Impacts on the Pastoral Sector from Emissions Charges on Agriculture Gases: Analysis from the model Land Use in Rural New Zealand version 1: Climate (LURNZv1: climate)

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Joanna Hendy and Suzi Kerr

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LURNZv1: climate simulates land-use change for dairy farming, sheep/beef farming, plantation forestry, and reverting scrubland in response to economic shocks. It also calculates the emission implications of that land-use change. We use LURNZv1: climate to simulate the effects of different combinations of emission charges and rewards. We calculate the resulting changes in land use and emissions. We also calculate changes in agricultural output implied by the emission changes.

We simulate the effects of annual charges for dairy and sheep/beef methane and nitrous oxide emissions, an annual reward for carbon sequestration in plantation forest and the liability associated with harvest, and an annual reward for carbon sequestration in reverting scrubland. The scenarios that we simulate are listed below.

Table 1 Scenario desciptions

Scenario Number	Emissions Charges at $15 per tonne of CO2 equivalent
A	None (reference case)
B	sheep/beef and dairy methane
	sheep/beef and dairy nitrous oxide from manure and fertiliser
C	sheep/beef and dairy nitrous oxide from manure and fertiliser
D	sheep/beef and dairy methane
	sheep/beef and dairy nitrous oxide from manure and fertiliser
	plantation forestry net carbon sequestration
E	sheep/beef and dairy methane
	sheep/beef and dairy nitrous oxide from manure and fertiliser
	reverting scrub net carbon sequestration

Land-use change in LURNZv1:climate is driven by changes in export prices, the interest rate, and time trends. The forecast prices that we use in the reference case (scenario A) are listed in the table below. We simulate from 2002 forward.

Table 2 Exogenous variables: Reference Case

Year	Interest Rate	Plantation Forestry Price cents per m3 of roundwood	Sheep / beef Price cents per kg of combined meat and wool	Dairy Price cents per kg of milksolids
actual values				
2003	5.71	8,270	353	363
2004	5.76	8,640	334	421
2005	6.06	7,497	343	455
2006	5.87	8,823	313	407
Forecast values				
2007	5.87	9,774	319	414
2008	5.87	9,638	333	400
2009	5.87	10,564	341	415
2010	5.87	11,660	344	427
2011	5.87	12,231	346	430
2012	5.87	12,342	347	432
2013	5.87	12,342	349	434
2014	5.87	12,342	352	436
2015	5.87	12,342	354	437
Source: MAF 2007.				

We model emissions charges as decreases in the reference case export prices, and sequestration rewards as increases in the reference case export prices. Our charge and reward is equal to $15 per tonne of CO2 equivalent. The corresponding charges and rewards for each unit of production associated with each land use are listed in the table below.

We model dairy emissions charges as a reduction in the annual average milksolids price and sheep/beef emissions charges as a reduction in the annual average weighted price for beef, lamb and wool.

Rewards for plantation forestry are modelled as a lumpsum payment, net of liability, in the year of harvest (31 years), added to the price per m3 of roundwood. We assume an 8% discount rate and that there is no inflation in the carbon reward. The value of the reward is that of the temporary sequestration only. Despite this, the resulting lumpsum payment is very high. This is because the payment is expressed as a future value, assuming an 8% nominal interest rate but no carbon price inflation. This implies a very high real interest rate of 8%.

Modelling rewards for scrub is more complicated because there is no historical, observable price associated with reverting scrub. So, we model a scrub reward as the opportunity cost of not sequestering carbon in scrub for each land-use. We calculate the opportunity cost for dairy and sheep/beef as equal to the annualised net present value of rewards associated with bare land reverting to scrub, assuming no future harvest and an 8% discount rate. We calculate the opportunity cost for plantation forestry as equal to the lumpsum payment, net of liability, the farmer would have received in the year of harvest (31 years) for rewards associated with bare land reverting to scrub. We assume the scrub is harvested in year 31 to be consistent with

our treatment of plantation forest. We subtract this from the price per m3 of roundwood.

Table 3 Emission Charges

Land use:	Revenue:	Emissions Charges			
Dairy	Production Revenue (2007)	Methane	N2O from Manure	N2O from Fertiliser	CO2 from displacing scrub reversion
	Cents per kg of milksolids				
	414.0	10.8	5.2	0.2	7.9
Sheep/beef	Production Revenue (2007)	Methane	N2O from Manure	N2O from Fertiliser	CO2 from displacing scrub reversion
	Cents per kg of weighted sheep/beef meat and wool				
	319.3	17.3	7.7	0.1	33.2
Plantation	Production Revenue (2007)	CO2 from plantation			CO2 from displacing scrub reversion
	Cents per m3 of plantation roundwood equivalent				
	9773.8	6821.9			888.4

Caveats

LURNZv1: climate is based on an econometric model of land-use change, estimated off a small number of data points. This weakens the robustness of the results.

In the model, farmers can only respond to emissions charges by changing land-use. They are not able to alter land-use intensity. Thus, our results will be a lower bound on the likely emissions and output reductions.

In LURNZv1: climate, plantation forestry land-use decisions are driven by the current plantation forestry price. A forestry rotation is typically about 30years, thus it is unlikely that the current plantation price is closely related to replanting and new-planting decisions. This means the simulations involving a plantation forestry reward are based on a weak relationship and should be considered illustrative only.

The method we use for modelling scrub sequestration rewards is incomplete, as it does not account for the conversion of existing scrub into other land-uses. In addition, when considering the opportunity cost of not reverting to scrub on dairy and

sheep/beef land, we assume that any conversion to scrub would be in perpetuity whereas other land uses can be altered at any time. Thus, the scenarios that include a scrub price are illustrative only.

Because we are not confident in the absolute values associated with simulations for plantation and scrub rewards, we only discuss directions of effects in scenarios D and E.

Results

LURNZv1 was run forward from 2003 to 2015 for each of the scenarios A to E. The table below shows land use areas for the reference case, scenario A. From 2003-2006, actual data was included for the exogenous variables (the export prices and the interest rate). Despite this, because it is a projection, land use calculated in by the model from 2003-2007 will not match actual land use measured from 2003-2007. In addition, the land use series here is calibrated to be consistent with land use measured in the Land Cover Database 1 (LCDB1) in 2002. This means it will not be consistent with land use data measured in the agricultural production surveys. Relative to LCDB1, the agricultural production census in 2002 found more pasture and more plantation forest (with conservation land excluded from LCDB1).

Table 4 Reference case land use change 2007-2015

Land use:	Millions of Hectares in 2007	Millions of Hectares in 2015	% Increase 2007-2015
Dairy	1.54	1.69	10%
Sheep/beef	7.05	6.81	-3%
Plantation	1.67	1.97	18%
Scrub	1.51	1.29	-14%

The table below shows the emissions associated with the reference case land-use change. As with the land use results above, the 2007 emissions are based on forecasts from 2003, so will not match the actual emissions given in the National Inventory Report. In addition, the plantation forestry sequestration given below includes sequestration in *all* forests, which include both Kyoto and non-Kyoto forests.

Table 5 Reference case emissions growth 2007-2015

Land use:		Emissions (Gg) in 2007	Emissions (Gg) in 2015	Increase (Gg) between 2007 and 2015
Dairy Farming	Methane	8,384	9,781	1397
	N2O from Manure	4,033	4,705	672
	N2O from Fertiliser	111	163	52
	Total	12,529	14,649	2121
Beef	Methane	5,533	5,720	188
	N2O from Manure	2,346	2,425	80
	Total (excl. Fertiliser)	7,878	8,145	267
Sheep	Methane	8,887	8,208	-679
	N2O from Manure	4,038	3,729	-309
	Total (excl. Fertiliser)	12,925	11,937	-988

Sheep/beef	N2O from Fertiliser	511	665	154
	Total (incl. Fertiliser)	21,314	20,747	-567
NET EMISSIONS				
Animal and fertiliser emissions		36,459	38,089	1629
Plantation sequestration (Kyoto and non-Kyoto forests)		22,328	33,385	11058
Total Emissions (excl. Scrub)		14,132	4,703	-9429
Scrub sequestration		4,051	-6,719	-10771
Total Emissions (incl. Scrub)		10,080	11,423	1342

The table below shows likely changes in output as a result of land-use change in the reference case, scenario A. Livestock numbers are directly calculated by LURNZv1: climate, using the projected land-use change and trends in stocking rates. We calculate the changes in export value and output, and farm revenue separately, by applying the percentage change in emissions between 2007 and 2015 to the current values of each of these variables.

Table 6 Reference case output growth 2007-2015 (output growth is calculated using the % change in emissions between 2007 and 2015)

	2007	**2015**	**2015-2007**
Growth in livestock (1000s of heads)			
Dairy cattle	5,080	5,690	610
Beef cattle	4,406	4,251	-155
Sheep	35,550	29,215	-6,335
Implied Export Value Growth ($ millions)			
Milksolids	5,964	6,973	1,009
Beef	1,727	1,786	59
Lamb	1,991	1,839	-152
Implied Output Growth (1000 tonnes)			
Milksolids	1,733	2,026	293
Beef	381	394	13
Lamb	295	272	-23
Farm Revenue $			
Dairy	540,786	632,319	91,533
Sheep/beef	338,980	329,968	-9,012
Sources: MAF SONZAF 2006, MAF farming monitoring reports 2006,			

The table below shows the increase in 2015 land use compared to scenario A, the reference case, for scenarios B and C (a charge for both methane and nitrous oxide, and a charge for nitrous oxide only, respectively).

Table 7 Impact of emission charges: % increase in land-use areas compared with reference case, 2015

	Scenario	
Land use:	B	C
Dairy	-0.5%	-0.2%
Sheep/beef	-0.1%	0.0%
Plantation	-0.1%	0.0%

Scrub	1.1%	0.3%

Scenario D includes a reward for plantation forestry as well as methane and nitrous oxide rewards. Compared to scenario B, scenario D results in more plantation forest, less scrub, more dairy, and more sheep/beef. Scenario E, which includes a reward for scrub as well as methane and nitrous oxide, results in more scrub, and less plantation forestry, sheep/beef, and dairy than scenario B.

Table 8 shows the resulting emissions increases relative to scenario A (reference case) for scenarios B and C. Table 9 shows the increases in output, implied by the emission changes, for scenarios B and C relative to reference case.

Table 8 Impact of emission charges: % increase in emissions relative to reference case, 2015

		Scenario	
		B	**C**
Dairy	Methane	-0.50%	-0.20%
	Nitrous Oxide from Manure	-0.50%	-0.20%
	Nitrous Oxide from Fertiliser	-1.90%	-0.60%
	Total	-0.50%	-0.20%
Beef	Methane	-0.09%	-0.02%
	Nitrous Oxide	-0.09%	-0.02%
	Total (excl. fertiliser)	-0.09%	-0.02%
Sheep	Methane	-0.09%	-0.02%
	Nitrous Oxide	-0.09%	-0.02%
	Total (excl. fertiliser)	-0.09%	-0.02%
Sheep/beef	Fertiliser	-1.46%	-0.48%
	Total	-0.13%	-0.04%
Total animal and fertiliser emissions		-0.27%	-0.09%
Total plantation sequestration		0.01%	-0.01%
Net Emissions (excl. scrub)		-2.22%	-0.60%
Total scrub sequestration		-2.02%	-0.65%
Net Emissions (incl. scrub)		-2.10%	-0.63%

Table 9 Impact of emission charges: increase in output areas compared with reference case, 2015 (output growth is calculated using the % change in emissions between 2007 and 2015)

	B	C
Growth in livestock (1000s of heads)		
Dairy cattle	-29.2	-9.8
Beef cattle	-3.7	-1.0
Sheep	-25.7	-6.8
Implied Export Value Growth ($ millions)		
Milksolids	-35.8	-12.0
Beef	-1.6	-0.4
Lamb	-1.6	-0.4
Implied Output Growth (1000 tonnes)		
Milksolids	-10.4	-3.5

Beef	-0.3	-0.1
Lamb	-0.2	-0.1
Farm Revenue $		
Dairy	-3,248	-1,084
Sheep/beef	-436	-126