Equitably slicing the Pie: Allocation of Non-Point Source Pollution for Water Quality Improvement

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Agro-environmental Policy Impacts on Regional Land Use and Ecosystem Services in New Zealand

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INTRODUCTION

Agriculture important sector of NZ's economy
- 15% of GDP including downstream processing
- Large proportion of export value
- NZ Government goal for primary industries to double the value of their exports by 2025.

Increases in intensive pastoral farming
- Surpassed population of 5 million dairy cows in 2012
- Landowners actively seeking new access to irrigation

Figure 1. NZ primary sector exports

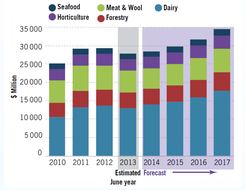
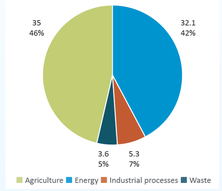


Figure 2. NZ 2012 GHG emissions ($MtCO_2e$)



Land use key source of environmental impacts
- 47% of national GHG emissions
- Forestry a net sink, but large areas expected to be harvested in next decade
- Diffuse sources often produces 90+% of nutrient discharges in a catchment
- Ongoing policy development for imposing nutrient load limits throughout NZ

STUDY & POLICY ANALYSIS

New Zealand Environmental Policy
- Climate Change: National Emissions Trading Scheme (2008)
- Water Quality: Regional nutrient load targets via 2014 National Policy Statement for Freshwater Management and National Objective Framework (still under development)

Question: What are potential impacts of GHG emissions and nutrient reduction policies on:
- net farm revenue
- food and timber production
- key environmental outputs
- other ecosystem services

Study Approach
- Use New Zealand Forest and Agriculture Model (NZFARM) to estimate policy impacts on farm income, land use, and ecosystem services
- Model initially developed for target catchments
- Recent attempt to parameterise at national-level (territorial authority and 5km grid cell)

Illustrative Policy Analysis
- Policy 1: Price on land-based GHG emissions ($0 to $30/tCO2e emitted)
- Policy 2: Tax on N leaching from diffuse sources ($0 to $30/kgN leached)
- Policy 3: Combination of #1 and #2

NEW ZEALAND LAND USE

Figure 3. Baseline Land Use

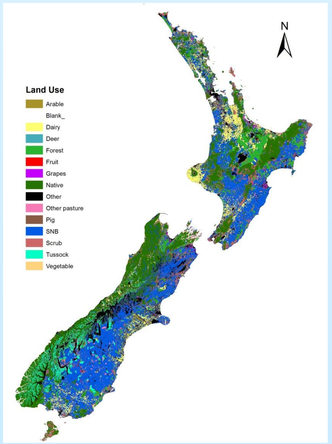


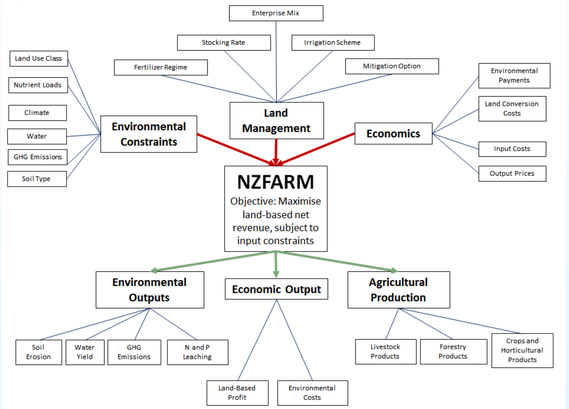
Table 1. Total Enterprise Area

Enterprise	Area (ha)	% Total
Dairy	1,751,847	7%
Sheep & Beef	8,639,242	32%
Other Pasture	1,179,259	4%
Arable	202,188	1%
Fruit	132,738	0%
Vegetables	18,643	0%
Exotic Forest	2,040,310	8%
Native	10,172,842	38%
Other	2,726,095	10%
Total	**26,863,164**	**100%**

NZ FOREST AND AGRICULTURE REGIONAL MODEL (NZFARM)

- A comparative-static, partial equilibrium, non-linear programming model of NZ land use
- Objective: Maximize total net revenue from 21potential farm enterprises in catchment subject to regional (R) constraints such as inputs, land quality, water availability and environmental regulations
- Endogenous mitigation and adaptation via stocking rate and fertilizer application adjustments and land use change

Figure 2. NZFARM schematic



KEY DATA SOURCES

- MPI Farm Monitoring, individual farms
- Lincoln Farm Budget Manual
- Motu forest profitability dataset
- Agribase (2012)
- NZ Land Resource Inventory (LRI)
- Land Cover Database (LCDB)3
- Biophysical models (Overseer, FARMAX, etc.)
- NZ ecosystem services quantification by Ausseil et al (2013)
- Farm consultants and local expertise

MODEL VALIDATION

- Empirical evidence is not always available to 'validate' a model, especially where a policy scenario has not been previously implemented. As a result, we:
- Test the model to see if it responds in an economically consistent manner
- Check that the model responds logically to historical changes in output prices and land-use policy
- Compare model outputs with other NZ-focused model outputs,
  - E.g, Anastasiadis et al. (2011), and Doole and Pannell (2011)
- Verify model estimates with local stakeholders, landowners, farm consultants, and other researchers

BASELINE ESTIMATES

Table 2. Key NZFARM baseline annual estimates for all of New Zealand land use sector

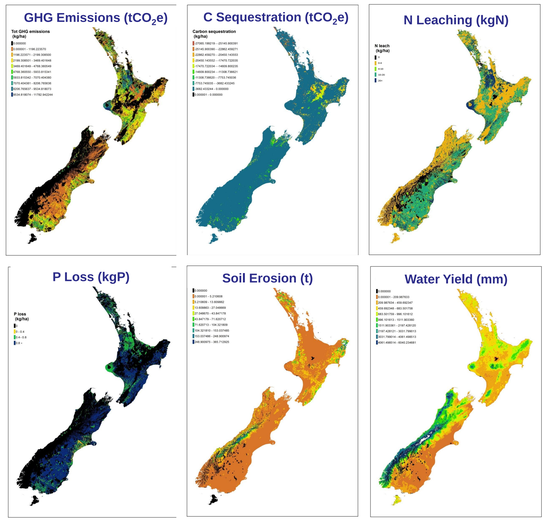
Net Revenue (bil NZD)	Total GHGs (Mt)	Total C Sequest (Mt)	Net GHG (Mt)	N Leach (t)	P Loss (t)	Soil Erosion (t)	Water Yield (mm)
$11.3	34.6	-24.3	10.3	216,000	11,800	294,000	869

Similar to recent national GHG inventories

Regional outputs inline with other studies

BASELINE ENVIRONMENTAL OUTPUTS

Figure 5. Environmental output estimates (per ha)

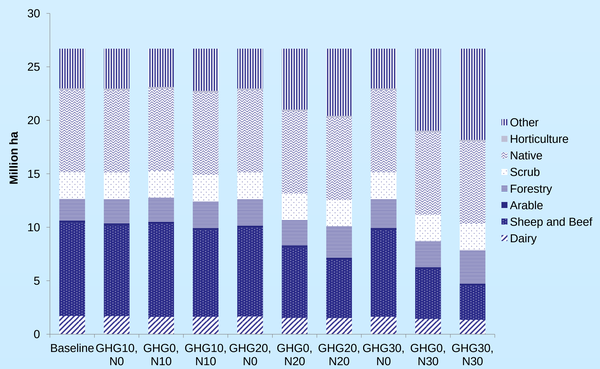


SCENARIO ANALYSIS

Table 3. New Zealand-wide policy scenario estimates of key indicators (% change from baseline)

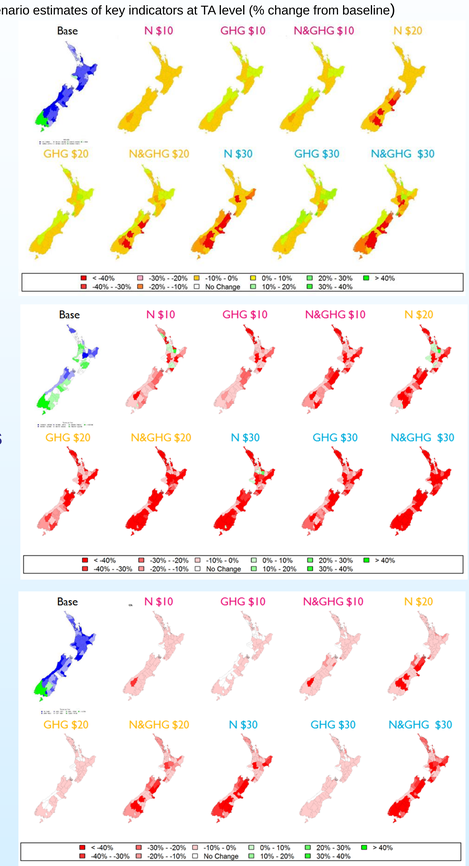
Scenario	Net Revenue	GHG	Carbon Sequest	Net GHG	N Leach	P Loss	Soil Erosion	Water Yield
$10 Scenarios								
GHG10, N0	-1%	-2%	8%	-26%	-1%	-2%	-1%	0%
GHG0, N10	0%	1%	7%	-16%	-3%	-1%	-1%	0%
GHG10, N10	-1%	-4%	15%	-50%	-4%	-5%	-2%	0%
$20 Scenarios								
GHG20, N0	-1%	-4%	15%	-50%	-2%	-4%	-1%	0%
GHG0, N20	-5%	-7%	12%	-50%	-17%	-20%	-3%	6%
GHG20, N20	-6%	-18%	31%	-134%	-20%	-29%	-5%	5%
$30 Scenarios								
GHG30, N0	-2%	-6%	23%	-75%	-3%	-6%	-2%	-1%
GHG0, N30	-11%	-19%	15%	-102%	-30%	-38%	-12%	10%
GHG30, N30	-13%	-36%	40%	-215%	-37%	-52%	-14%	12%

Figure 6. NZ-wide policy scenario aggregate land use area estimates



REGIONAL IMPACTS

Figure 7. Policy scenario estimates of key indicators at TA level (% change from baseline)



SUMMARY

- Net revenue declines relatively modest, particularly for GHG price scenarios
- Some TAs experience increase from policy incentives
- Land use change greatest for sheep and beef enterprises, where shifts to forestry and low-intensity pasture
- N reduction policy → always reduces GHGs
  - Policy could achieve some goals of ETS, even if agricultural GHG emissions not priced
- Converse not always true, particularly at regional level
- Policies evaluated provide co-benefits for other environmental outputs
  - P loss and soil erosion reduced
- Similar findings for in some - but not all - case studies using more-detailed catchment-level NZFARM (e.g., Daigneault et al 2012,2013, 2014)

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