



**Landcare Research**  
Manaaki Whenua

# **Modelling Economic Impacts of Water Storage in North Canterbury, New Zealand**

**Adam Daigneault, Suzie Greenhalgh, James Lennox**  
*Landcare Research*

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# The Issue: Water, water, everywhere...or not

- Growing concern over water use and environmental flows in North Canterbury
  - Limited water currently available to be allocated
  - Large difference in farm incomes for farms with and without irrigation
  - Recent demands from landowners to begin irrigating, expand their current irrigation or increase the reliability of their water supply.
- Proposed Hurunui Water Project (HWP) would nearly double area of land that can be irrigated (22 to 42 THA):
  - Build a dam on the South Branch of the Hurunui River (costing upwards of \$42 million)
  - and/or to construct a control weir (costing about \$3 million) at the outlet of Lake Sumner in the western part of the catchment

# The Issue...

- Opponents of HWP contest that additional irrigation would harm local ecosystem and impact river-based recreation opportunities
  - Regional Council also considering nutrient loading constraints in same catchment as HWP
- This paper uses catchment-level economic model to estimate changes in land use, agricultural output, and environmental factors for two scenarios
  1. Proposed irrigation scheme
  2. Proposed irrigation scheme with nutrient load limits

# New Zealand Forest And Agriculture Regional Model (NZ-FARM)

- Objective Fn: Maximize total net revenue from all farm enterprises in catchment
- Constraints:
  - $\text{Inputs}_R \leq \text{Inputs Available}_R$
  - $\text{Land Use}_R \leq \text{Land Available}_R$
  - $\text{Irrigated Enterprises}_R \leq \text{Irrigated Land Available}_R$
  - $\text{Environmental Outputs}_R \leq \text{Regulated Environmental Output}_R$
- Method: comparative-static, partial equilibrium, non-linear programming model solved in GAMS



# New Zealand Forest And Agriculture Regional Model (NZ-FARM)

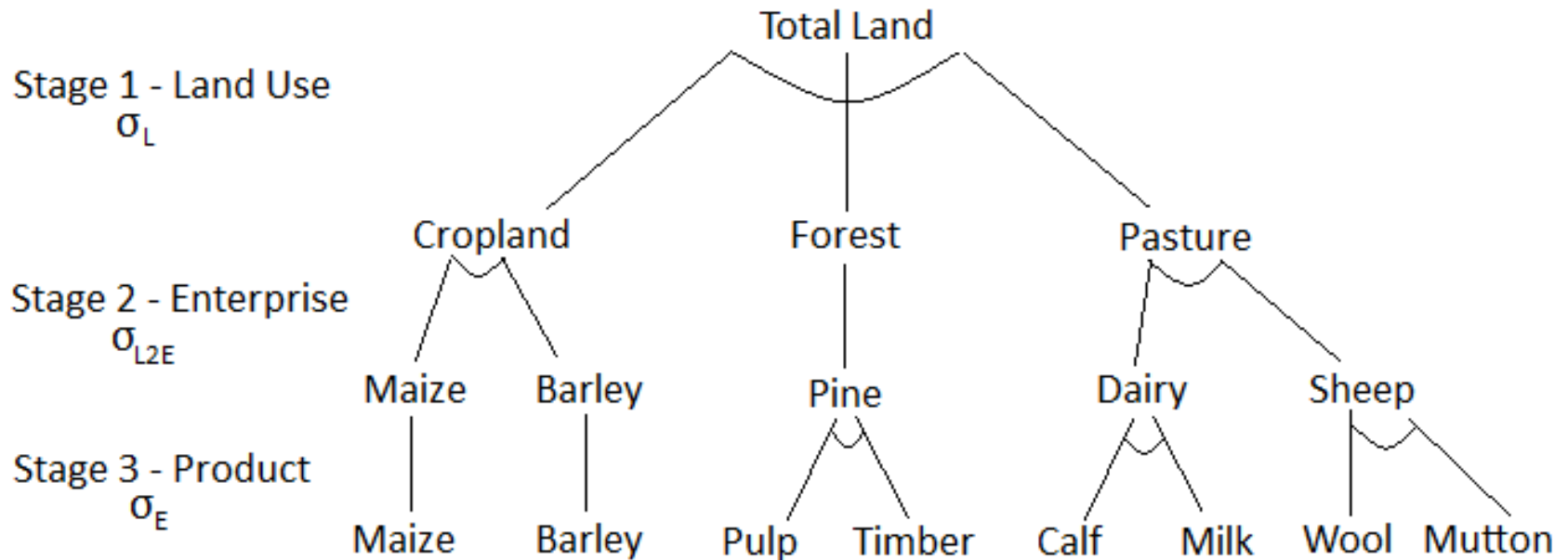
- Land-use/enterprises:
  - Pastoral: Dairy, sheep, beef, deer
  - Arable: Wheat, barley, maize
  - Horticultural: Potatoes, grapes, berryfruit
  - Forestry: Pine, eucalyptus, native
  - Other: Scrub and Conservation Land
- Environmental outputs:
  - Nutrients: Nitrogen and Phosphorous
  - GHGs for farm and forest activities
  - Water use
- Endogenous farm practices:
  - Change enterprise or land use
  - Adjust fertilizer and stocking rates
  - Add dairy feed pad or apply DCDs
  - Enroll in forest carbon sequestration



# Structure of CET Nest in NZ-FARM

Given land area and soil type, landowner simultaneously chooses:

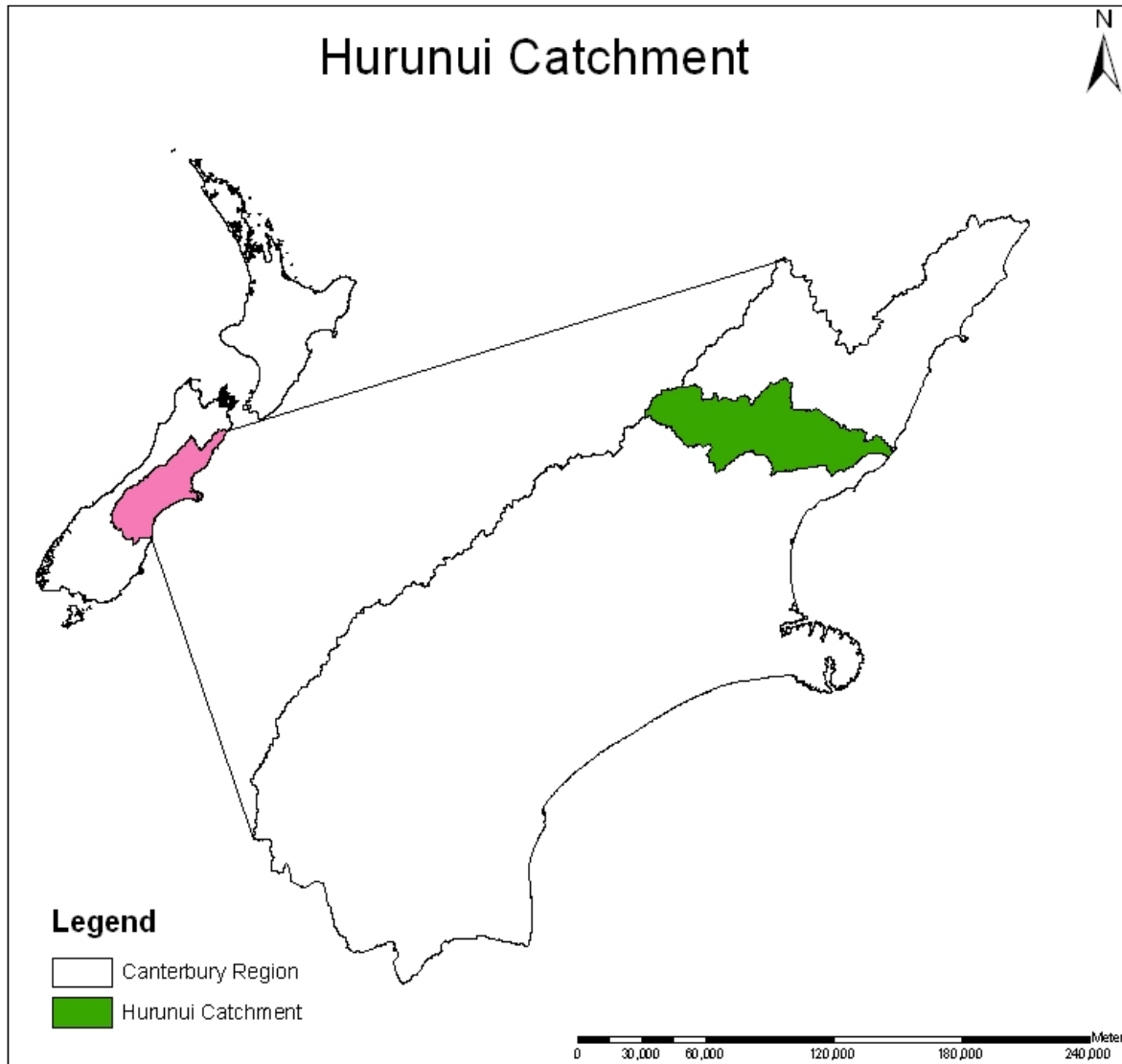
- (a) Land Use Mix
- (b) Enterprise Mix
- (c) Product Output



Transformation across these choices is constrained by constant elasticity of transformation (CET) functions with parameter,  $\sigma_i$ , where  $i = \{L, L2E, E\}$

# Modelling the Hurunui Catchment

- Baseline
  - Calibrated to 2010 land use, enterprises, inputs costs and output prices
- Scenario Analysis
  1. Increase area of irrigation available from 22 THA to 42 THA
  2. Same as #1, but constrain 'negative' environmental outputs to baseline totals

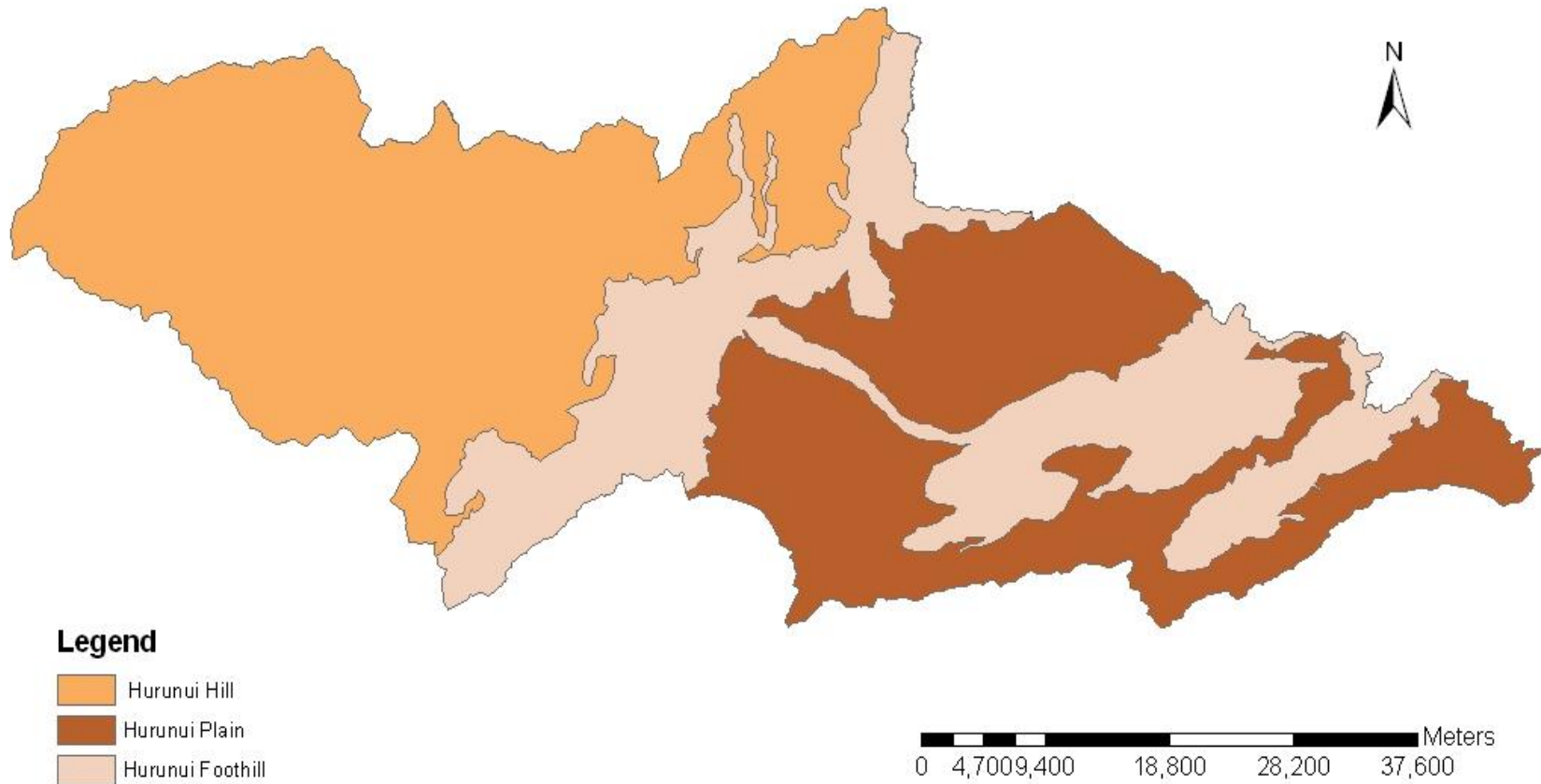


Total Area:  
246,600 HA

Dryland Area:  
224,300 HA

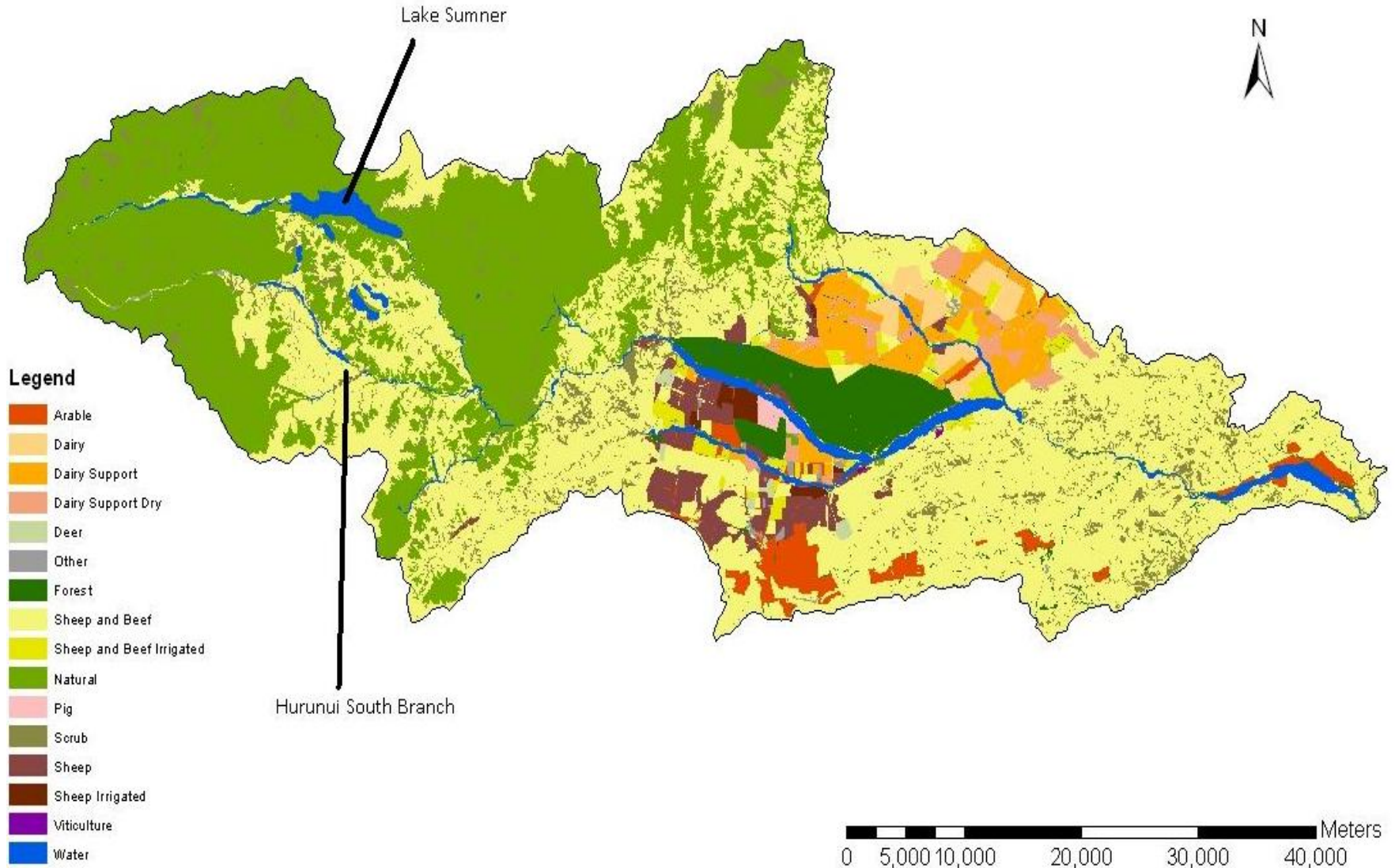
Irrigated Area:  
22,300 HA

# Sub-Zones within Hurunui Catchment

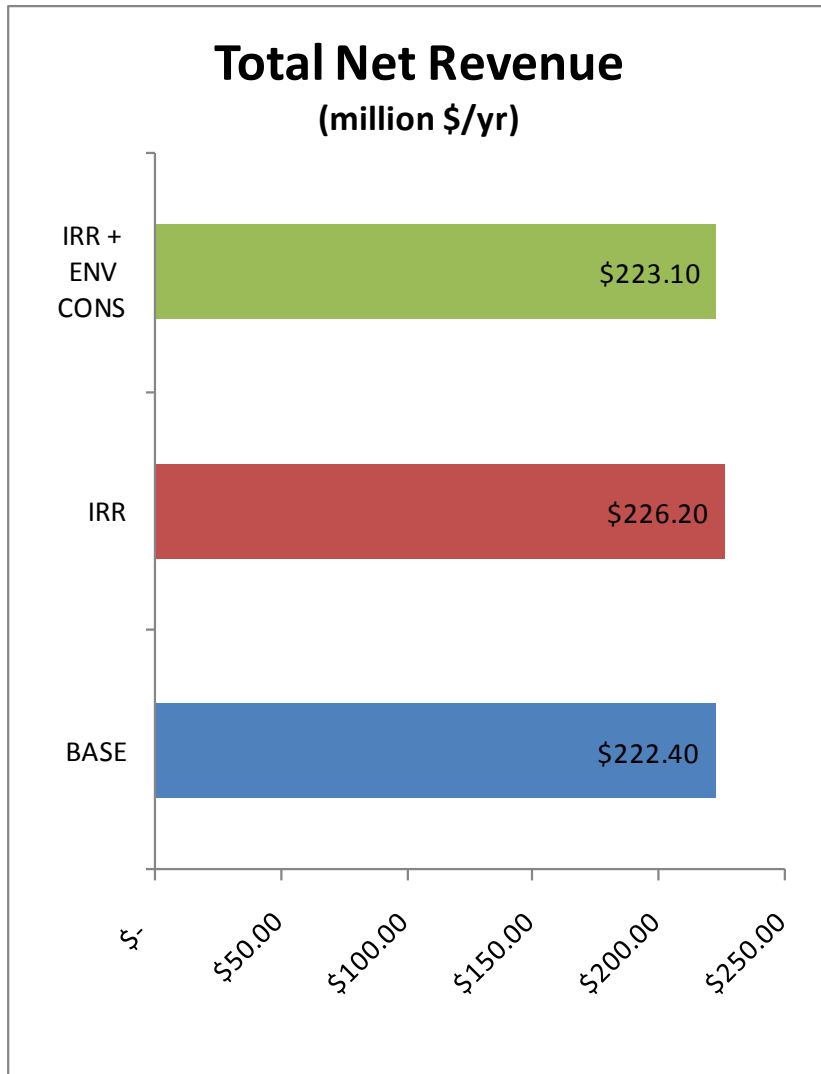


Plains most productive land-use classes with 99% of irrigated area in baseline

# Baseline Enterprise Mix

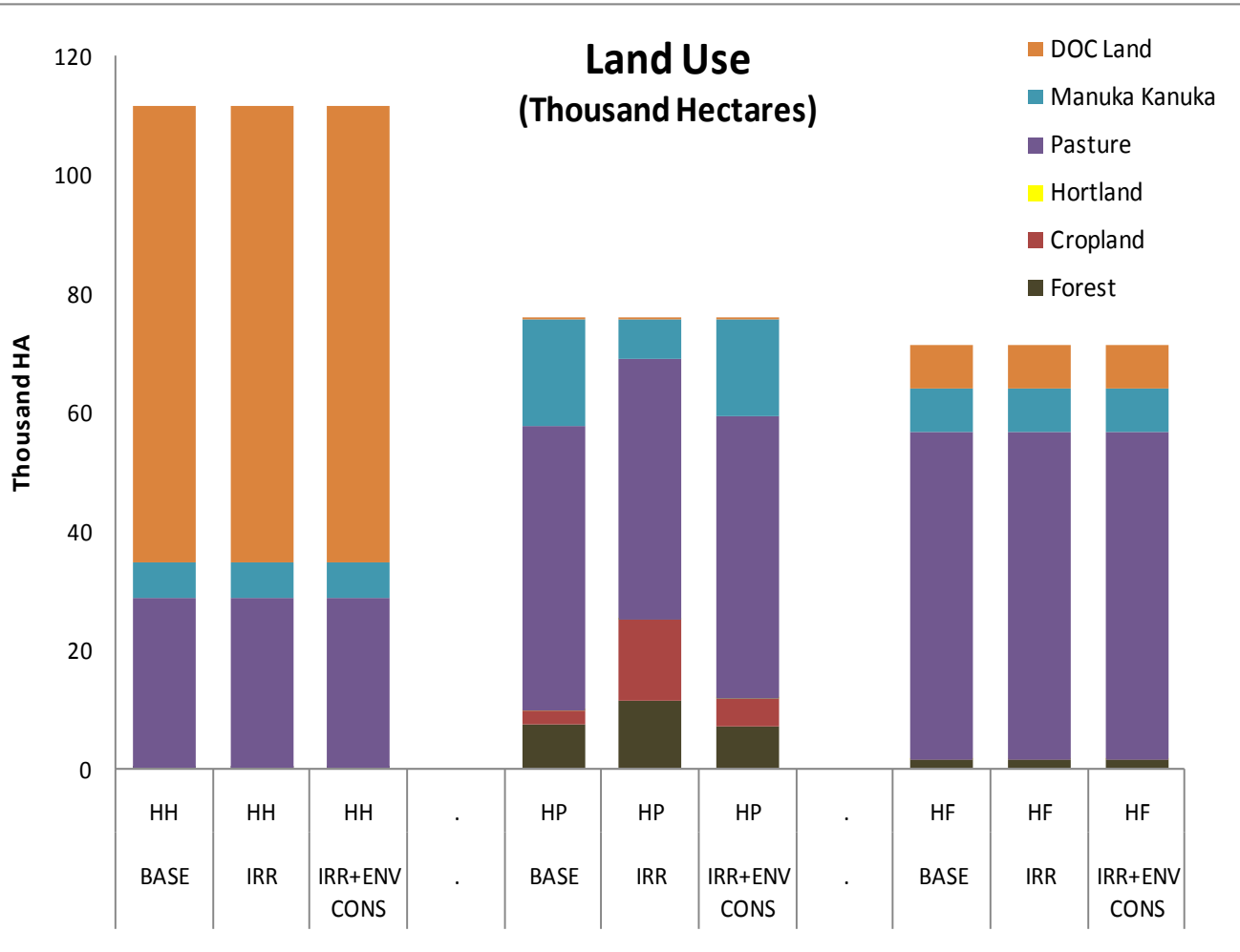


# Estimates: Catchment Income and Irrigated Area



Hurunui Hills			
	BASE	IRR	IRR+ENV CONS
Irrigated	0.0	0.0	0.0
Dryland	111.3	111.3	111.3
Hurunui Plains			
	BASE	IRR	IRR+ENV CONS
Irrigated	22.2	41.4	24.5
Dryland	41.8	22.5	39.5
Hurunui Foothills			
	BASE	IRR	IRR+ENV CONS
Irrigated	0.1	0.1	0.1
Dryland	71.2	71.2	71.2
Total Catchment			
	BASE	IRR	IRR+ENV CONS
Irrigated	22.3	41.6	24.6
Dryland	224.3	205.1	222.1

# Land Use



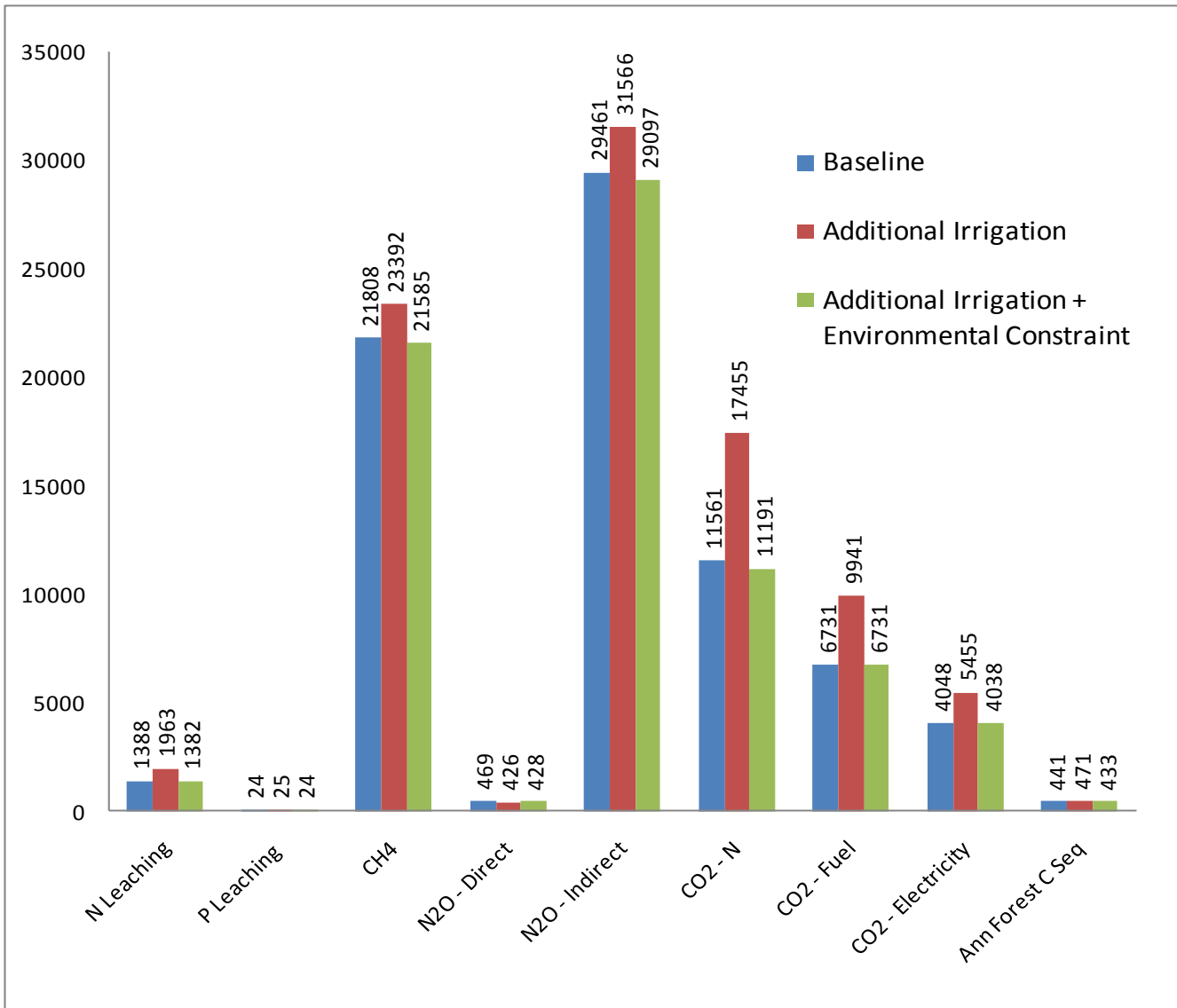
As nearly all new irrigation occurs in Plains, only zone that see LUC

Results for Plains IRR:

Land Use	Plains LUC
Pasture	-8%
Horticulture	+77%
Cropland	+477%
Forests	+58%
Scrub	-64%
DOC	No Change



# Environmental Outputs



Results for IRR:

Factor	Change
N_LEACH	40%
P_LEACH	3%
CH4	8%
N2O_EED	-9%
N2O_EEI	8%
CO2_N	45%
CO2_FUEL	48%
CO2_ELECT	30%
ANN C SEQ	7%

**Note:** All units are in tonnes. GHGs are in tCO<sub>2</sub>e.

# Conclusions

- Hurunui Water Project: Proposal to increase irrigated land from 22 THA to 42 THA,
  - Results in 1.7% increase in catchment level farm income, but also increases nearly all ‘negative’ environmental outputs
- Land use expected to shift from pasture and scrub to water intensive arable and horticultural crops
- Constraining landowners to hold environmental outputs at baseline levels results in minimal increase in irrigated land
  - Increase in capital and operational costs for irrigation too costly to change base farm practices and input mix
  - Suggests strong trade-off between water quantity and water quality (in deterministic framework)

# Future Work

- Impact of recent increase in milk solids on enterprise mix
- Estimate economic 'values' of ecosystem services to improve assessment of irrigation/ecosystem trade-off
- Water storage impact on adaptation and resilience in a changing climate
- Improve/update biophysical parameters in model
- Add more farm level mitigation options

# Questions/Comments? Contact Us:

**Adam Daigneault  
Senior Economist  
Landcare Research  
Auckland, New Zealand**

**[daigneault@landcareresearch.co.nz](mailto:daigneault@landcareresearch.co.nz)**

**+64 09 574 4138**

**Suzie Greenhalgh**

**[greenhalghs@landcareresearch.co.nz](mailto:greenhalghs@landcareresearch.co.nz)**

**James Lennox**

**[lennoxj@landcareresearch.co.nz](mailto:lennoxj@landcareresearch.co.nz)**

