

*Forestry Climate Mitigation Potential and
Costs:
GCOMAP Model, Transaction Costs and India
Mitigation Forestry Case Studies*

Jayant Sathaye, Peter Chan, Larry Dale and Willy Makundi
Lawrence Berkeley National Laboratory
Berkeley CA

Ken Andrasko
US Environmental Protection Agency,
Washington DC

Washington, DC 2004

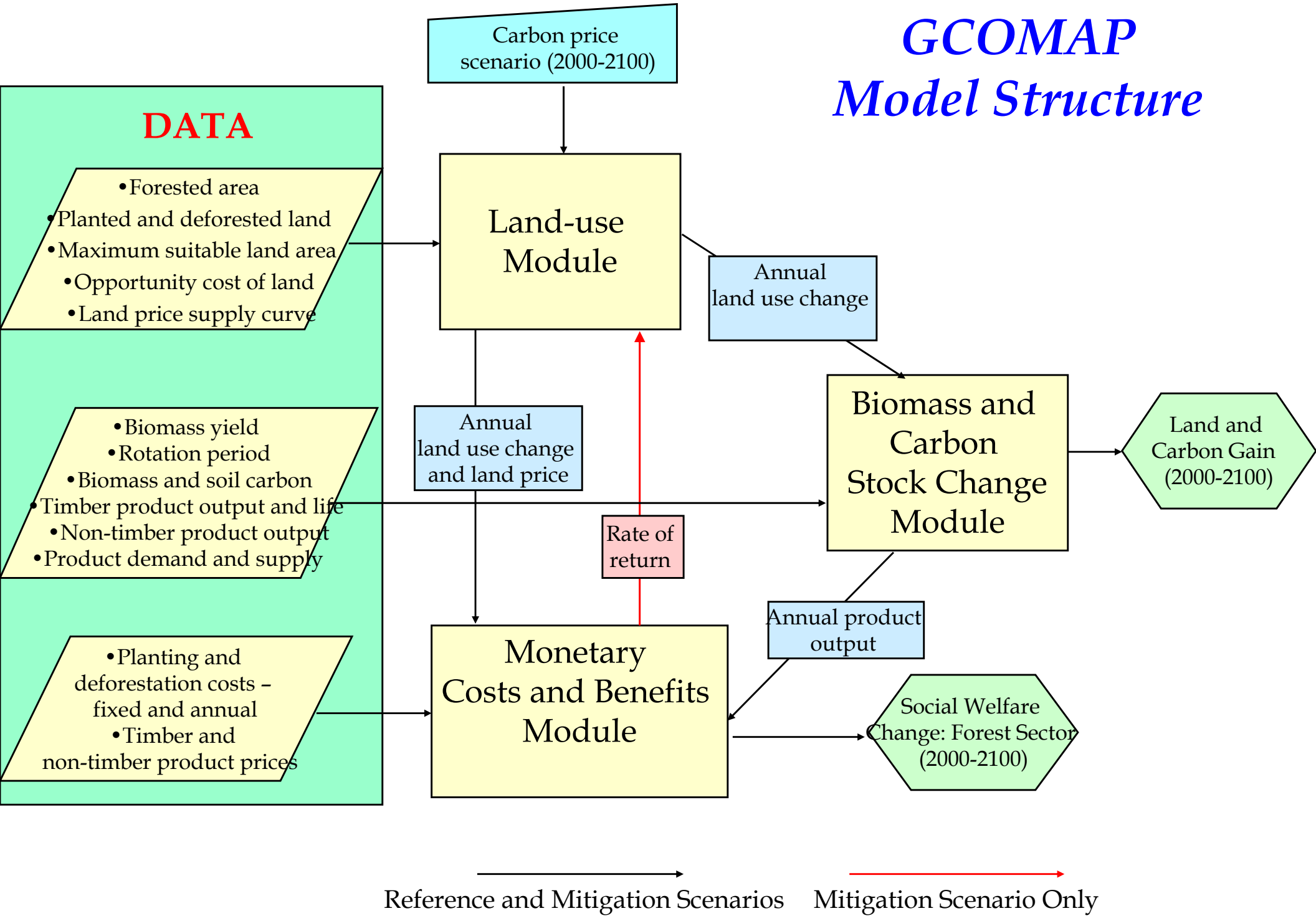
Contents

- Introduction
- GCOMAP description
- Model Structure
- Key Input Data -- Tropics
- Results for six carbon price scenarios
- Deforestation
- Forestation
- Effect of biofuels

GCOMAP Current Scope

Mitigation Option	Current Geographic Regions	Carbon Pools
<p>Forestation – Short-rotation Long-rotation</p> <ul style="list-style-type: none"> • Without biofuels • With biofuels (not analyzed yet) 	<p>North America South / Central America Europe Russia (not FSU) China India Australia/NZ Asia-Pacific Africa</p>	<ul style="list-style-type: none"> • Above/below ground biomass • Soils • Litter • Post-harvest residue • Domestic timber products • International timber products • Fuelwood • Mill-waste products • Biofuels – used as a substitute for coal in power plants
<p>Avoided deforestation (no biofuels)</p>	<p>South / Central America Asia-Pacific Africa</p>	<ul style="list-style-type: none"> • Biofuels – used as a substitute for coal in power plants

GCOMAP Model Structure



Key GCOMAP Data Inputs: Variables and

parameters

- Land area:
 - Sources: FAO and country-specific data, by sub-regions for large countries
 - Total forest area
 - Historical and projected reference case planted and deforested area
 - Total area suitable for planting – degraded forests, croplands, grasslands, etc.
- Economic data:
 - Sources: Country-specific data and from literature on global timber trade
 - Planting and deforestation costs
 - Timber and non-timber products prices
 - Discount rates
 - Exchange rates
 - Price elasticity values
- Carbon data:
 - Sources: Country-specific data
 - Soil, vegetation and product carbon intensity
 - Vegetation yield
 - Rotation periods
- Country-specific data from
 - Tropics: Eight research groups for 14 options in the tropics and used in the COMAP bottom-up model (Sathaye, Makundi, Andrasko et al. 2001)
 - Temperate and boreal regions: Published literature and personal communication

Key Data Inputs

Deforestation Rate: Historical and Projected

- Global deforestation currently about 17 Mha/yr (FAO)
 - India and China deforestation has declined to almost zero now
 - Brazil has constant or accelerating deforestation
- Africa 1990-00 deforestation rate increased, unlike in other regions
 - Deforestation rate is projected to increase to 2020 before declining
- Rest of tropics: Deforestation rates are projected to continue declining

Region	Change in	Deforestation Rates (% / year)				
	Deforestation Rate (%/yr)	1990 –00	2000	2020	2040	2050
Africa	+ 0.026	0.80	1.29	0.78	0.65	0.26
Rest of Asia	- 0.005	1.03	0.82	0.60	0.52	0.12
Central America	- 0.011	1.19	0.97	0.75	0.65	0.37
South America	- 0.030	0.40	0.26	0.21	0.20	0.13

The deforestation rate gives the percent decline in the forest area per year

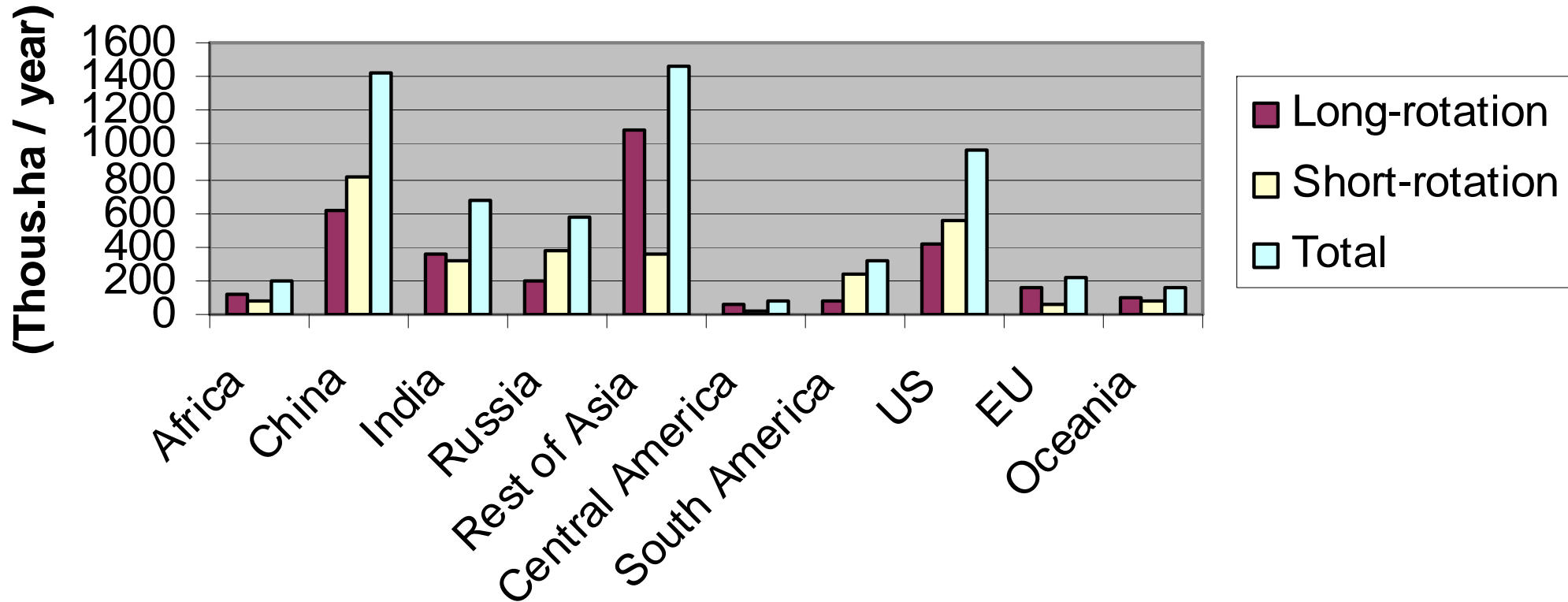
(-) rate is an annual decline in the deforestation rate

Based on FAO 2001 – Forest Resource Assessment-2000; Kaimovitz 1996 Livestock and deforestation in Central America in 1980s and 1990s; Barraclough and Ghimire 2000. Agricultural Expansion and Tropical Deforestation

Key Data Inputs

Historical Afforestation Rates

(Data for each region for periods varying from 1975 to 2000)



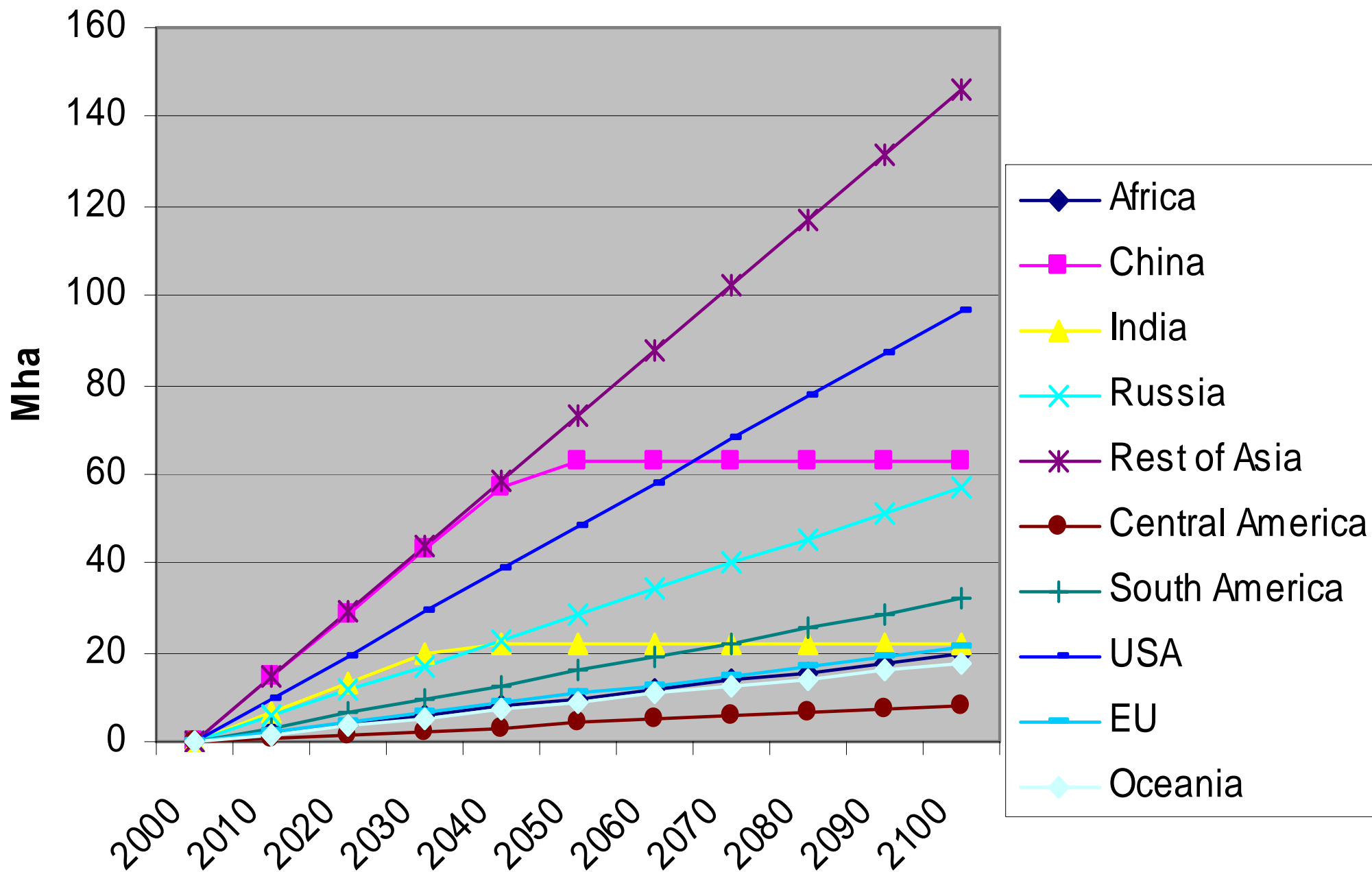
Source:

FAO 2001 - Forest Resource Assessment-2000, and

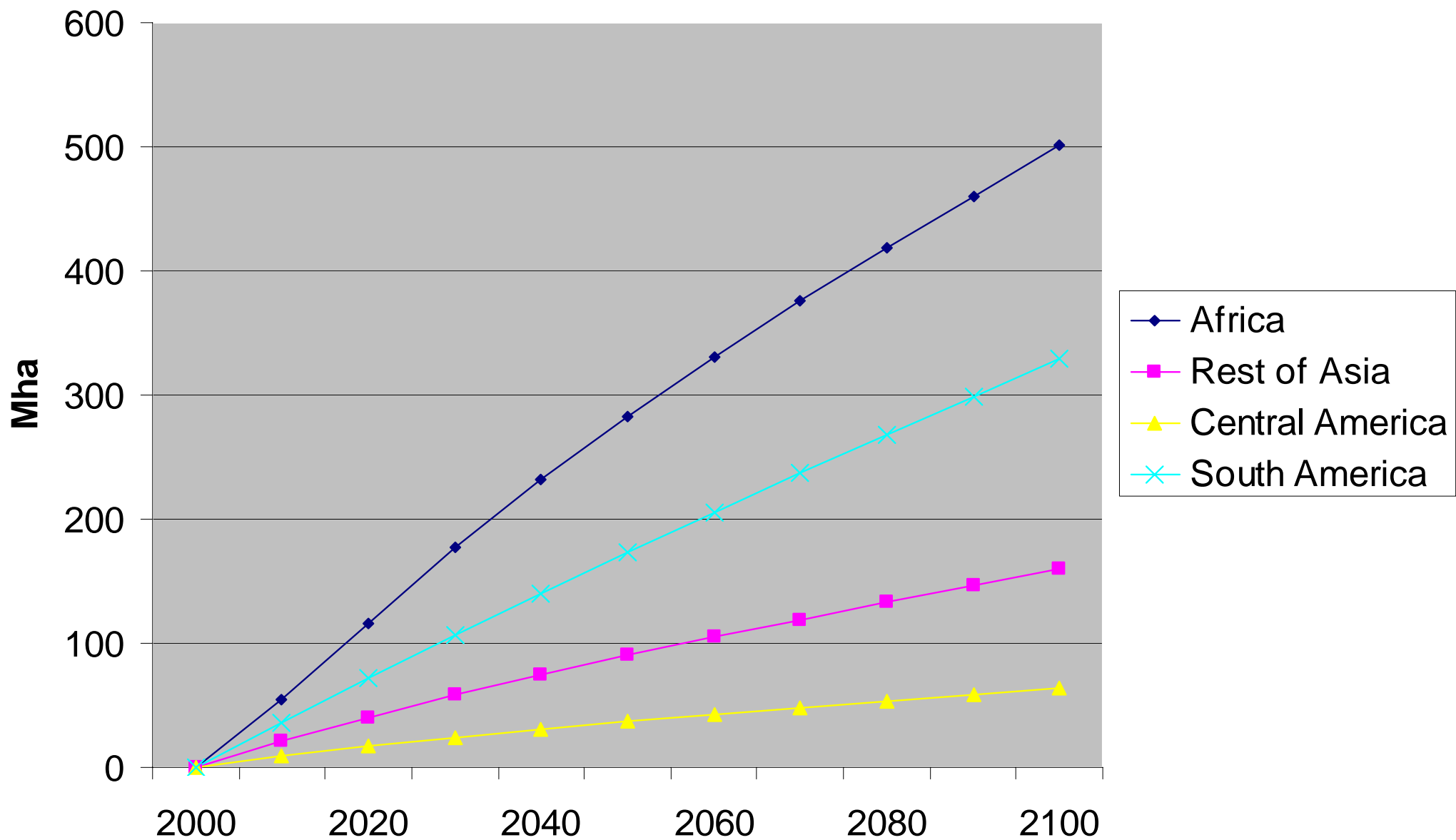
FAO 2000 - The Global Outlook for Future Wood Supply from Plantations

US - Moulton et al., 1996: Tree Planting in the United States

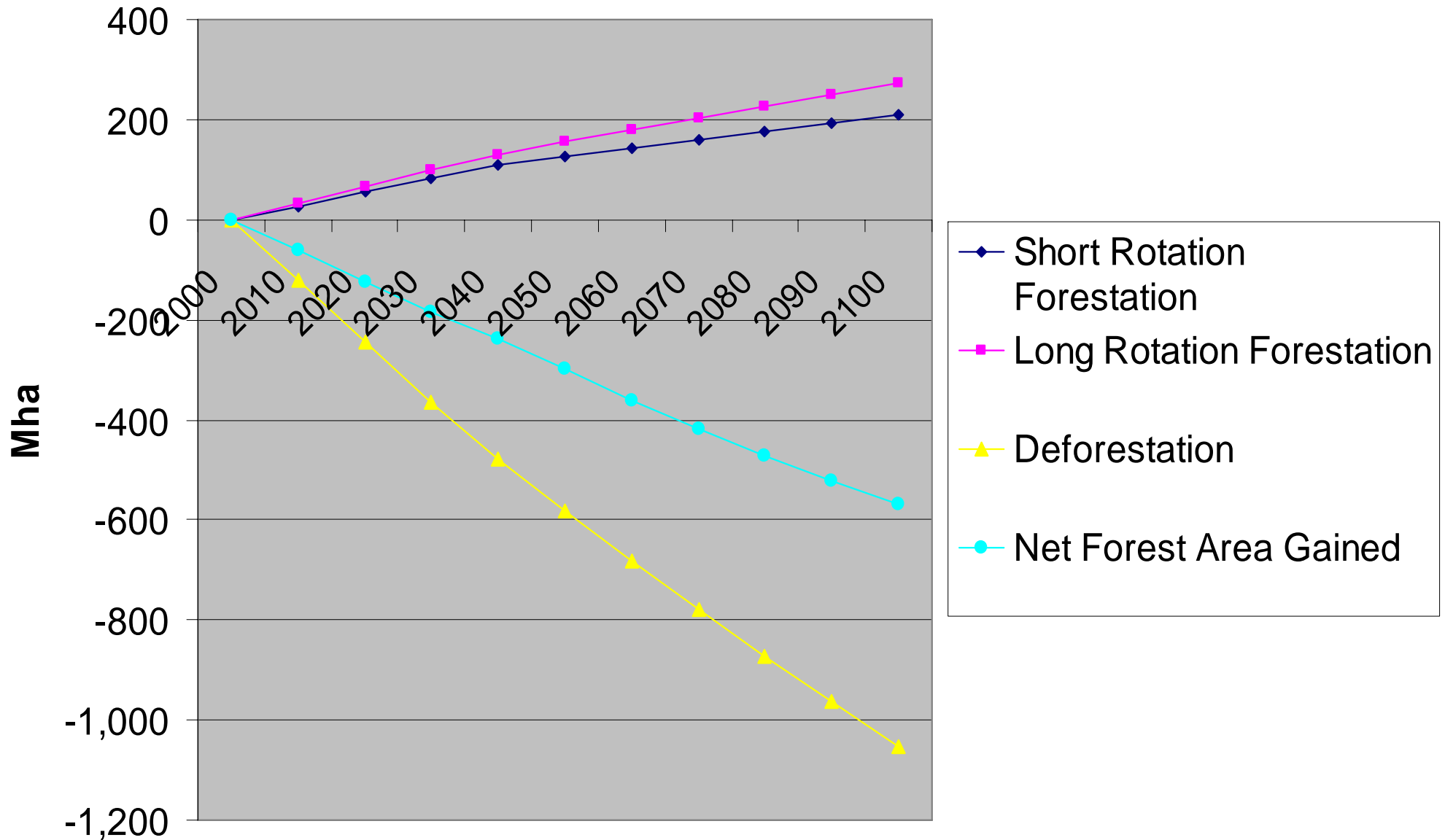
Reference Case: Land Area Planted (Cumulative) Short- and Long-Rotation



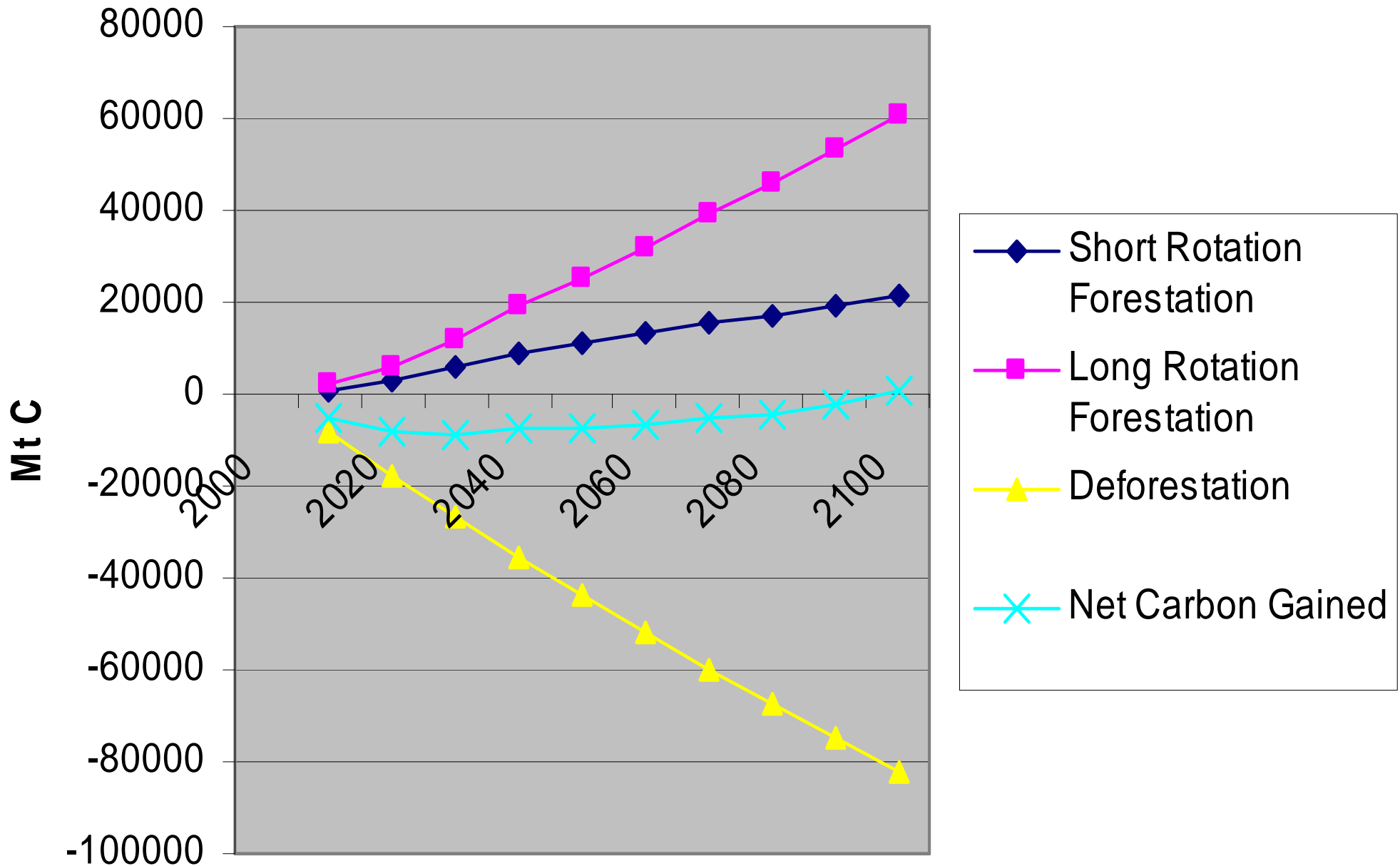
Reference Case: Land Area Deforested by Region (Cumulative to year reported)



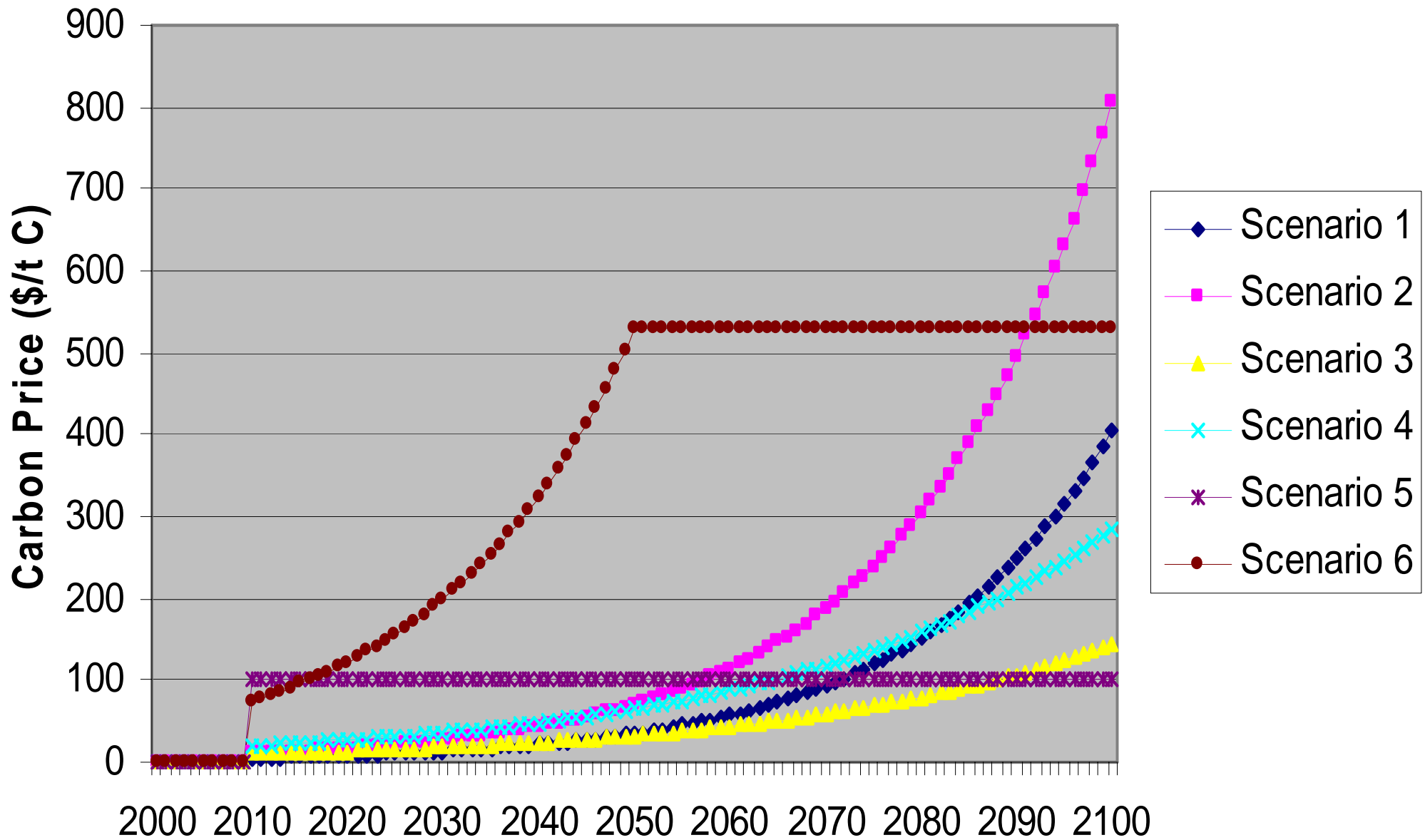
Reference Case: Land Use Change by Activity for All Regions (Cumulative to year reported)



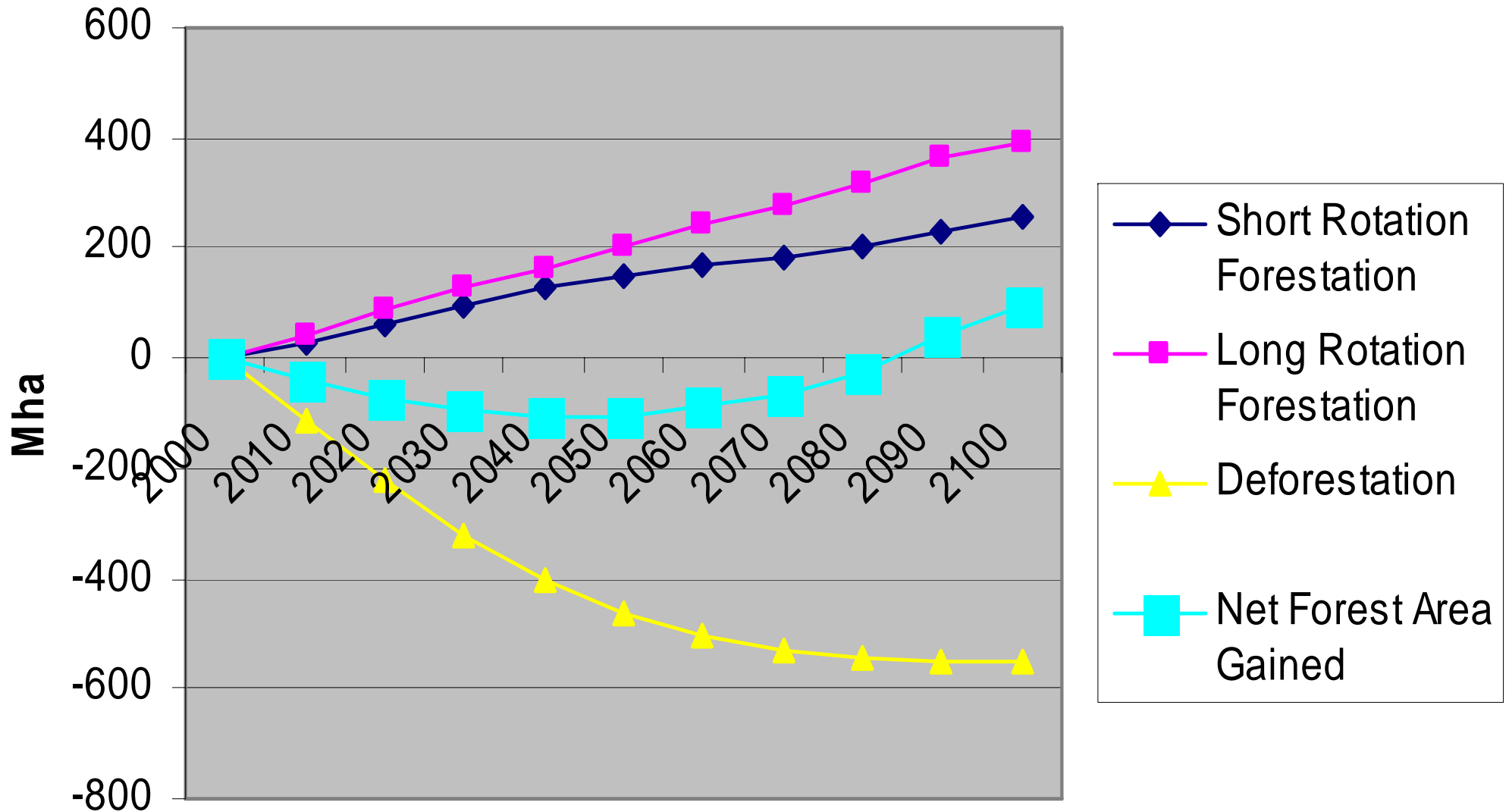
Reference Case: Carbon Stock Change (Cumulative to Year Reported)



Carbon Price Mitigation Scenarios



Scenario 1 (\$5 + 5% /year) -- Land Use Change by Activity for All Regions (Cumulative to year reported)



Results - Global land area and carbon gain* across scenarios

Mitigation Options : Long and short rotation forestry, and avoided deforestation

Scenario ^b	Carbon Price (\$/t C)		Land Area Gained (Mha)		Carbon Benefits Gained (Mt C)	
	2050	2100	2050	2100	2050	2100
2010 C Price + Annual Increase						
1. \$5 + 5%	35	404	190	662	13,570	70,145
Forestation			68	163	5,554	33,162
Avoided deforestation			122	499	8,034	37,105
2. \$10 + 5%	70	807	327	880	24,917	96,496
Forestation			108	231	10,123	47,849
Avoided deforestation			219	649	14,796	48,835
3. \$10 + 3%	33	143	212	555	15,628	50,905
Forestation			52	77	4,934	16,358
Avoided deforestation			160	478	10,694	34,547
4. \$20 + 3%	65	286	363	819	28,582	79,559
Forestation			75	135	8,917	28,575
Avoided deforestation			288	684	19,665	50,985
5. \$100 + 0%	100	100	537	866	47,252	78,970
Forestation			83	56	13,587	17,245
Avoided deforestation			454	810	33,665	61,725
6. \$75 + \$5	275	275	664	1081	63,300	113,208
Forestation			192	146	25,675	38,422
Avoided deforestation			501	959	37,625	74,786

Notes: a) Gained amount refers to the cumulative difference between a mitigation scenario and the reference case scenario by 2050 and 2100

b) All carbon prices are zero until 2009, and begin with the stated value in 2010

Results - Global land area and carbon gain* across scenarios

Mitigation Options : Long and short run

Higher the carbon price, larger the gained land and carbon amount, but

deforestation

Scenario ^b	Carbon Price (\$/t C)		Land Area	Carbon Gained (Mt C)		
	2050	2100		2050	2100	2100
2010 C Price + Annual Increase						2100
1. \$5 + 5%	35	404	190	662	2,570	70,145
Forestation			68	163	1,141	33,162
Avoided deforestation			122	499	8,034	37,105
2. \$10 + 5%	70	807	327	880	24,917	96,496
Forestation			108	231	10,123	47,849
Avoided deforestation			219	649	14,796	48,835
3. \$10 + 3%	33	143	212	555	15,628	50,905
Forestation			52	77	4,934	16,358
Avoided deforestation			160	478	10,694	34,547
4. \$20 + 3%	65	286	363	819	28,582	79,559
Forestation			75	135	8,917	28,575
Avoided deforestation			288	684	19,665	50,985
5. \$100 + 0%	100	100	537	866	47,252	78,970
Forestation			83	56	13,587	17,245
Avoided deforestation			454	810	33,665	61,725
6. \$75 + \$5	275	275	664	1081	63,300	113,208
Forestation			192	146	25,675	38,422
Avoided deforestation			501	959	37,625	74,786

Notes: a) Gained amount refers to the cumulative difference between a mitigation scenario and the reference case scenario by 2050 and 2100

b) All carbon prices are zero until 2009, and begin with the stated value in 2010

Results - Global land

Mitigation Options : Long and

Higher the carbon price, larger the gained carbon amount, but paths starting low and rising produce majority of carbon after 2050 and vice versa.

cross scenarios

avoided deforestation

Scenario ^b	Carbon Price (\$/t C)		Benefits Gained (Mt C)			
	2050	2100	2050	2100	2050	2100
2010 C Price + Annual Increase	2050	2100				
1. \$5 + 5%	35	35	122	499	8,034	37,105
Forestation					5,554	33,162
Avoided deforestation						
2. \$10 + 5%	70	807	327	880	24,917	96,496
Forestation			108	231	10,123	47,849
Avoided deforestation			219	649	14,796	48,835
3. \$10 + 3%	33	143	212	555	15,628	50,905
Forestation			52	77	4,934	16,358
Avoided deforestation			160	478	10,694	34,547
4. \$20 + 3%	65	286	363	819	28,582	79,559
Forestation			75	135	8,917	28,575
Avoided deforestation			288	684	19,665	50,985
5. \$100 + 0%	100	100	537	866	47,252	78,970
Forestation			83	56	13,587	17,245
Avoided deforestation			454	810	33,665	61,725
6. \$75 + \$5	275	275	664	1081	63,300	113,208
Forestation			192	146	25,675	38,422
Avoided deforestation			501	959	37,625	74,786

Notes: a) Gained amount refers to the cumulative difference between a mitigation scenario and the reference case scenario by 2050 and 2100
 b) All carbon prices are zero until 2009, and begin with the stated value in 2010

Results - Global land area

Avoided deforestation accounts from 51% to 78% of gained 2100 carbon depending on the carbon price and path.

cross scenarios

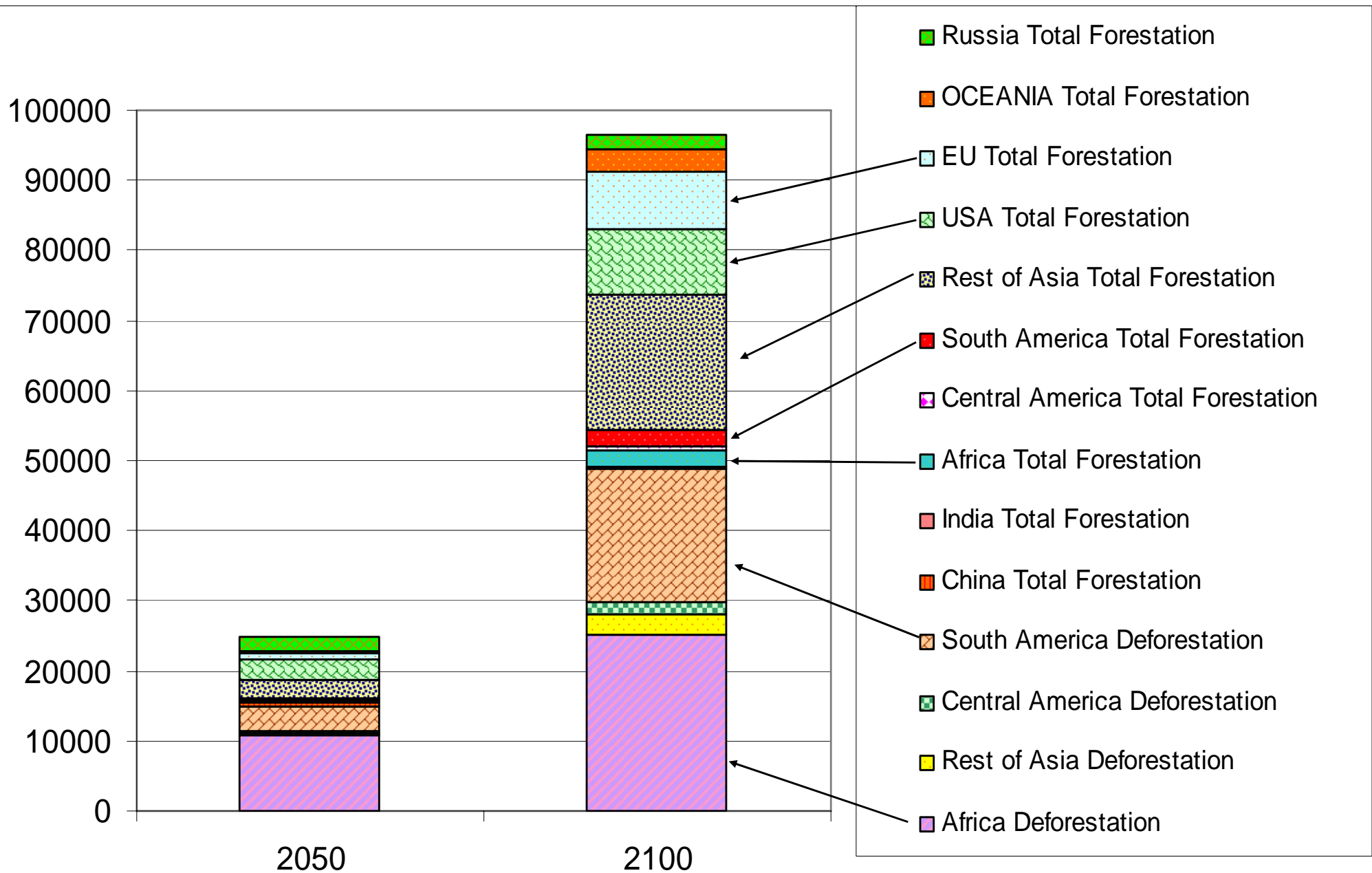
Mitigation Options : Long and s

avoided deforestation

Scenario ^b	Carbon Price (\$/t C)		Benefits Gained (Mt C)			
	2050	2100	2050	2100	2050	2100
2010 C Price + Annual Increase						
1. \$5 + 5%	35	404			13,570	70,145
Forestation					5,554	33,162
Avoided deforestation			122	499	8,034	37,105
2. \$10 + 5%	70	807	327	880	24,917	96,496
Forestation			108	231	10,123	47,849
Avoided deforestation			219	649	14,796	48,835
3. \$10 + 3%	33	143	212	555	15,628	50,905
Forestation			52	77	4,934	16,358
Avoided deforestation			160	478	10,694	34,547
4. \$20 + 3%	65	286	363	819	28,582	79,559
Forestation			75	135	8,917	28,575
Avoided deforestation			288	684	19,665	50,985
5. \$100 + 0%	100	100	537	866	47,252	78,970
Forestation			83	56	13,587	17,245
Avoided deforestation			454	810	33,665	61,725
6. \$75 + \$5	275	275	664	1081	63,300	113,208
Forestation			192	146	25,675	38,422
Avoided deforestation			501	959	37,625	74,786

Notes: a) Gained amount refers to the cumulative difference between a mitigation scenario and the reference case scenario by 2050 and 2100
 b) All carbon prices are zero until 2009, and begin with the stated value in 2010

Scenario 2 (\$10+5%/year): Regional Contribution to Carbon Gain in 2050 and 2100



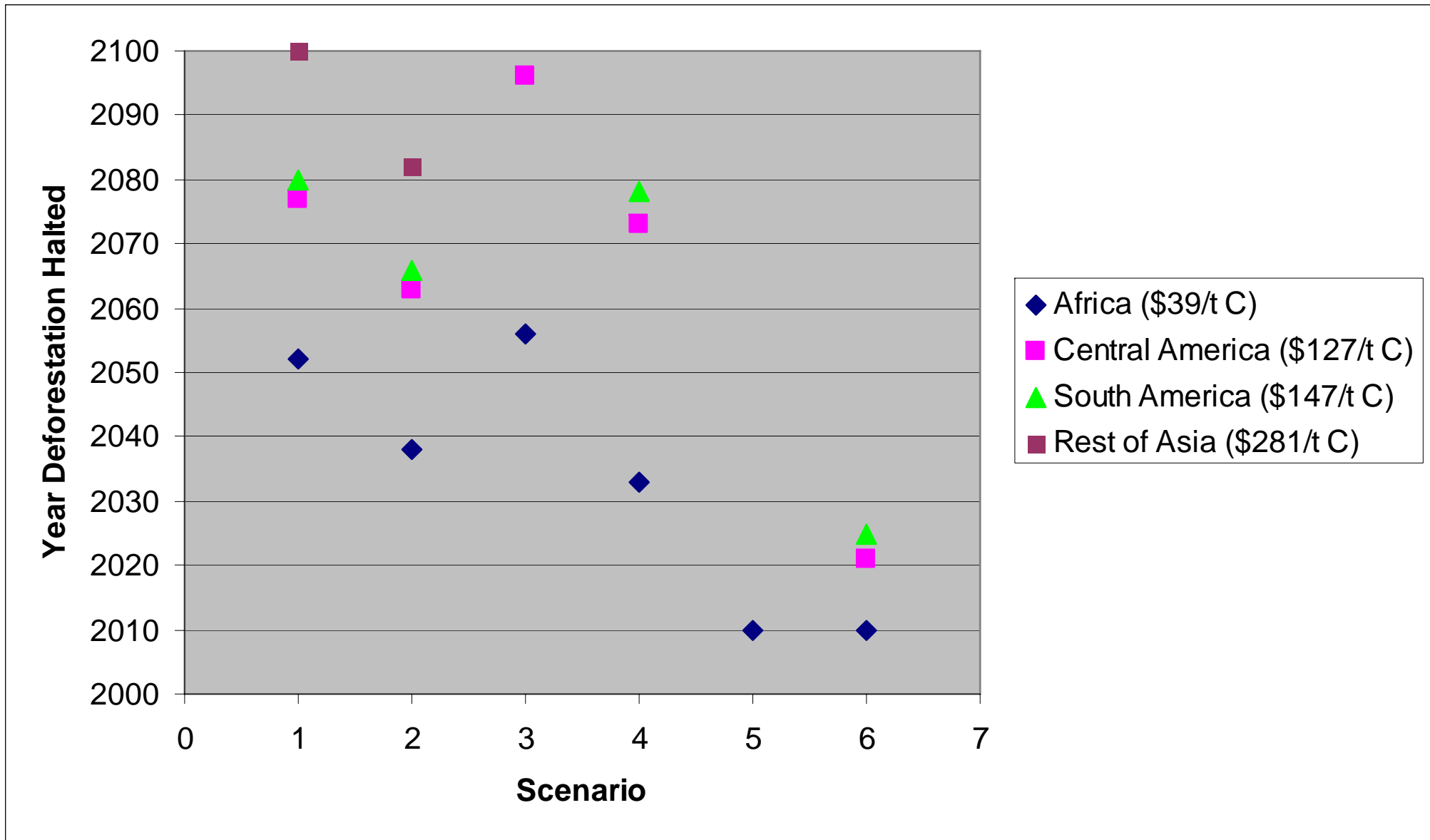
*Carbon price to virtually stop deforestation
(i.e., C price > opportunity cost) varies across the
tropics*

- Carbon price to halt deforestation depends on opportunity cost of land and products
 - Timber products fetch higher prices than land or other products
 - Higher the timber revenue higher the carbon price required to slow or avoid deforestation

- Feasibility of stopping deforestation complicated by many barriers.

Region	Carbon price to virtually stop deforestation (\$/ t C)
Africa	\$ 39
Central America	\$ 127
South America	\$ 147
Rest of Asia (Asia without China and India)	\$ 281

Deforestation virtually halted – Dates by 4 regions and 6 scenarios



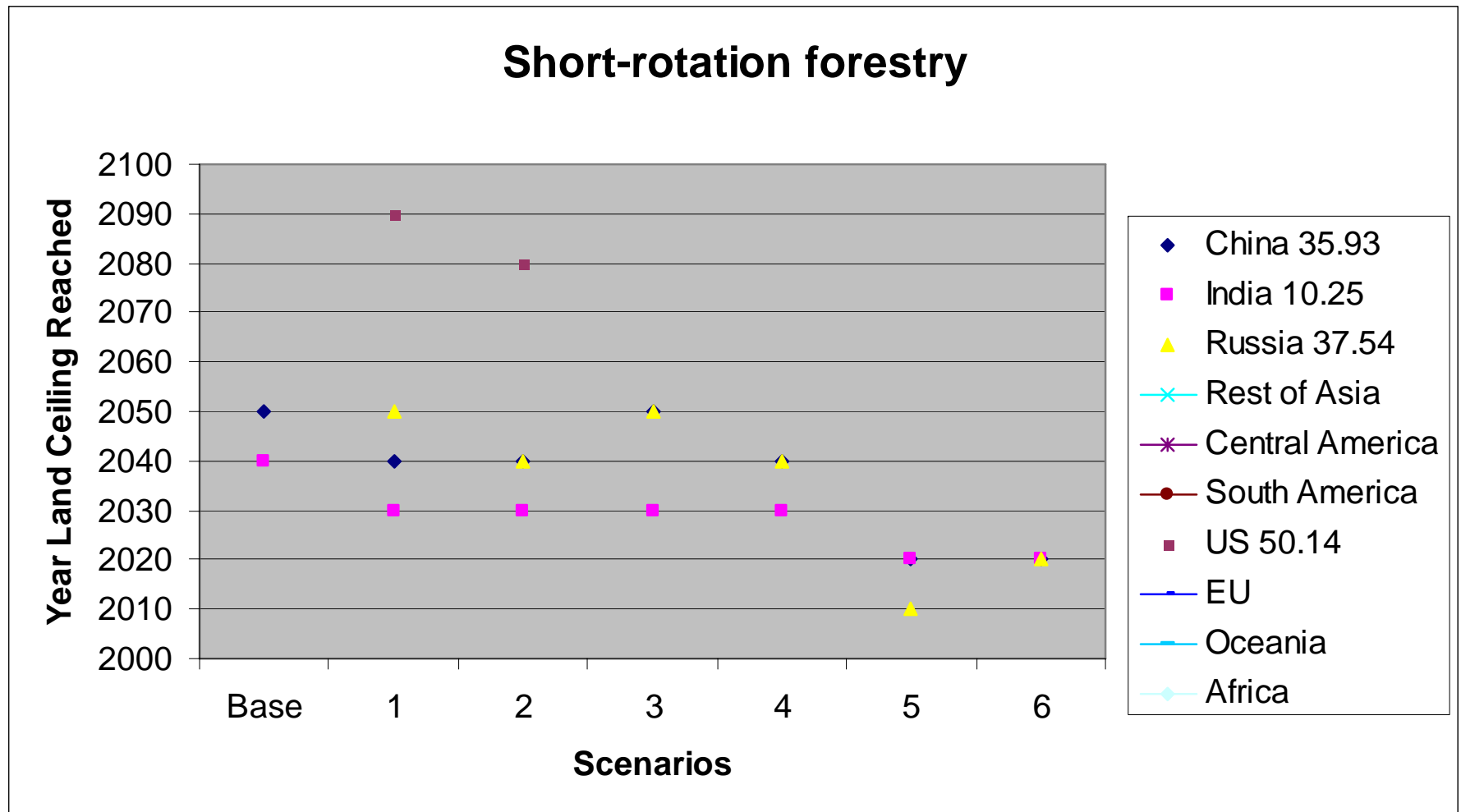
Caps on land suitable for forestation limits the full benefit of the carbon price in several regions

Land availability for forestation varies by region and

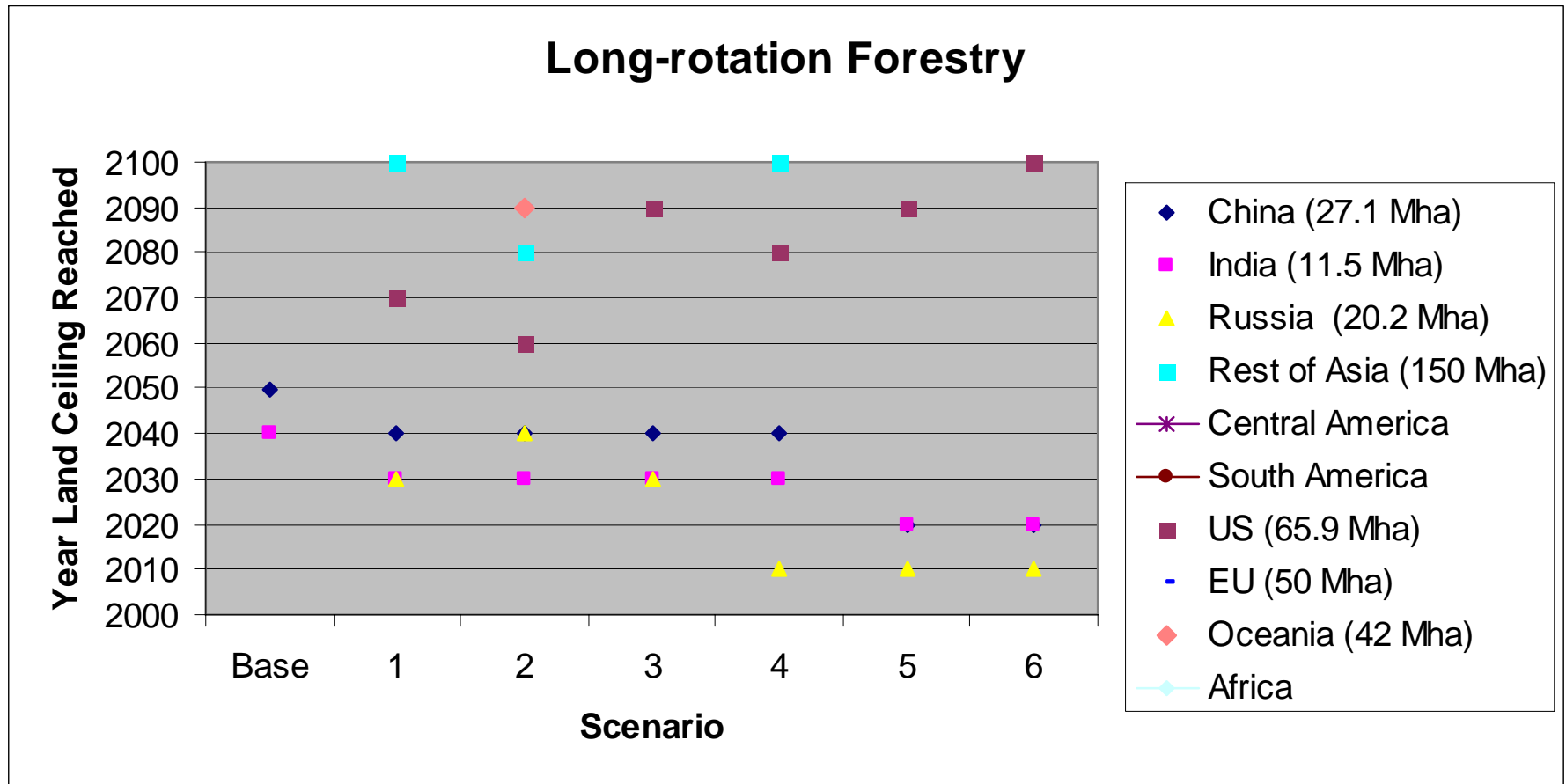
Regions	Short-rotation Mha	Long-rotation Mha	Comments
Africa	80.0	120.0	Grassland, abandoned ag. land, and some deforested land.
China	35.9	27.1	Based on China's short, medium, and long-term expansion plans
India	10.2	11.5	Government forestry plans to 2020
Russia	37.5	20.2	Doubled current afforestation rate-- half the available land
Rest of Asia	50.0	150.0	Degraded forest land and waste land.
Central America	6.5	15.0	Degraded forest land and waste land.
South America	50.0	150.0	Degraded forest land and waste land.
United States	50.1	65.9	Dry and wet soil pasture and cropland and non-grazing forests by 9 US regions
European Union	40.0	50.0	Forestry, cropland and agricultural land
Oceania	28.0	42.0	Australia plans, New Zealand FAO 2050 scenario, and Japan and PNG estimated areas
TOTAL	388.3	651.7	

Yellow highlighted figures show regions where land cap was reached in at least one scenario

Carbon price effect is mitigated since land area ceiling is reached before 2100 in a few regions

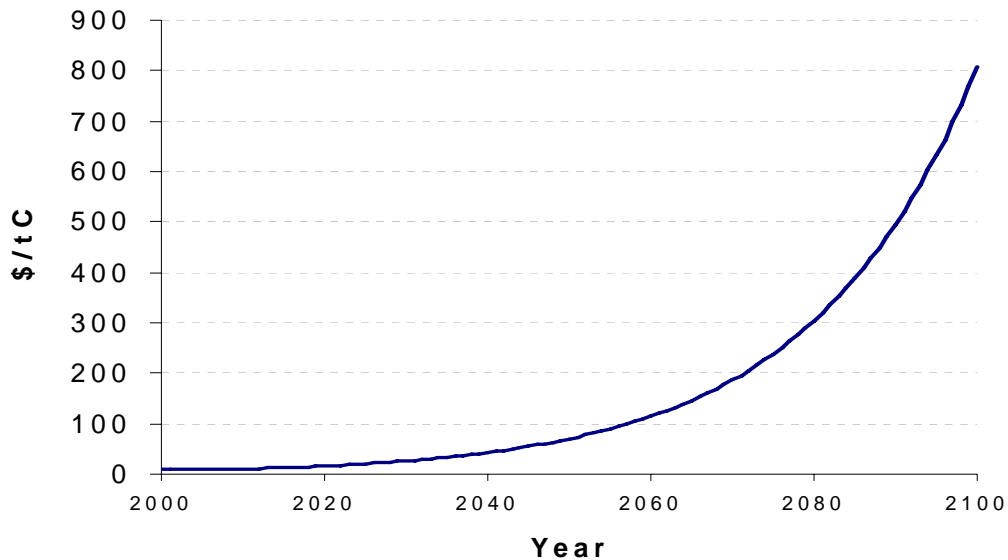


Carbon price benefit is mitigated since land area ceiling is reached before 2100 in some regions

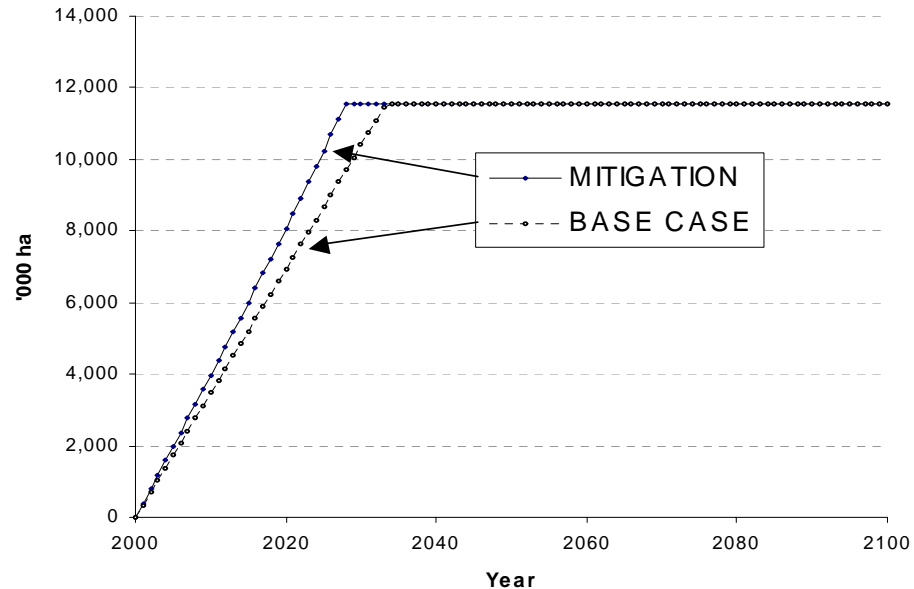


Base Case 1990-2000 - All planting Rates (thousands ha/yr) :
India - 350; China - 615; Rest of Asia - 1,100; Africa - 115;
Central America - 60; S America - 80

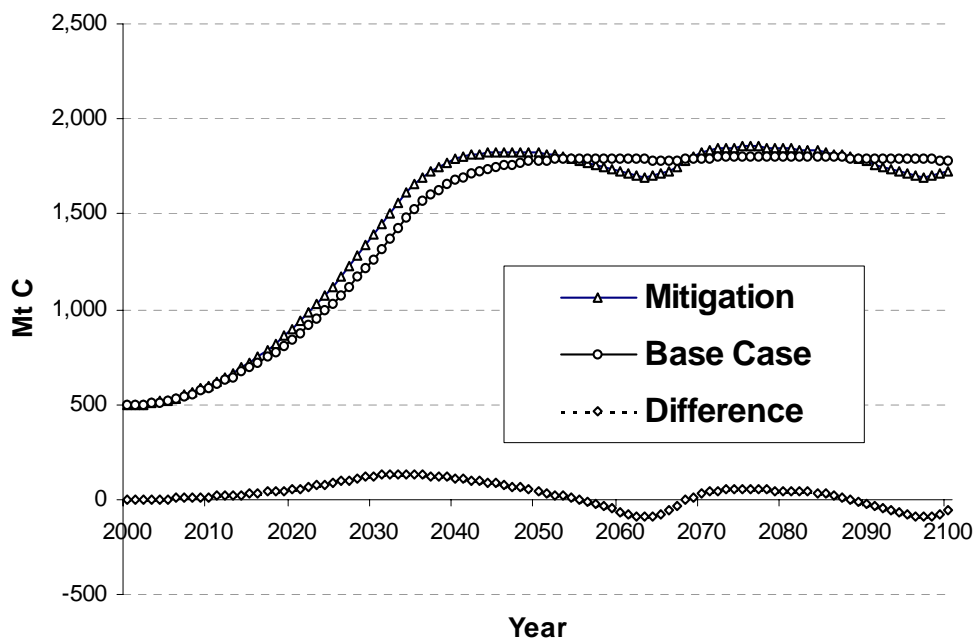
Carbon Price Scenario



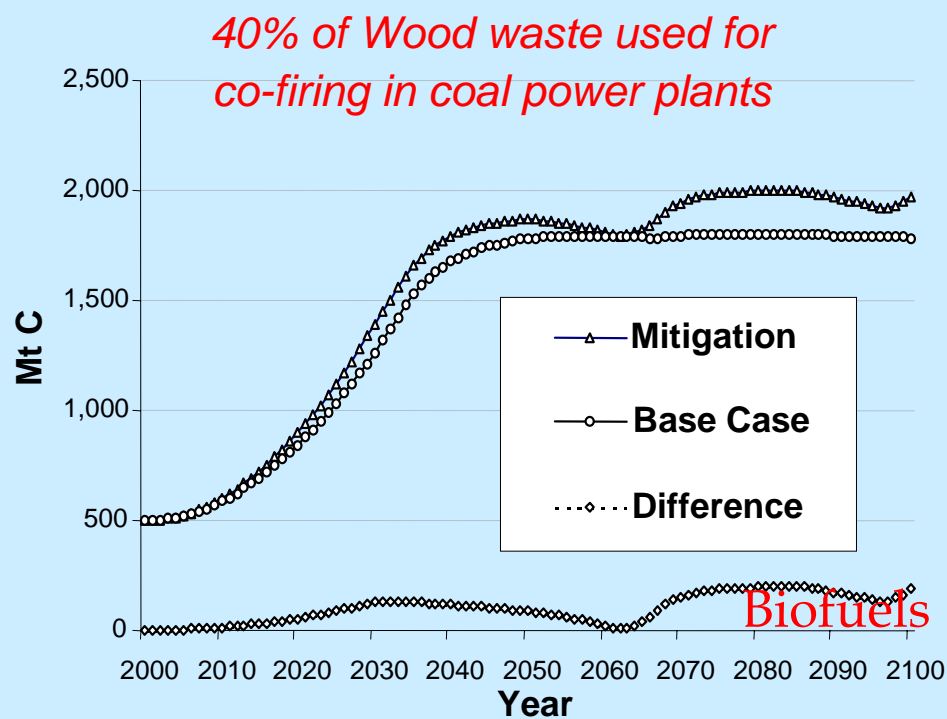
Cumulative Land Area for LR Forestation



No Biofuel -- Carbon Stock on Planted and Suitable Land and in Products



With Biofuel -- Carbon Stock on Planted and Suitable Land and in Products



Summary and Conclusions

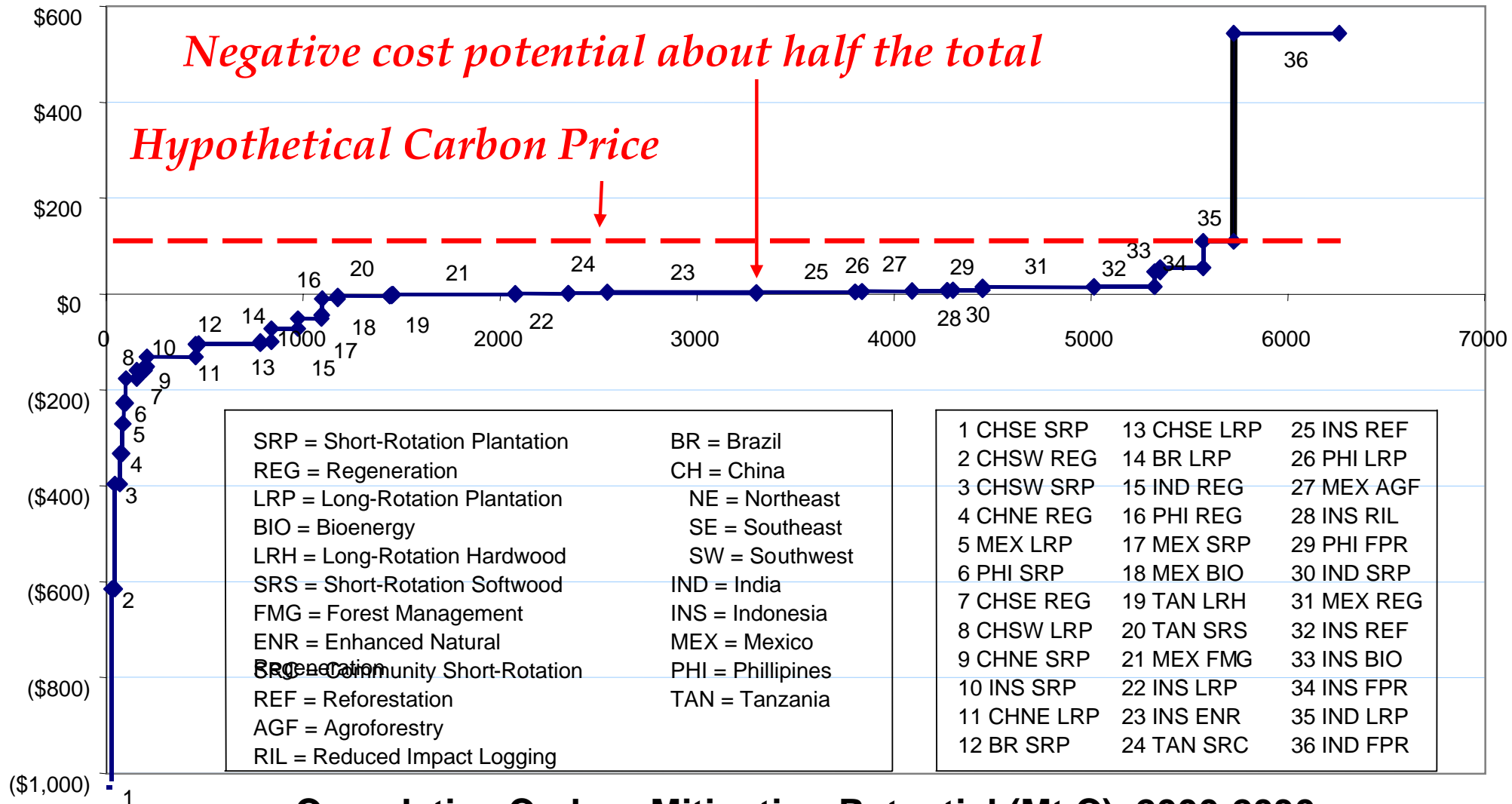
- **Sequestered carbon and avoided emissions:**
 - IPCC SAR estimate: 60 – 80 Gt C
 - This study: 11 – 58 Gt C by 2050, and 43 – 103 Gt C by 2100
 - Quantity depends on reference case forestation and deforestation and on carbon price and path
 - Land availability limits planting in China, India, Russia, and US in many scenarios, and in Oceania and Rest of Asia in some scenarios
 - Biofuels could significantly increase the above values
- Carbon price could virtually halt deforestation in Africa and Latin America in all scenarios, and in Asia in the high priced scenarios

*Barriers, Transaction Costs and
Opportunities: Focus on Forestry Projects*

COMAP: Forestry Mitigation Potential

(Brazil, China, India, Indonesia, Mexico, Philippines and Tanzania)

Cost (\$/ t C) DR = 8-12%



Cumulative Carbon Mitigation Potential (Mt C), 2000-2030

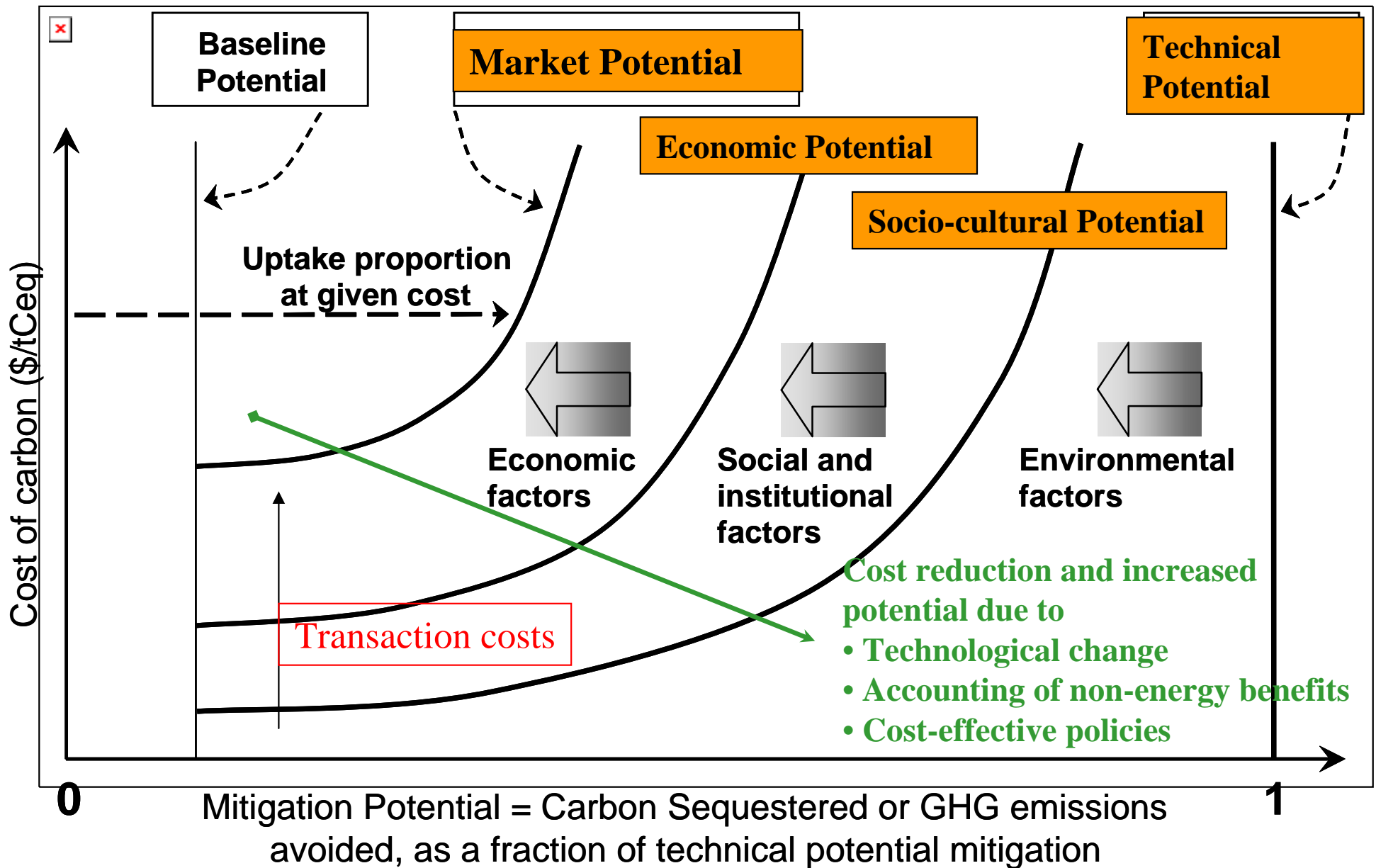
Source: 1. Sathaye J. Makundi W., Andrasko K. Boer R., Ravindranath N.H., Sudha P., Rao S., Lasco R., Pulhin F., Masera O., Ceron A., Ordonez J., Deying X., Zhang X., and Zuomin S. 2001. Carbon mitigation potential and costs of forestry options in Brazil, China, India, Indonesia, Mexico, the Philippines, and Tanzania. *Mitigation and Adaptation Strategies for Global Change*, Vol. 6. Nos. 3-4, pp. 185-211.

Bottom-up Models: How to explain negative cost results?

- Factors that could increase costs:
 - Transaction costs
 - Hidden costs, such as the risks of using a new technology
 - Rebound effect
 - Real preferences of consumers
- Factors that could reduce costs:
 - Technological change over time
 - Complete accounting of benefits
 - Policies that remove costlier barriers

Effects of economic, environmental and social-institutional factors on mitigation costs and potential

(based on Raupach et al. 2004)



Cost of Carbon Benefit (CCB): Accounting for Changes in Costs and Increased Carbon Benefit

$$CCB = \frac{I \cdot q + M}{CB}$$

$$q = \frac{d}{(1 - (1 + d)^{-n})}$$

where:

CCB = Cost of carbon benefits for a forestry option, in \$/t C

I = Capital cost (\$)

q = Capital recovery factor

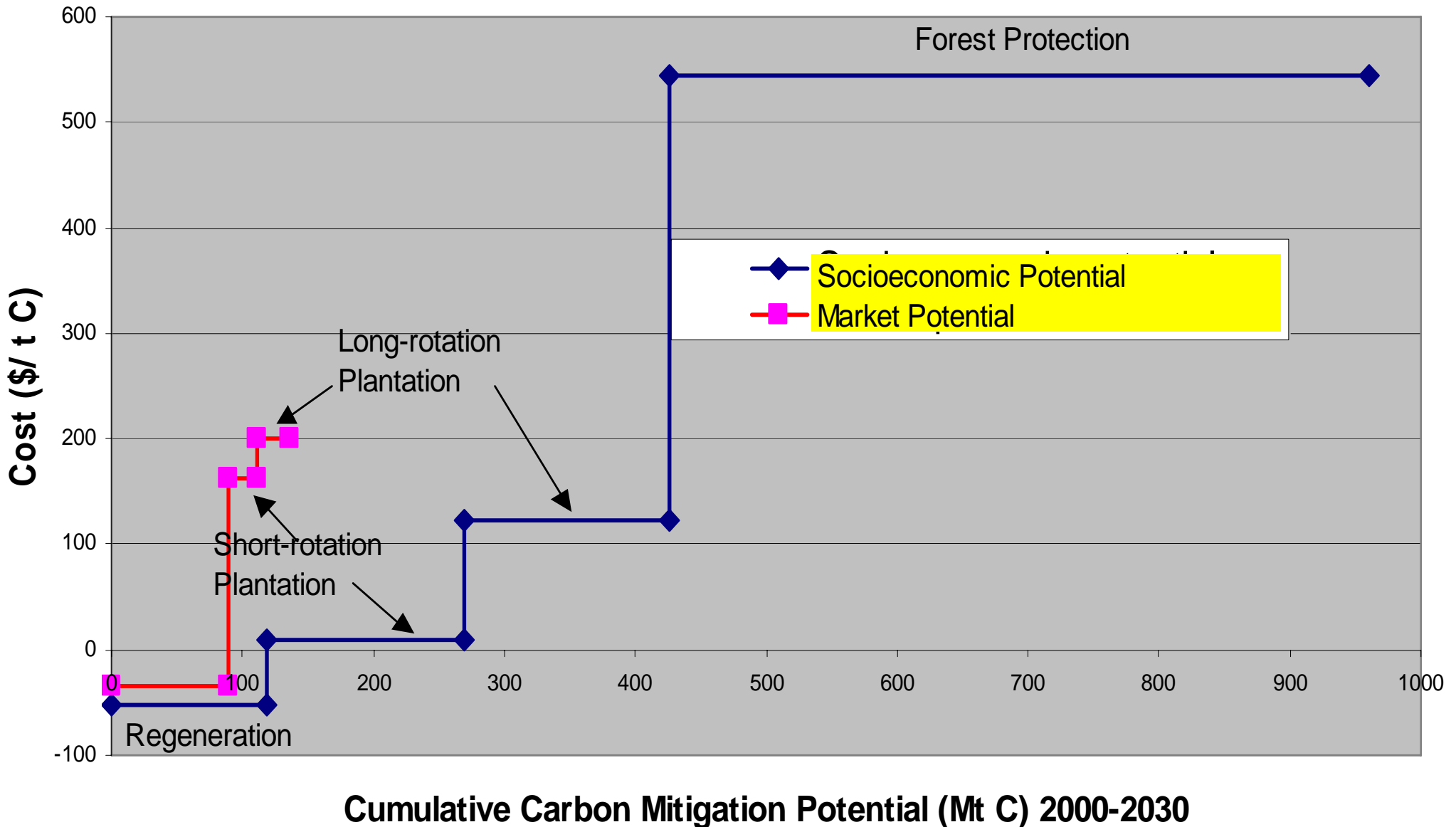
M = Annual change in labor, material and other costs, and monetizable benefits (\$)

CB = Annual carbon benefit (t C)

d = discount rate

n = lifetime of the forestry option (years)

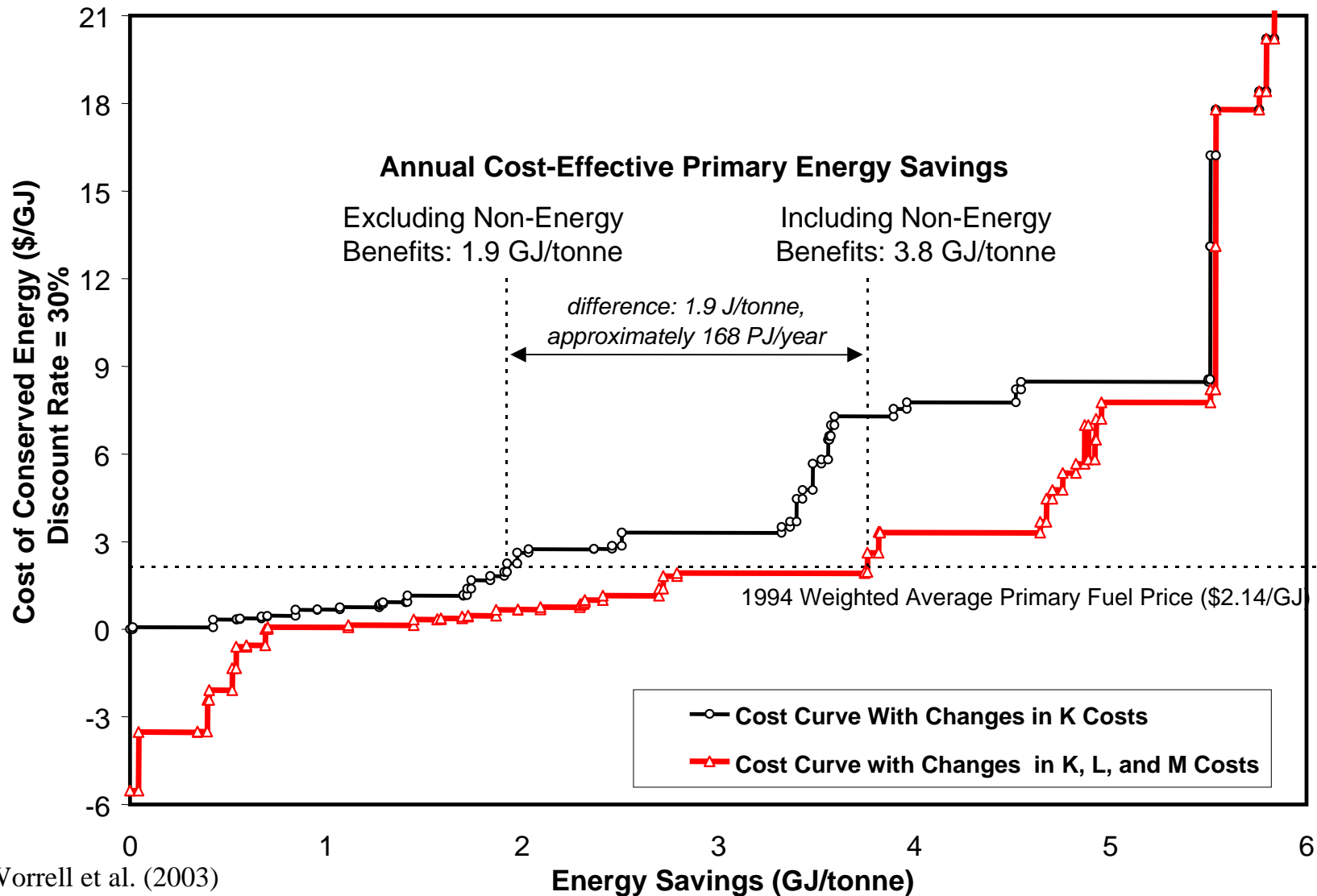
Forestry Mitigation Options With and Without Barriers, India: Preliminary COMAP Results



Key Barriers: Absence of organized markets, long distance to market, lack of access to credit, long gestation period, poor seed quality and inadequate fertilizer inputs,

US Steel Industry Supply Curves: Accounting for Changes in Capital, Labor, and Material Costs

Benefits double cost effective energy efficiency potential to 19%



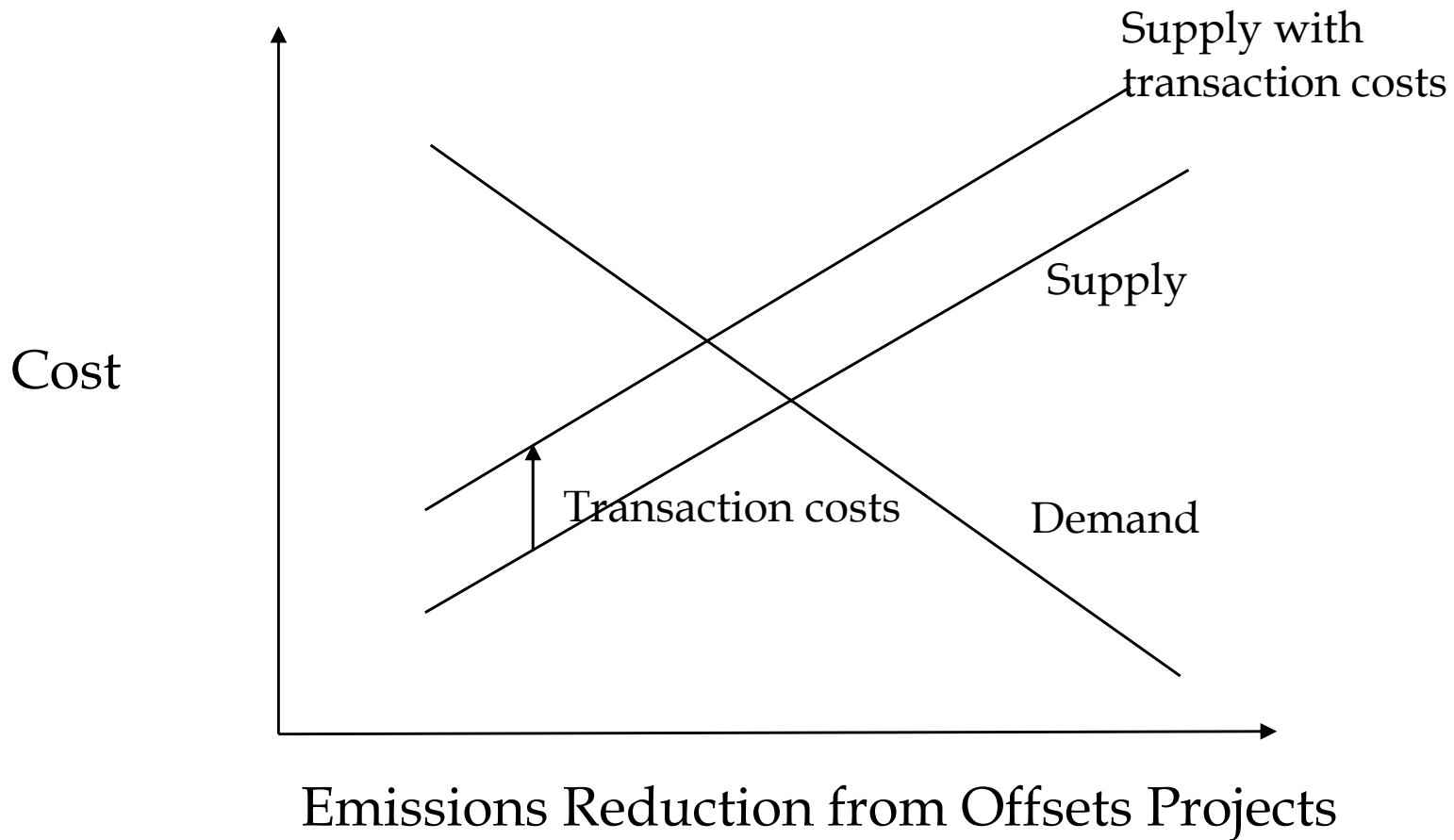
Source: Worrell et al. (2003)

Effect of Accounting for Changes in L and M Costs on Cost-Effectiveness and Ranking of Measures

Measure	With Energy (E) Benefit Only			With K,L,E, M Benefits		
	CCE (\$/GJ)	Rank (of 47)	Cost- Effective?	CCE (\$/GJ)	Rank (of 47)	Cost- Effective?
Inj. of NG – 140	3.1	19	NO	-0.5	8	YES
Coal inj. – 225	3.9	22	NO	1	23	YES
Coal inj. – 130	4.4	23	NO	0.1	11	YES
DC-Arc furnace	5	26	NO	-1.3	6	YES
Process control	5.6	27	NO	-2.1	5	YES
Scrap preheating	6.7	31	NO	-0.6	7	YES
Thin slab casting	8.5	35	NO	1.9	27	YES
Hot charging	8.9	36	NO	5.3	35	NO
FUCHS furnace	12.7	37	NO	-3.5	3	YES
Adopt cont. cast	14.3	39	NO	-3.5	2	YES
Twin shell	16.6	40	NO	3.3	30	NO
Oxy-fuel burners	17.4	41	NO	-5.5	1	YES
Bottom stirring	20.5	45	NO	-2.4	4	YES
Foamy slag	30.1	46	NO	7.2	40	NO

NOTE: These cost of conserved energy (CCE) and cost-effectiveness calculations are based on a discount rate of 30% and an average primary energy price of \$2.14/GJ.

Transaction Costs Influence Supply of Offsets Emissions Credits



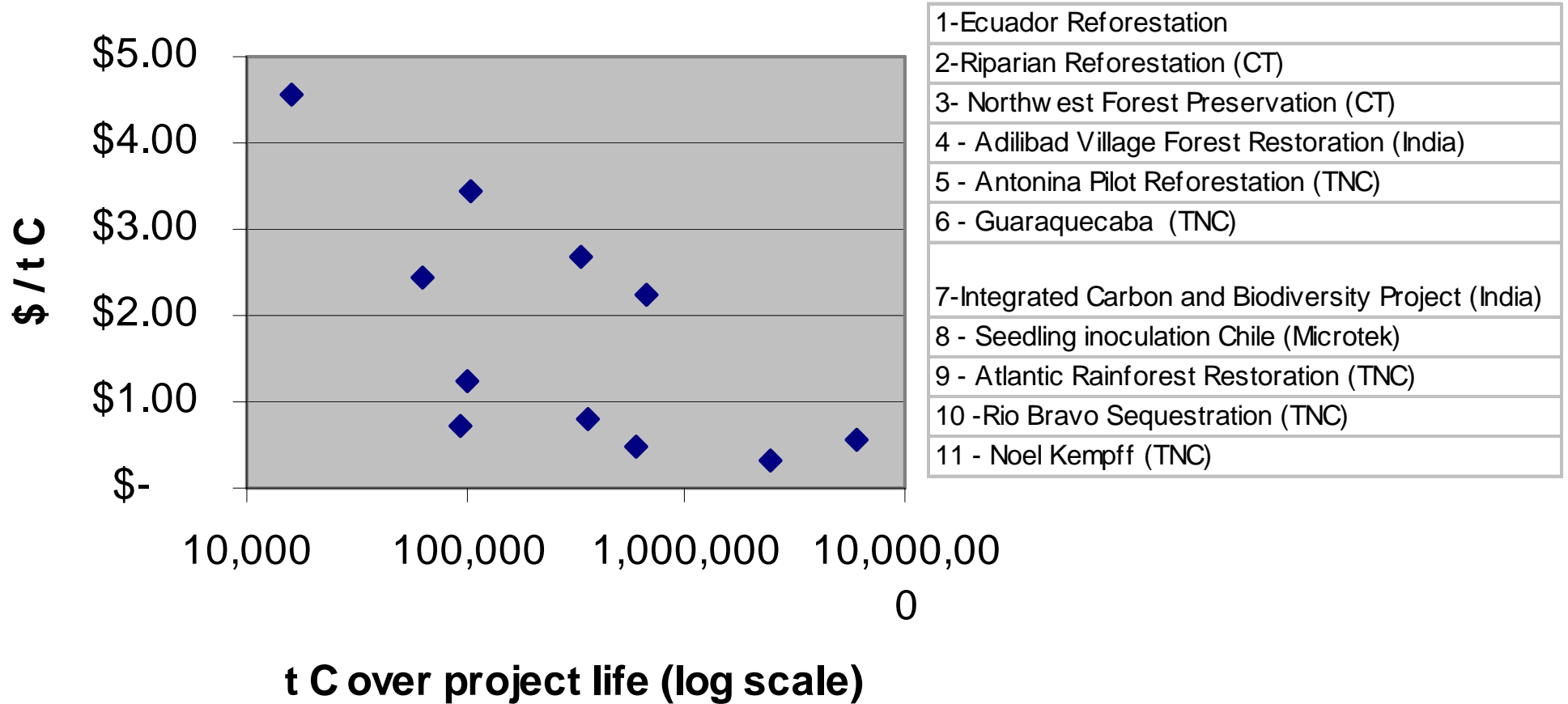
Transaction Cost Components

- Project search costs – Identification and stakeholder consultation
 - May be spread over many projects
- Feasibility studies costs – engineering, economic, and environmental assessments
 - GHG Baseline estimation and establishing additionality
- Negotiations costs – obtaining permits, negotiating and enforcing contracts for fuel supply, arranging financing
 - Marketing GHG credits, carbon contracting and enforcement
- Insurance costs – project risk insurance
 - GHG credit insurance (Difficult to get or too expensive today)
- Regulatory approval costs (GHG)
 - Project validation and government review (May include both domestic and international validation costs)
- Monitoring and verification costs (GHG) – During project implementation
 - Monitoring including equipment cost, verification and certification (Spread over many years of project life)

Transaction Costs: Data Sources

- Data Set 1: (26 projects)
 - The Nature Conservancy (Forestry) -- Bolivia, and Brazil
 - Indian Institute of Science (Forestry) , LBNL (Household woodstoves)
 - Oregon Climate Trust (Forestry, energy efficiency, renewable energy)
 - Natural Resources Canada (Forestry)
 - Trexler and Associates (Forestry, methane, large power plants, energy efficiency, carbon capture)
- Data Set 2: (13 projects)
 - Ecofys (renewable energy)
 - Ecoenergy (bagasse cogeneration)
- Data Set 3: (50 projects) -
 - Swedish AII Programme (Energy efficiency and renewable energy)
- Data Set 4: (10 projects)
 - Global Environmental Facility
 - Transportation, energy efficiency, renewable energy

Transaction Cost - Forestry Projects



Source: Data collated by LBNL from 11 international projects of varying sizes

Transaction costs: Work in progress on

- Statistical analysis to determine significant influence on cost components – search, feasibility, insurance, negotiation, regulatory, and monitoring and verification costs, of
 - Project Size
 - Multiple benefits – technology demonstration, social development, other environmental benefits
 - Forestry, energy efficiency, and renewable energy dummies
 - Regional dummies – Asia and Latin America
 - Mature vs. nascent markets
 - Smaller size projects

*India:
Case studies and mitigation analysis*



Technical Cooperation with Experts and Via Bilateral Relationships is Critical

- **FORCLIMIT: Forestry and Climate Change Mitigation Network, EPA & LBNL with in-country institutes & government**
- **2000-02: Indonesia, Philippines, and Malaysia:**
 - Tech transfer & training in LBNL sinks models: COMAP.
 - Mitigation cost curves, by in-country experts
 - 2-3 stakeholder dialogs on policy & project issues: govt., private industry, NGOs, academics. Foreign experts.
 - Publication of results.
- **2002-to date: FORCLIMIT-India**
- **Proposal: FORCLIMIT-Mexico**
 - Same activities as above, or as agreed with country.

India – FORCLIMIT Organization

- An activity in the US-India bilateral climate change program
- Project Steering Committee:
 - Min. of Environment and Forests – Mr. Verma, Joint Secretary (International Cooperation) as Chairman, and xx, Deputy Inspector General of Forests as Secretary
 - US EPA – Ken Andrasko
 - Indian research institutions – Mr. R.P.S. Katwal, Director, Indian Council for Forestry Research and Education (ICFRE), Dehradun, and Prof. N.H. Ravindranath, Indian Institute of Science (IISC), Bangalore
 - US research institution – Dr. Jayant Sathaye, Lawrence Berkeley National Laboratory, Berkeley

FORCLMIT-India Network: Objectives and Accomplishments

- Improve national-level assessment of forestry mitigation opportunities and potential for India
 - Paper by IISc on gaps and areas requiring improvement of a national assessment (completed)
- State-level assessment of mitigation opportunities, costs, issues, 2 states: Karnataka & Uttaranchal.
- Develop case studies of mitigation projects:
 - Village-level studies: Kolar district, Karnataka, and Bazpur and xx, Uttaranchal (completed)
 - Industry-collaborative studies: ITC Industries, Andhra Pradesh, and Neyvelli Lignite, xx (ongoing)
 - Training program in the use of Procomap model (completed)
- Dialog by government, private, NGO, academic, and local stakeholders on technical & institutional issues
 - Workshops in Delhi (Sept. 2002), Bangalore (July 2003), and Delhi (April 2004)
 - Steering Committee meetings on the above dates, and in the interim about every three months
- Publish results: peer-reviewed international & Indian journals
 - Case study reports being prepared for submission to Miti special issue
- Network Website: <http://ces.iisc.ernet.in/climatechange/>

*FORCLMIT-India Network:
Case Studies: Identify and Mobilize Cost-
Effective, Credible Sequestration Activities*

- Assess data availability and needs
- Identify promising options and regions
- Assess technical issues: additionality, baseline setting, leakage, monitoring, and duration, transaction costs
- Estimate costs of project carbon sequestration under different carbon price scenarios
- Identify co-benefits and co-effects of options: How do they affect farmers? Water quality? Wildlife? Barriers? Biodiversity index?

FORCLMIT-India Network: Kolar Case Study Description

- South India – Kolar District, Karnataka
 - A community forestry (8,625 ha) afforestation and reforestation project, planting on community grazing land, and degraded forest land, short rotation trees and fruit orchards; and
 - A private farm forestry (5,380 ha) project in 30 villages – cropland bund and block planting, long and short rotation trees and fruit orchard
- Baseline – established using historical data on afforestation and farm forestry planting for above activities; most of the carbon is in soil (from 31-46 t C/ha depending on type of land)

FORCLMIT-India Network: Kolar Case Study

Key Findings: Land category and area proposed for project activities

Option	Land category proposed	Total potential area (ha)	Area proposed (ha)	Project activities	Area (ha) dedicated for each option ^c	Phasing
Community forestry	Community grazing land & Degraded forestland	15755 ^a	8636 ^b	Short rotation	2500 (29%)	5
				Fruit orchard	6125 (71%)	5
Farm forestry	Cropland bund planting	39363	3960	Long rotation + Fruit orchard	3960 (60% orchard & 40% teak)	3
	Cropland block planting		1420	Short rotation	228 (16%)	1
				Long rotation	128 (9%)	1
				Fruit orchard	1065 (75%)	3

a includes 7498 ha of community grazing land and 8257 ha of degraded forestland

b includes 3524 ha of community grazing land and 5112 ha of degraded forestland, based on community decision

c number in parenthesis indicates the percent area allocated for different options

FORCLMIT-India Network: Kolar Case Study

Key Findings: Estimated carbon stock

- Carbon stock determined through primary data collection – sampling, plot design, and vegetation and soil carbon measurement

Location	Annual aboveground biomass growth rate (t/ha/year)	Soil organic carbon (tC/ha)	Rate of carbon uptake in soil* (t/ha/yr)
COMMUNITY FORESTRY			
<i>Baseline (Wasteland)</i>	0.01	37.48±7.12	-
<i>Eucalyptus spp.</i>	4.0±0.5	48.30	0.51
<i>Mangifera indica</i>	1.41±0.35	46.42±1.53	0.40±0.94
FARM FORESTRY (Block Plantation)			
Baseline		36.27	
Fruit Orchard (Mango + Tamarind)	2.50±0.86	44.49±4.18	0.58±0.72
<i>Eucalyptus spp.</i>	5.35±2.22	43.99±3.59	0.94±0.12
<i>Tectona grandis</i>	5.00	43.15	0.36
FARM FORESTRY (Bund Plantation)			
Baseline	-	31.01	-
<i>Tectona grandis</i> + Mango	0.3	41.82±1.72	0.46±0.08

FORCLMIT-India Network: Kolar Case Study

Key Findings: Input data for PROCOMAP Model

Input data for PROCOMAP Model

Activity	Aboveground biomass growth rate (t/ha/yr)	Below ground biomass (t/ha/yr)*	Soil organic carbon uptake (tC/ha/yr)**	Rotation period (years)	Life of harvested product (years)***	Litter decomposition t/ha/yr
COMMUNITY FORESTRY						
Short Rotation	4.00	1.04	0.51	8	5	0.22
Fruit orchard	1.41	0.36	0.40	-	-	0.25
FARM FORESTRY (Block Planting)						
Short Rotation	5.35	1.39	0.94	6	5	0.22
Long Rotation < 20 years > 20 years	5.0 2.5	1.3	0.36	25	25	-
Fruit orchard	2.5	0.65	0.58	-	-	0.25
FARM FORESTRY (Bund Planting)						
Long rotation+fruit orchard	0.3	0.07	0.46	30	25	-

FORCLMIT-India Network: Kolar Case Study

Key Findings: Investment indicators

Investment indicators of mitigation options
(2005-2035 at 8% discount rate)

Option	Present value of initial cost/ha	Present value of initial cost/tC	Life cycle cost Rs/tC	Life cycle cost (Rs/ha)	Net present value of benefits Rs/tC	Net present value of benefits Rs/ha.	Internal rate of return	Benefit cost ratio
Short Rotation (CF)	22661	1456	2013	31325	225	3505	9.72%	1.58
Fruit Orchard (CF)	30578	1187	4888	125885	8153	209953	29.65%	3.99
Short Rotation (FF)	22661	1945	4087	47620	2150	25044	16.60%	2.01
Fruit Orchard (FF)	30578	665	2973	136599	5073	233113	29.92%	4.06
Long Rotation (FF)	63716	2271	2800	78558	-1402	-39326	3.99%	2.87
Fruit Orchard + Long Rotation (FF-Bund)	4125	615	3423	22956	1973	13233	29.46%	1.79

CF: Community Forestry; FF: Farm Forestry

Initial and annual costs; include establishment cost for land preparation, nursery, planting, fencing, etc; operation and maintenance cost includes watering, protection etc; harvest and transport cost for activities involving harvesting; silvicultural cost pertaining to costs incurred for weeding, pruning, non-commercial thinning, marking for commercial thinning; recurring costs for administration, monitoring, management, etc; monitoring cost for monitoring biomass growth, soil carbon content, quantity of timber harvested, flow of benefits, etc. for baseline and mitigation scenario.

Flow of benefits: The components of benefits include measurable and monetized benefits, such as timber – sawn logs, chip logs, pulp logs, poles, fuelwood, etc., and Non Timber Forest Products - Resin, gum, honey, fruits, seeds, etc.

FORCLMIT-India Network: Kolar Case Study

Key Findings: Carbon price influence on NPV

Influence of carbon price on NPV (Rs./t C; 2005-2035)

Discount Rate	6%	8%	10%
Short Rotation (Community Forestry)			
Without carbon price	586	225	-31
With carbon pricing @US\$20	1227	804	494
Fruit Orchard (community forestry)			
Without carbon price	12148	8153	5541
With carbon pricing @US\$20	12557	9362	7471
Short Rotation (Farm Forestry)			
Without carbon price	3232	2150	1377
With carbon pricing @US\$20	4310	3196	2382
Long Rotation (Farm Forestry)			
Without carbon price	-885	-1402	-1700
With carbon pricing @US\$20	-17	-607	-980
Carbon price to achieve zero net present value of benefits	938 (US\$21)	1623(US\$35)	2170 (US\$47)
Fruit Orchard (Farm Forestry)			
Without carbon price	7470	5073	3491
With carbon pricing @US\$20	7889	6030	4962
Fruit Orchard + Long Rotation (Farm Forestry-Bund)			
Without carbon price	2748	1973	1435
With carbon pricing @US\$20	3329	2481	1882

FORCLMIT-India Network: Kolar Case Study

Key Findings: Carbon Leakage

Carbon leakage estimated from primary surveys is small (low above ground biomass density; survey shows little or no extraction from farm forestry on reference case plantations)

Option	Total project area (ha)	Annual extraction or loss kg/ha	Total leakage/year (t)	% of total mean annual carbon stock change
Community forestry	8625	10	86.25	0.025%
Farm forestry	5380	-	-	-

FORCLMIT-India Network: Kolar Case Study

Key Findings: Transaction Costs

Transaction Costs for Baseline and Project Proposal Preparation

	Community forestry		Farm forestry	
	Baseline Scenario Development	Project Proposal Preparation	Baseline Scenario Development	Project Proposal Preparation
Ecological	36,000	33,000	2,700	24,000
PRA	2,700	7,500	300	3,000
Laboratory work	10,500	99,000	18,300	165,000
Secondary Data	600		300	
HH survey		16,000		
Land survey-farmer		5,500		3,000
Consultation process, analysis and proposal preparation	27,000	90,000	27,000	90,000
Total for project (Rs.)	76,800	251,000	48,600	285,000
Cost /t of carbon (Rs.)	0.45	1.50	0.65	3.75
Cost /t of carbon (US\$.)	0.01	0.03	0.01	0.08

FORCLMIT-India Network: Kolar Case Study

Key Findings: Biodiversity

Diversity estimates of baseline and project scenarios for community and farm forestry (Shannon Wiener Diversity Index (H') shows project improves biodiversity since multi-species forestry is promoted)

Community Forestry		Farm Forestry			
Baseline scenario	Project scenario	Baseline scenario		Project scenario	
		Bund	Block	Bund	Block
0.32-2.09	2.09	0.0-0.2	-	2.04	1.31

FORCLMIT-India Network: Kolar Case Study

Conclusions

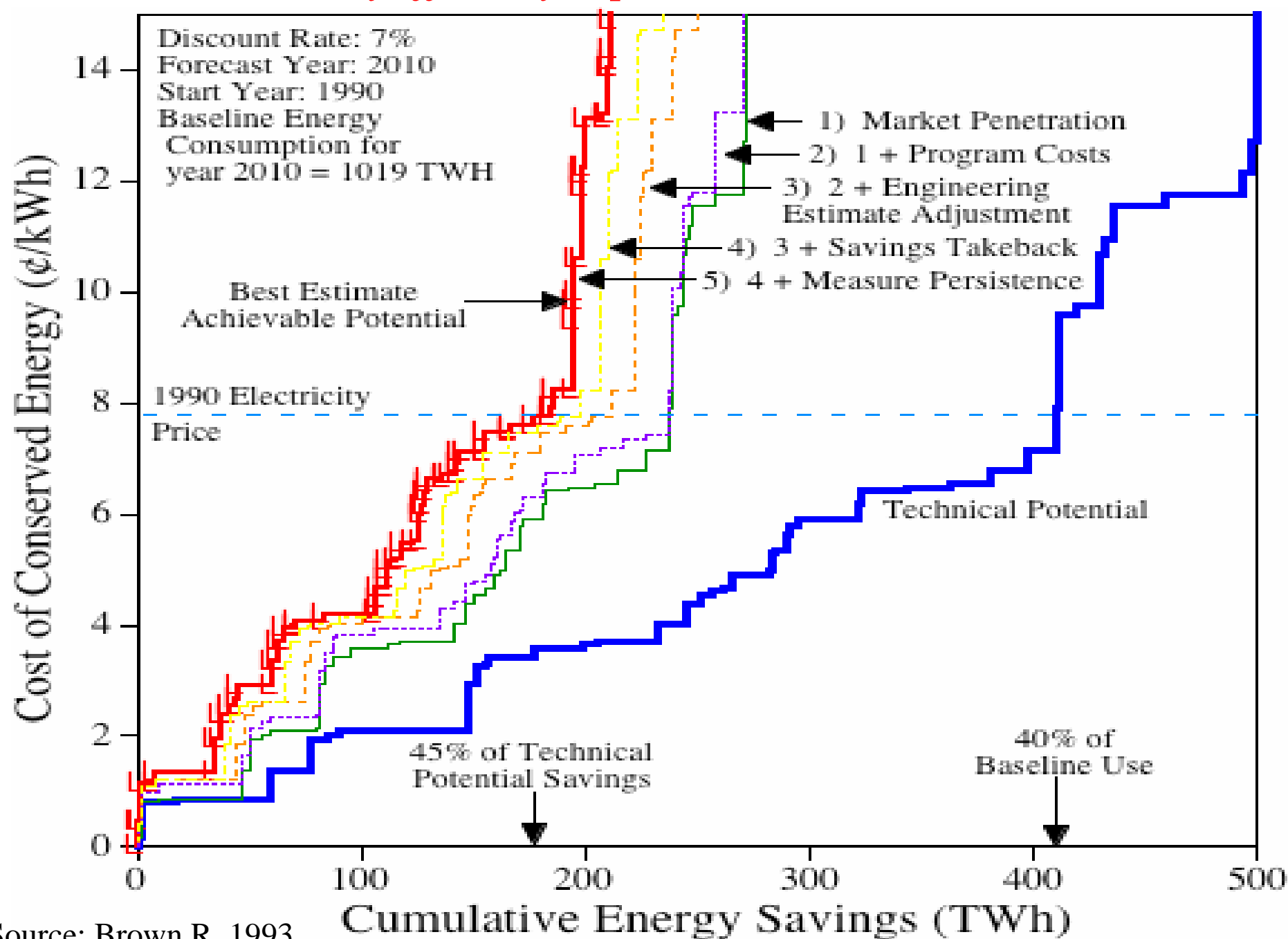
- Estimating carbon pools:
 - Above ground biomass and soil carbon was estimated using standard and reliable field ecological methods
 - Limited methods are available for estimation of below ground biomass and woody litter. Study estimated woody litter through primary data collection, but bgm had to be estimated using a default conversion factor of 0.26
 - Growth rate of baseline carbon pools are not readily available; project had to measure short run changes but may not be applicable over the long term
 - Leakage was not a critical issue, since basecase biomass density and extraction is very low
 - Project improves biodiversity contrary to popular belief
 - Transaction costs of baseline development and project preparation were low

Additional slides



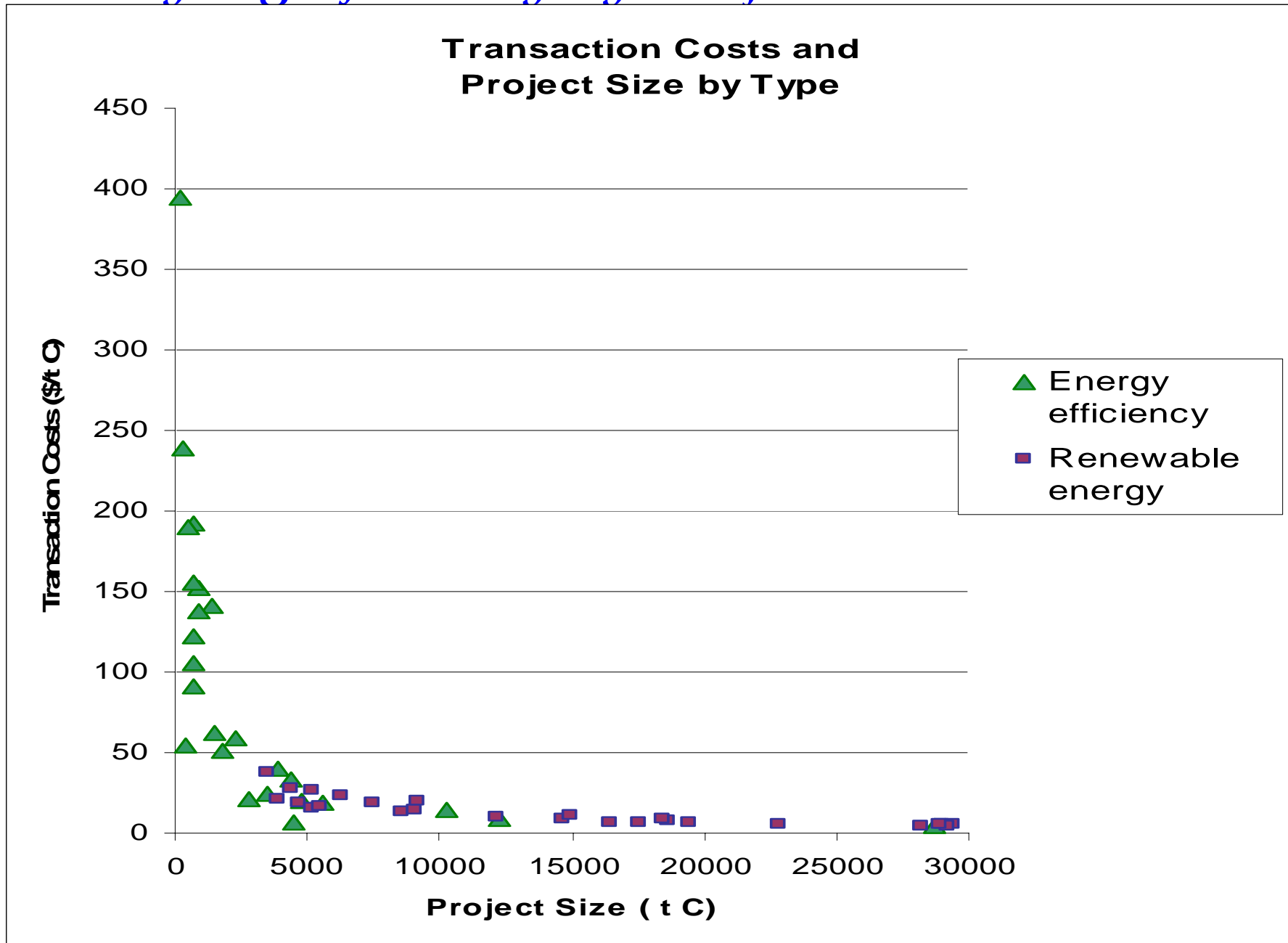
ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

Estimates of the achievable potential for electricity efficiency improvements in US residences



Source: Brown R. 1993

Transaction Costs per t C Vary Significantly by Project Size



Source: Swedish AIJ Projects; technical assistance, follow-up, reporting, and administration costs

Transaction Cost (Other Definitions)

- Direct Costs and Opportunity Costs (Mullins and Baron, 1997):
 - Costs to initiate and complete a trade
 - Loss of time and resources through delay and managerial attention
- Fixed and variable costs (Furubotn and Richter, 1997)
 - Variable costs depend on the number or volume of transactions

planting

Regions	Short-rotation	Long-rotation	Comments
	(Mha)	(Mha)	
Africa	80.0	120.0	50% of the deforested land (4 Mha/yr 1970-2020), the rest from grasslands, woodlands, and abandoned agricultural lands. (FRA 2000, TFRA, 1990, Barraclough and Ghimire, 1986)
China	35.9	27.1	Based on China's short, medium, and long-term expansion plans for timber and non-timber forests by 117 Mha by 2050. (MOF, 2000)
India	10.2	11.5	National Forest Action Plan to increase Indias Forest area by 33% by 2020 (FSI, 1999)
Russia	37.5	20.2	50% of the 115 Mha of the Unforested land under FFS, part of which is currently used for Reforestation (NEAP, 1995 In National Implementation of Agenda 21)
Rest of Asia	50.0	150.0	Degraded forest land and waste land. (FAO, (FRA 2000), FAO, 1992 (TFRA 1990), CIFOR, 2000)
Central America	6.5	15.0	Degraded forest land and waste land. (FAO, (FRA 2000), FAO, 1992 (TFRA 1990), Cairns et al., 1995, Kaimowitz, 1996)
South America	50.0	150.0	Degraded forests, deforested lands and cerrados. (FAO (FRA, 2000; TFRA, 1990), Fearnside, 2001; Cairns et al., 1995.)
United States	50.1	65.9	Dry and wet soil pastureland and cropland and non-grazing forest from 10 US regions. (US Forest Service, 2001; Moulton et al., 1990; 1996, Lubowski et al., 2001)
European Union	40.0	50.0	Abandoned crop and pasturelands and sparse woodlands. (ECE/FAO, 1990, FAO 2000 (GFPOS) FRA 2000, Nilsson et al., 1992)
Oceania	28.0	42.0	Australia wastelands and cropland, NZ FAO 2050 scenario, and Japan sparsely wooded lands, and PNG degraded and deforested land. (ECE/FAO, 1990, TFRA 1990, UNFCCC National Communications, Kirschbaum 2000)



Key Data Inputs: Monetary and Biophysical Data

	<u>Notes</u>	Africa		Central America	
<i>Variable Name</i>		SR	LR	SR	LR
Initial Cost (Land cost + Establishment Cost) (\$/ha)	a	871	1104	415	394
Recurrent Cost (\$/ha/yr)	b	121	116	30	17
Monitoring Cost (\$/ha/yr)	c	0	0	8	24
Harvesting and Transport Cost(\$/m³)	d	38	38	60	80
Timber domestic market price(\$/m³)	e	63	150	35	98
Timber international market price (\$/m³)	f	128	242	65	175
% of timber exported	g	10.5%	26.5%	6.5%	12.3%
Max area dedicated to SR & LR afforestation (Mha)	h	80	120	20	21.5
Area planted so far (Mha)	i	3.3	4.8	0.3	1
Planting rate in base year (Kha/yr)	j	80	115	20.3	61
Base-year Vegetation C-stock(t C/ha)	k	56.8	38.8	30.2	42
Rotation Period (Yrs)	l	13	29	7	20
Mean annual increment (t biomass/ha/yr)	m	29.1	18.5	8.7	4.9
Deforestation rate (Kha/yr)	n	5264		21.4	

Africa

a, b, d: From Makundi, 2001 data for Tanzania, adjusted by wage index for the region.

c: Monitoring is combined with recurrent cost.

e, f: FAO Forest Product Year Book for exports, and GFPOS 1999 for domestic prices.

g: Based on 2000 Export data: FAO, 2003.

h: Deforestation rate of 4 mi ha/ year in the last 30 yrs & next 20. Assume that 50% available for forestation. We also

assume an equivalent area of 100 mi ha of grassland and abandoned agricultural land will also be available for reforestation. Partitioned using weighted average for individual spp plantations in the region: FRA2000.

i: FAO 2000, GFPOS plantation areas of the world

j: .Planting rate 2000 (FAO 2003, Table 4) FAO, 2001 FRA200 Annual Planting for 2000. Past rates have been low so we take the latest as a minimum rate for the future

k: From COMAP runs, 2001 data

l, m: Weighted average for existing plantation species in the region, FAO 2000, GFPOS

n: FAO, 2000 data, average for 1990-2000

Central America

a, b, c: From Fearnside 1995 Brazil data adjusted by wage index for the region.

d: Apply Mexico data: Masera et: 2001.

e, f: From ITTO, Jan1, 2003 Tropical Timber Market Report, Brazil Pine sawlog price.

g: : FAO, 2003 Export data.

h: Degraded lands and deforested lands: FAO, 2001 FRA2000.

i: FAO, 1997, Chapter 3, Table 3-1. Assume 75% was for SR planting.

j: From ITTO Table 6-1, Annual Review, 1990-00 annual planting rate.

k: Fearnside, 1995 Table I for Brazil deforested landscape
l, m: from Masera, 2001 Table IX for Mexico

n: FAO 2000 data, Average for 1980-2000, see Kaimowitz, 1996 for iustification

Key Data Inputs: Monetary and Biophysical Data

China

Variable Name	Notes	China		India	
		SR	LR	SR	LR
Initial Cost (Land cost + Establishment Cost) (\$/ha)	a	245	245	340	778
Recurrent Cost (\$/ha/yr)	b	12	3	19	19
Monitoring Cost (\$/ha/yr)	c	12	3	2	2
Harvesting and Transport Cost(\$/m ³)	d	60	40	49	40
Timber domestic market price(\$/m ³)	e	150	200	123	421
Timber international market price (\$/m ³)	f	250	450	483	915
% of timber exported	g	5.0%	1%	0.5%	0.5%
Max area dedicated to SR & LR afforestation (Mha)	h	35.9	27.1	10.2	11.6
Area planted so far (Mha)	i	27.2	20.5	15.2	16.8
Planting rate in base year (Kha/yr)	j	814	614	307.4	346.6
Base-year Vegetation C-stock(t C/ha)	k	25	25	1	1
Rotation Period (Yrs)	l	15	42	14	34
Mean annual increment					

a, b, c: Weighted average for NE, SE & SW regions (Deying Xu et al, 2001).

d: 40% of the product price goes towards harvesting and transport (Xu & Zhang, 2002).

e, f: FAO Forest Products Year book, 2000 and Xu et al, 2001.

g: Average 1995-2000, FAO 2000, Forest Products Yearbook.

h: Long term plans to add 117 mi ha to Chinas Forestry, of which 63 mi ha will be for timber production. (PEER – Long term nationwide environmental restoration. From I – IV NFRI planting schedules adjusted for survival rate, minus the 11.5 mi ha of non-timber forests e.g. bamboos and orchards.

i: FAO, 2000, GFPOS

j: Current stated planting rate adjusted for survival rate of 80% (Zang, 2001).

k: Original COMAP runs for wastelands.

l, m: Weighted average for individual spp, with LR/SR decided on the basis of rotation age.

India

a: Investment Cost + Discounted value of costs in yrs 1 & 2 – Comap

b: Comap 500 Rs/ha/yr @42Rs/\$, Source: Ravindranath, 2001.

c: Comap 100 Rs/ha/yr @42Rs/\$, 200 rate, Source: Ravindranath, 2001.

d: 40% of millsite domestic log price for SR & 10% of LR price due to smaller size and price differential while cost of operations, machinery and fuel is still as high as that of LR.

e: LR Average Teak, Sal & Shisan, girth 91-120 cm, SR Average Sal, Eucs and Populus in Agra, Chandagar and Ambala.

f: LR Average for Teak, Sal and Shisan Girth 151cm, SR Shorea Robusta at Agra, Barely & Shahampur: Source FRI Market Report, 2000.

g: Average RWE for 1995-2000. India exports 3% of WBP and 1% of Pulp output.

h: National Action Plan propose to increase area under Forest Cover by 33% (21.8 mi ha) over 20 yrs.

i: Sum of all areas under forest plantations up to 2000.

j: Same target as NFAP of 1.09 mi ha/yr, adjusted by survival rate of 60% and existing LR: SR ratios.

k: Mostly, shrub and grass wastelands (Ravindranath, 2001).

l, m: Average for all major spp, weighted by area under each.

	Notes	Rest of Asia		South America		<p style="text-align: center;"><i>Key Data Inputs: Monetary and Biophysical Data</i></p>
<i>Variable Name</i>		<i>SR</i>	<i>LR</i>	<i>SR</i>	<i>LR</i>	
Initial Cost (Land cost + Establishment Cost) (\$/ha)	a	467	1034	716	716	<p style="text-align: center;">Rest of Asia</p> <p>a, b, c, d: Data for Indonesia adjusted by Wage rate index for the region. e, f: FAO, 2000 Indonesia prices. g: FAO 2000 average export data 1995-2000 h: Large area from degraded forests and grasslands, especially in Indonesia, and other SE Asian countries. i: FAO, 2001 j: Average from FAO, 2003 Table VI, State of Forests. k: ITTO Table VI Annual Review 1990-2000. l, m : Weighted. Average for Indonesian plantation species with 75%LR. Assumes Indonesia biomass data is representative of the region. n: FAO, 2000 data, average 1990-2000</p>
Recurrent Cost (\$/ha/yr)	b	13	27	34	30	
Monitoring Cost (\$/ha/yr)	c	39	40	28	24	
Harvesting and Transport Cost(\$/m³)	d	64	64	0	0	
Timber domestic market price(\$/m³)	e	80	161	6	15	
Timber international market price (\$/m³)	f	250	250	6	60	
% of timber exported	g	15%	26.5%	28.1%	16.6%	
Max area dedicated to SR & LR afforestation (mi ha)	h	50	150	150	150	
Area planted so far (mi ha)	i	6.4	19.2	7.8	2.6	
Planting rate in base year (Kha/yr)	j	365	1095	283.5	79.5	
Base-year Vegetation C-stock(t C/ha)	k	74	74	30.2	30.2	
Rotation Period (Yrs)	l	10	35	6	25	
Mean annual increment (t biomass/ha/yr)	m	14	17.6	13	8.6	<p style="text-align: center;">South America</p> <p>a, b, c: Data for Brazil adjusted by wage index for the region: Fearnside, 2001. d: Since the timber price here is stumpage, transport price is excluded. e, f: From ITTO, Jan1, 2003 Tropical Timber Market Report, Brazil Pine sawlog price. g: FAO, 2003 Export data. h: Mostly from deforested lands and cerrados. i: From FAO, 1997, Chapter 3, Table 3-1. Assume 75% was for SR planting. Also, From ITTO Table 6-1, Annual Review, 1990-00 annual planting rate. 75% assumed planted for short rotation. In Brazil 95% was planted in 1995 for SR. k: Fearnside 2001 for Brazil. k: From Fearnside 1995, Biomass and Bioenergy, Table 1. l, m: Fearnside, 1995 B&B -- Time between harvests is 6 years; 3 coppices, 24 year replanting cycle. n: FAO 2000 data, average 1990-2000</p>

	Notes	EU		Oceania	
<i>Variable Name</i>		<i>SR</i>	<i>LR</i>	<i>SR</i>	<i>LR</i>
Initial Cost (Land cost +Establishment Cost) (\$/ha)	a	1068	1068	1598	1897
Recurrent Cost (\$/ha/yr)	b	80	80	11	11
Monitoring Cost (\$/ha/yr)	c	13	13	1	1
Harvesting and Transport Cost (\$/m³)	d	42	42	7	7
Timber domestic market price (\$/m³)	e	127	93	27	53
Timber international market price (\$/m³)	f	160	110	53	86
% of timber exported	g	52%	52%	38%	38%
Max area dedicated to SR&LR afforestation (Mha)	h	40	50	28	42
Area planted so far (Mha)	i	3	6.1	71	106.4
Planting rate in base year (Kha/yr)	j	63.7	148.6	3	10.7
Base-year Vegetation C-stock (t C/ha)	k	59	8.8	64	64
Rotation Period (Yrs)	l	45	100	19	44
Mean annual increment (t biomass/ha/vr)	M	11.6	6.9	18.5	10.1

Key Data Inputs: Monetary and Biophysical Data

EU

a, b, c: Based on EU agricultural subsidy data for land rental. FAO,2000 (GFPOS, 1999).

d: Assumed same as US.

e, f: Timber trade statistics, FAO,2000 FP Yearbook data.

g: Average standing biomass in EU forestlands and LR in sparsely wooded lands: ECE/FAO 1992.

h: LR is average for woodland, pastureland and cropland, SR average for European forestland.

I: Weighted average of RWE of IRW, SW, WBP, PaP & PaPB for 2000.

j: Average 1995-2000: FAO FP Yearbook.

k: EU has woodlands estimated at 133 mi ha.

l: Land planted since 1930.

m: Average rate between 1975-1995.

Oceania

a: Includes land rental and establishment cost: Australia and NZ estimates.

b, c: Average from other regions: Sathaye et al 2001.

d: Average for 100 km average distance in Australia: Arthur Lyons, 1998.

e: Average for NZ on South and North island.

f: Export price for IRW for Australia.

g: ECE/FAO, 1992.

h, i: Average for spp in Australia and NZ.

j: Average RWE for 2000. FAO, 2000 (FP Yearbook).

k: Assume 20% of Australia sparse forest area, with the rest from croplands and grasslands. PNG from deforested lands and 5 mi ha each from NZ and Japan.

l: Average planting rate 1970-1990.

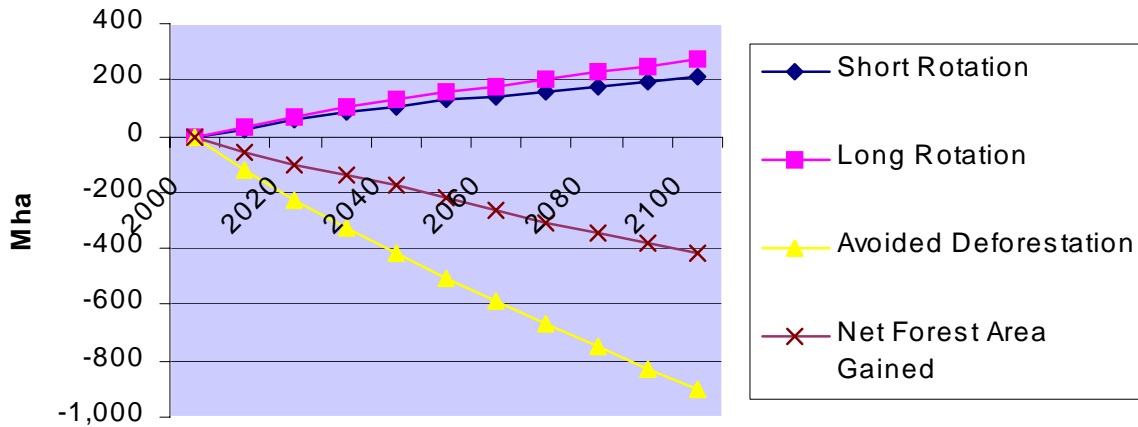
m: FAO, 2000 (Global Timber Outlook).

	Notes	Russia		USA		Key Data Inputs: Monetary and Biophysical Data
Variable Name		SR	LR	SR	LR	
Initial Cost (Land cost + Establishment Cost) (\$/ha)	a	123	123	1744	2277	Russia a: Based on cost data from Khosika Project and Petrov, 2000 (CIFOR). b, d: Data from Vologda Rusafor Project afforested 93 & 94. c: Excludes project development monitoring cost. e, f: Petrov for exports CIF Finland millgate, with FAO FP Yearbook.
Recurrent Cost (\$/ha/yr)	b	1	1	30	29	g, h: US Country Study Final Report, (Izrael and Avdjushin, 1997).
Monitoring Cost (\$/ha/yr)	c	1	1	13	13	I: From Russian Forestry Handbook, 1995 and Israel and Avdjushin, 1997.
Harvesting and Transport Cost (\$/m ³)	d	16	16	42	42	j: FAO, 2000 FP Yearbook data for 2000.
Timber domestic market price (\$/m ³)	e	49	20	127	93	k: 50% of the unforested land under FFS (degraded from past activities). l: PV@7% of weighted average of land rental and establishment cost compiled from data for Cropland & Pasture on Wet soils and all non-grazing forestland from the major land use regions in US, i.e., NE, Appalachian, SE, Lake States, Corn Belt, Delta States, Northern Plains, Southern Plains Mountain and Pacific.
Timber international market price (\$/m ³)	f	78	31	160	110	USA m: Average of land rental and establishment cost compiled from data for Cropland & Pasture on Wet soils and all non-grazing forestland from the major land use regions in US, i.e., NE, Appalachian, SE, Lake States, Corn Belt, Delta States, Northern Plains, Southern Plains Mountain and Pacific.
% of timber exported	g	27%	30%	16%	16%	n: Average of land rental and establishment cost compiled from data for Cropland & Pasture on Wet soils and all non-grazing forestland from the major land use regions in US, i.e., NE, Appalachian, SE, Lake States, Corn Belt, Delta States, Northern Plains, Southern Plains Mountain and Pacific.
Max area dedicated to SR&LR afforestation (Mha)	h	37.5	20.2	50.1	65.9	o: Average of land rental and establishment cost compiled from data for Cropland & Pasture on Wet soils and all non-grazing forestland from the major land use regions in US, i.e., NE, Appalachian, SE, Lake States, Corn Belt, Delta States, Northern Plains, Southern Plains Mountain and Pacific.
Area planted so far (Mha)	i	7.4	4	18.2	24.1	p: Average of land rental and establishment cost compiled from data for Cropland & Pasture on Wet soils and all non-grazing forestland from the major land use regions in US, i.e., NE, Appalachian, SE, Lake States, Corn Belt, Delta States, Northern Plains, Southern Plains Mountain and Pacific.
Planting rate in base year (Kha/yr)	j	371	200	417.3	548.6	q: Average of land rental and establishment cost compiled from data for Cropland & Pasture on Wet soils and all non-grazing forestland from the major land use regions in US, i.e., NE, Appalachian, SE, Lake States, Corn Belt, Delta States, Northern Plains, Southern Plains Mountain and Pacific.
Base-year Vegetation C-stock (t C/ha)	k	21	21	8.8	8.8	r: Average of land rental and establishment cost compiled from data for Cropland & Pasture on Wet soils and all non-grazing forestland from the major land use regions in US, i.e., NE, Appalachian, SE, Lake States, Corn Belt, Delta States, Northern Plains, Southern Plains Mountain and Pacific.
Rotation Period (Yrs)	l	60	100	45	100	s: Average of land rental and establishment cost compiled from data for Cropland & Pasture on Wet soils and all non-grazing forestland from the major land use regions in US, i.e., NE, Appalachian, SE, Lake States, Corn Belt, Delta States, Northern Plains, Southern Plains Mountain and Pacific.
Mean annual						t: Average of land rental and establishment cost compiled from data for Cropland & Pasture on Wet soils and all non-grazing forestland from the major land use regions in US, i.e., NE, Appalachian, SE, Lake States, Corn Belt, Delta States, Northern Plains, Southern Plains Mountain and Pacific.

Key Data Inputs: Elasticity Values

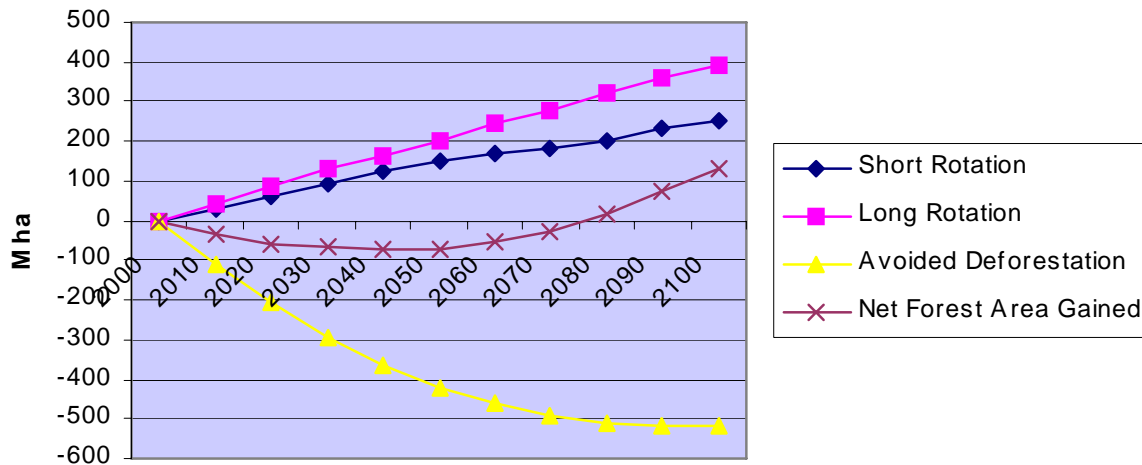
<i>Elasticities</i>	<i>Values</i>	<i>Sources</i>
Timber supply price elasticity	0.49	Adams, MacCarl, Farouk et al, 1988
Timber domestic demand price elasticity	-1.0	McKillop, 1977, Robinson, 1976.
Timber international demand price elasticity	30	Makundi, 1990

Reference Land Use (Cumulative)
Scenario 1 -- \$5 + 5%/year



Reference: Net forest area declines through 2100

Mitigation Land Use (Cumulative)
Scenario 1 -- \$5 + 5%/year



Mitigation: Decline is halted in 2080. Paths and dates vary by scenario.

South and Central America and Africa account for bulk of carbon avoided from deforestation

Scenario 2 -- \$10 + 5% /year						
	2050	2100	2050	2100	2050	2100
	(Mt C)	(Mt C)	(%)	(%)	(%)	(%)
Africa	6,806	16,222	63%	41%	42%	100%
Rest of Asia	400	3,001	4%	8%	13%	100%
Central America	350	1,639	3%	4%	21%	100%
South America	3,305	19,130	30%	48%	17%	100%
WORLD TOTAL	10,862	39,992	10,862	39,992	27%	100%
Scenario 5 -- \$100 /t C Constant						
	2050	2100	2050	2100	2050	2100
	(Mt C)	(Mt C)	(%)	(%)	(%)	(%)
Africa	12,923	22,360	45%	43%	58%	100%
Rest of Asia	1,650	2,877	6%	6%	57%	100%
Central America	1,455	2,406	5%	5%	60%	100%
South America	12,753	24,289	44%	47%	53%	100%
WORLD TOTAL	28,780	51,932	28,780	51,932	55%	100%

Short-rotation: Russia C gain important up to 2050, other regions by 2100

	Scenario 2 -- \$10 + 5%/year					
	2050	2100	2050	2100	2050	2100
	(Mt C)	(Mt C)	(%)	(%)	(%)	(%)
Africa	55	686	3%	8%	8%	100%
China	121	-38	6%	0%	-323%	100%
India	16	-15	1%	0%	-109%	100%
Russia	880	165	45%	2%	533%	100%
Rest of Asia	210	2,444	11%	27%	9%	100%
Central America	1	13	0%	0%	5%	100%
South America	196	1,548	10%	17%	13%	100%
USA	278	1,703	14%	19%	16%	100%
EU	102	1,226	5%	14%	8%	100%
Oceania	101	1,262	5%	14%	8%	100%
WORLD TOTAL	1,960	8,994	1,960	8,994	22%	100%

	Scenario 5 -- \$100 /t C Constant					
	2050	2100	2050	2100	2050	2100
	(Mt C)	(Mt C)	(%)	(%)	(%)	(%)
Africa	156	187	4%	6%	83%	100%
China	140	-56	3%	-2%	-249%	100%
India	7	7	0%	0%	101%	100%
Russia	1,906	536	45%	16%	356%	100%
Rest of Asia	454	469	11%	14%	97%	100%
Central Am	1	5	0%	0%	27%	100%
South Ame	340	593	8%	18%	57%	100%
USA	825	957	19%	29%	86%	100%
EU	299	321	7%	10%	93%	100%
Oceania	139	260	3%	8%	54%	100%
WORLD TOT	4,268	3,278	4,268	3,278	130%	100%

South and Central America and Africa account for bulk of carbon avoided from deforestation

Scenario 2 -- \$10 + 5% /year						
	2050	2100	2050	2100	2050	2100
	(Mt C)	(Mt C)	(%)	(%)	(%)	(%)
Africa	6,806	16,222	63%	41%	42%	100%
Rest of Asia	400	3,001	4%	8%	13%	100%
Central America	350	1,639	3%	4%	21%	100%
South America	3,305	19,130	30%	48%	17%	100%
WORLD TOTAL	10,862	39,992	10,862	39,992	27%	100%
Scenario 5 -- \$100 /t C Constant						
	2050	2100	2050	2100	2050	2100
	(Mt C)	(Mt C)	(%)	(%)	(%)	(%)
Africa	12,923	22,360	45%	43%	58%	100%
Rest of Asia	1,650	2,877	6%	6%	57%	100%
Central America	1,455	2,406	5%	5%	60%	100%
South America	12,753	24,289	44%	47%	53%	100%
WORLD TOTAL	28,780	51,932	28,780	51,932	55%	100%