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Role of New Zealand Forests in Global Climate Change Mitigation

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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. More thorough reviews of existing forest carbon sequestration protocols can be found in Pajot (2007), Galik et al. (2009), and Erikson et al. (2011). This paper also provides additional detail on the potential forest carbon sequestration in New Zealand.

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

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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 intertemporally 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 9 regions, including New Zealand.

Baseline

The baseline policy assumes a business as usual scenario with no climate policy, and hence a carbon price of \$0 per tonne of carbon dioxide equivalent (\$/tCO_2e). Timber demand is assumed to increase at a 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 close to unitary (1.1). Timber yield functions are assumed to be constant over time, with the exception of subtropical plantations, which grow at 0.25% per year from improved technological innovation. The baseline also assumes that harvesting and plantation establishment costs remain constant for the duration of the model. The model is run from 2010 through 2150 at decadal time steps, but results are only presented from 2010 to 2100.

Results for baseline global industrial roundwood price[2] (\$/m3) and regional annual timber harvest quantities for the 9 aggregated regions are listed in Table 1. The

[2] All prices in this paper are in 2010 New Zealand dollars

roundwood price starts at $179/m^3$ and rises at a slightly declining rate over the next century. Global timber production also rises over time, increasing from about 1.8 billion m3/yr in 2010 to more than 2.2 billion m3/yr in 2100. Large producers such as USA and EU-27 are expected to remain key suppliers over the course of the century, but emerging regions such as Brazil and Asia are expected to contribute to a larger proportion of global supply over time. New Zealand's timber harvests are estimated to fluctuate dramatically over time because of the currently uneven age class distribution of its pinus radiata and other exotic plantations which produce nearly all of the nation's logs.

Table 1. Baseline Global Timber Price ($/m3) and Annual Regional Harvest (M m3/yr)

Year	Global Price	NZ	USA	Canada	EU-27	Rest of Annex I	Brazil	Rest of America	Asia	Africa	Total
2010	$ 179	16.0	457	240	361	221	169	71	212	83	1829
2020	$ 194	26.5	412	234	285	166	182	109	359	124	1898
2030	$ 211	16.6	474	188	352	159	175	92	383	87	1927
2040	$ 229	17.6	264	162	387	167	193	100	524	129	1945
2050	$ 242	31.5	406	142	411	184	186	99	430	94	1983
2060	$ 249	18.8	538	161	366	203	202	100	349	132	2068
2070	$ 257	21.0	274	219	506	201	209	106	498	88	2122
2080	$ 263	35.1	449	243	337	198	211	101	497	113	2184
2090	$ 267	20.6	622	215	346	204	201	108	414	108	2238
2100	$ 278	26.0	389	219	475	237	218	108	437	116	2226

Table 2 shows the baseline estimates of global forest area, which is estimated to decline over the next century. This decline is projected to occur in the regions of Brazil, the Rest of America, Africa and Asia are estimated to have the largest decline in forestland due to increased pressure on land use for agriculture. The total area of forestland (indigenous and plantation forest) in New Zealand is expected to increase slightly (2%) over the next century all due to a 200,000 ha expansion in exotic plantations. These findings are consistent with trends reported in the most recent MAF National Exotic Forest Description (2010), which indicate that the annual area of new plantings have recently been larger than the area of deforestation.

Table 2. Baseline Forestland Area (M ha)

Year	NZ	USA	Canada	EU-27	Rest of Annex I	Brazil	Rest of America	Asia	Africa	Total
2010	8.2	202	413	187	1069	549	349	449	240	3466
2020	8.2	200	414	189	1074	543	337	425	213	3403
2030	8.2	203	415	189	1068	532	326	413	203	3357
2040	8.2	203	415	190	1071	520	319	405	198	3329
2050	8.3	202	417	192	1078	509	311	407	197	3321
2060	8.3	204	415	194	1075	497	304	397	190	3284
2070	8.3	205	418	197	1082	487	299	400	195	3291
2080	8.4	210	420	193	1089	482	293	411	193	3301
2090	8.4	213	421	197	1090	471	292	403	180	3275
2100	8.4	217	424	205	1095	463	286	401	168	3268

Table 3 shows the change in total forest carbon stocks[3] over the next century. Estimates indicate that total global forest carbon stocks will decline by about 2% between 2010 and 2100, however above ground carbon stocks are expected to decline by about 15%. This difference can be attributed to a relatively constant stock of below ground (soil) carbon and an increasing pool of carbon in harvested wood products. At the regional level, large sources of forest-based emissions occur in Brazil, Rest of Americas, Asia and Africa, while most developed countries increase their forest sinks. Carbon stored in harvested wood products is expected to increase at a rate of nearly 1

[3] Total forest carbon stocks are tabulated as a sum of above ground carbon, soil carbon in forests, and carbon stored in harvested wood products (HWP).

$PgCO_2e$[4]/yr globally over the next century. New Zealand is estimated to have a relatively stable but increasing level of total forest carbon sequestration from 2010 through 2100 (4%), while above ground carbon could grow by more than 11% from an increase in exotic plantations.

Table 3. Baseline Carbon Sequestration ($PgCO_2eq$)

Year	NZ	USA	Canada	EU-27	Rest of Annex I	Brazil	Rest of America	Asia	Africa	Total
2010	5.0	187	524	103	1118	508	314	333	172	3265
2020	5.0	185	523	104	1109	504	309	341	168	3249
2030	4.9	186	524	108	1107	500	306	346	163	3244
2040	5.0	187	525	111	1106	496	302	346	158	3235
2050	5.1	191	526	113	1106	491	298	333	154	3218
2060	5.0	195	528	114	1107	486	295	322	151	3203
2070	5.1	194	529	117	1109	481	291	328	148	3202
2080	5.2	199	530	116	1111	475	288	332	149	3204
2090	5.1	202	530	119	1113	471	285	332	147	3204
2100	5.2	201	531	122	1116	468	282	328	145	3199

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 prices of $25 and $50/$tCO_2e$ and remain constant for the duration of the policy. Both scenarios assume a policy that compensates landowners for positive changes in forest management, afforestation, and avoided deforestation relative to the baseline case.

[4] 1 metric tonne is equivalent to 1 mega gram (Mg) or 10^6 grams. 1 tera gram (Tg) = 10^{12} grams (1 million tons) and 1 peta gram (Pg) = 10^{15} grams (1 billion tonnes).

Estimates show that a global carbon price will increase the price of industrial roundwood in the near term as landowners opt for carbon payments that lengthen rotations or reduce the conversion of forests to other land uses, such as agriculture (Table 4). As a result, the quantity of timber supplied in 2010 is reduced by 200 million m^3/yr or more. Over time, the amount of timber supplied increases as forests planted in the early periods become mature and are felled. This causes the global timber price to actually become lower than the baseline levels in 2050 and 2100.

Table 4. Global Roundwood Price, Harvests and Forest Area for Scenarios

Year	Timber Price (NZD/m3)			Quantity (million m3/yr)			Forest Area (million ha)		
	Base	$25/t	$50/t	Base	$25/t	$50/t	Base	$25/t	$50/t
2010	$ 179	$ 198	$ 223	1829	1633	1435	3466	3466	3466
2020	$ 194	$ 206	$ 224	1898	1777	1616	3403	4123	4547
2030	$ 211	$ 215	$ 228	1927	1891	1772	3357	4103	4527
2040	$ 229	$ 226	$ 233	1945	1965	1909	3329	4091	4517
2050	$ 242	$ 239	$ 237	1983	2018	2033	3321	4087	4514
2060	$ 249	$ 235	$ 235	2068	2200	2203	3284	4093	4518
2070	$ 257	$ 226	$ 223	2122	2452	2482	3291	4083	4511
2080	$ 263	$ 227	$ 217	2184	2571	2704	3301	4096	4513
2090	$ 267	$ 221	$ 211	2238	2762	2909	3275	4085	4500
2100	$ 278	$ 228	$ 210	2226	2770	3019	3268	4057	4521

Table 5 lists the net changes in total forest carbon sequestration ($TgCO_2e$/yr) relative to the baseline case. For both carbon price scenarios, most net sequestration is expected to occur in Asia, Rest of America, Brazil, and Africa. Interestingly, most of the countries have low or negative net sequestration in 2010. This is generally because some less productive ‘natural’ forests are being felled to meet timber demand and being replaced with fast growing timber plantations. With a carbon price of $50/$tCO_2$-e, all regions increase their carbon sequestration over time, resulting the net increase in total carbon stock in 2100 by 715 $PgCO_2e$ relative to the baseline, or more than 22%. New Zealand is not expected to see large increases in forest carbon sequestration over time from carbon payments. Instead, it benefits from its highly productive plantations, which spurs and increase in forest area and annual harvests to meet shortfalls in global timber supply. This finding counters some of the projections of forest mitigation potential under the current New Zealand Emissions Trading Scheme, which does not assume that all forests in all regions of the globe are eligible for carbon payments.

Table 5. Net Carbon Sequestration for Carbon Policy Scenarios ($TgCO_2e/yr$)

$25/tCO2e

Year	NZ	USA	Canada	EU-27	Rest of Annex I	Brazil	Rest of America	Asia	Africa	Total
2010	0.0	-2	0	-6	-12	-10	-29	-58	-27	-144
2020	0.3	74	14	55	875	631	1,014	1,411	497	4,571
2030	1.8	563	179	89	1,277	2,549	2,806	3,937	1,148	12,550
2040	3.4	1,047	361	209	1,547	3,872	4,221	7,117	1,773	20,150
2050	0.9	1,407	510	389	1,771	4,955	5,064	10,496	2,076	26,668
2060	0.2	1,596	627	510	2,053	5,758	5,633	14,120	2,422	32,720
2070	0.2	1,929	771	782	2,254	6,741	6,489	15,238	2,849	37,053
2080	0.0	1,606	755	1,199	2,484	5,211	6,819	17,098	2,543	37,715
2090	-2.1	1,967	735	1,411	2,704	6,538	7,458	17,874	2,928	41,614
2100	-0.4	938	565	1,760	2,984	7,632	8,310	19,535	3,334	45,058

$50/tCO2e

Year	NZ	USA	Canada	EU-27	Rest of Annex I	Brazil	Rest of America	Asia	Africa	Total
2010	0.0	-4	0	-22	-16	-75	-44	-75	-53	-288
2020	0.8	129	28	116	927	1,634	1,495	1,631	809	6,770
2030	4.3	894	327	191	1,397	5,314	4,581	5,143	2,322	20,174
2040	6.8	1,701	646	391	1,777	7,483	7,012	9,192	3,742	31,952
2050	-0.2	2,277	909	693	2,078	8,925	8,781	13,764	4,848	42,274
2060	3.8	2,556	1,119	982	2,458	9,773	10,244	17,843	5,733	50,712
2070	3.4	3,128	1,400	1,509	2,788	10,487	11,374	19,748	6,440	56,878
2080	-2.7	2,584	1,244	1,945	3,247	12,231	12,441	22,216	6,714	62,620
2090	2.2	3,059	1,258	2,387	3,613	10,917	13,221	24,148	7,167	65,772
2100	2.0	1,617	936	3,224	4,128	12,383	14,078	27,380	7,729	71,477

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 New Zealand. 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 New Zealand can provide a relatively small source of the global timber supply and forest carbon sequestration, the region can still benefit from a global forest carbon sequestration policy by using its highly productive exotic plantations to increase its supply of logs to global markets. Additional analysis needs to be conducted to estimate the changes in timber price, supply, and carbon sequestration under policies where not all countries face a forest carbon price as well as the impacts of including the agricultural sector into a land-based climate mitigation policy.

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