Role of Global Forests in Climate Change Mitigation

Adam Daigneault and Brent Sohngen[1]

Introduction

This paper uses a dynamically optimal global timber model that can measure responses in forest management and carbon sequestration from a global climate change mitigation policy. There are a variety of policies that could influence specific changes in the management of existing forests, payments for avoided deforestation, and schemes that encourage afforestation. While the mechanism in which a landowner is compensated for changes in forest land use can vary by the policy (e.g. clean development mechanism, carbon tax or subsidy, etc.), and by geographic region (Annex I, developing countries, etc.) this analysis simply estimates the changes in regional forest carbon sequestration through the introduction of two possible carbon price scenarios on all regions of the world through 2100. This paper also provides additional detail on the potential forest carbon sequestration in India as it is one of the major regions represented in the model.

Forest Model Description

For this analysis, we use a modified version of the Global Timber Model (GTM) originally developed by Sedjo and Lyon (1990), and subsequently updated by Sohngen et al., (1999) and Sohngen and Mendelsohn (2007). GTM is an economic model capable of examining global forestry land-use, management, and trade responses to a variety of policies, including climate change mitigation. In responding to a policy, the model captures regional afforestation, forest management, and avoided deforestation behavior, as well as changes in regional timber supply and global timber prices. The model is a partial equilibrium inter temporally optimizing model that maximizes total welfare in timber markets over time across approximately 250 world timber supply regions by managing forest stand ages, compositions, and acreage given production and land rental costs. For expositional purposes, the results from these many forest types are aggregated into 8 regions, including India.

Baseline

The baseline policy assumes a business as usual scenario with no climate policy, and hence a carbon price of \$0 per ton of carbon dioxide equivalent (\$/CO_2e). Demand is assumed to increase at a

[1] The authors are, respectively, Environmental Fellow, Deshpande Foundation, Bangalore, Karnataka India, daigneault.adam@dfmail.org; and Professor, The Ohio State University, Department of Agricultural, Environmental, and Development Economics, Columbus, Ohio USA, sohngen.1@osu.edu.

decreasing rate, growing initially at 0.5% per year, but then declining at a rate of 5% per year thereafter. The demand elasticity is assumed to be unitary (1.0). Timber yield functions are assumed to be constant over time, with the exception of subtropical plantations, which grow at 0.25% per year. The baseline also assumes that harvesting and plantation establishment costs remain constant for the duration of the model. The model is run from 2005 through 2190 at decadal time steps, but results are only presented from 2010 to 2100.

Results estimate that global forest carbon sequestration will decline over the next century (Table 1). The largest annual sources of forest-based emissions occur in South America (mostly Brazil), Russia, and the Rest of the World. India is estimated to have a relatively stable level of carbon sequestration from 2010 through 2050, with a slight decline thereafter. The small change in total carbon stock for India is a function of a relatively low proportion of land currently classified as forestland. The change is also minimized because of India's potential to increase timber supply from plantations that can provide high yields of timber and carbon stock, thus reducing the pressure on existing natural forests.

Table 1: Baseline Carbon Sequestration ($PgCO_2eq$)

Year	USA	EU-27	Rest of Annex I	South America	Russia	China	India	Rest of World	Total
2010	185.4	140.9	593.7	771.5	901.0	100.7	36.3	567.1	3296.7
2020	183.2	142.2	590.3	757.1	891.1	102.7	36.5	531.0	3234.1
2030	178.2	144.9	590.4	743.6	885.8	105.4	36.6	503.4	3188.1
2040	178.9	144.0	590.5	731.9	883.7	105.4	36.4	479.9	3150.8
2050	182.4	143.2	592.2	722.2	881.5	106.3	35.8	454.8	3118.4
2060	183.8	145.1	594.8	714.2	880.5	104.8	34.5	432.6	3090.3
2070	185.6	147.0	597.1	708.0	878.7	101.6	33.4	425.7	3077.1
2080	185.6	148.3	595.7	703.9	878.9	100.8	32.9	424.8	3070.8
2090	187.7	144.6	598.2	701.6	879.9	102.2	32.9	423.1	3070.0
2100	185.9	147.2	597.0	700.4	882.0	104.6	33.3	416.1	3066.5

Table 2 shows the baseline estimates of global forest area, which is also estimated to decline over time. Regions such as South America and the rest of the world that are largely made up of developing countries are estimated to have the largest decline in forestland due to increased pressure on land use for agriculture. The total area of forestland in India is expected to decline by about 10% over the next century despite the estimate that subtropical timber plantations are expected to increase from 3.8 Mha in 2010 to 5.8 Mha by 2100.

Table 2. Baseline Forestland Area (Mha)

Year	USA	EU-27	Rest of Annex I	South America	Russia	China	India	Rest of World	Total
2010	201.7	220.2	635.7	868.7	804.6	154.0	49.9	659.6	3594.4
2020	204.9	222.3	639.9	833.8	806.2	159.9	48.9	577.2	3493.0
2030	206.0	223.7	636.5	801.5	806.0	162.3	46.8	508.7	3391.5
2040	205.1	225.1	632.0	773.6	806.1	164.2	44.5	457.2	3307.8
2050	205.1	224.7	627.7	750.5	806.1	165.4	44.7	421.2	3245.4
2060	205.2	225.7	623.9	731.7	806.0	166.3	45.0	408.0	3211.8
2070	205.5	227.3	620.4	723.8	806.4	166.6	45.1	398.6	3193.8
2080	205.1	225.7	616.8	719.3	805.8	167.3	45.7	395.7	3181.4
2090	205.8	224.5	613.1	717.7	802.5	167.8	45.1	395.0	3171.4
2100	205.4	233.8	609.9	711.7	807.9	168.0	45.8	389.2	3171.7

Climate Change Policy Scenarios

This analysis assumes all baseline conditions with the exception that the forestry market faces a climate policy that starts in 2010 and continues through 2100. Because a global climate change policy is still under development and the overall stringency of the caps and roles that forests will play in the global carbon market is still undefined, we investigate changes in forest carbon under two potential carbon price paths that start at initial prices of \$5 and \$30/tCO_2e and rise at 5% per year. Both scenarios assume a policy that compensates landowners for positive changes in forest management, afforestation, and avoided deforestation relative to the baseline case.

Results for the two carbon policy scenarios are shown in Table 3, and listed as net changes in carbon sequestration (TgCO_2e/yr) relative to the baseline case. For the scenario where the carbon price starts at \$5 in 2010 and rises at 5% per year, most near term net sequestration is expected to occur in Russia, China, and the Rest of the World. Interestingly, most of the developed countries have low or negative net sequestration in 2010, which indicates that they would increase their relative supply of timber to meet global demand. As the carbon price rises over time, all regions increase their carbon sequestration resulting the net increase in total carbon stock in 2100 by 1,257 PgCO2e relative to the baseline, or more than 40%.

Table 3. Net Carbon Sequestration for Carbon Policy Scenarios (TgCO2e/yr)

Scenario	Year	USA	EU-27	Rest of Annex I	South America	Russia	China	India	Rest of World	Total
$5 Rising at 5%	2010	-23.5	10.2	-151.8	148.7	453.3	200.6	-16.7	570.8	1191.6
	2050	436.5	516.7	398.7	1591.7	451.2	1707.7	268.9	4375.0	9746.4
	2100	1855.1	2500.3	1091.9	3866.8	879.5	2997.5	492.1	5951.5	19634.7
$30 Rising at 5%	2010	87.3	35.5	542.0	2038.0	1175.3	98.3	171.0	4613.9	8761.3
	2050	3225.4	1850.7	2172.9	5629.5	798.4	3264.6	648.9	7332.6	24922.9
	2100	1261.4	2196.9	1099.0	1690.2	758.0	1857.3	144.4	3563.7	12570.9

For the scenario where the carbon price starts at $30 in 2010 and rises at 5% per year, all regions increase their net carbon sequestration relative to the baseline, with most the greatest sequestration occurring in South America, Russia, and tropical forests in the Rest of the World. This increase in carbon sequestration is primarily made up of payments for avoided deforestation to tropical countries and the boreal forests of Russia as well as the gradual increase in afforestation and changes in forest management over the course of the century (e.g., increased rotation ages and yield-enhancing stand management). For the high carbon price scenario, the total carbon stock in 2100 is estimated to increase by 1,649 $PgCO_2e$, nearly 54% more than the projected level of carbon in the baseline case.

More detailed results of the estimates of changes in carbon sequestration for India under the two carbon price scenarios are shown in Table 4. Interestingly, the low carbon price scenario shows a net increase in forest carbon emissions in 2010, before becoming a net sink relative to the base case as time progresses, as it is more economical in the near-term to expand timber production and then wait until prices are higher before starting to receive carbon payments. For both of the carbon price scenarios, most of the increases in carbon sequestration are a result of afforestation, with the next largest change coming from improved forest management. There is little to no annual net change in carbon sequestration from payments for avoided deforestation in India as the baseline estimated a relatively small annual loss of forestland over time. Estimates also show that the dynamics of the carbon sequestration differ as well, with increases occurring more rapidly in the high price scenario but then tapering off as the market becomes saturated. Finally, India's forest carbon stock for the two price scenarios in 2100 is estimated to increase over the baseline by 26.4 for the low-price scenario and 32.2 PgC for the high price scenario, a respective gain of 79% and 96%.

Table 4. India Net Carbon Sequestration for Carbon Policy Scenarios ($TgCO_2e/yr$)

Scenario	Year	Avoided Deforestation	Afforestation	Forest Management	Total
$5 Rising at 5%	2010	0.0	-17.6	0.9	-16.7
	2050	34.4	214.0	20.5	268.9
	2100	0.0	317.4	174.7	492.1
$30 Rising at 5%	2010	0.0	168.5	2.5	171.0
	2050	34.4	503.7	110.8	648.9
	2100	0.0	124.0	20.4	144.4

Conclusion

This paper presents the results of a scenario analysis exploring how various carbon prices could potentially affect the amount of carbon sequestration in global forests. Special attention is paid to the estimates for the region of India. While baseline results show a decline in global forestland area and carbon sequestration over the next century, the climate change policy scenarios estimates that this trend could be reversed if forest landowners are eligible for carbon payments in all regions of the world, and that while India can provide a relatively small source of the global forest carbon sequestration, the region can still increase their forest carbon stocks by 79% or more through payments for afforestation, changes in forest management, and avoided deforestation.

References

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