What's the Use? How can we get more from land-use and economic models?

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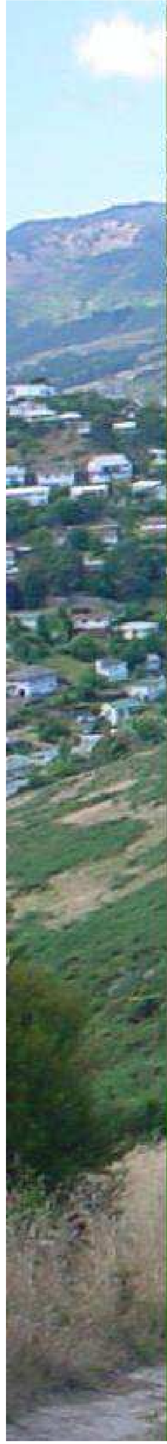
Adam Daigneault, Landcare Research



Introduction

- Agricultural production, economic and social wellbeing, water quality and quantity, erosion, biodiversity and climate mitigation and impacts are all heavily influenced by land use on a catchment scale and beyond.
- The evolution of these issues over time is heavily influenced by private land-use decisions.
- Regional and national decision-makers try to forecast and influence these decisions and want to explore the likely effects of potential policies.

The key challenges for using models to inform decisions are

- Defining questions to be explored
- Choosing a model (or combination of models)
- Interpreting model results

Outline

Land use Modelling

- What is a model?
- Why are models used to understand land-use change?
- How are models developed?
- How are models used?

Existing land use models in New Zealand

- Applications: LURNZ and NManager
- Applications: NZ Farm and ARLUNZ

Challenges for land-use modelling

- Data; parameterisation and calibration; model development and validation;

Suggestions for model end-users to consider

What is a model?

- Simplified representation of reality
- Capture key agents, elements, and relationships relevant to exploring a question
- ‘Everyone is a modeller’

    But not explicitly

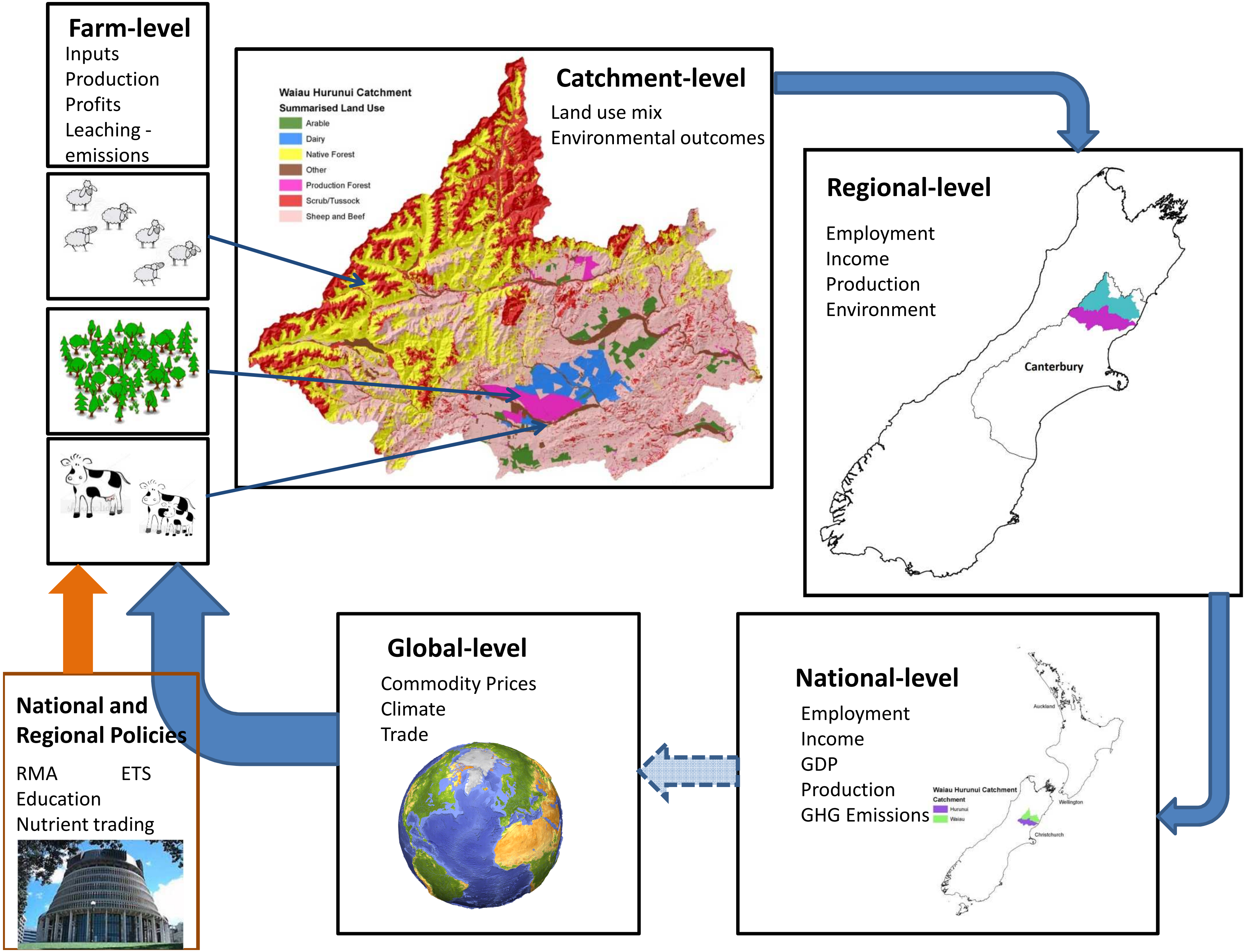
Two types of model:

Theoretical – interrelationships - cause: effect

Numerical – quantify – summarise and embody existing science

Why are models used to understand land-use change?

- Complexity: humans and their interactions
  - Geographic variability
  - Multiple interacting processes
- Makes assumptions explicit so results can be challenged scientifically and tested for robustness
  - Separate analysis from ideology/opinion
- Explore things that haven’t happened yet in an artificial world

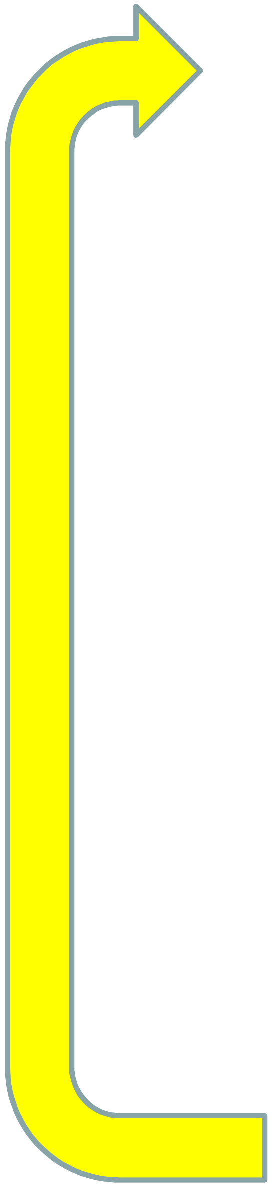


Farm-level
Inputs
Production
Profits
Leaching -
emissions
Catchment-level
Land use mix
Environmental outcomes
Waiau Hurunui Catchment
Summarised Land Use
Arable
Dairy
Native Forest
Other
Production Forest
Scrub/Tussock
Sheep and Beef
Regional-level
Employment
Income
Production
Environment
Canterbury
National-level
Employment
Income
GDP
Production
GHG Emissions
Waiau Hurunui Catchment
Catchment
Hurunui
Waiau
Auckland
Wellington
Christchurch
Global-level
Commodity Prices
Climate
Trade
National and
Regional Policies
RMA
ETS
Education
Nutrient trading

What sort of questions can models address?

1. Projection: What is likely to happen if we do nothing?
2. Policy impact: What is likely to happen if we do policy X?
3. Policy Design: What is cost and effectiveness of one policy relative to another?
4. Distribution: Who will bear costs under different policies and design?
5. How do systems work? – fundamental science

How are models developed?



- Define purpose(s)
- Identify key factors and relationships
- Choose scope and resolution
- Collect data
- Parameterise / calibrate relationships using existing and new empirical evidence
- Code and document
- Test and validate
- Apply

How are models best used?

- Active interaction between modellers and users
- Choose the model best suited to the question
- Transparent process with peer review from other experts
- Publicly available documentation
- Careful interpretation of results and caveats
- Use to complement other knowledge
- Iterate to improve models

Good modeling and use of models takes time

Classification of NZ Land-Use Models*

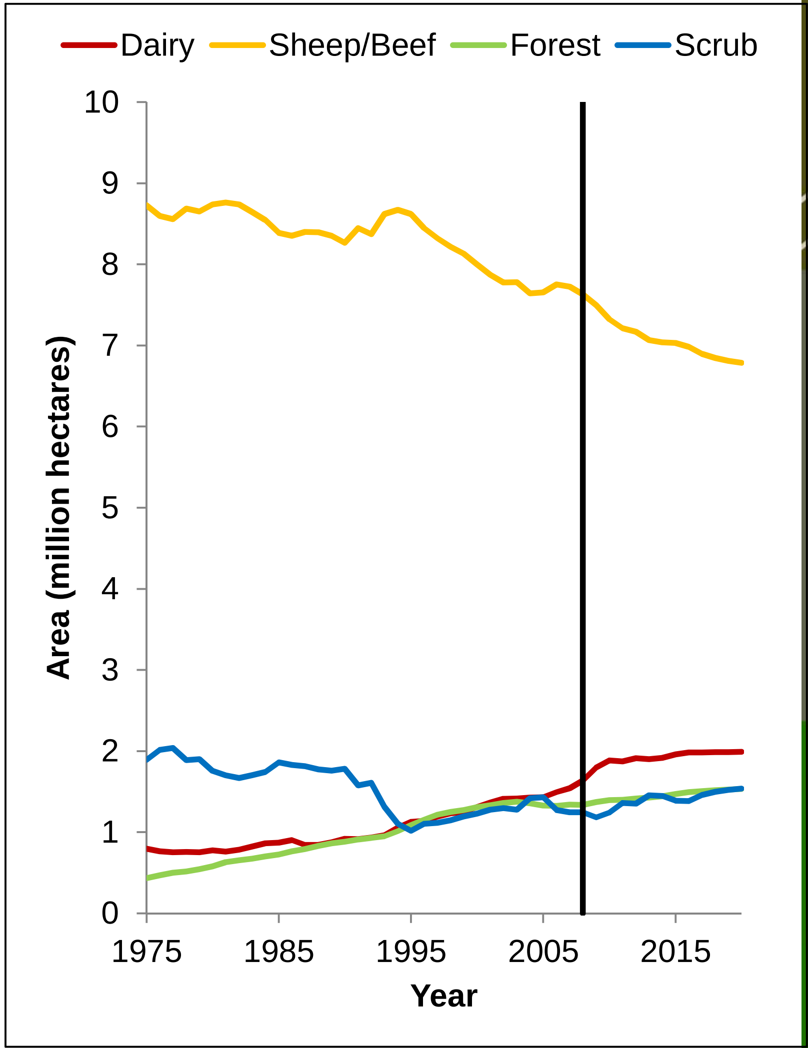
Model methodology	Area covered: Catchment	Area covered: Region	Area covered: National
Individual decision makers	ARLUNZ Waikato M.A.	Rural Futures	
Optimization / Best option	NZ-FARM NManager	LUMASS	
Statistical / Amalgamated preferences		WISE	LURNZ

International:
NZIAMS

* Not necessarily exhaustive

1. LURNZ: Land Use Change and ETS
Projection and policy impact

- Econometric model estimated from historic land use
- Inputs: commodity prices, policy design, climate scenarios…
- Simulate No ETS baseline from 2008



Kerr, Suzi, and Alex Olssen. 2012. "Gradual Land-use Change in New Zealand: Results from a Dynamic Econometric Model", *Motu Working Paper* 12-06, Motu Economic and Public Policy Research

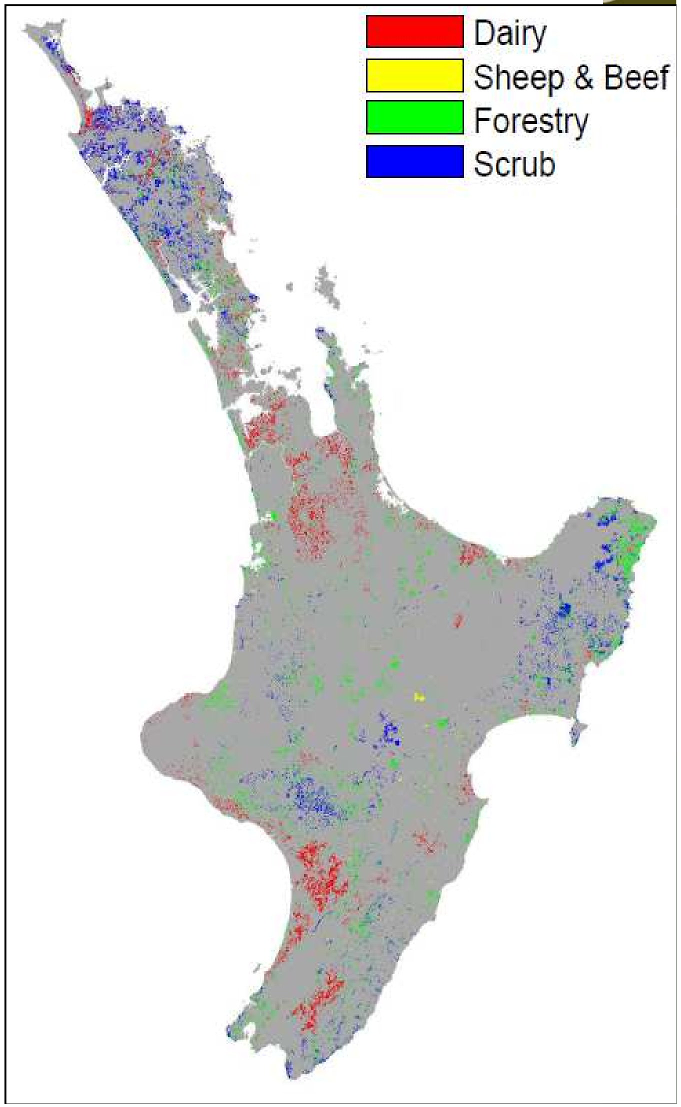
Spatial changes in Land Use

- Spatial algorithm assigns land use changes to map

- Change depends on suitability of land:

  quality, slope, ownership, and distance to ports and towns

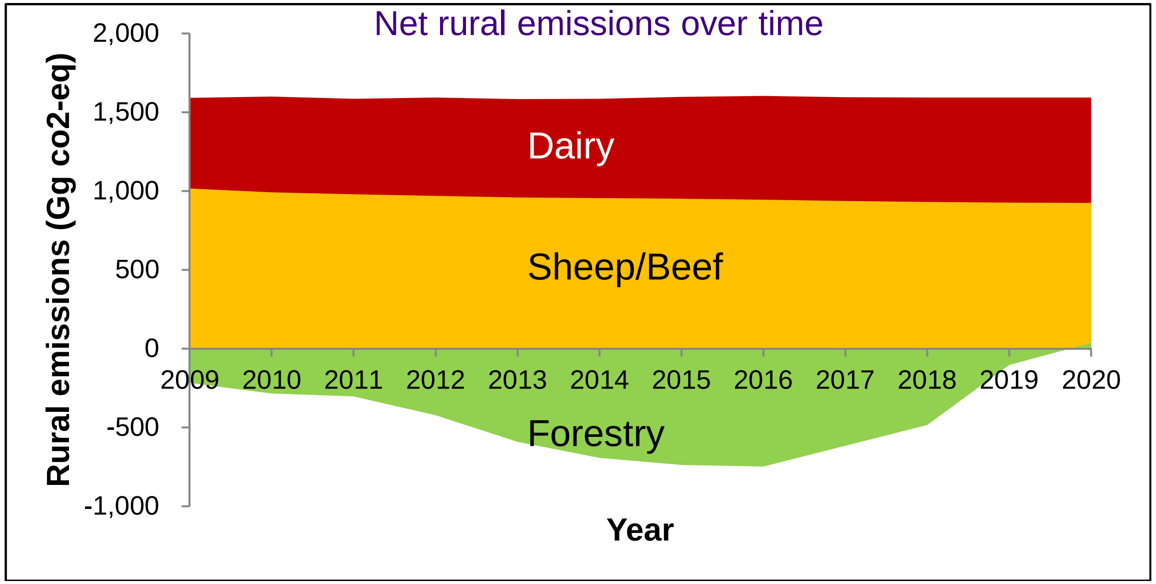
- Map gives new land use

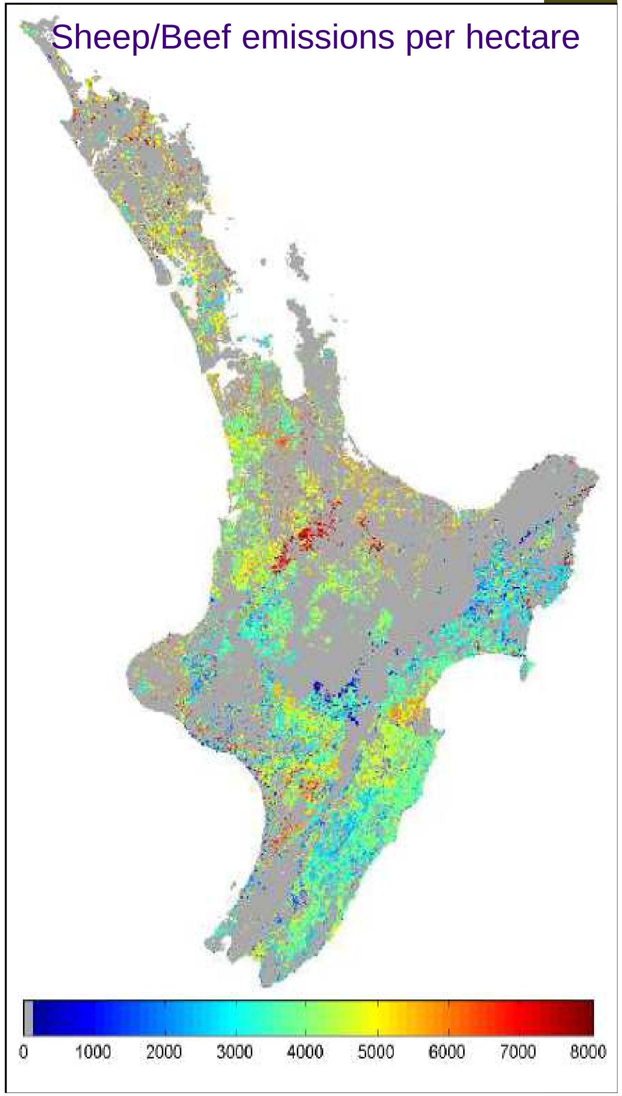


Tímár, Levente. 2011. "Rural Land Use and Land Tenure in New Zealand," Motu Working Paper 11-13, Motu Economic and Public Policy Research, Wellington.

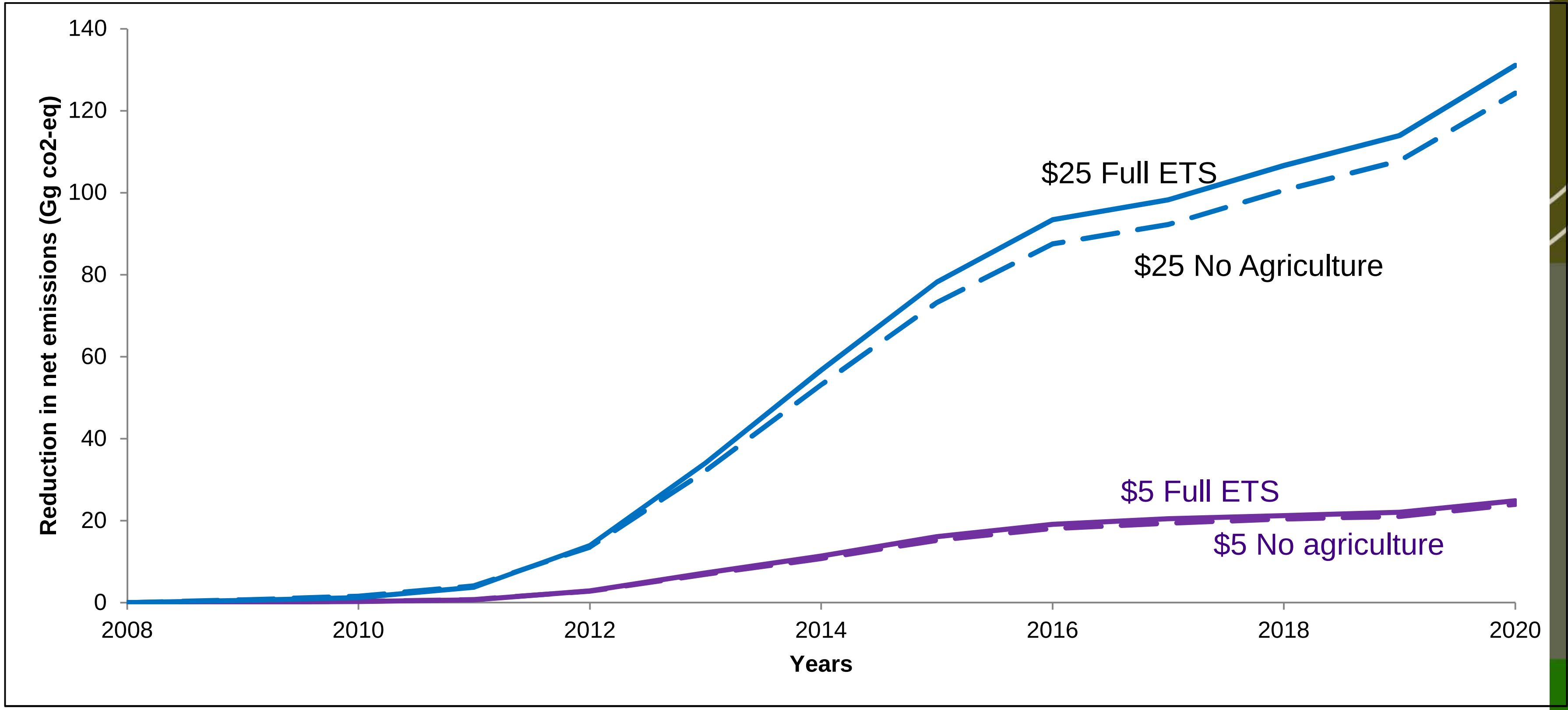
Implications for GHG emissions

- Forestry age determines sequestration
- Production intensity determines emissions





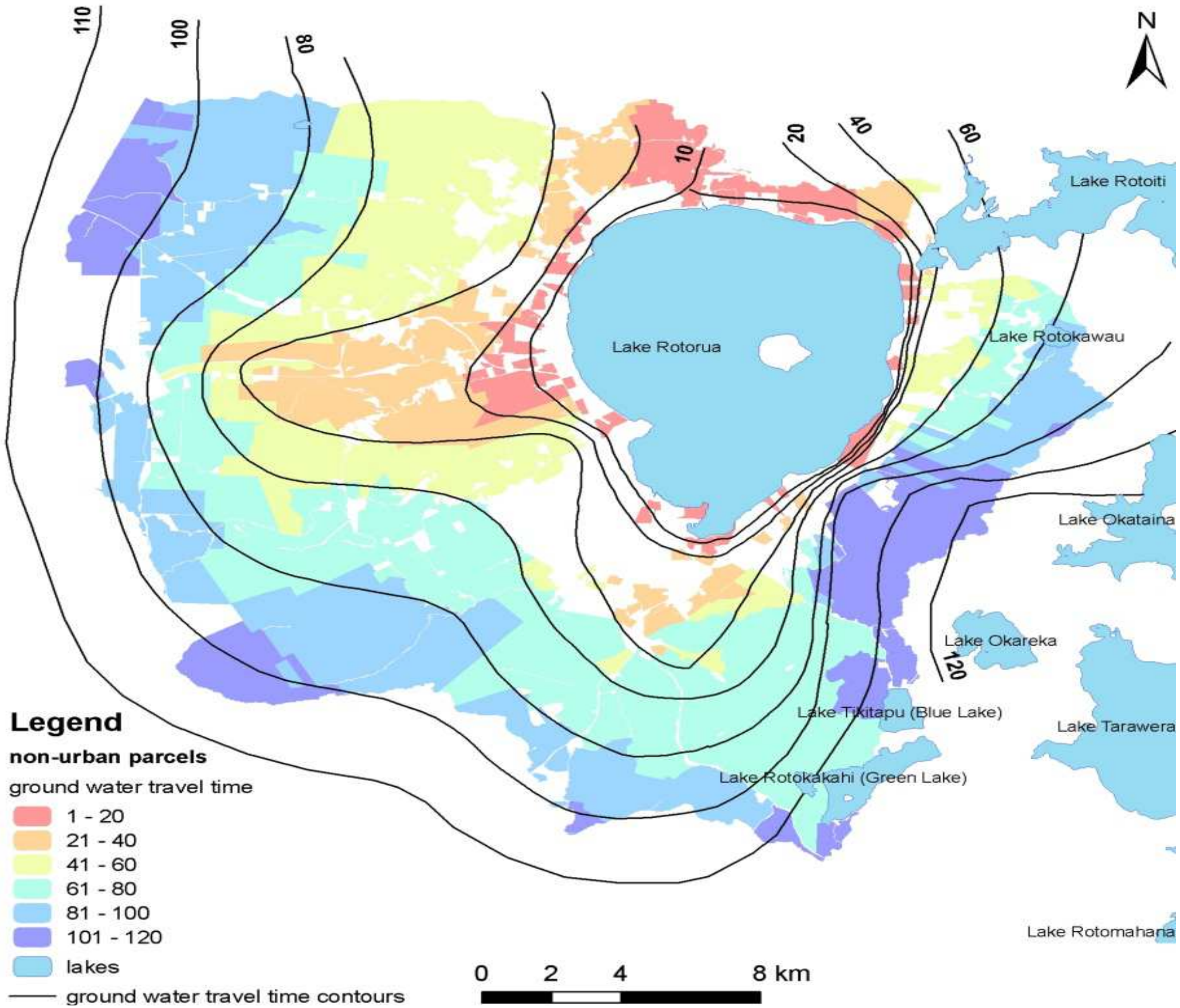
Forecast of GHG reductions under ETS



Land-use related impact of ETS driven by effect on forestry

2. NManager: ground water lags

Policy Design



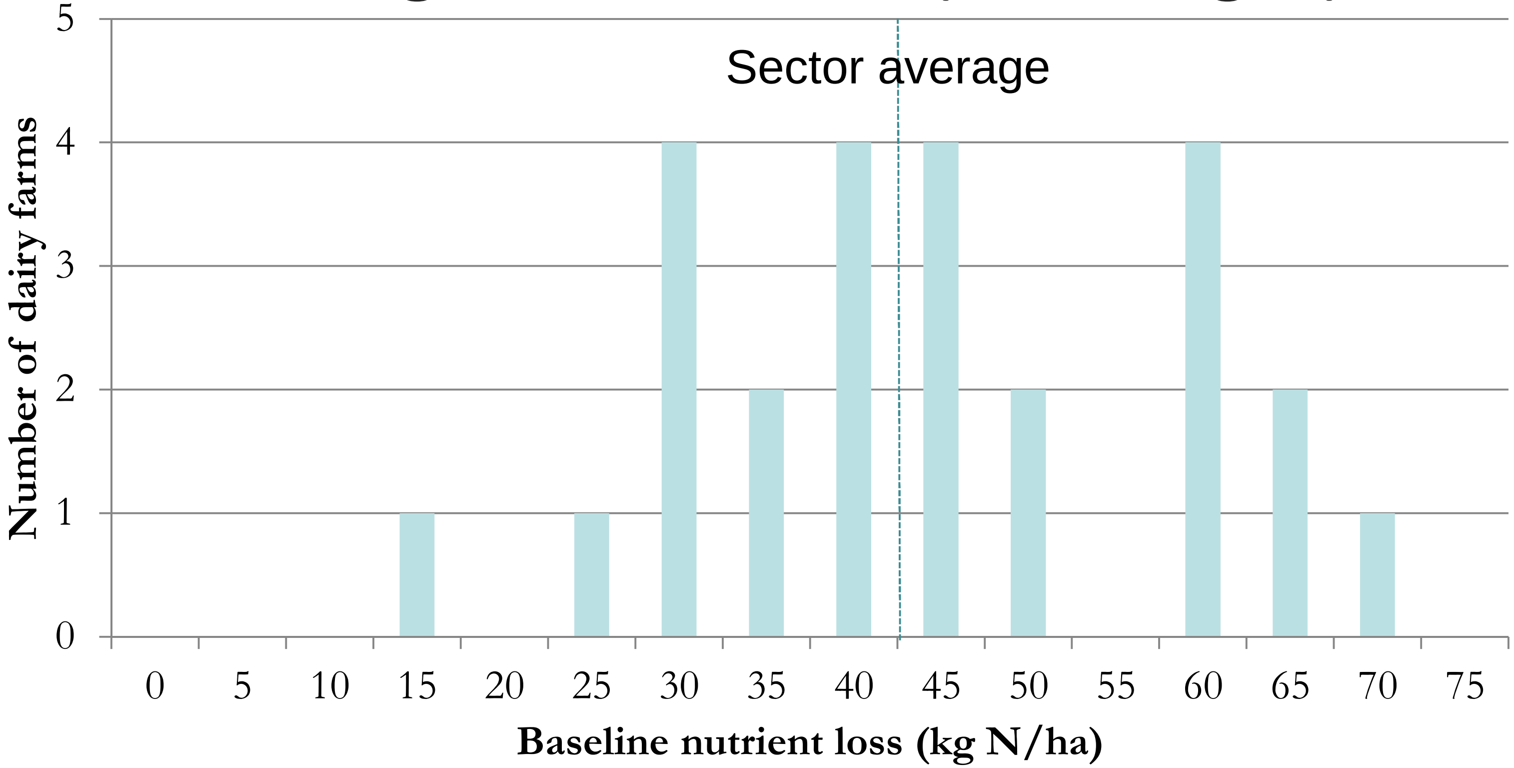
N-Manager simulations

NPV of the Cost of Mitigation ($ millions)

Reduction in leaching	30%	50%	70%
Surface water scheme	26.5	58.7	100.4
2 pulse scheme	25.9	57.4	99.3
Cost reduction	2.5%	2.4%	1.9%

3. Distribution of costs

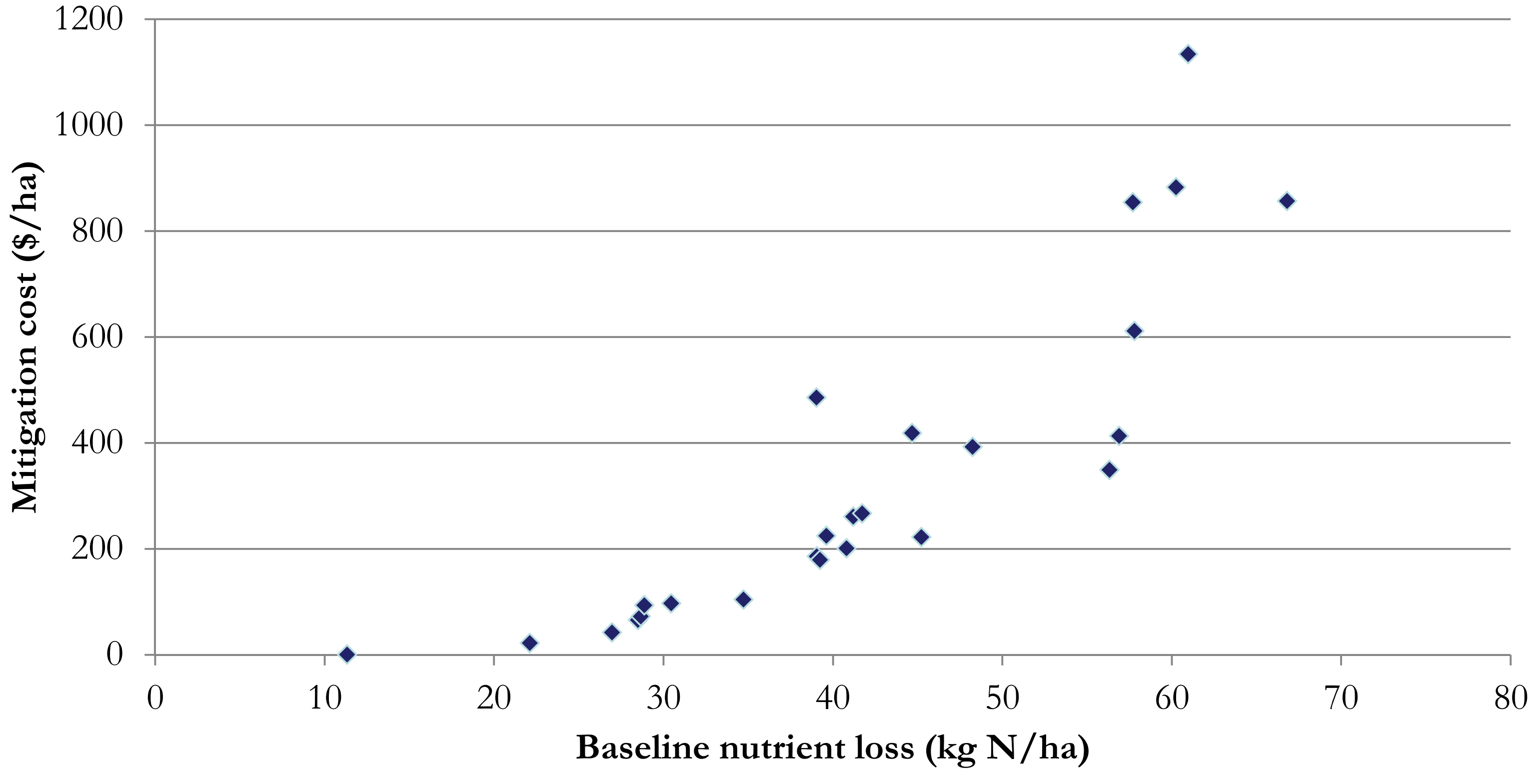
Heterogeneous farms (NManager)



- Farmers with high nutrient loss prefer grandparenting
- Farmers with low nutrient loss prefer sector-based averaging

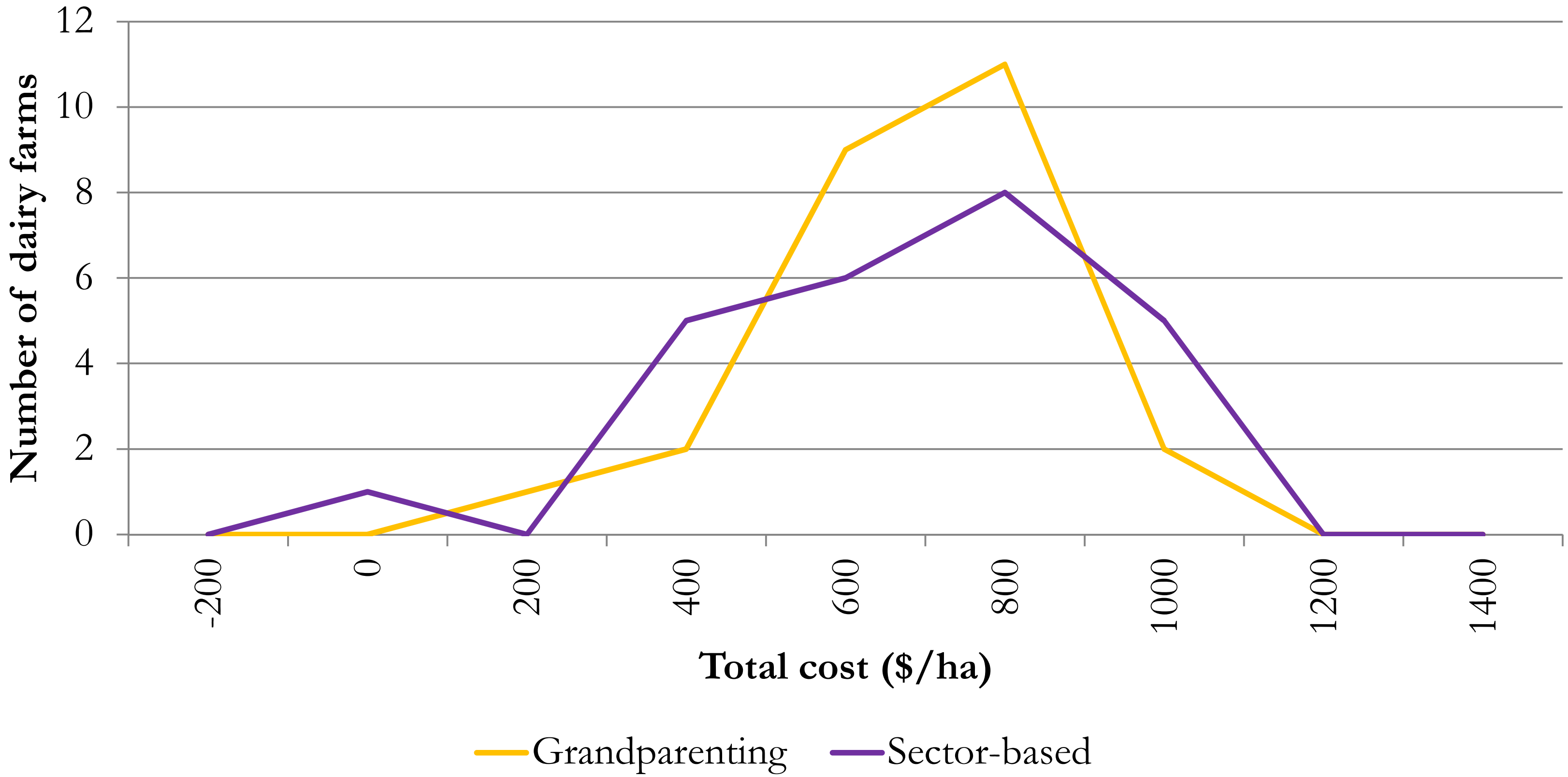
(Does not depend on modelling assumptions)

Farm heterogeneity



In this application, we estimate that farmers with higher baseline loss will tend to bear higher mitigation costs

Distribution of total costs after mitigation and trading



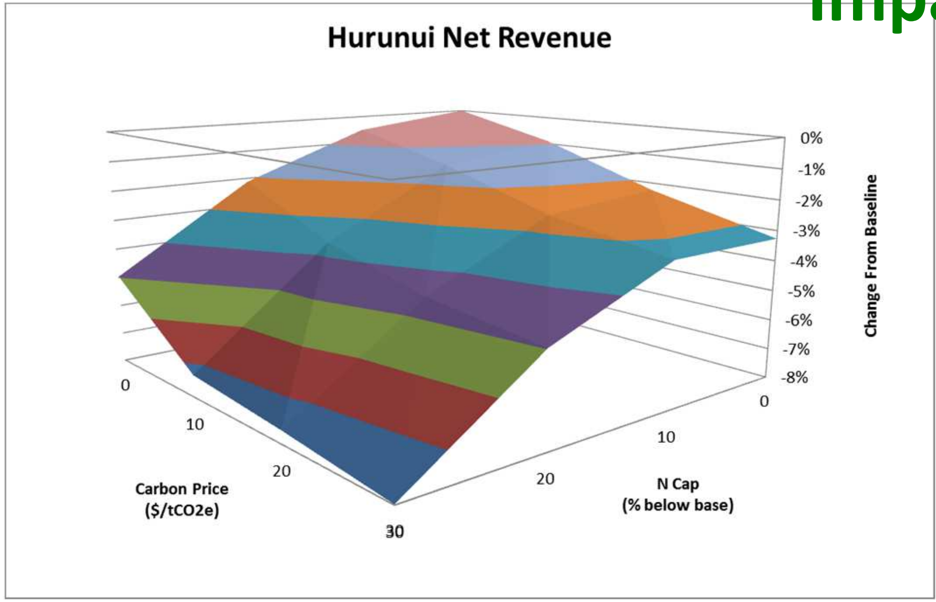
More equal under grandparenting (in this one instance)

More equitable?

New Zealand Forest And Agriculture Regional Model (NZFARM)

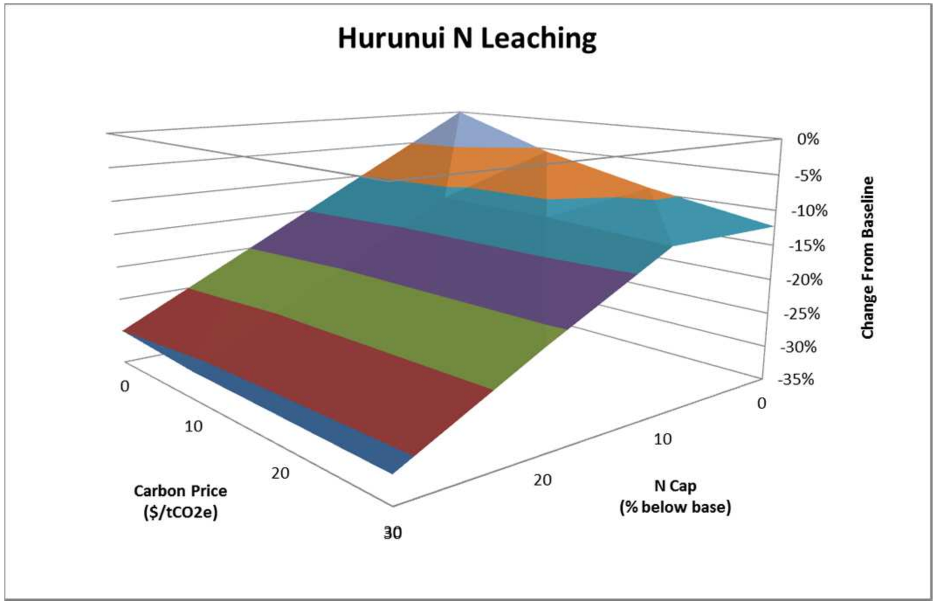
- A catchment-level economic model of NZ land use
  - Objective is to maximize income from land-based activities
  - Spatial scale at sub-catchment level
  - Models changes in land use and land management
  - Key outputs include changes in income, land use, GHG emissions, and nutrient losses
- Designed to consistently compare the economic & environmental impacts of a range of policy scenarios
- Detailed parameterisation for 5 catchments

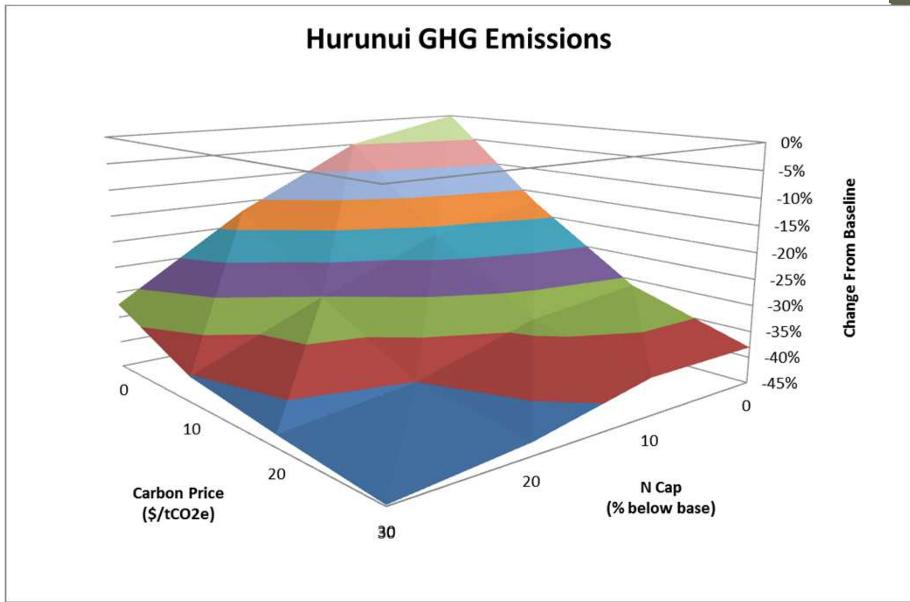
NZFARM Example #1 – GHG and/or Nutrient Policy Impacts



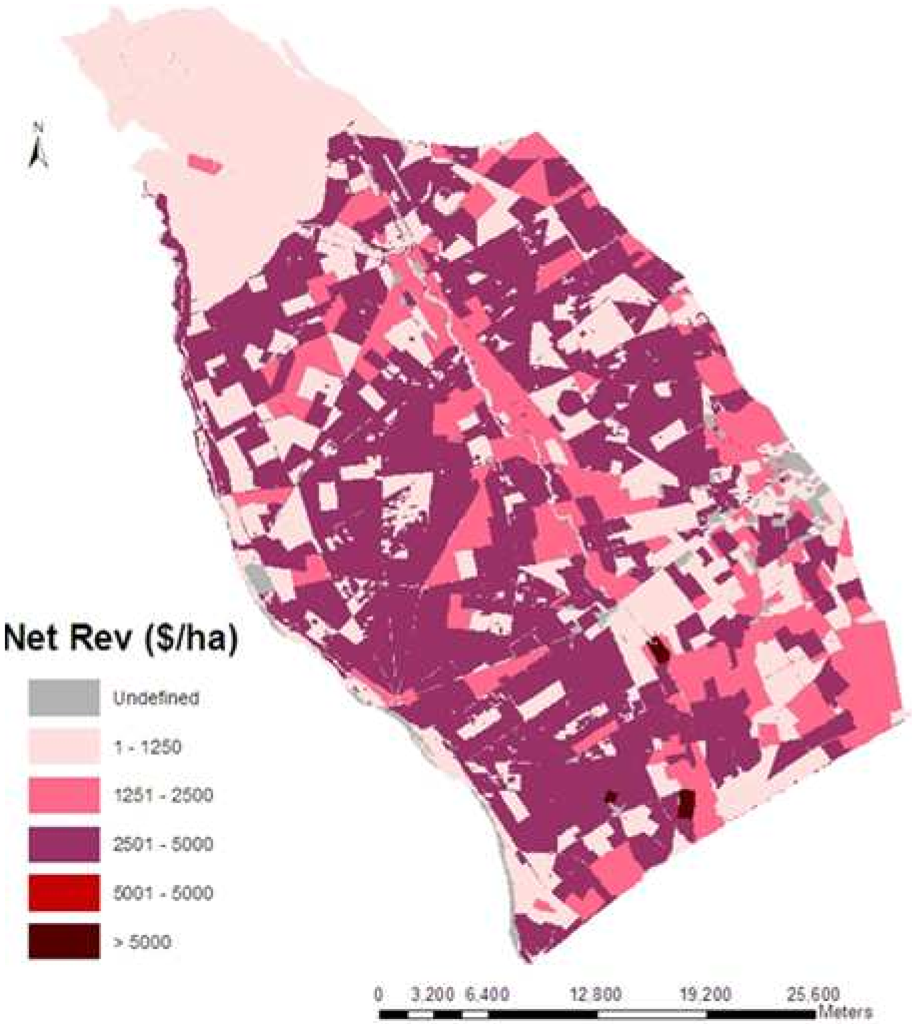
Impacts of various:

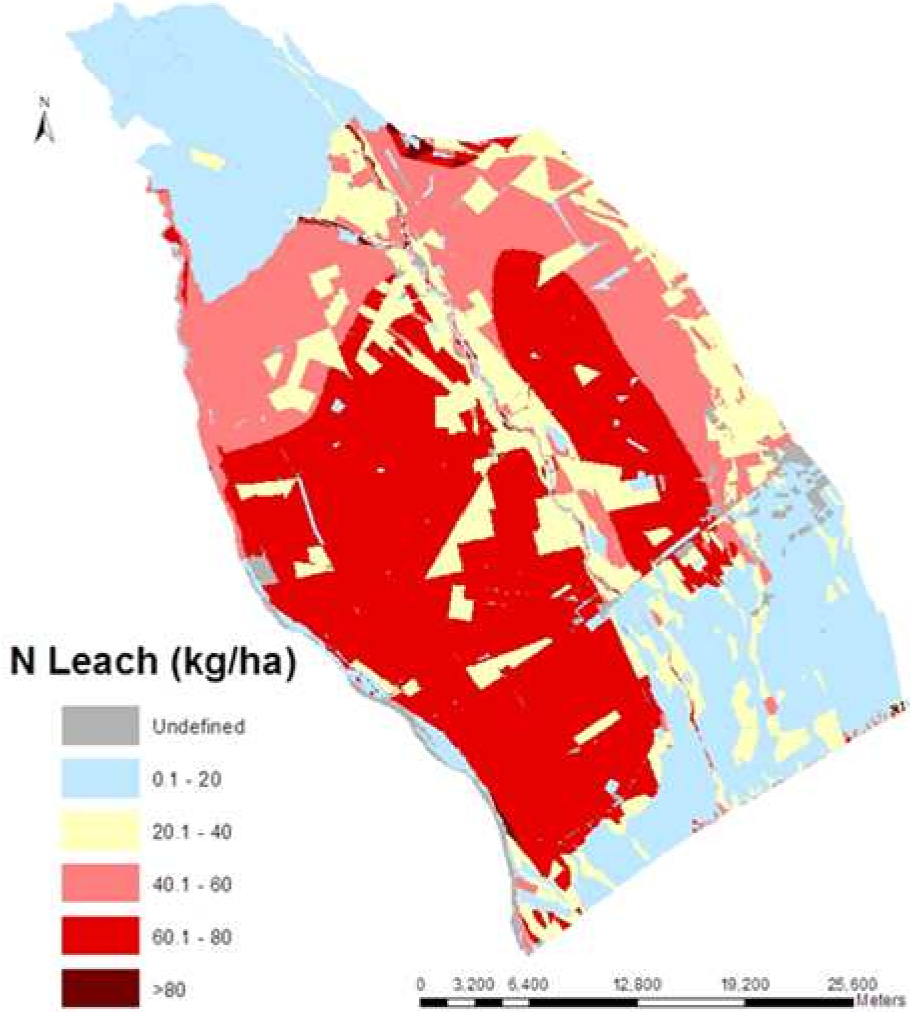
1. GHG prices on ag emissions ($0-30/tCO2e)
2. Caps on N leaching (0-30% below baseline
3. Combination of #1 and #2



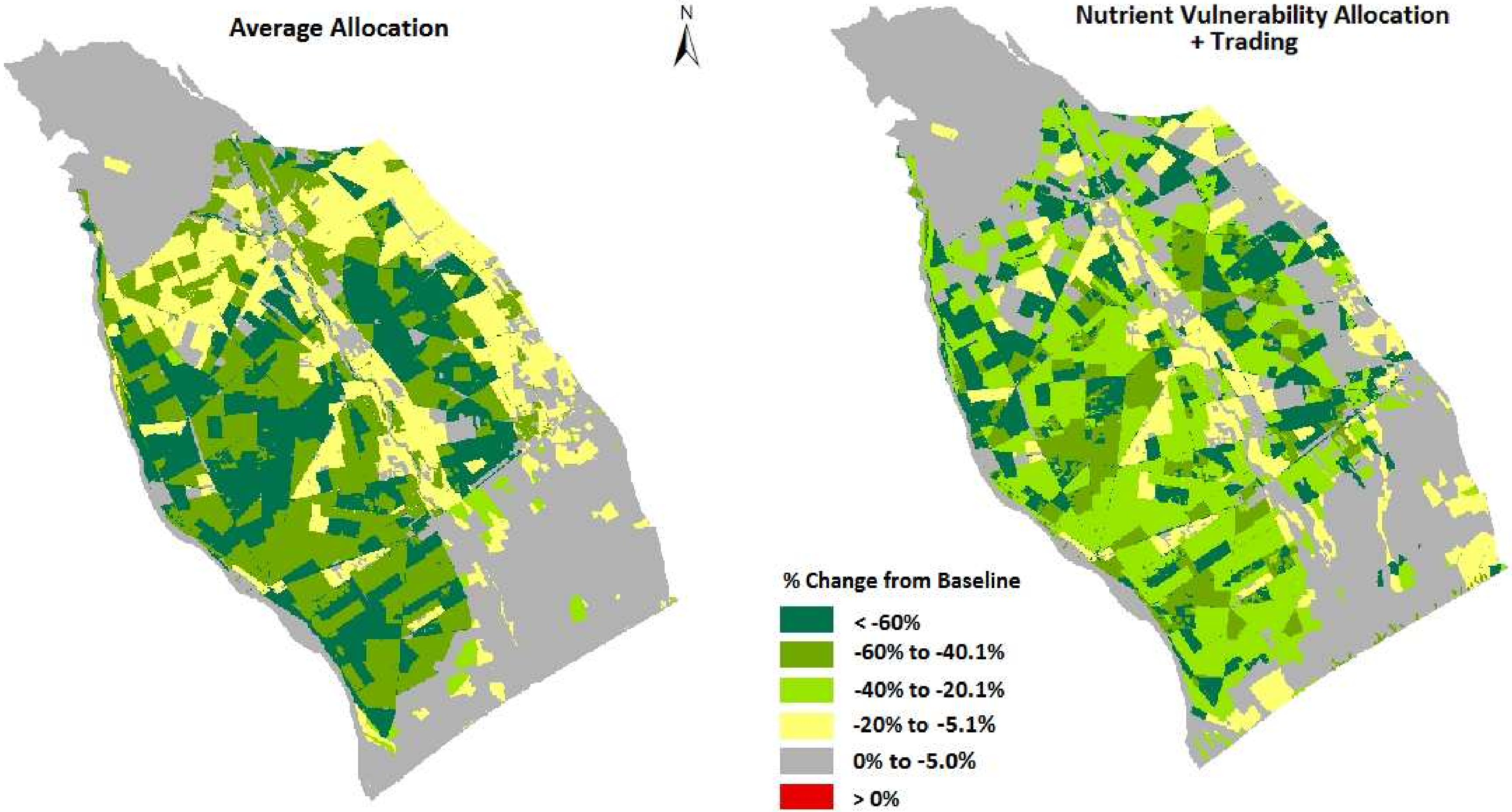


NZFARM Example #2 Distributional effects

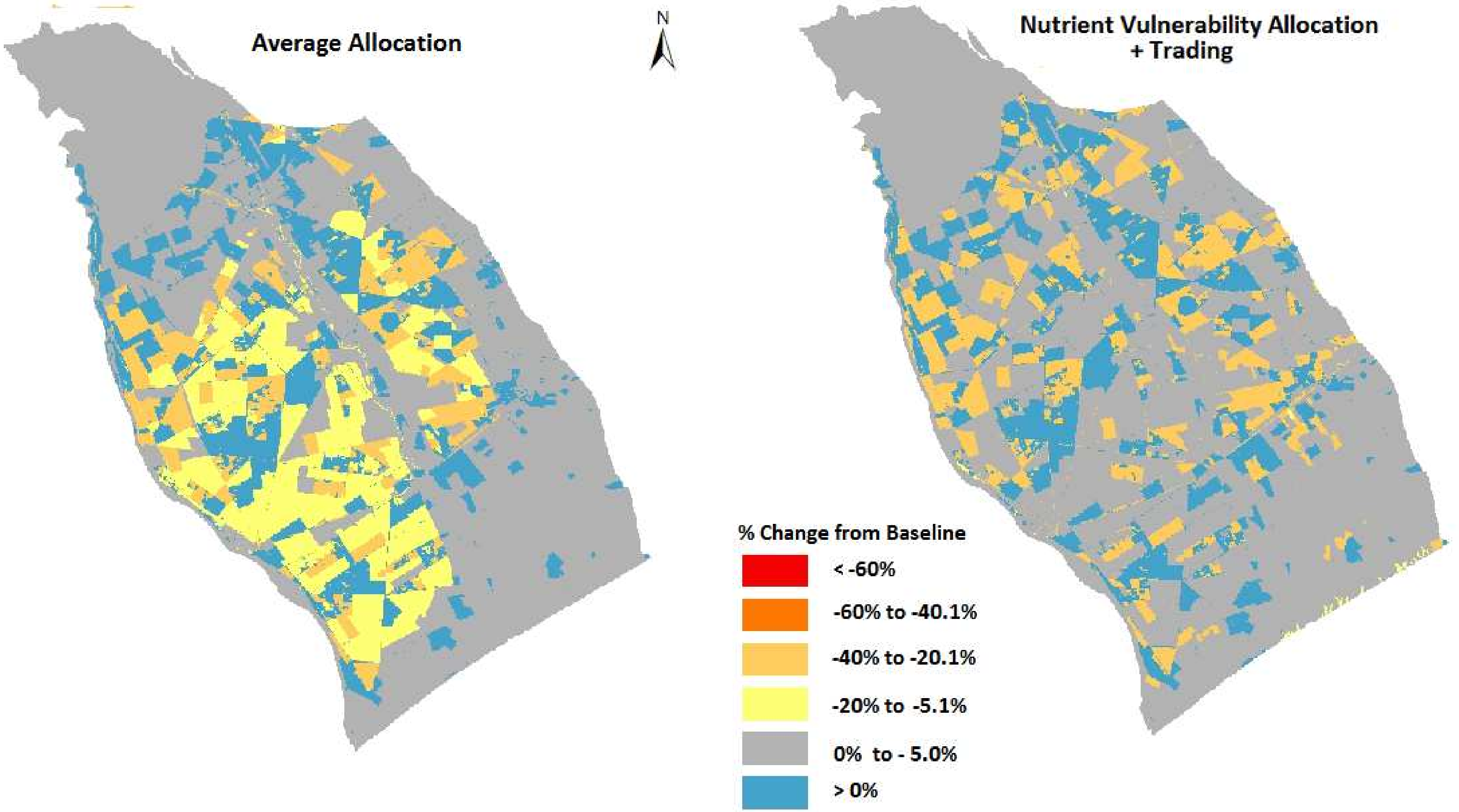




Change in N Leaching From Baseline



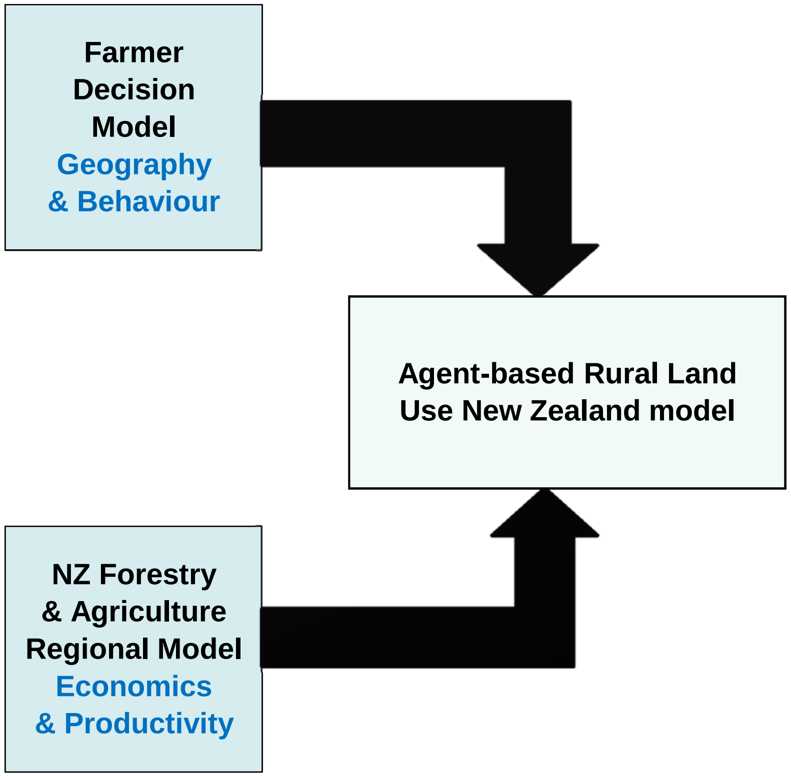
Change in Net Revenue From Baseline

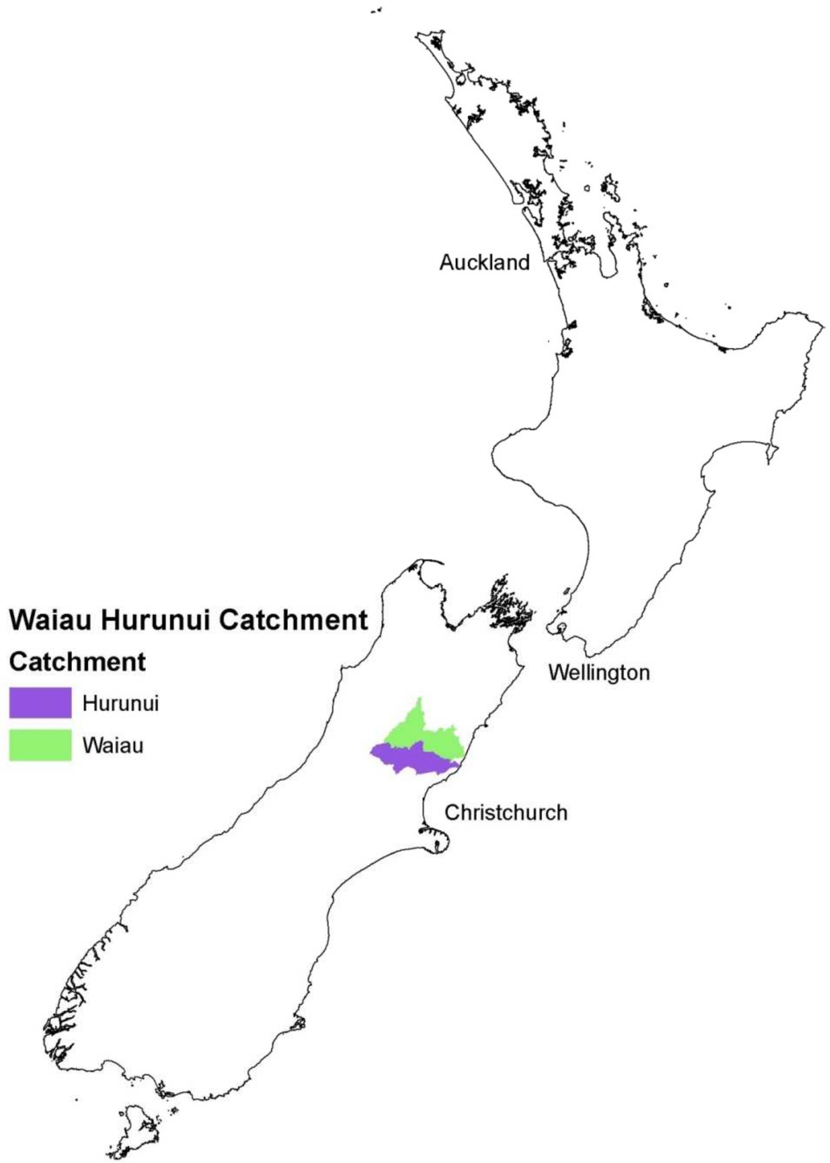


Agent-Based Land Use New Zealand (ARLUNZ)

- In addition to profit maximisation, other objectives/aspects of decision-making taken into account:
  - Farm size, location, attitudes, perceived control, social expectations all play a role
  - Risk tolerance
  - Attitudes towards the environment
  - Stage of life
  - Networks
- Agents are defined using national survey of 1000+ landowners conducted in 2013

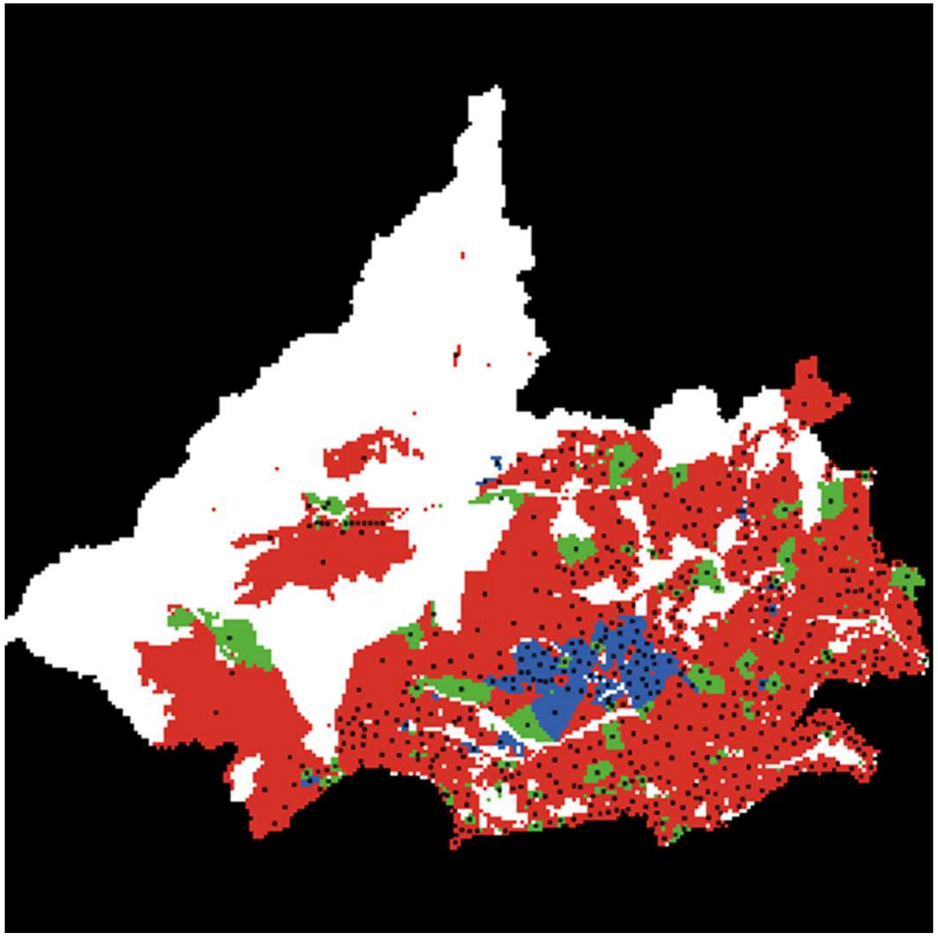
Agent-based model ARLUNZ



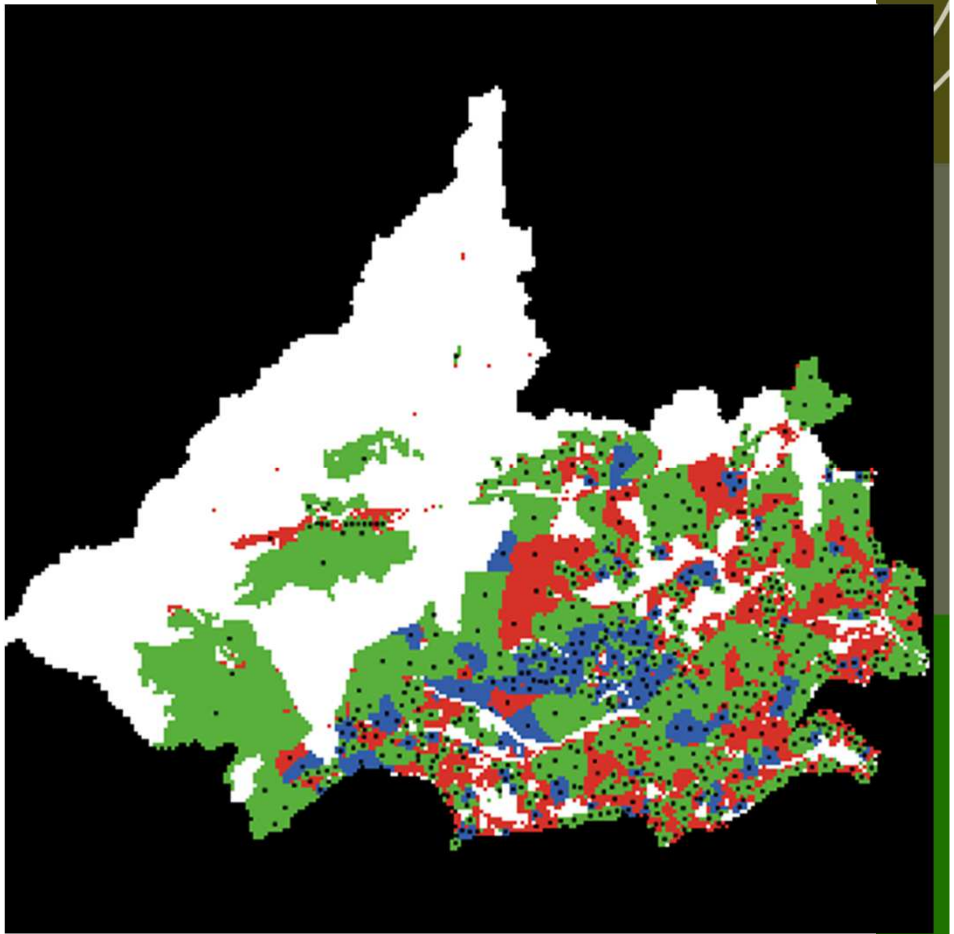


ARLUNZ Example:
Land Use Change: 2010-2060

GHG price = \$0/tCO_2e

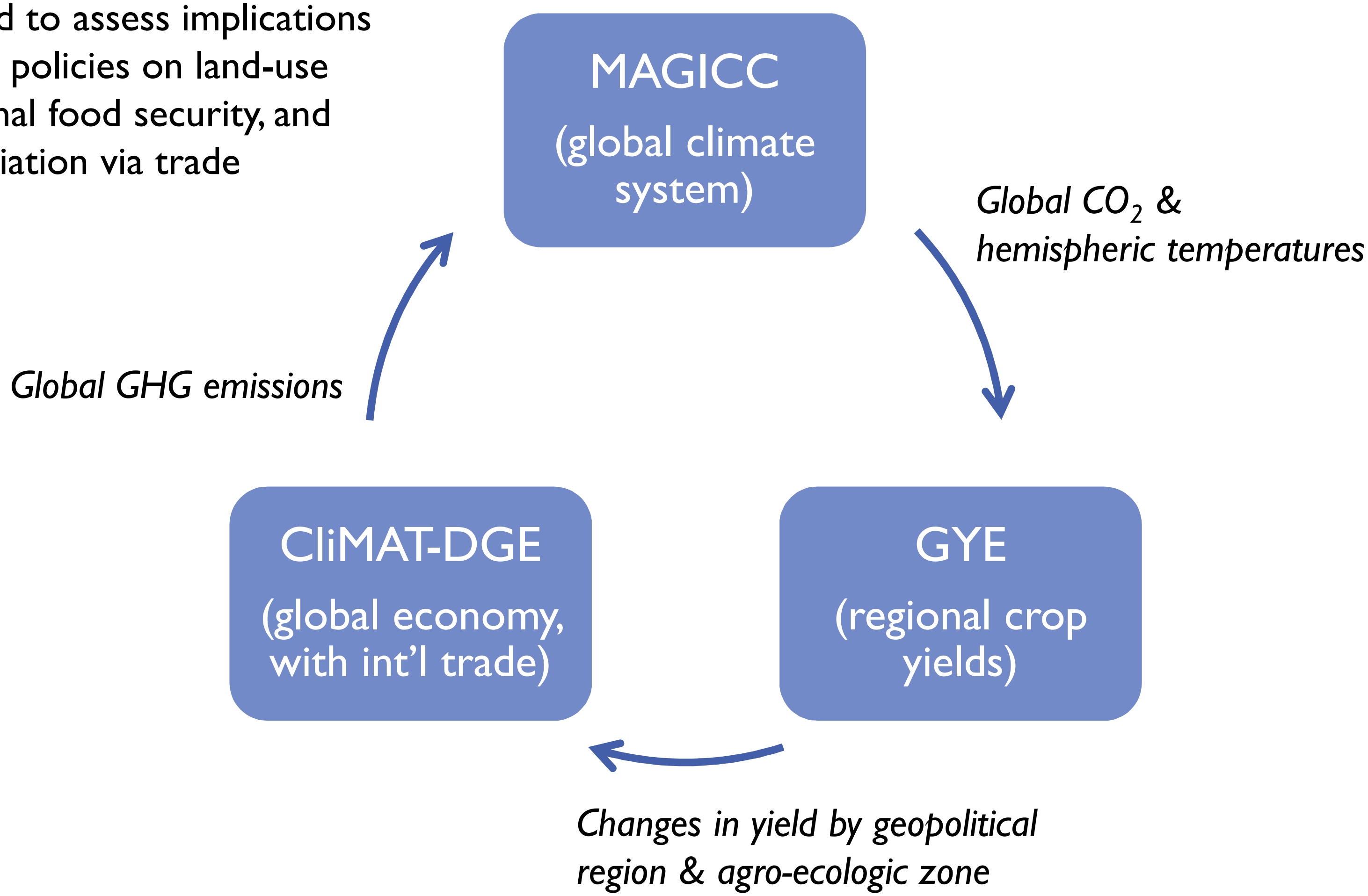


GHG price = \$50/tCO_2e

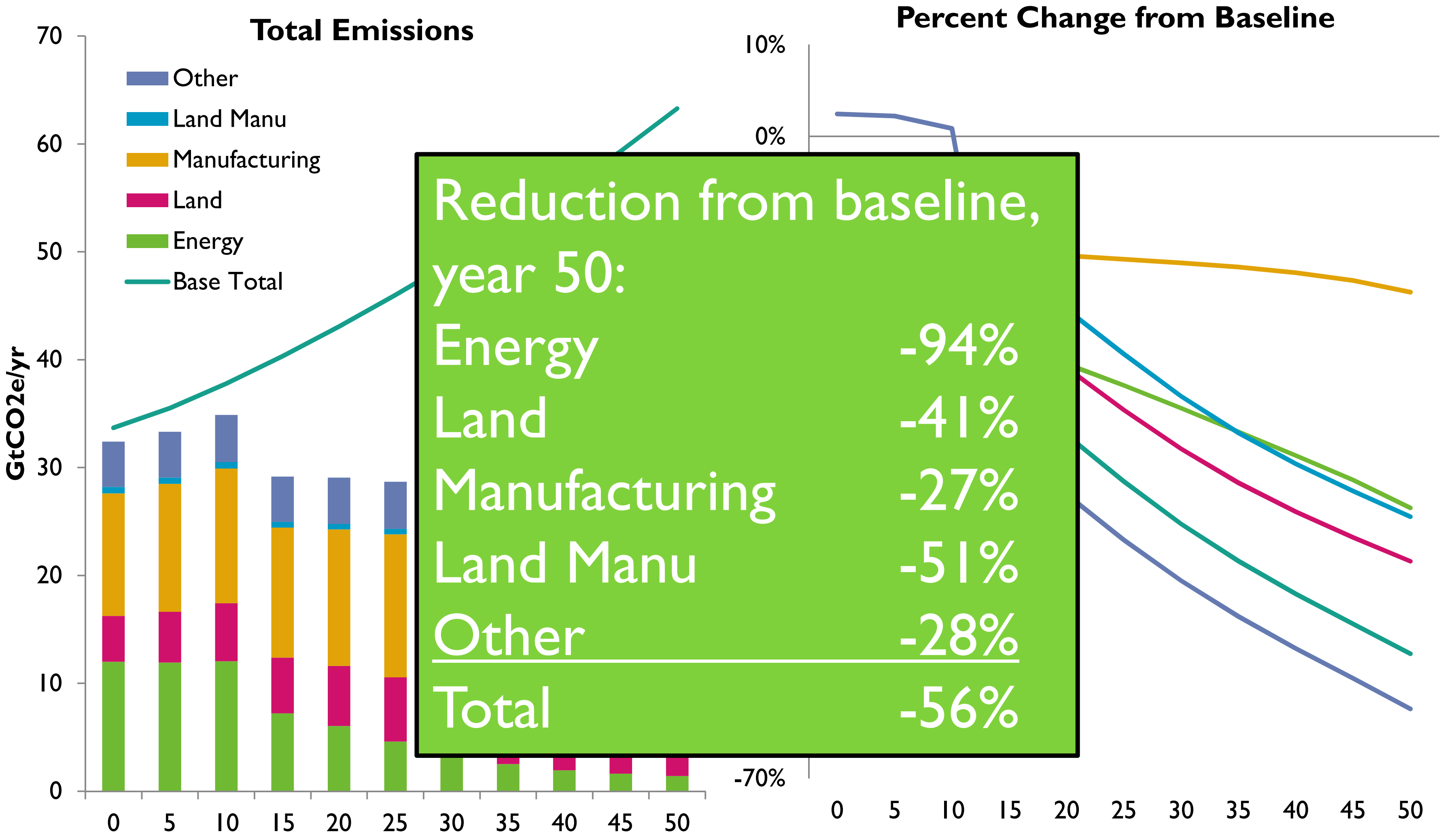


NZ Integrated Assessment Framework

Developed to assess implications of climate policies on land-use and regional food security, and their mediation via trade



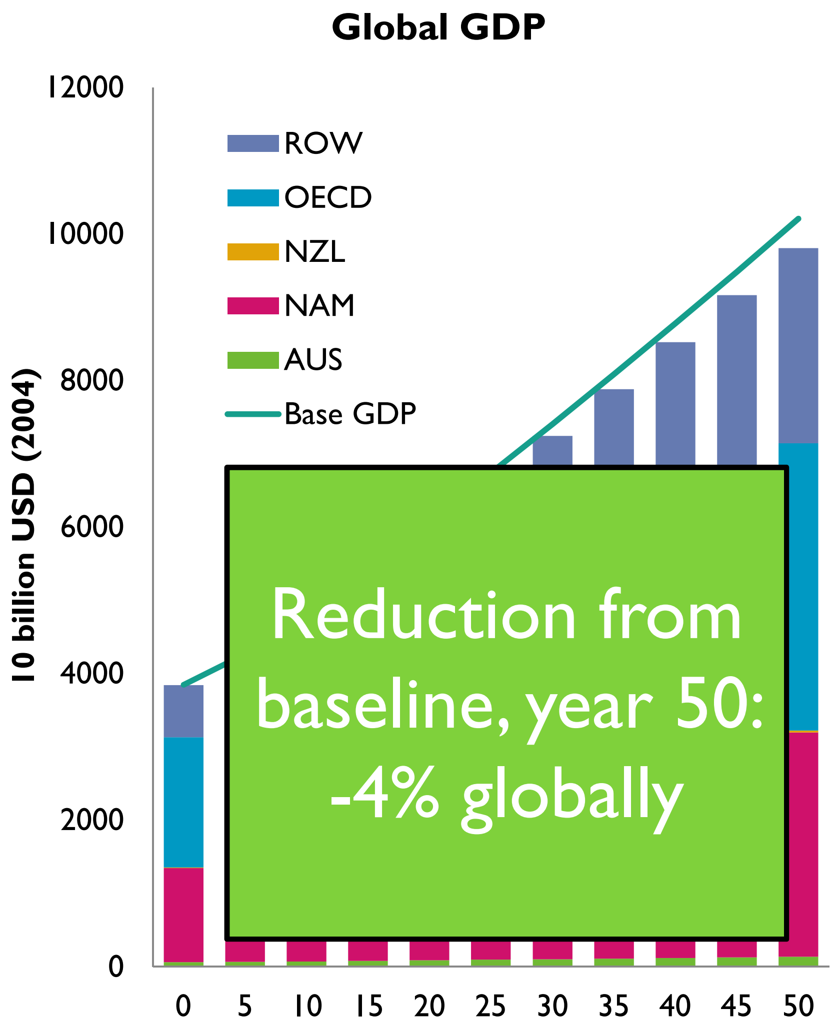
GHG Price Policy Impacts – GHGs

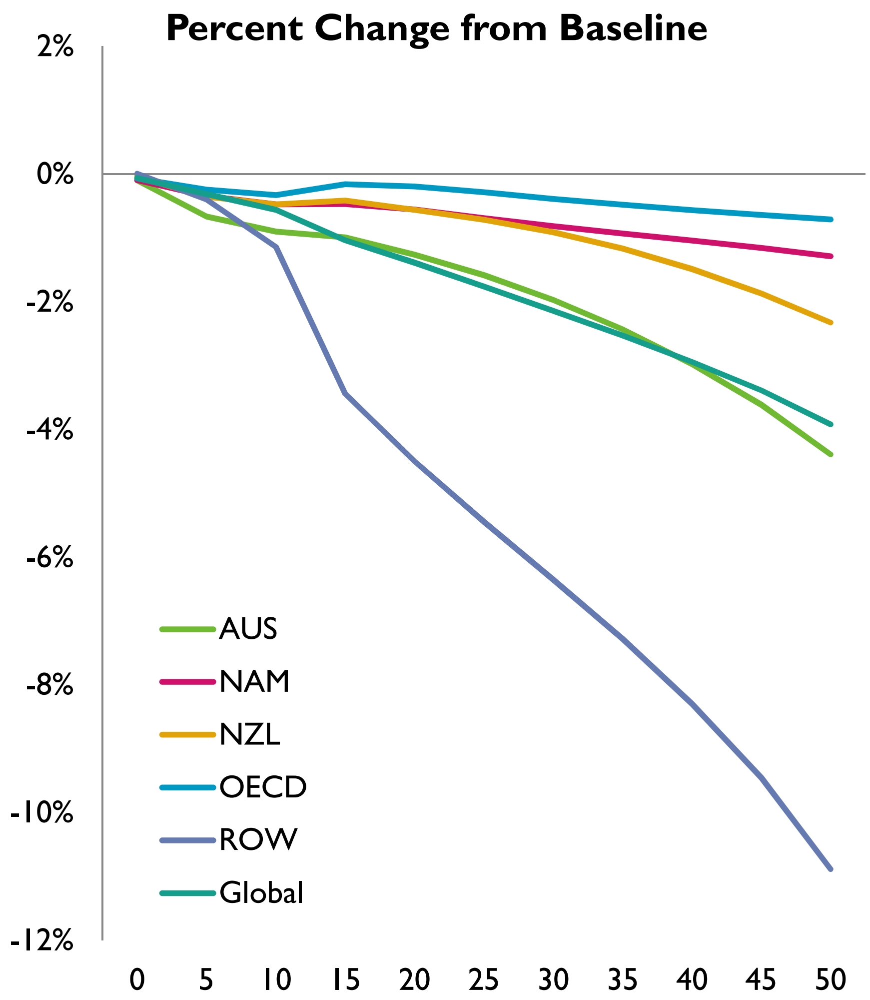


Reduction from baseline, year 50:

Energy	-94%
Land	-41%
Manufacturing	-27%
Land Manu	-51%
Other	-28%
Total	-56%

GHG Price Policy Impacts - GDP





Challenges

- Data
  - Current and historical land use maps
  - Farm-level management, costs and production
  - Environmental
- Calibration and Validation
  - Many policies not yet implemented
  - Will future land use follow past performance?
    - Regardless of policy under consideration?

Challenges

- Model Complexity
  - Heterogeneous landowners and landscapes
  - Management options to include
  - Policy instruments
  - Spatial and temporal resolution to consider
- Model Estimates
  - Context specific
  - Not always generalizable
  - Open to (mis)interpretation

How Users Can Help Improve Models

- Enable model comparisons – fund the same question on two + models
- Push for clear publicly available documentation of model and data
- Support ongoing development and refinement of models
- Encourage modelers to work together and review each others' models
- Encourage intellectual criticism but not financial competition among modelers

Questions for End Users to Consider About Modelling

1. How is the issue related to land use?
2. How much data do I have/need?
3. What is my timeframe?
4. What is the minimum detail I need to get useful input into decision making?
5. What are the options under consideration?
6. What are the possible policy instruments?

Rules of Thumb for End Users

- When you first think about using land use modelling, talk to a couple of land use modellers
- Find the strongest model that can address the questions you have
- Be realistic about what you demand from models and how you use results
- Run open iterative process to discuss modelling as it evolves
- Plan ahead – good modelling takes time

Model Resources*

Agent Based models

ARLUNZ: http://purl.umn.edu/124973

MAS/Rural Futures: Schilling, C; W. Kaye-Blake; E. Post and S. Rains. 2012.

Catchment models

NZFARM: http://www.landcareresearch.co.nz/science/soils-and-landscapes/ecosystem-services/nzfarm

ARLUNZ: http://purl.umn.edu/124973

N-Manager: http://www.motu.org.nz/files/docs/resources/NManager_overview_final.pdf

Waikato Multiple Agent Model: Doole (2012) Doole et al (2011)

LUMASS: http://www.academia.edu/1787302/Optimising_land_use_for_multiple_ecosystem_services_objectives_a_case_study_in_the_Waitaki_catchment_New_Zealand

Model Resources*

Regional/National models

ARDEEM: http://tools.envirolink.govt.nz/dsss/auckland-regional-dynamic-ecological-economic-model/

Reginal Irrigation model: Saunders C, Saunders J. 2012. The Economic Value of Potential Irrigation in Canterbury. Research report prepared for CDC: AERU, Lincoln University, September.

WISE: http://tools.envirolink.govt.nz/dsss/waikato-integrated-scenario-explorer/

LURNZ: http://www.motu.org.nz/research/group/land_use_in_rural_new_zealand_model

Global economic models

NZIAMS/CliMAT-DGE: Lennox et al (2013); Lennox et al (2012)

***Not necessarily exhaustive**

Questions?

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