Implications of CO_2 fertilization for global forests and industries

Joseph Buongiorno

University of Wisconsin-Madison

Background

CO_2 emissions =>

- (-) Climate change
- (+) Fertilization

Objectives

CO_2 Fertilization

⇓

Forest Growth

Wood supply

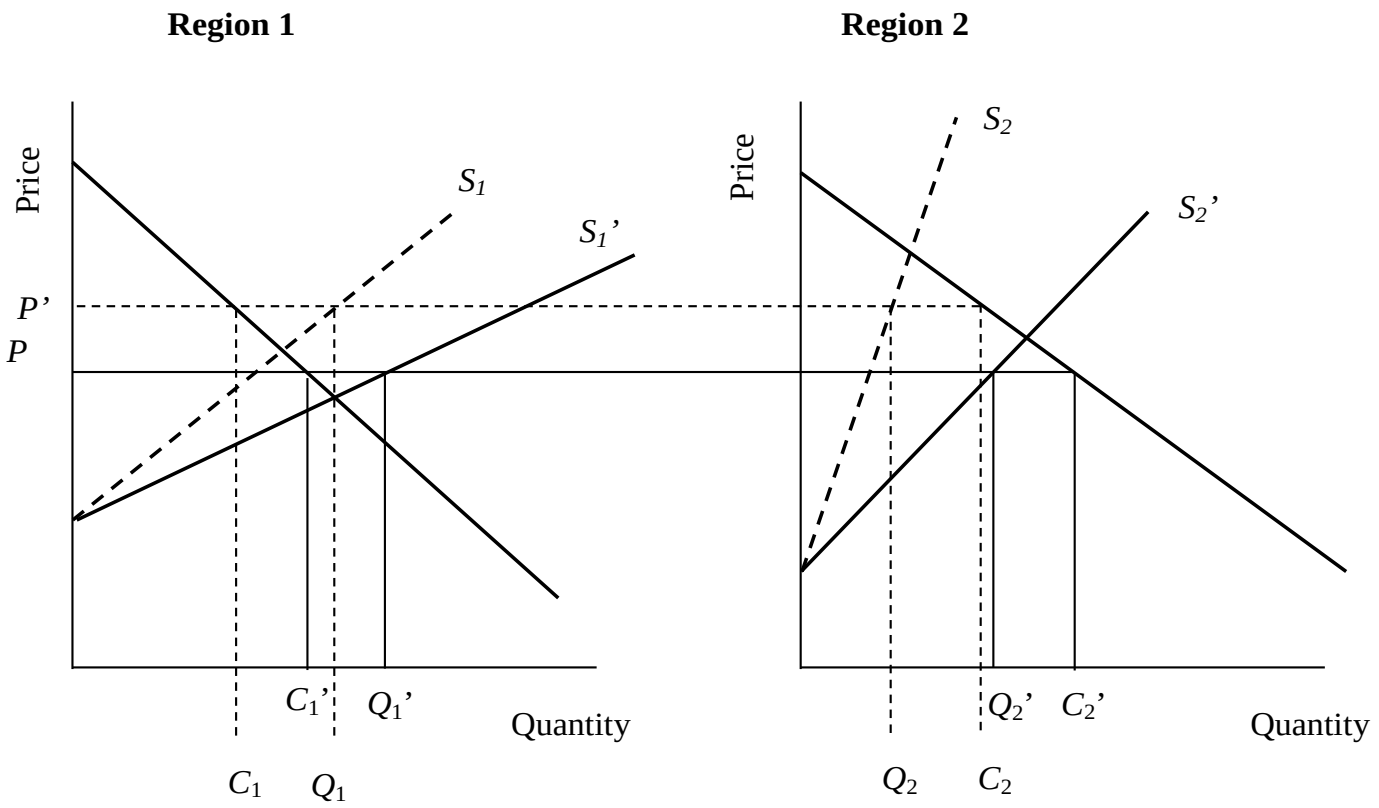
Prices

Consumption & Production

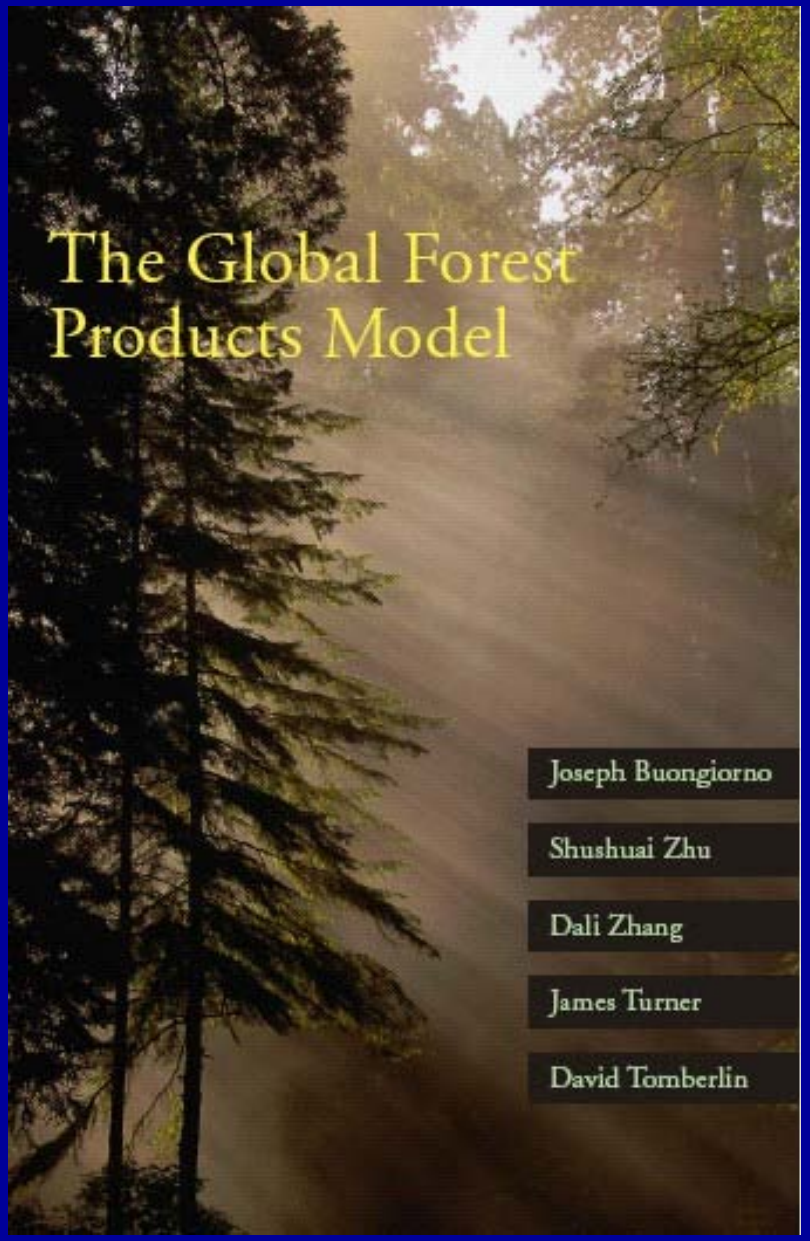
Trade

Forest stock

Theory

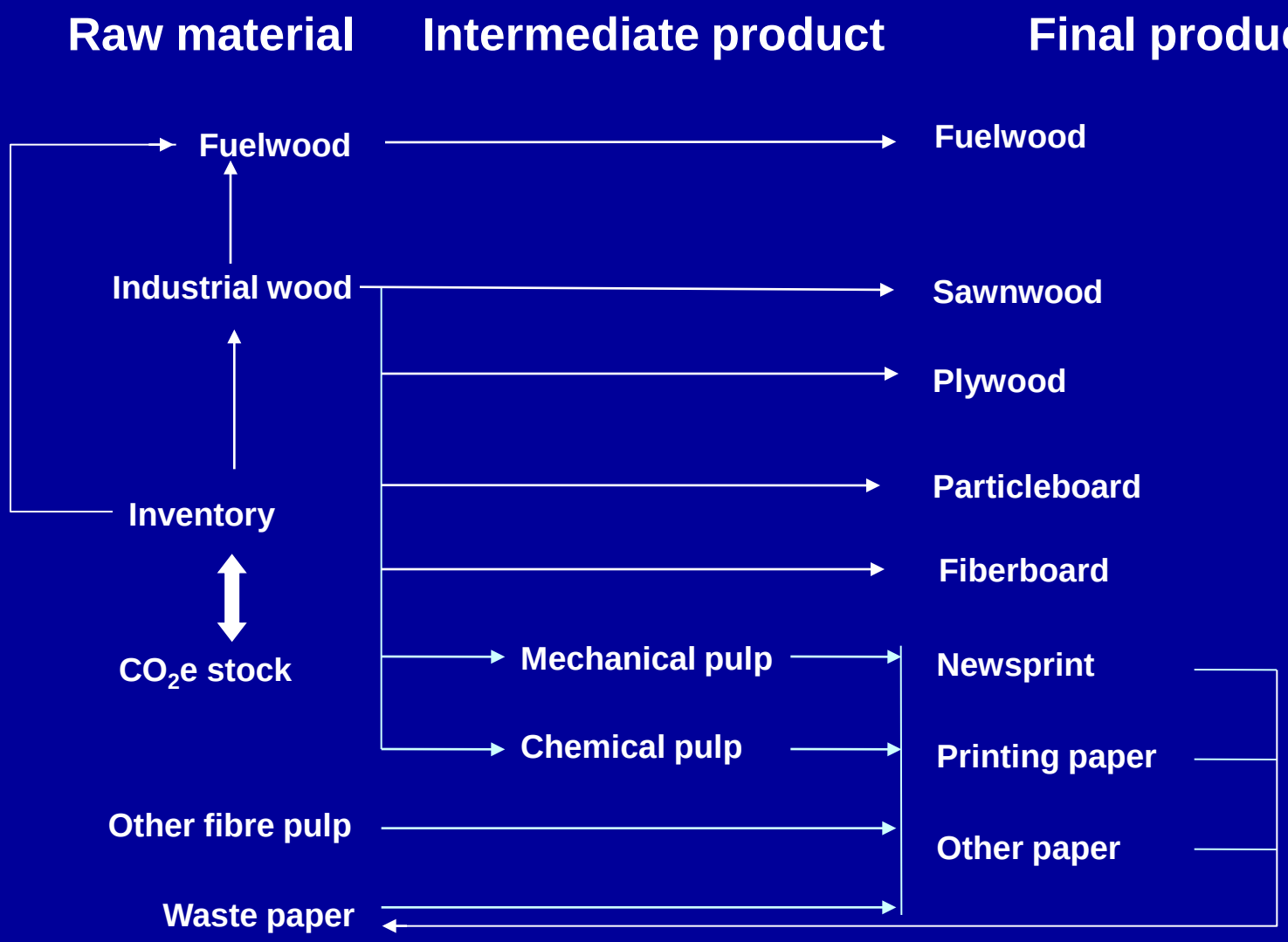

Region 1
Region 2
Price
Price
S_1
S_1'
S_2
S_2'
P'
P
C_1'
Q_1'
Q_2'
C_2'
Quantity
Quantity
C_1
Q_1
Q_2
C_2

GFPM



- Dynamic spatial economic model
- 180 countries
  - Forest area, stock
  - 14 commodities + CO_2e
    - Production
    - Consumption
    - Imports, exports
    - Prices
- Current version 2015

GFPM Product Flows



Static phase

Market surplus:

$$\max\left(\sum_{i,k}\int_{0}^{D_{ik}} P_{ik}(D_{ik})\,dD_{ik} - \sum_{i,k}\int_{0}^{Y_{ik}} m_{ik}(Y_{ik})\,dY_{ik} - \sum_{i,j,k} c_{ijk}T_{ijk}\right)$$

Equilibrium:

$$\sum_{j} T_{jik} + Y_{ik} = D_{ik} + \sum_{n} a_{ikn}Y_{in} + \sum_{j} T_{ijk} \qquad \forall i,k$$

Dual => P_{ik}

$I_{-1} + G_{-1} - S_{-1}$

Dynamic phase

Supply shift

$$S = S_{-1}(1 + \beta_I g_I)$$

Forest inventory change

$$I = I_{-1} + G_{-1} - S_{-1}$$

CO_2 fertilization

Inventory growth

$$G_{-1} = (g_a + g_u(1 + g_u^*))I_{-1}$$

DATA

Base year = 2011
(FAOSTAT, 2014)

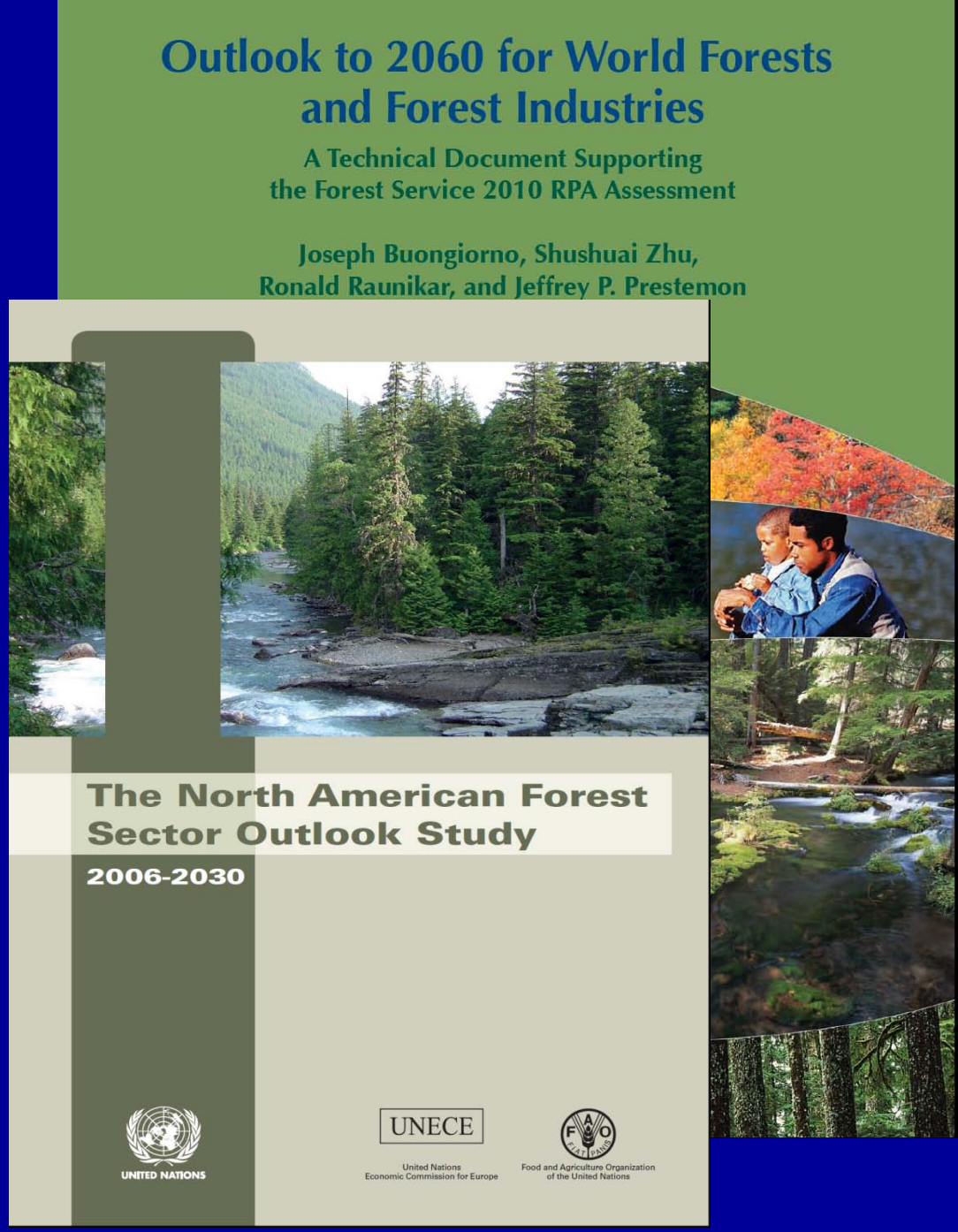
Resources = FRA 2010
(FAO, 2010)

GDP

Population

2009-2065

USDA-ERS
(2012)



CO_2 fertilization

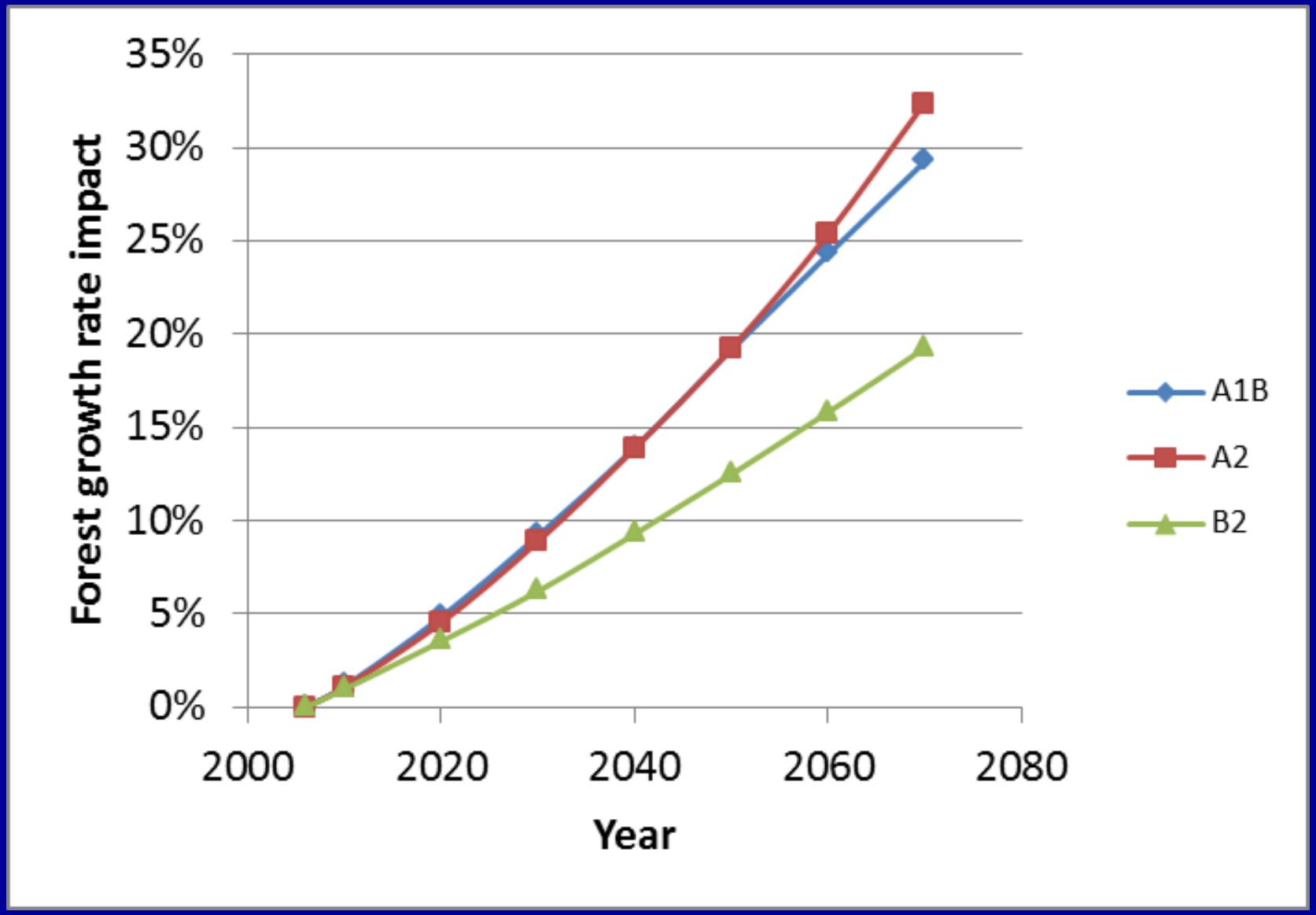
"The response of NPP to elevated CO_2 is highly conserved across a broad range of productivity, with a median response of 23±2%"

(Norby et al. 2005. PNAS)

⇓

$\Delta NPP = 0.13\%/ppm\ CO_2$

CO_2 fertilization



Effects on wood markets

Price effects ($/m^3)

		2065, A1B		
	2011	Without	With	Difference
Fuelwood	63	61	49	-20%
Industrial roundwood	101	135	110	-19%

Δ Fuelwood

	Scenario A1B, 2065	
	Production	Consumption
	(%)	(%)
Africa	12.5	12.5
N/C America	2.8	2.8
S America	2.7	2.7
Asia	5.4	5.4
Oceania	2.9	2.9
Europe	2.4	2.5
EU-28	0.2	2.2
World	7.7	7.7

Δ Industrial roundwood

	Scenario A1B	
	Production	Consumption
	(%)	(%)
Africa	15.3	19.5
N/C America	-7.6	-10.4
S America	5	19.1
Asia	18.4	-0.3
Oceania	-2.3	5.5
Europe	6.9	10
EU-28	4.3	9.6
World	4.2	4.2

Effects on sawnwood & panels markets

Price effects ($/m^3)

		2065, A1B		
	2011	without	with	
Sawnwood	259	324	295	-9%
Veneer & plywood	573	999	963	-4%
Particleboard	285	552	518	-6%
Fiberboard	433	915	883	-3%

Δ Sawnwood & panels

	Scenario A1B, 2065	
	Production	Consumption
	(%)	(%)
Africa	21.1	2.3
N/C America	-24.6	1.1
S America	23.9	2.0
Asia	-2.7	1.1
Oceania	3.4	1.0
Europe	5.6	1.2
EU-28	4	1.2
World	1.2	1.2

Effects on Pulp & paper

Price effects ($/t)

		2065, A1B		
	2011	Without	With	
Mechanical pulp	509	942	901	-4%
Chemical pulp	642	1036	978	-6%
Other fiber pulp	1309	3848	3812	-1%
Waste paper	187	563	524	-7%
Newsprint	632	774	731	-6%
Printing & writing paper	974	1128	1088	-4%
Other paper & paperboard	986	1586	1538	-3%

∆ Wood pulp

	Scenario A1B, 2065	
	Production	Consumption
	(%)	(%)
Africa	9.2	4.8
N/C America	-4.9	0
S America	-1.7	-3.4
Asia	4.1	0.2
Oceania	0.6	0.6
Europe	19.2	8.8
EU-28	28.8	10.8
World	1.8	1.8

Δ Value added

	Scenario A1B		Scenario B2	
	(10^9 $)	(%)	(10^9 $)	(%)
Africa	1.3	8.8	0.8	5.7
N/C America	-11.8	-4	-5.1	-2.6
S America	7.3	10.4	3.0	4.9
Asia	-6.1	-0.9	-3.1	-0.6
Oceania	0.2	1.9	0.2	2.3
Europe	16.8	5.3	6.5	2.3
EU-28	14.0	5.2	6.6	2.6
World	7.6	0.6	2.3	0.2

Effects on stock=> CO_2e

Δ Growing stock

	Scenario A1B		Scenario B2	
	($10^9 m^3$)	(%)	($10^9 m^3$)	(%)
Africa	26	34%	16	21%
N/C America	11	11%	3	3%
S America	318	19%	17	10%
Asia	20	27%	9	10%
Oceania	2	14%	1	5%
Europe	26	19%	15	11%
EU-28	5	14%	3	7%
World	117	20%	62	10%

Conclusion

- Caveats
  - CO_2 fertilization
  - Related climate changes
- Market effects
  - Scenario dependent
  - Lower prices
  - Regional differences
- (+) Effect on stock > (-) Harvest => (+) CO_2e

Acknowledgments:
USDA Forest Service,
Jeff Prestemon,
Shushuai Zhu

Thank you!