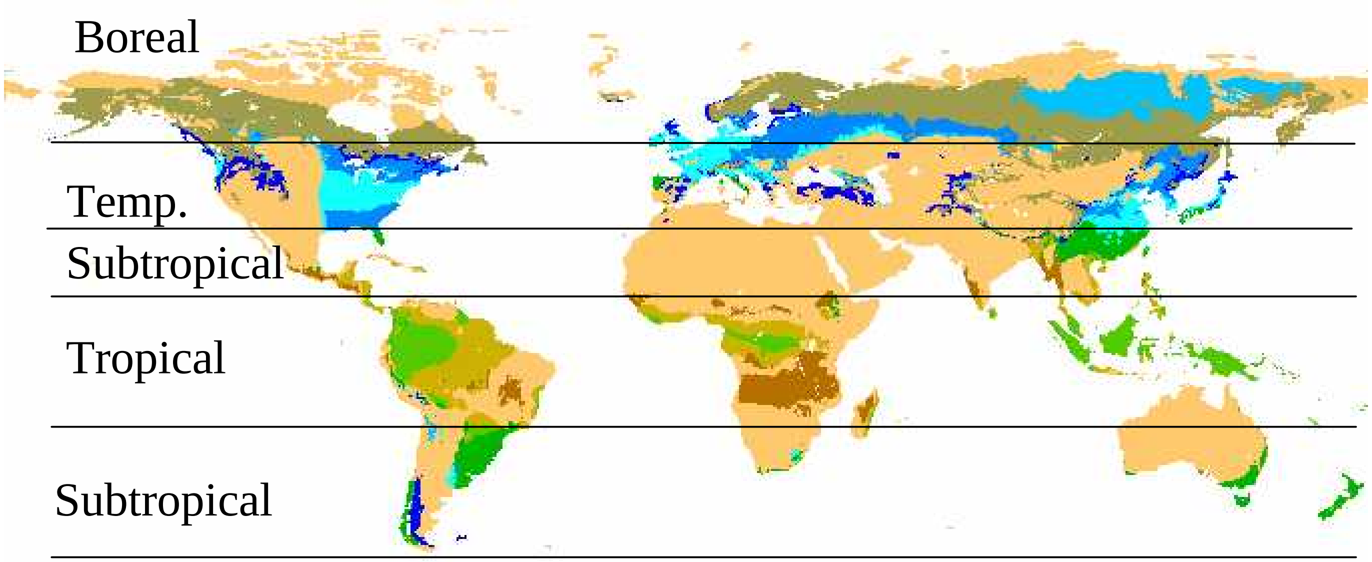
- Maximize welfare in timber markets
  - Max NPV(CS - Costs + Annual Carbon Rent)
  - 200 year time horizon in 10 year increments.
  - Costs = production costs & land rental costs.
  - Total of about 250 timber supply regions
    - Most detailed: US; Russia; China
    - Less detailed: Europe, Canada, Australia, NZ, SA, Cent. Am., Africa, SE Asia, India.

- Papers:
  - Timber Model/Parameter description: Sohngen et al. (1999)
  - Carbon parameters from Sohngen and Sedjo (2000)
  - Sequestration scenarios (Sedjo et al., 2003; Sohngen and Mendelsohn, 2003; **Sohngen et al., 2005;** Sohngen and Sedjo, 2006; Sohngen and Mendelsohn, 2006; Sohngen and Beach, 2006)

- Current Efforts:
  - Update global forest inventories
  - Provide country data tables through GTAP (Purdue)
  - Develop dynamic global forestry and agricultural land use model

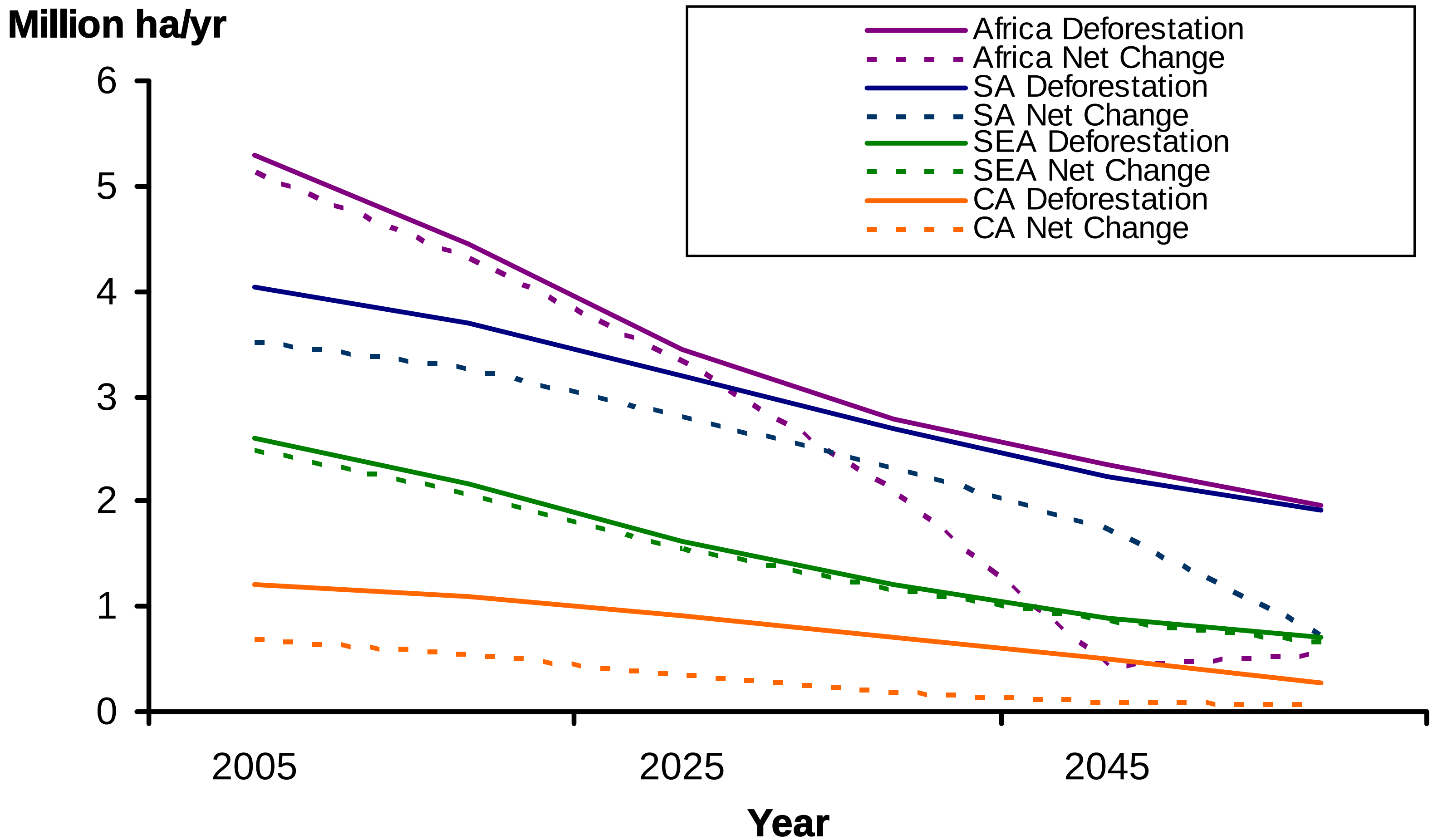
Regions Included

- 250 Ecosystem and Management Classes:
  - *Temperate forests (US, Canada, Europe, China, FSU, SA)*
  - *Subtropical Plantation (US, S&CA, Africa, Europe, SE Asia)*
  - *Low-mid latitude temperate and subtropical (S&CA, Africa, SE Asia)*
  - *Northern Inaccessible (Canada, Europe, FSU)*
  - *Tropical Inaccessible (S&CA, Africa, SE Asia)*



Haxeltine and Prentice, 1996

Base Case Deforestation

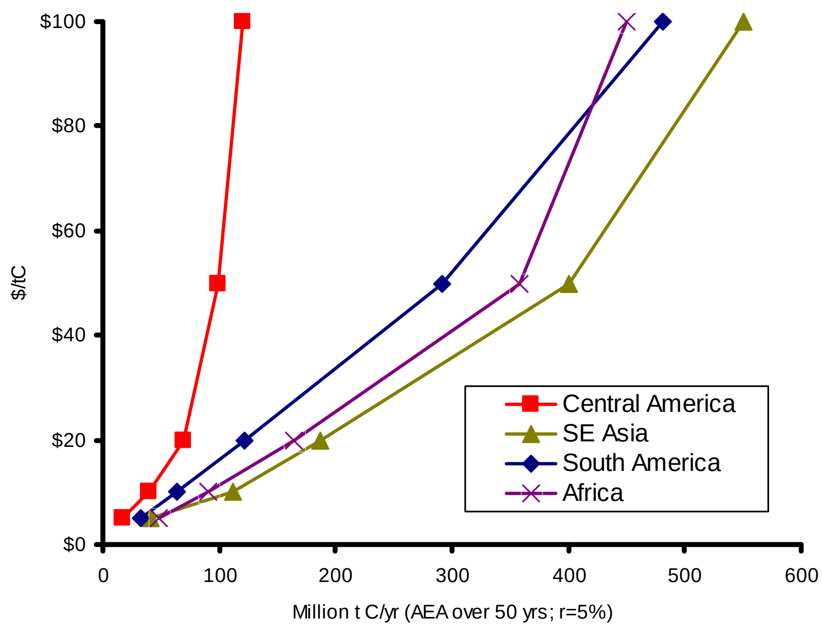


How Much Deforestation is This?

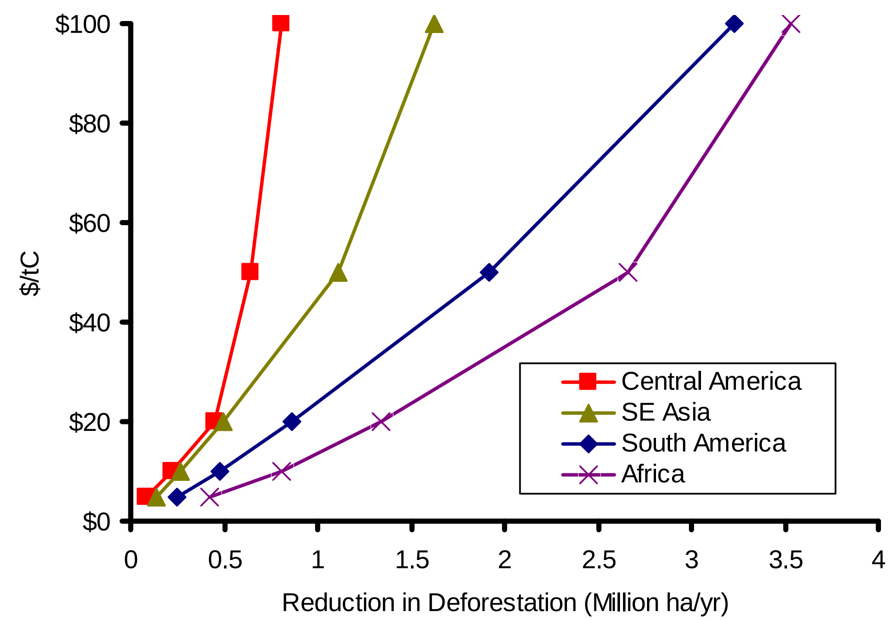
	Area Change		Carbon Change	
	Deforest.	Net Chg.	Deforest.	Net Chg.
	Million ha	Million ha	Cum. Pg	Cum. Pg
2005 – 2015				
South America	40.4	35.2	4.3	4.2
Central America	12.1	6.9	1.3	1.3
SE Asia	26.0	24.8	3.7	3.6
Africa	52.9	51.2	5.4	5.3
Total	131.3	118.1	14.6	14.4
2005 - 2055				
South America	158.6	136.4	17.3	16.7
Central America	44.1	18.5	4.6	4.5
SE Asia	85.1	81.4	16.0	15.9
Africa	183.1	153.3	18.8	18.6
Total	470.8	389.5	56.7	55.7

Supply Curve for Reducing Deforestation (2005 – 2055)

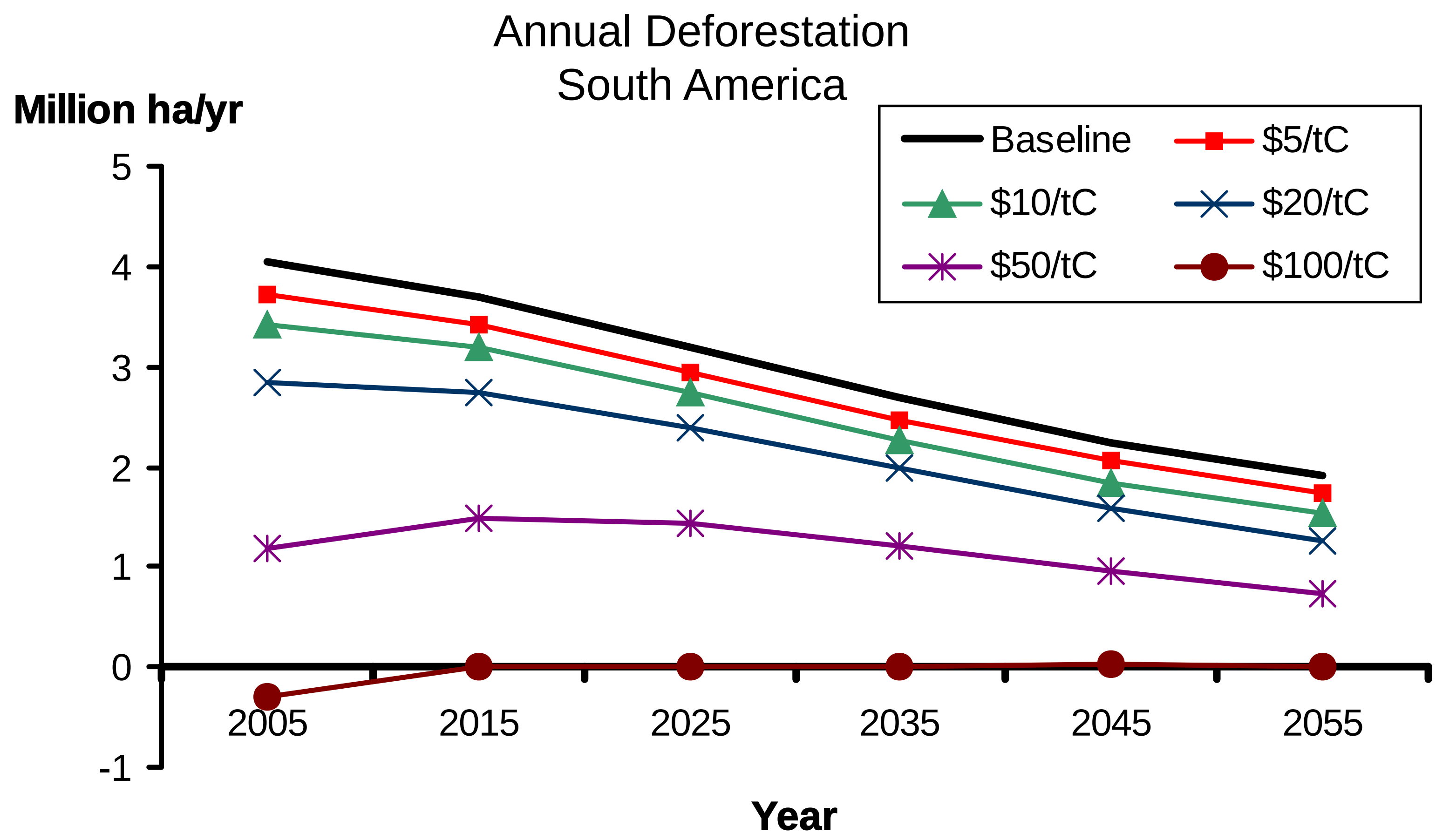
Carbon Supply (Million tC/yr)



Land Supply (Million ha/yr)



How Much May C Incentives Reduce Deforestation?



Note: All Carbon Prices, Pc, are assumed to be constant over time period

Comparison to Soares-Filho et al. (*Science, 2006*) Brazil/South America

	Soares-Filho et al. (2006)	GTM
Loss of Forest and Carbon in Baseline by 2050		
Ha's Lost	210	136
Pg C Lost	32	16.7
t C/ha Lost	152.4	122.8
Gain from Reduction in Deforestation		
Ha's Gained	130	167.0
Pg C Gained	17	22.4
t C/ha Gained	130.8	134.1
$/t C	N/A	$100
$/ha/yr		$596

What Do These C Prices Mean On the Ground?

	P^C = \$5 tC^{-1}	P^C = \$50 tC^{-1}	P^C = \$100 tC^{-1}
South Amer.	$29.84	$298.46	$596.98
Cent. Amer.	$23.22	$232.66	$465.83
SE Asia	$32.93	$329.55	$659.37
Africa	$24.97	$249.83	$499.79

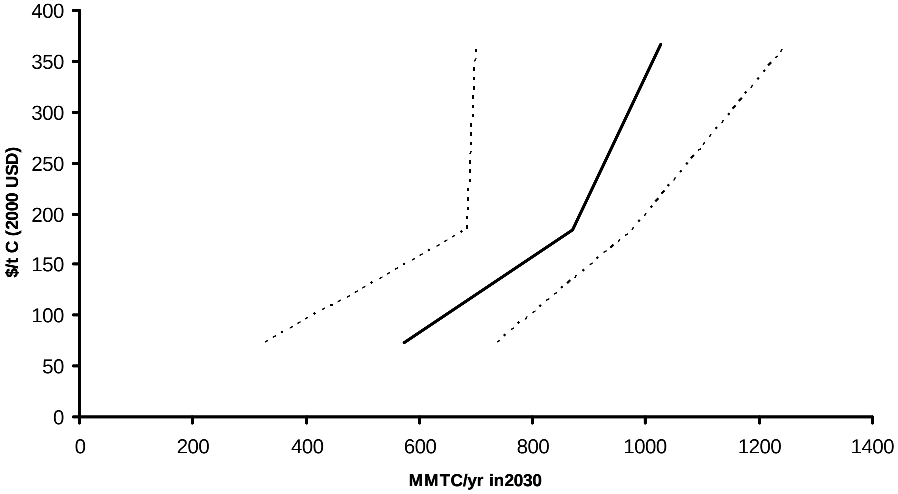
Effect of C Payments on Annual Rates of Deforestation (2005 – 2055)

	P^c ($ / tC)	$5	$10	$20	$50	$100
S. Amer.	$/ha/yr	$30	$60	$120	$300	$598
	% red. in def.	-8.4%	-16.2%	-28.9%	-62.3%	-101.5%
Cent. Amer.	$/ha/yr	$21	$43	$93	$241	$492
	% red. in def.	-17.7%	-39.3%	-65.2%	-83.0%	-94.7%
SE Asia	$/ha/yr	$32	$70	$142	$376	$761
	% red. in def.	-9.8%	-18.9%	-34.1%	-69.8%	-96.4%
Africa	$/ha/yr	$25	$50	$100	$252	$499
	% red. in def.	-15.3%	-28.0%	-43.9%	-78.0%	-97.4%

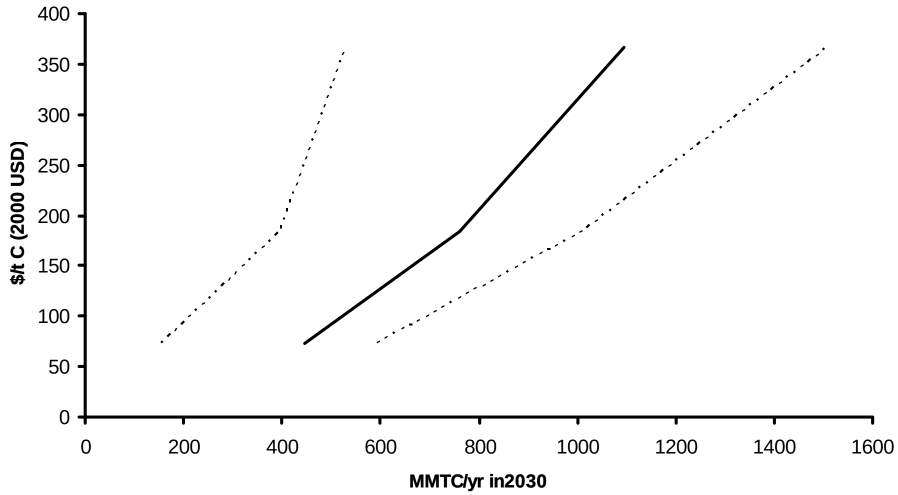
Comparison Across Models

DIMA (IIASA); GCOMAP (LBNL); GTM (OSU-RFF)

Avoided Deforestation
MMTC in 2030



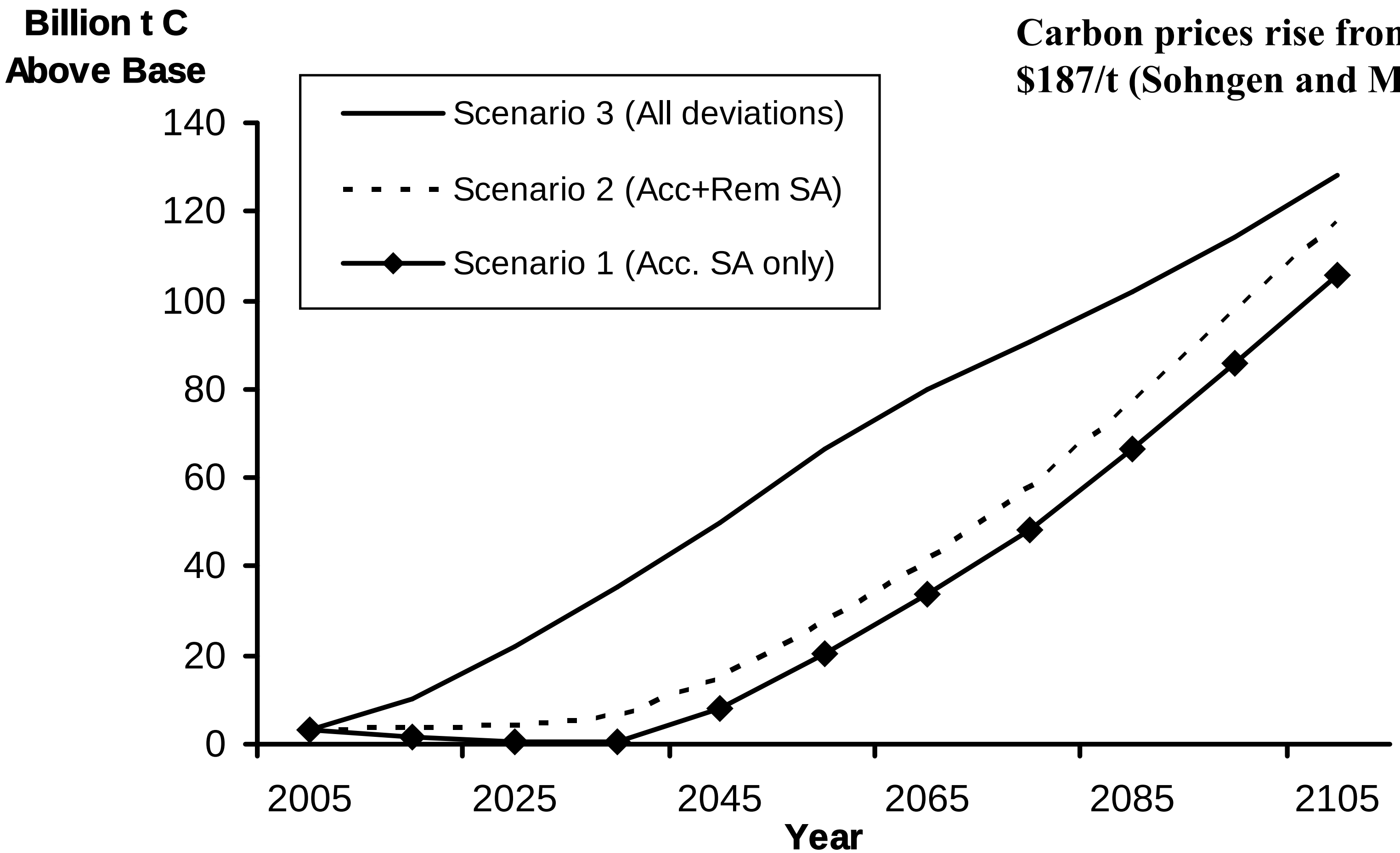
Afforestation
MMTC in 2030



Source: IPCC AR4

Policy Consequences: Global Carbon Gain Under Set-Aside Policies

Carbon prices rise from $20/t to $187/t (Sohngen and Mendelsohn, 2003)



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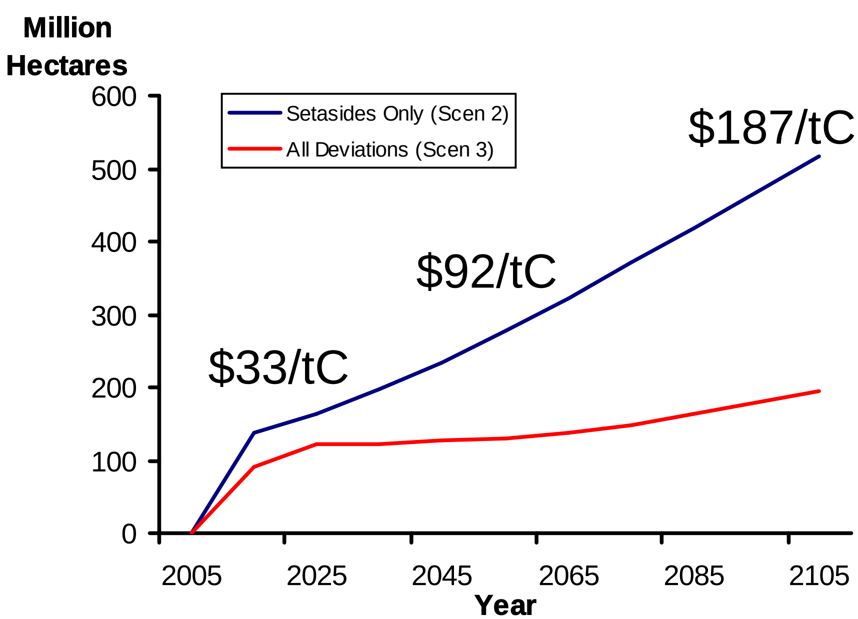
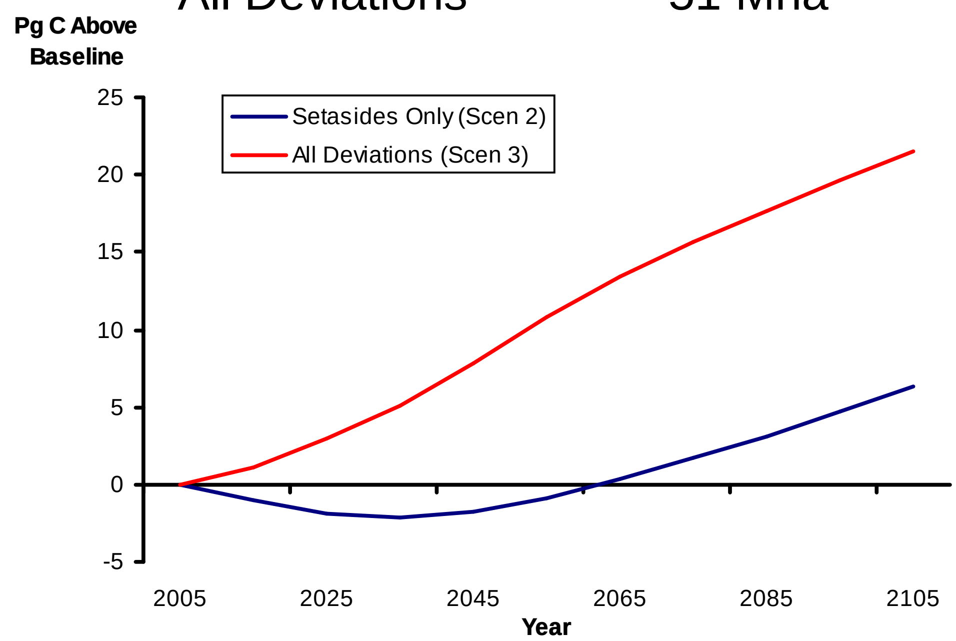
Leakage Could be Substantial!
Results for Set-asides in South America



LAND SET-ASIDE ←

	Net Forest Loss
Baseline	136 Mha
Set-Aside Only	55 Mha
All Deviations	51 Mha

NET C GAIN →



Summary so far….

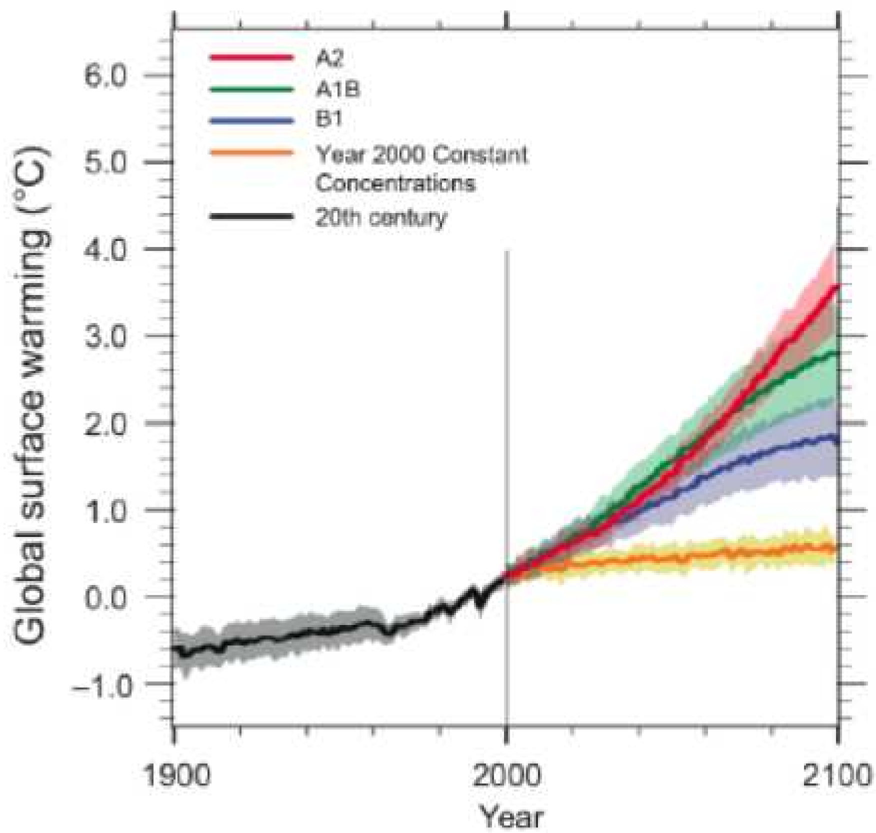
- Global Timber Model (2005 – 2055)
  - 471 Million hectares lost due to deforest. (9.4 MMha/yr)
  - 57 Pg C Lost (1.1 Pg C/yr)
  - $100/t C ($400-$760/ha/yr) could "stop deforestation."
  - AD activities are similar to, or larger than, the gains from Afforestation projects.

- Comparison to other models suggests similar range of potential gains from afforestation and reductions in deforestation.

- Leakage is an important consideration.

Forests in Stabilization Policy

Joint work with M. Tavoni (FEEM)



IPCC Figure SPM-5

- Costs of stabilization could be exceedingly large
  - Clarke et al (2006) suggest >6% of GWP in 2100 for <550 ppmv.
- Could forestry reduce these costs?
  - Sohngen and Mendelsohn (2003) suggested not, but looked at efficient policies.
- Most IA models do not include land use.

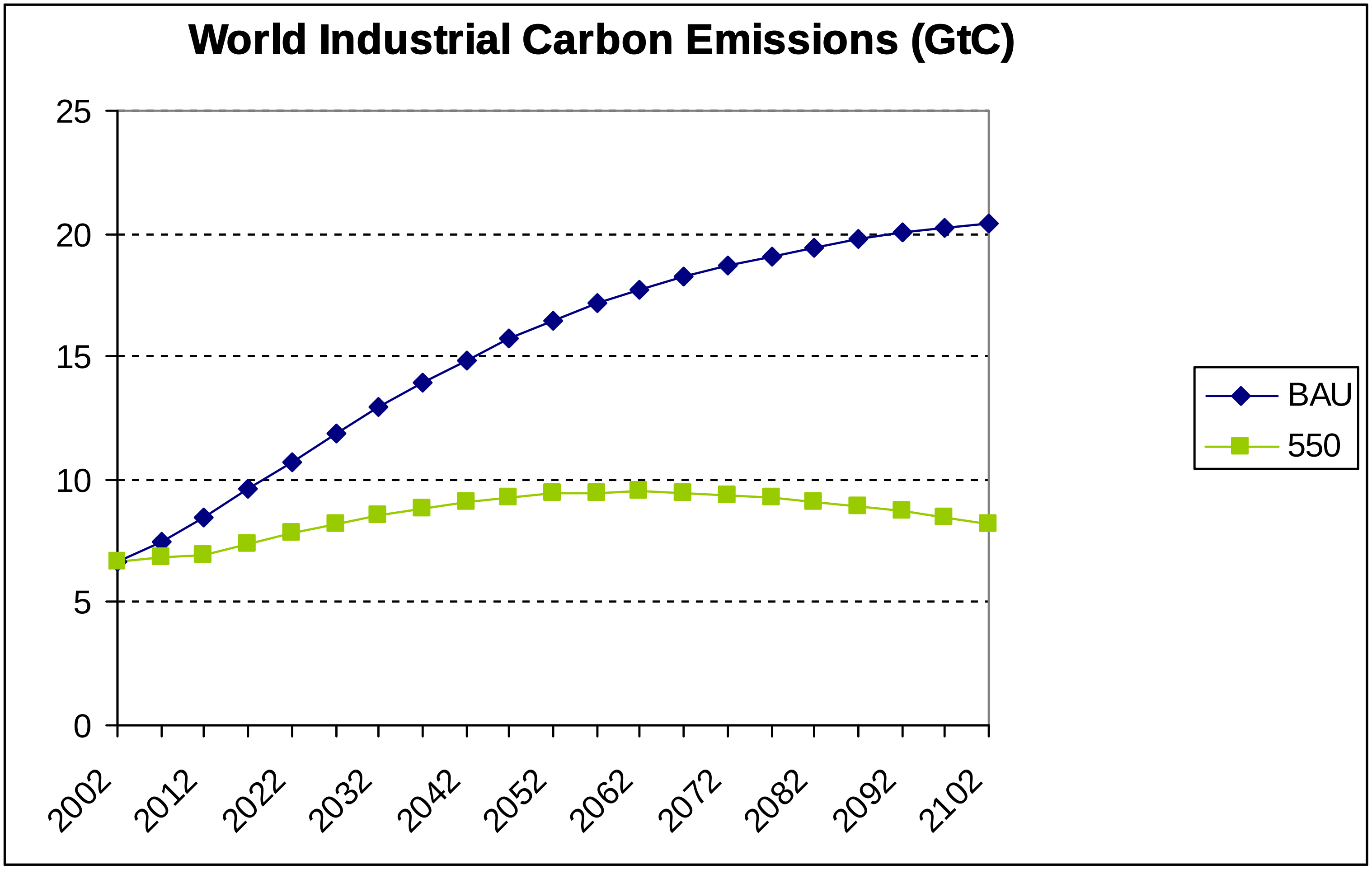
Analysis
Link WITCH to Global Timber Model

- Joint analysis with M. Tavoni and V. Bosetti (FEEM).
- Link an energy model with Forestry/LU Model.
- **WITCH**
  - A dynamic growth model
  - TOP DOWN optimization framework, with a energy sector description and a game theory set up.
    - World, 12 regions
    - Economy: optimal growth
    - Energy: Energy sector specification
    - Climate: damage feedback
    - The 12 regions interact strategically
- **Analysis**: What Impact does forestry have on "optimal" carbon prices under a 550 ppmv stabilization scenario?

WITCH Emission Profile

Policy: 550 ppm constraint.

Without Forestry



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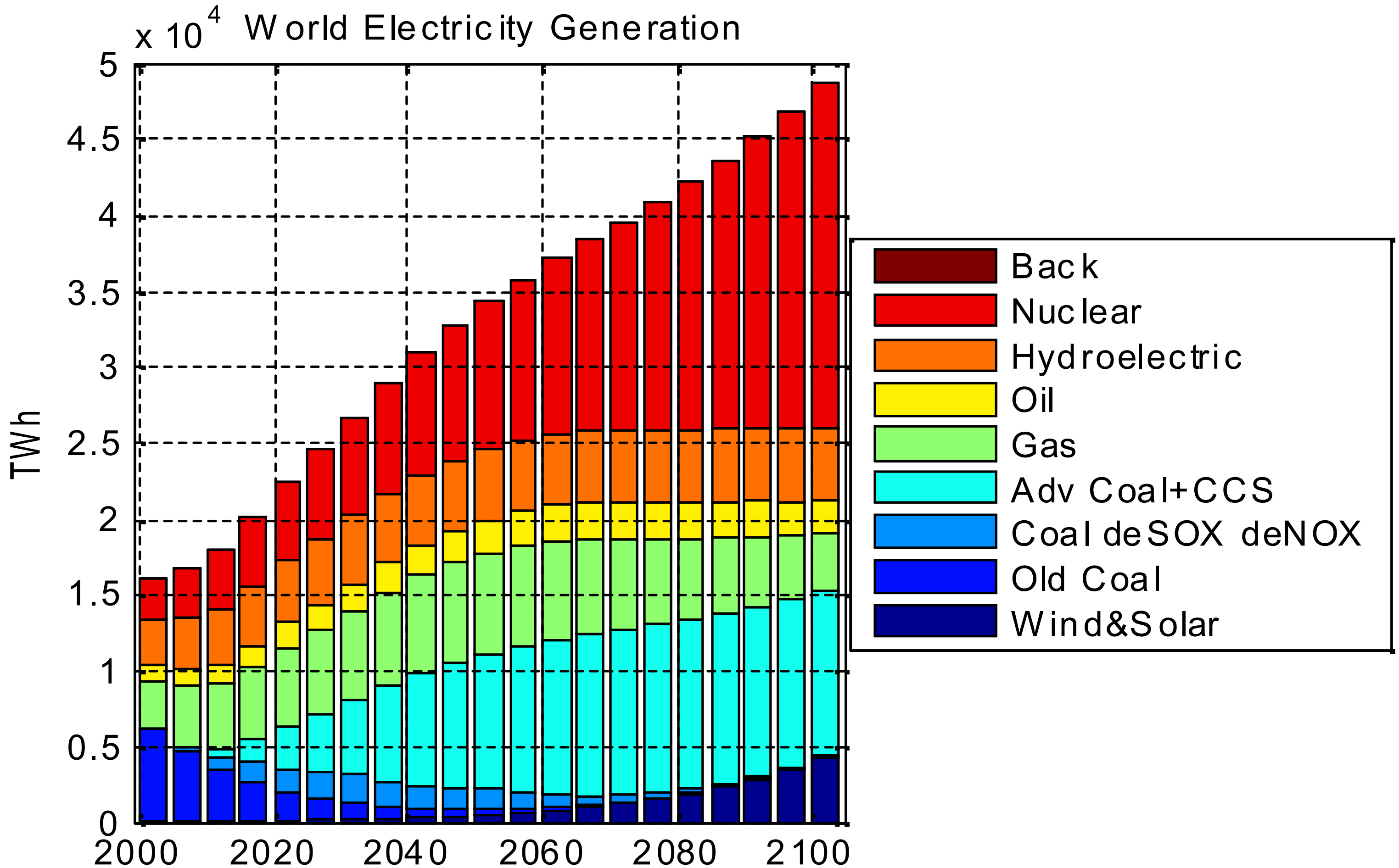
Energy Abatement Options

550 PPM; Without Forestry



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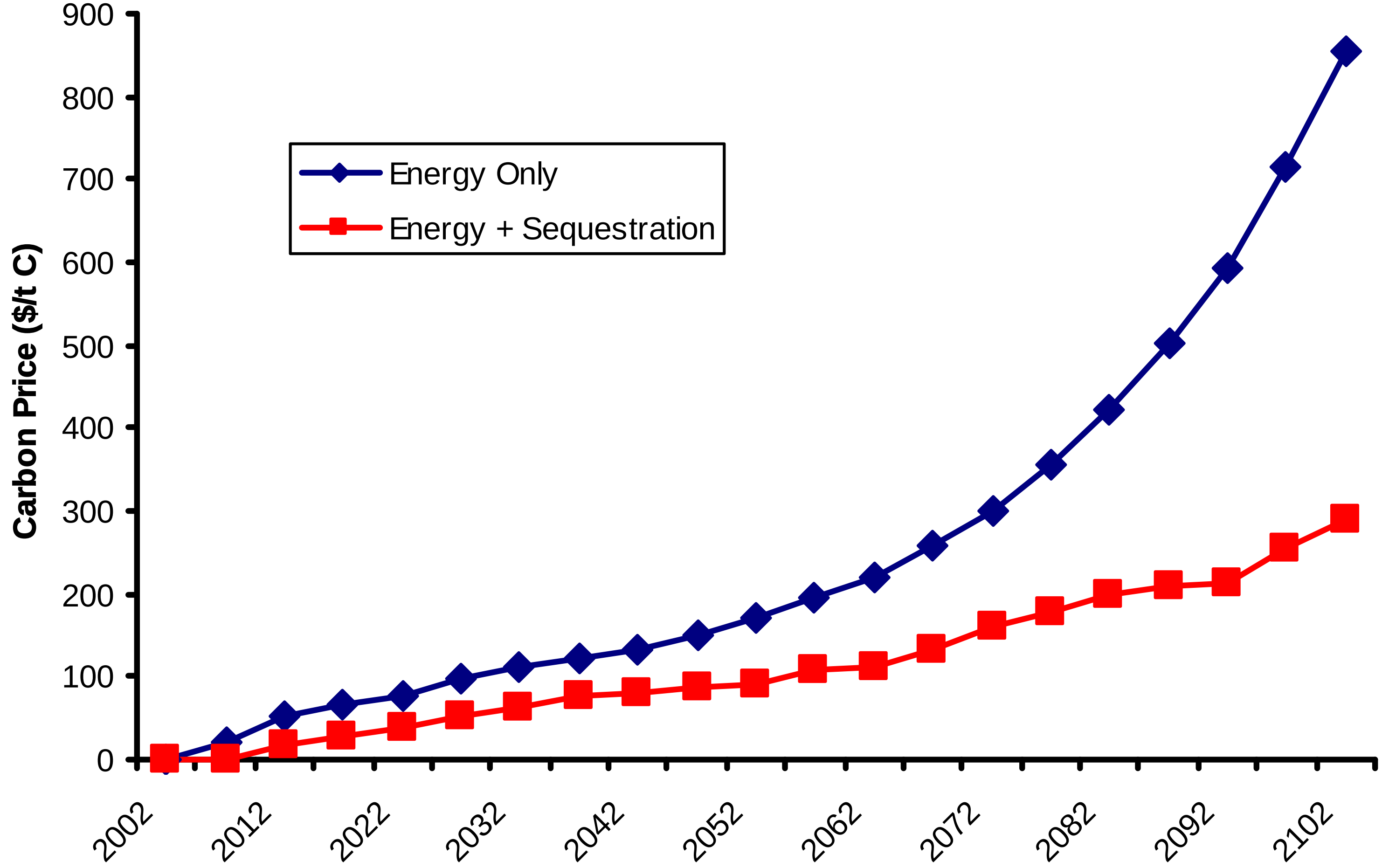
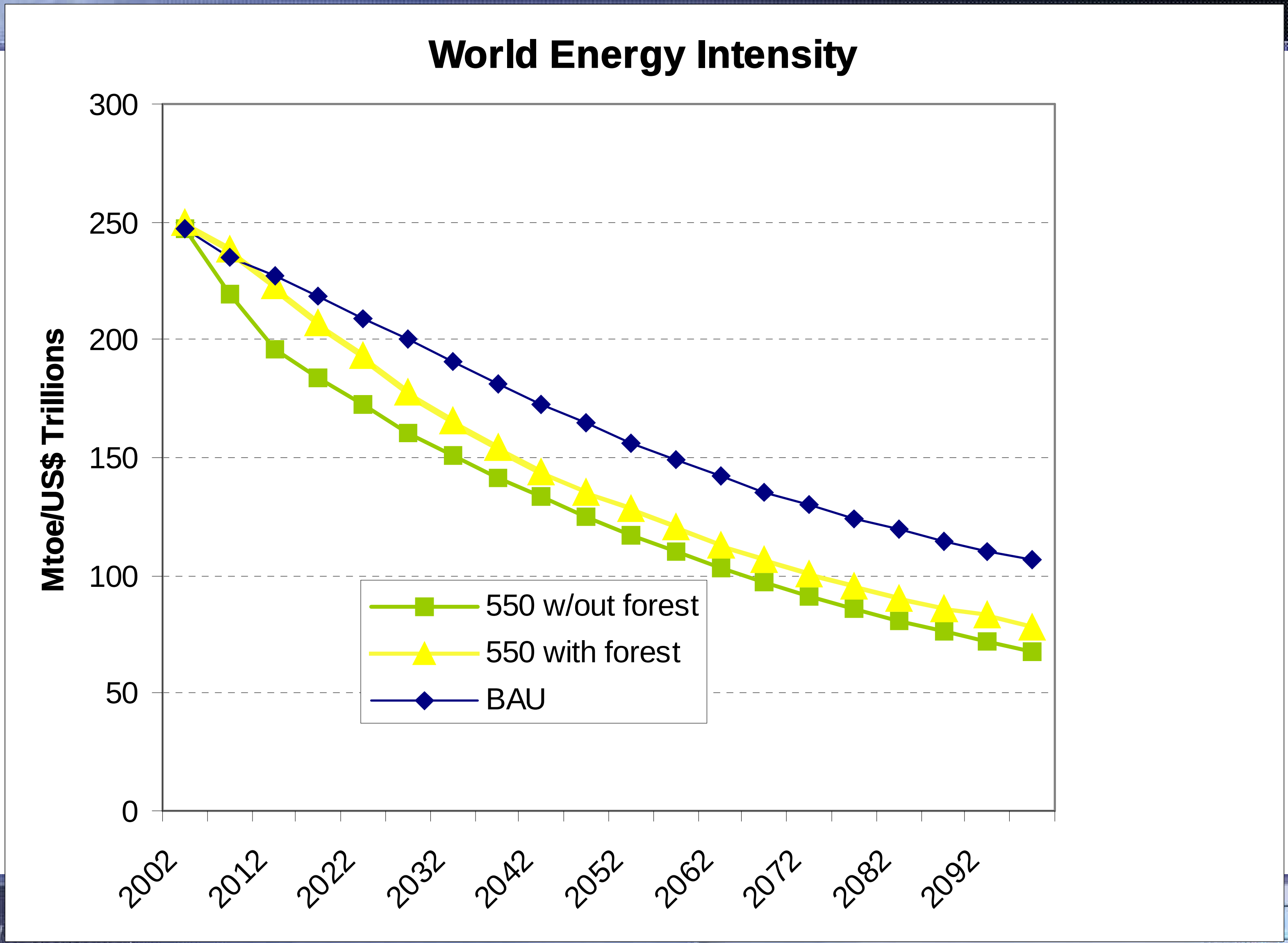
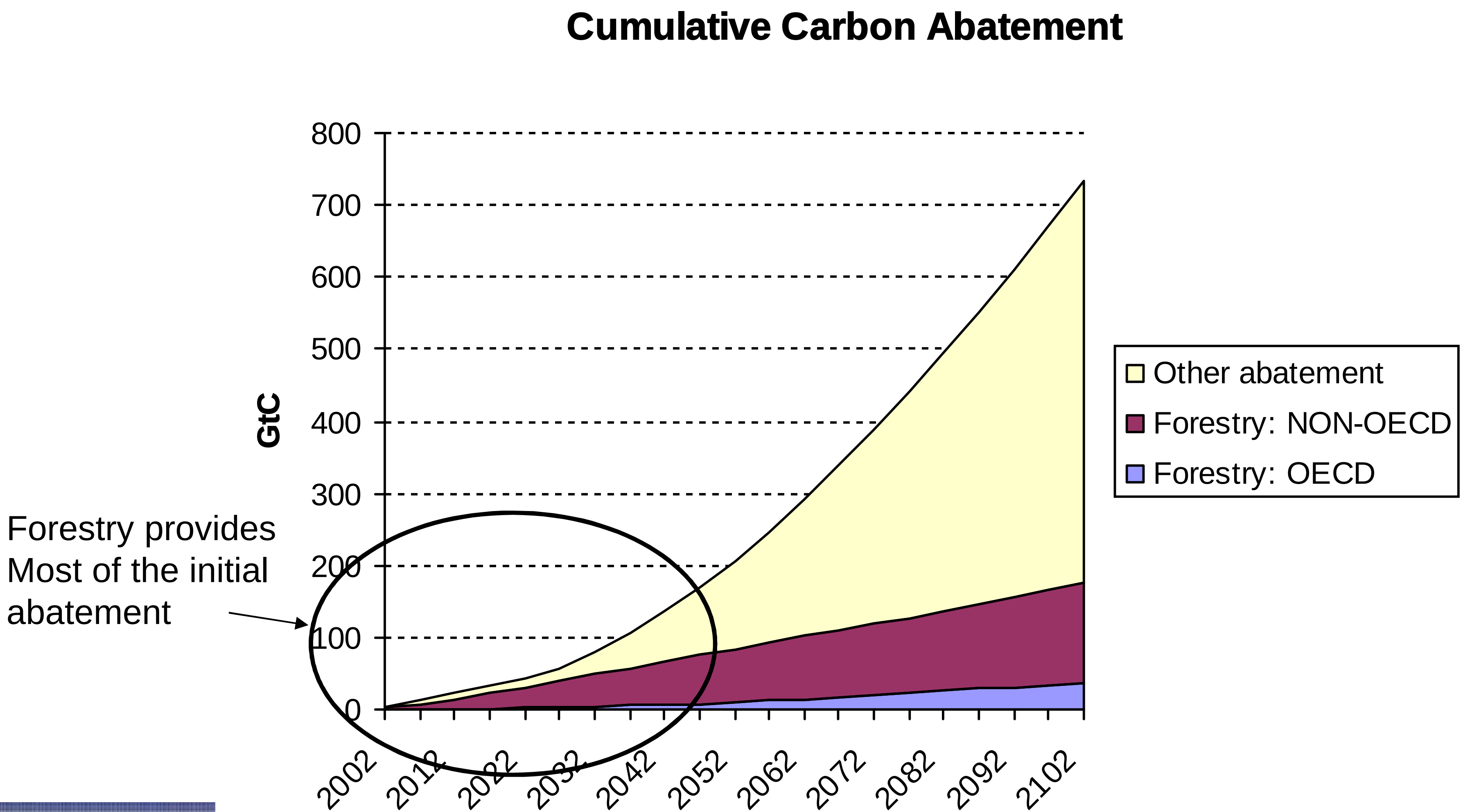
Adding Forestry Reduces Carbon Prices by ~ 50% over Century
Reduces Average Rate of Price Growth from >7% to 3.8% per year.



Delays Abatement in Energy



Most Initial Abatement is Land Use!



Where is Sequestration Projected to Occur?

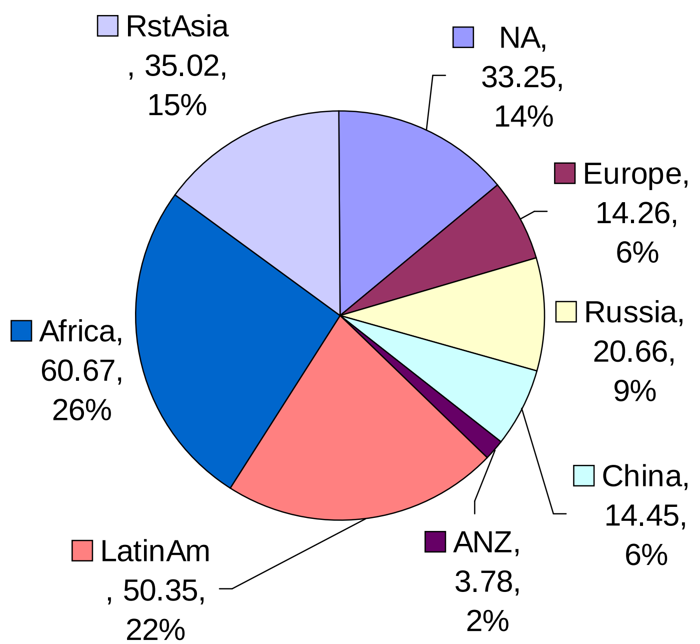
Sequestration Grows in Temperate forests (USA, OLDEURO, NEWEURO, KOSAU, CAJAZ)

Red Areas are Largely due to Reducing Defor. (ME/NA, SubSahA, E. ASIA, LACA)

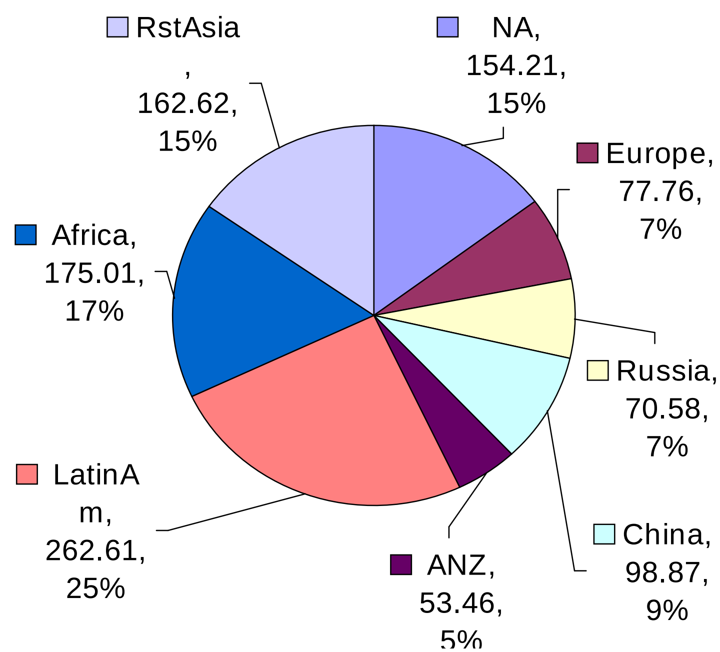
	2025	2055	2095
	Million TCE/year (Tg C)		
USA	42	144	193
OLDEURO	37	82	132
NEWEURO	8	18	29
KOSAU	25	27	36
CAJAZ	31	115	125
Trans. Ec.	179	117	134
ME/NA	**73**	**49**	**31**
SubSahA	**270**	**175**	**106**
S. ASIA	34	57	32
CHINA	109	155	431
E. ASIA	**451**	**481**	**371**
LACA	**391**	**326**	**330**
Total	1649	1746	1950
C Price	$57	$113	$271

Global Additional Forest Land

2025
Total Gain = 232 Mha

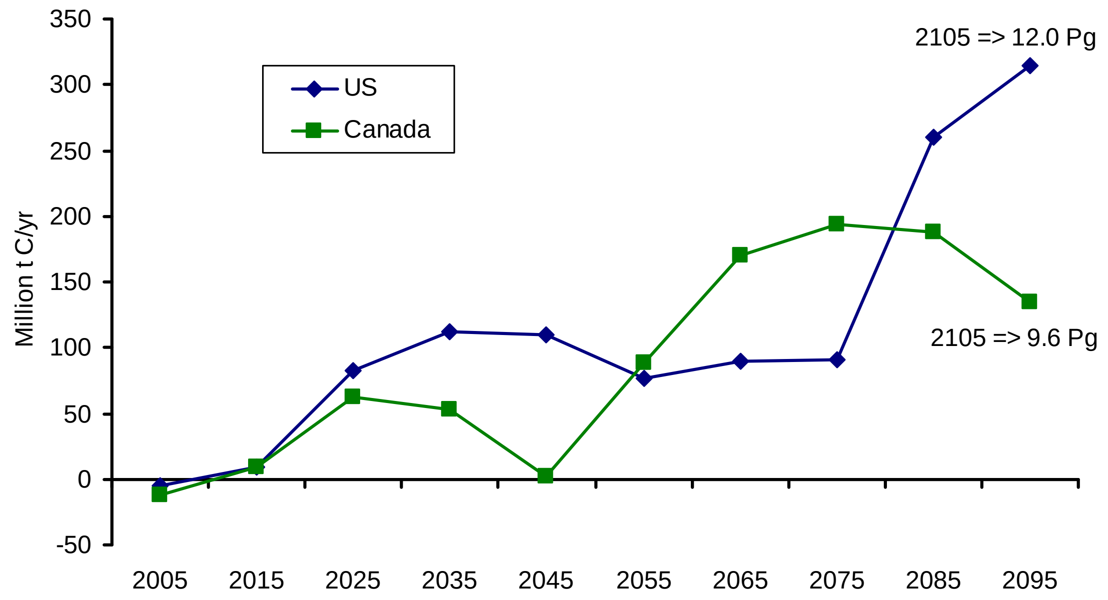


2095
Total Gain = 1055 Mha



US & Canada

Annual Net Sequest.



	2025	2095
■ Afforestation:		
● US:	19 Mha	89 Mha
● Canada:	14 Mha	66 Mha
■ Harvests		
● US:	+4 Mm^3/yr (1%) + 5-10 years rotation	+26 Mm^3/yr (8%) + 5-10 years rotation
● Canada	-32 Mm^3/yr (2%) +10 – 20 year rotation	+365 Mm^3/yr (226%) +10 – 20 year rotation
■ Management	(PV - $/ha) base -> stabil.	
● US:	$158 -> $400	$142 -> $3100
● Canada:	$23 -> $39	$47 -> $1100

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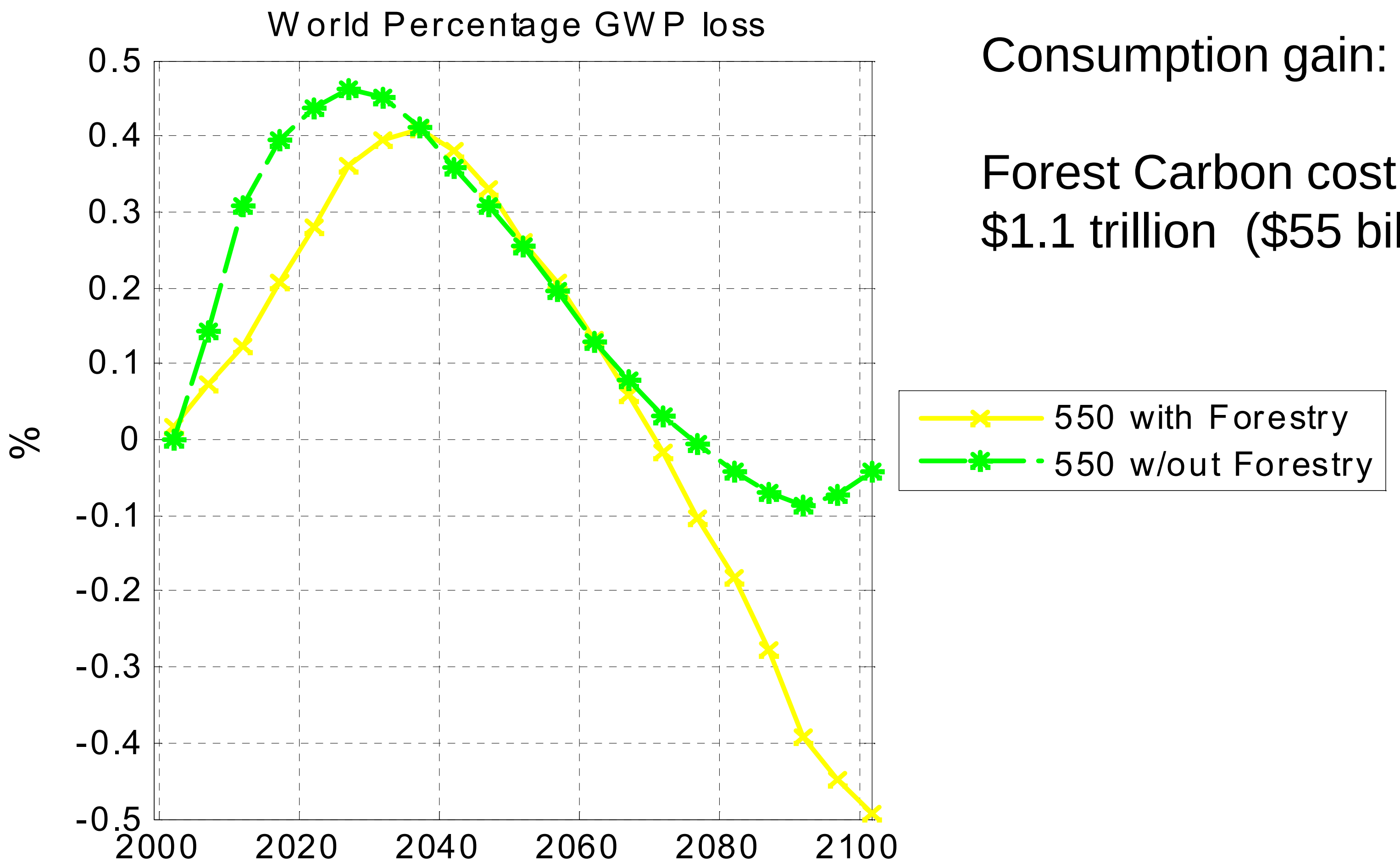
Benefits and Costs of Sequestration Program



Consumption gain: $3 trillion

Forest Carbon cost:
$1.1 trillion ($55 billion/yr)

Conclusions

- **Can potentially sequester 1250 million t C/yr over 20-50 years in tropics for $100 per t C**
  - **Caution**: That's $17-$18 billion/yr.
  - 10% reduction in deforestation would be less costly, but obtain less carbon.
- **Reducing deforestation and afforestation are 70 - 80% of carbon potential in tropics**.
  - Robust across a range of price scenarios.
  - **Caution**: results are most sensitive to assumptions about land markets.
- **Leakage will have large implications for efficiency**
- **AD activities could be key to lowering costs of stabilizing carbon concentrations.**
  - $1.1 trillion rental program could reduce consumption losses by $3 trillion.
- **Investments in developed regions that are consistent with stabilization policy are relatively modest in the near-term.**