

Improving Land-use Data & Modelling in Global CGE Modelling for New Zealand

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Outline of Presentation

- P2 I
- Agriculture, livestock & the environment
- Land use modelling in cge
 - Model structure
 - Data
 - Land
 - Emissions
- Exploratory simulation
- What's comes next?

FRST/Pastoral2 I

- Our work contributes to this program
- We are to assist in the development of quantitative tools for assessing economic/environmental trade-offs & policy impacts, and guide future pastoral and policy strategy
- Specifically – to enhance the GTAP cge model for use as a quantitative tool in economic & environmental analyses of the New Zealand pastoral sector.
- The contribution of a global cge model like GTAP to New Zealand analyses is its ability to explore international trade issues

New Zealand Farming Continues to Intensify

- Between 1990 and 2005:
 - Total area of farmland fell 15%
 - But total livestock units fell 6.6%
 - And total dairy cows rose by 50%
 - Use of N fertiliser rose by 590%
 - Use of P fertiliser rose by 186%
- Raises questions about future sustainability relative to
 - national commitments to global GHG reductions
 - and to national environmental outcomes

Livestock, Environmental Degradation & Policy Issues

- The environmental impacts of livestock farming well known
 - land degradation, deforestation, GHGs & climate change, air & water pollution
- New Zealand Domestic policy concerns:
 - Impact on environment, especially water availability & pollution, and GHG emissions
- New Zealand Trade policy concerns:
 - Foreign consumer trends towards 'green' & environmentally-friendly agriculture & livestock production
 - Failure to respond poses a trade risk
 - But possible loss of market share if New Zealand responds earlier than competitors
 - International competitiveness & leakage
 - A global cge model is potentially valuable
 - We develop GTAP-ENZ for this

GHG: The Unique New Zealand Situation

- Total GHG emissions increased by 1.5% per year 1990-2005
- Half of total emissions are from agricultural sector
- 35% of total emissions in 2005 were of methane
 - Mainly from ruminant cattle digestion
 - Methane accounts for 63% of total agricultural emissions in NZ
 - Reducing this is major priority for New Zealand
 - And to reduce New Zealand's international trade risks
- In absence of further policies – agriculture (& transport) emissions will grow the most rapidly by 2010.

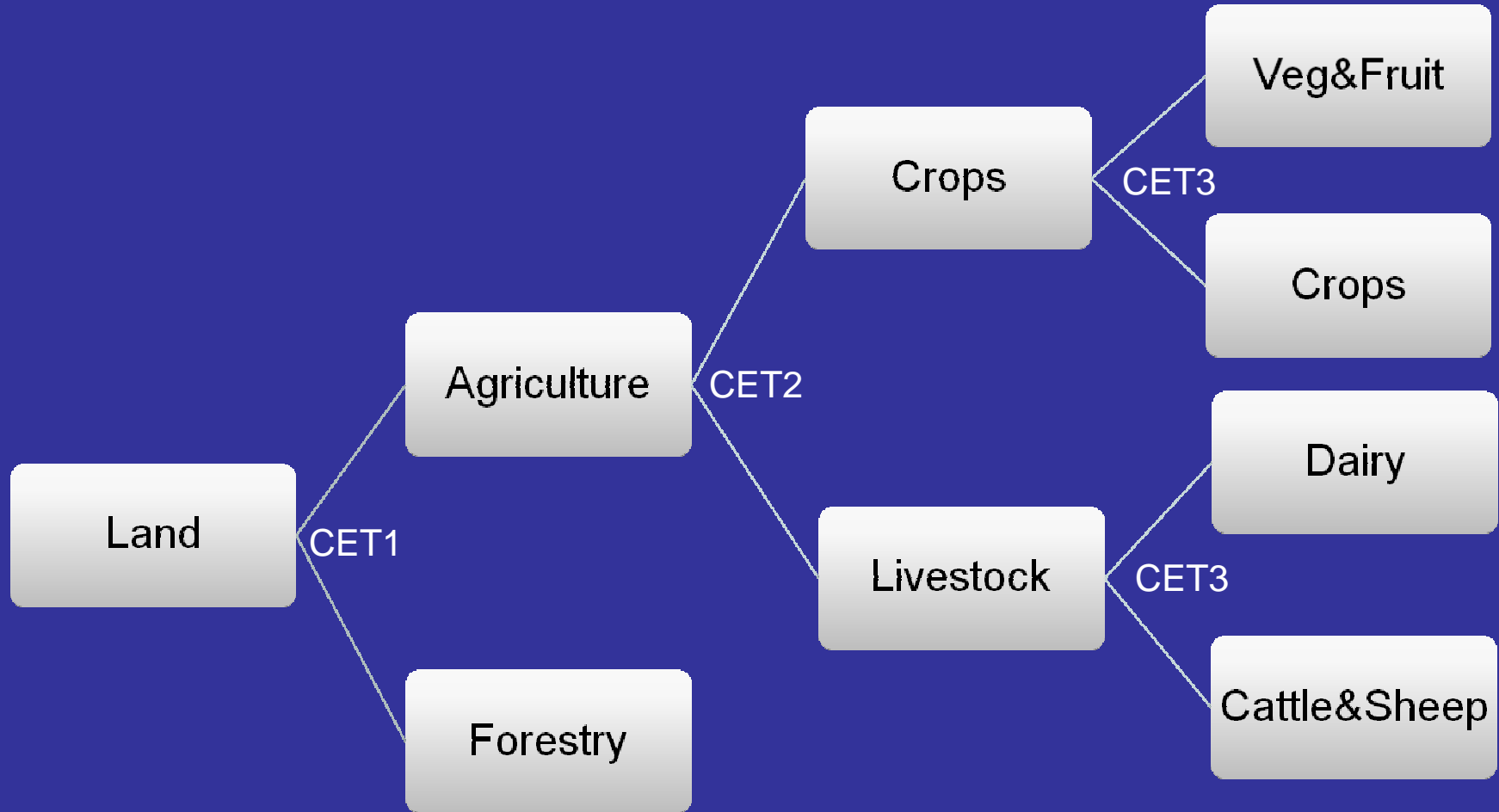
CGE Modeling of New Zealand Agriculture & the Environment

- Our past work used standard GTAP model, modified to incorporate additional substitution possibilities – purchased feed and land in livestock production, and agro-chemicals and land in cropping
- Looked at impacts of global trade reform on certain environmental indicators
 - N balances
 - Farm intensification
- But used a single land resource

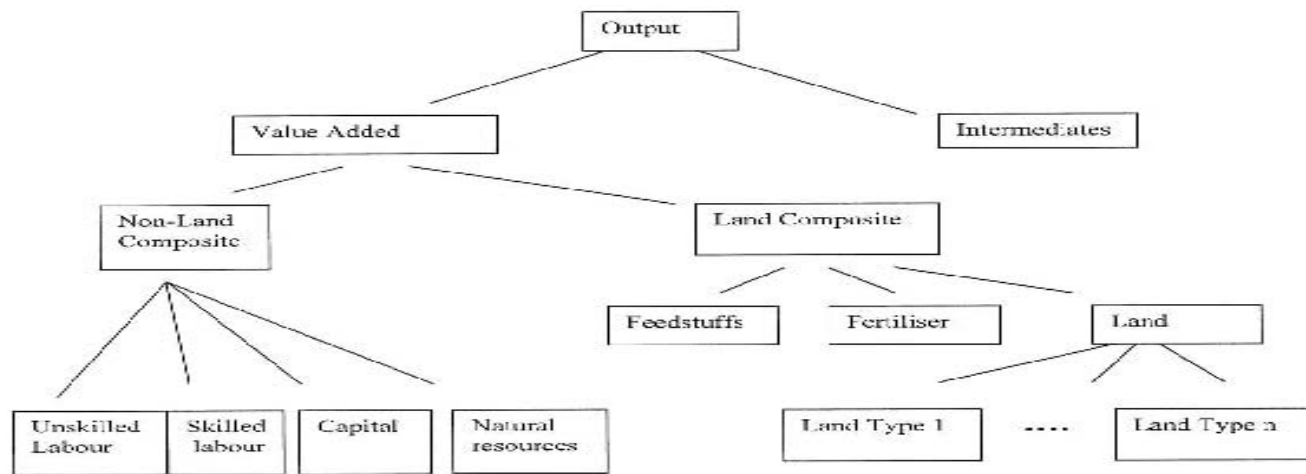
Land use modelling in GTAP-ENZ

- Represent multiple land types
 - rather than one
- Land-using sectors (farming & forestry) compete for this land
- Where a given sector can be present on more than one type of land
 - Ideally specify production function for each sector/land type combination
 - Producing homogeneous output
 - For the moment, the various land types are inputs into a single sectoral production function.

Allocation of each land type to sectors in GTAP-ENZ



Modified Production structure in GTAP-ENZ



Land Data for GTAP-ENZ

- Agro-ecological zones
 - GTAP-AEZ land use data:
 - Developed at IIASA & FAO
 - Climatic variables, growing season length
 - Pastoral dairy, cattle and sheep contribute the bulk of agricultural GDP in NZ
 - BUT the AEZ database used the distribution of *total pasture land* across AEZ's
 - and resulted in *identical* distributions of pastoral land used by dairy, cattle & sheep across AEZ's.
 - This is clearly wrong!
 - How to address?

Are AEZ's used in New Zealand?

A second problem was that scientists in New Zealand did not appear to use the AEZ approach.

- This suggested potential problems for us should we persist with this concept, due to
 - Lack of familiarity on the part of the research community
 - Therefore communication difficulties
 - Difficult to collaborate with other related programs in NZ
- So we took a different approach

Land Environments of New Zealand (LENZ)







- Designed to facilitate resource management
- Defines environments with degrees of similarity using multivariate classification techniques
- Concept of 'environmental distance' measures how "close" two areas are based on a set of environmental variables






LENZ: The environmental variables




- Are 15: they include—
 - Annual temperature
 - Winter min. temperature
 - Annual solar radiation
 - Winter solar radiation
 - Monthly water balance
 - Vapour pressure deficit
 - Drainage
 - Slope of land surface
 - Phosphorous & calcium content of soil
 - Chemical limitations to plant growth







LENZ Level I

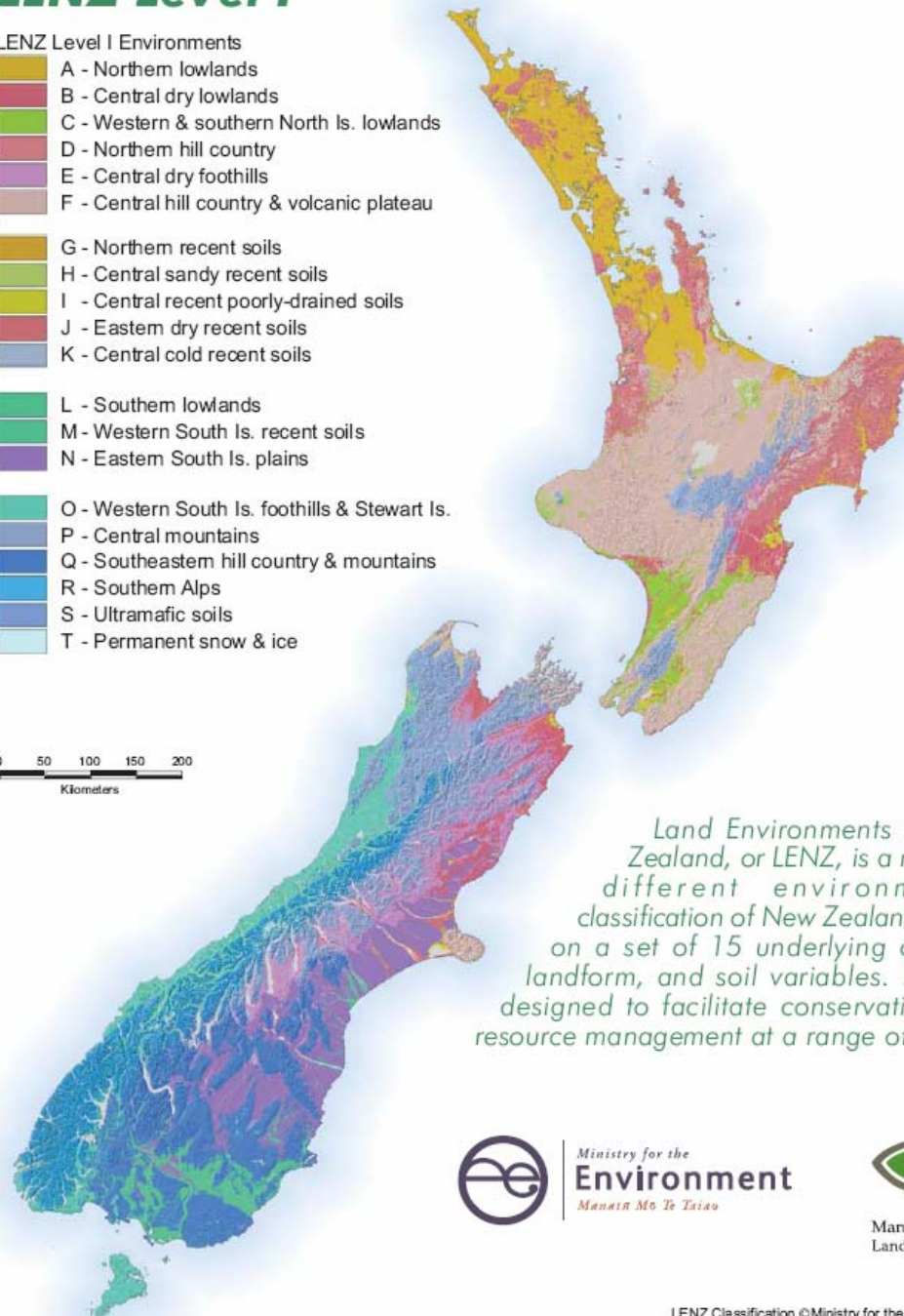
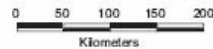
LENZ Level I Environments

-  A - Northern lowlands
-  B - Central dry lowlands
-  C - Western & southern North Is. lowlands
-  D - Northern hill country
-  E - Central dry foothills
-  F - Central hill country & volcanic plateau

-  G - Northern recent soils
-  H - Central sandy recent soils
-  I - Central recent poorly-drained soils
-  J - Eastern dry recent soils
-  K - Central cold recent soils

-  L - Southern lowlands
-  M - Western South Is. recent soils
-  N - Eastern South Is. plains

-  O - Western South Is. foothills & Stewart Is.
-  P - Central mountains
-  Q - Southeastern hill country & mountains
-  R - Southern Alps
-  S - Ultramafic soils
-  T - Permanent snow & ice



Land Environments of New Zealand, or LENZ, is a radically different environmental classification of New Zealand based on a set of 15 underlying climate, landform, and soil variables. LENZ is designed to facilitate conservation and resource management at a range of scales.



Ministry for the
Environment
Manaia Mo Te Taiao

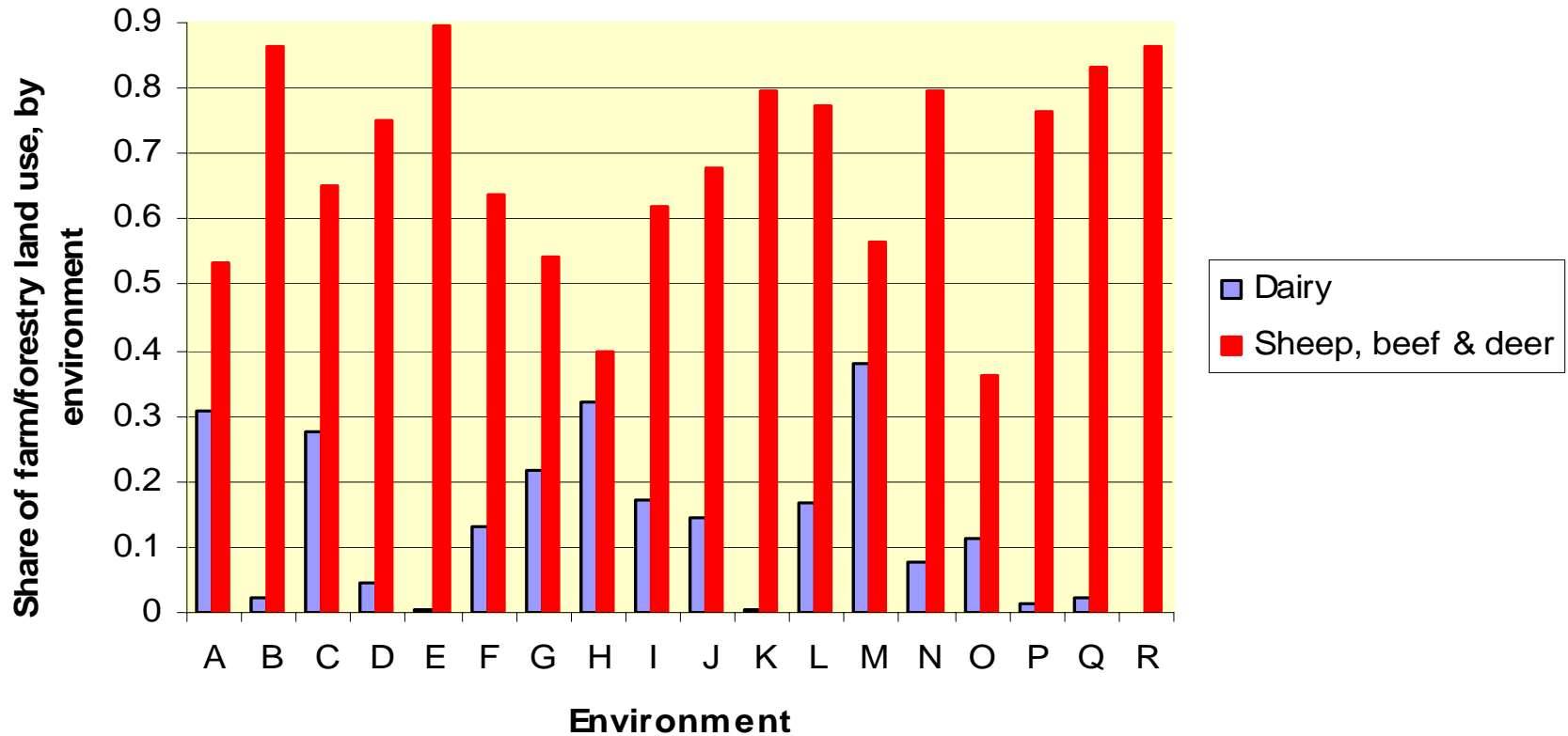


Manaaki Whenua
Landcare Research

New Zealand Regional Land Use Classification (LUNZ) - 2003

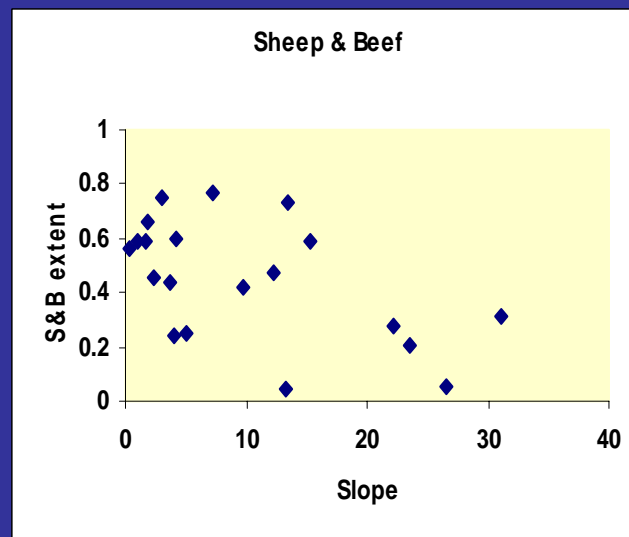
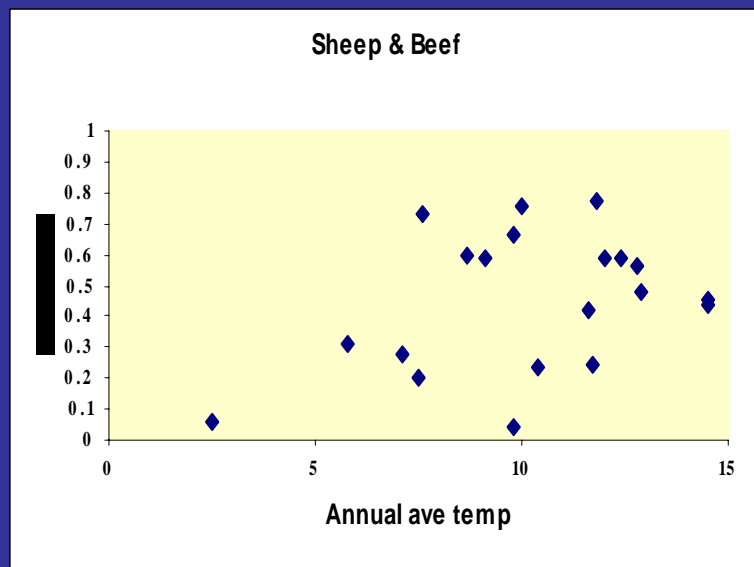
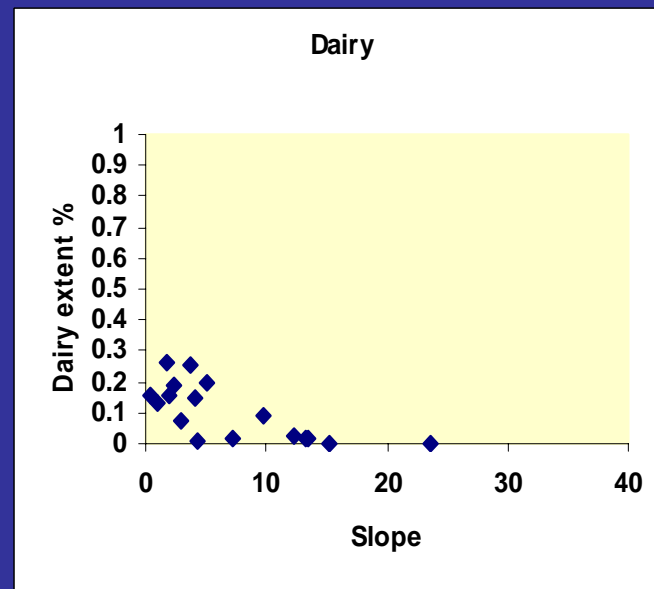
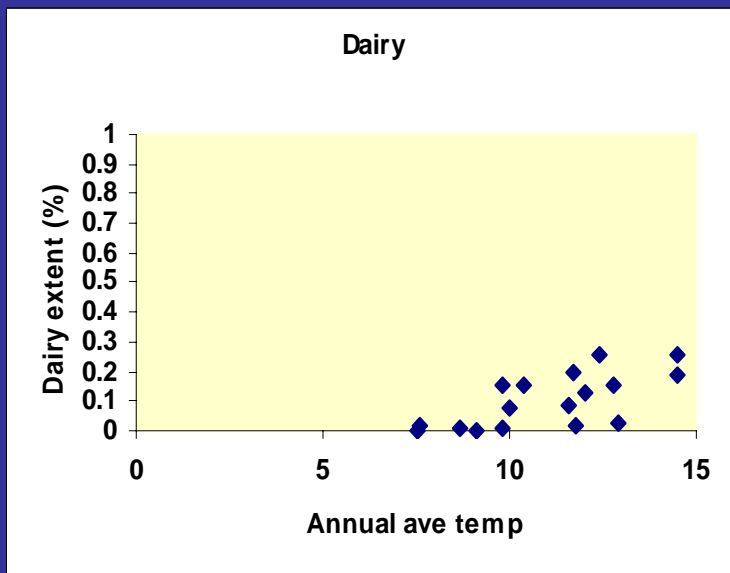
- Constructed from two sources:
 - *Land Cover Database* (Ministry for the Environment) : land cover mapping; e.g. urban, pastoral, horticulture, forestry
 - *Agribase*: contains information on >100,000 rural properties: location, size, livestock, cropping, forestry; uses geospatial technology to produce land use maps
- LENZ was overlaid with LUNZ to obtain land use details for each of the 20 environments.
- Is easily mapped to the LUC-classes used, for example, by Motu, if necessary

Dairy and Sheep&Cattle are distributed quite differently across environments (in contrast to the AEZ data)



The resulting database suggests how environmental factors drive land use in NZ

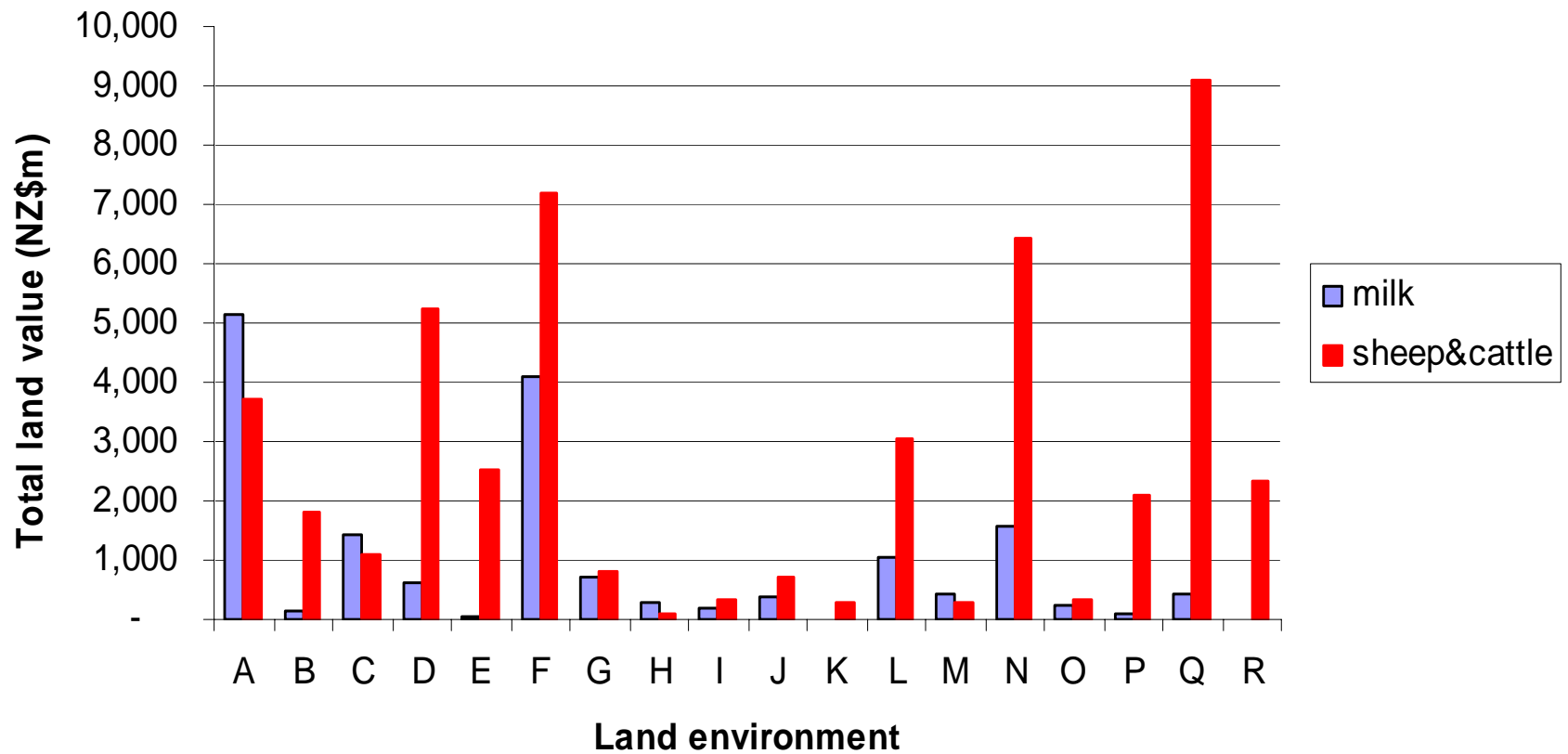
- For example:
- Developed farmland is most extensive in warm, dry, lowland environments, and on recent soils
- Pastoral farming largely in environments with mean temps $>10^{\circ}\text{C}$, slopes $<15^{\circ}$ and low-to-moderate water balance ratios
- Can plot extent of a land use in any environment against that environment's characteristics.



GTAP uses values, rather than hectares, for land

- Quotable Value New Zealand maintains a very detailed database of rural land valuations....
- by land use, and a large number of geographical regions (77 Territorial Authorities)
- Used average 2001-2003 values to smooth out inter-year variation in valuations: thanks MOTU!
- Combined with LENZ-LUNZ database to achieve valuation of land areas by land use and environment.
- We assume land rents are proportional to values

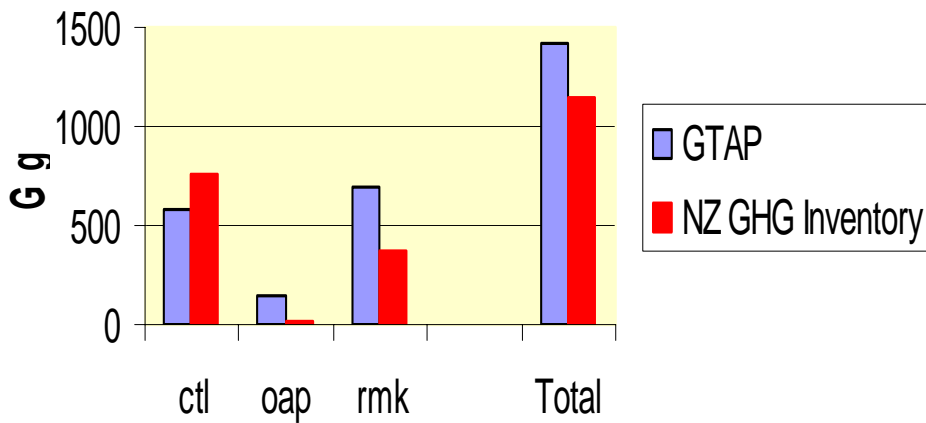
Distribution of dairy and sheep&beef farming across land environments: NZ



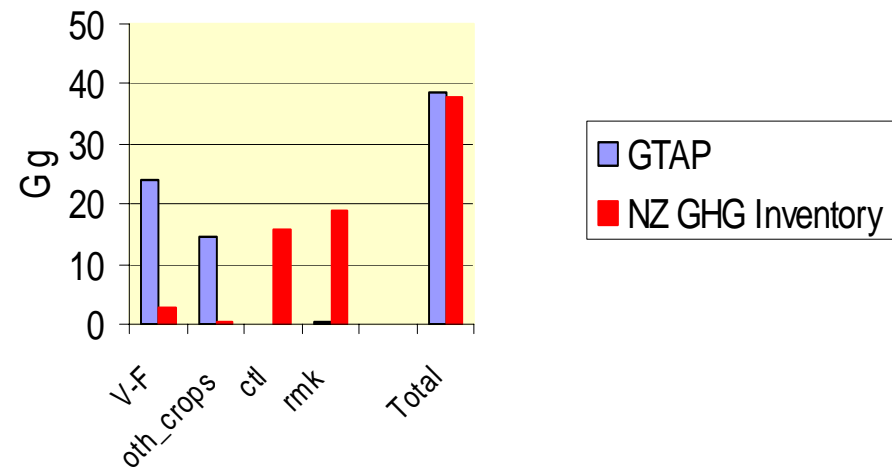
Emissions Data for GTAP-ENZ

GTAP vs New Zealand GHG Inventory Data

CH4 emissions from NZ agriculture: 2000



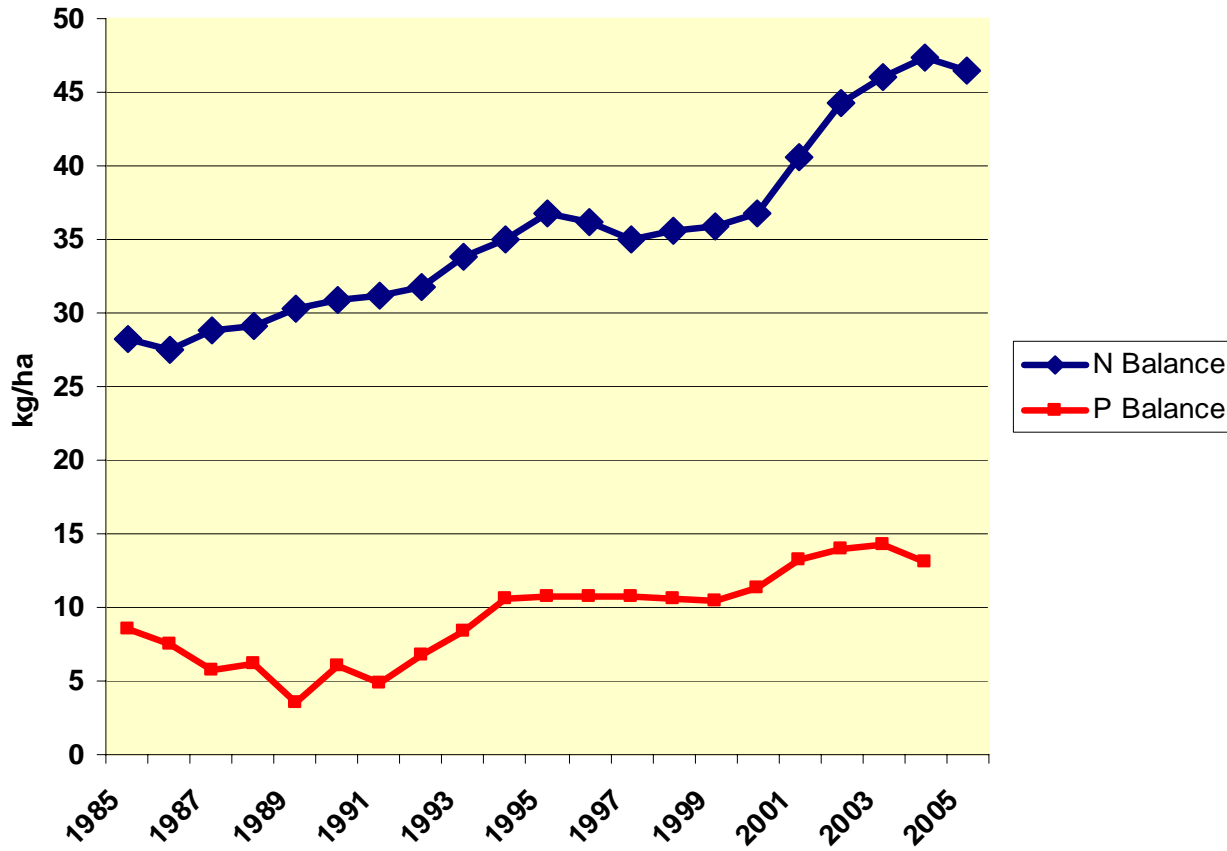
N2O emissions from NZ agriculture: 2000



Livestock & Nutrient Pollution in New Zealand

- Livestock excreta can contain nutrients (e.g. N & P), drug residues, heavy metals & pathogens
 - Pose threats to environment & human health
- New Zealand unique in N input from biological fixation via clover pastures
 - But use of N fertiliser has been rising rapidly
- N excretion is major problem in New Zealand, especially from dairy cows
 - 17% groundwater in Waikato had nitrate-N levels >WHO limit
 - N concentrations increasing in Lake Taupo, New Zealand's largest lake
- Govt., regional & district councils, and Fonterra are working on solutions (and MOTU)

N & P Balances: NZ Agriculture

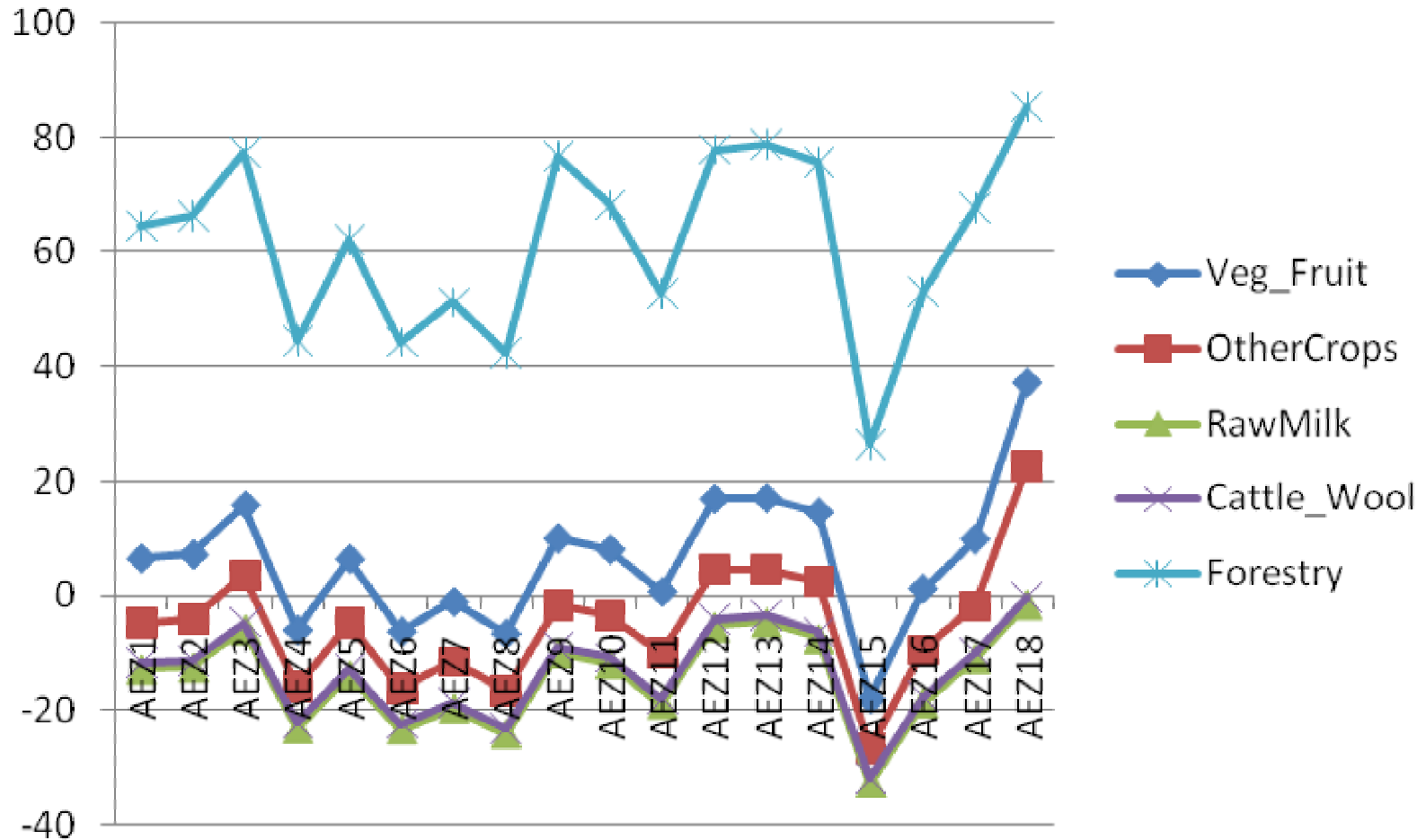


Source: Roger Parfitt, personal communication

Illustratory Simulation

- BAU Projection to 2010
- CET parameters in Land allocation module
 - CET1 = -0.2
 - CET2 = -0.4
 - CET3 = CET4 = -0.5
- Choice of CET elasticities makes a big difference

Projected (2010) New Zealand land allocation changes to sectors



GTAP-ENZ: The Road Ahead

- More work on farmland – forestry substitution
 - To what extent do labour/capital substitute for land?
- Refinement of CET parameters in land allocation
 - Econometric approaches?
- Recognise land type-specific production functions
 - Allows I-O structure of dairy, sheep&beef, to change across some land environments
 - Agricultural GHG emissions may also vary by environment
- Make projections of GHG and N emissions
- Simulate policy issues

- Trade analyses: is the competitive effect a big deal?
 - New Zealand land use changes & impacts on global commodity prices, for different C prices
 - Interactions with Australian ETS – agriculture??
- Incorporation of abatement cost curves
- Impacts of climate change on NZ agricultural productivity & land use
- Analysis of alternative post-Kyoto frameworks on New Zealand export trade & welfare