Climate change impacts on land use suitability

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$40+ billion in primary sector exports

Earth System

Ocean-Atmosphere Climate System ↔ Agroecosystems ↔ Economy

*consequences of change on New Zealand’s climate and our land use*
*NSC Cabinet Paper 2013

Dairy 41%
Meat/Wool 20%
Forestry 14%
Seafood 4%
Other 6%
Arable 0.5%
Horticulture 14%

$44 billion in estimated exports for 2020 (SOPI)

See poster!
Production up 15-20% with 0.7°C temperature change
Incorporating climate and climate change in land-use suitability (2017-2019)

OLW funds

- Expert workshop
- Identify climate attributes affecting LUS
- Develop hypotheses to be tested in theme 2

DSC I&I funds

- Biophysical modelling
- Climate change scenarios
- Change in LUS due to climate change
- Decision making implications
Key concepts

• OLW-led workshop, collaboration framework
• Review of Climate Change Impacts and Implications (CCII) and prior research
• Utilise CCII outputs for framework development and to engage decision-makers
• Tiered model applications
• Hypotheses examining climate drivers & impacts
• Potential to clarify needs from ESM
Decision contexts

• Land use suitability:
  – is current or proposed land-use suitable given economic, social and environmental constraints?

• Value chain sustainability and reliability

• Regional policy and decision-making
  – NPS-Freshwater implementation, irrigation

• On-farm infrastructure investment

• Adaptation research & investment
Land Use Suitability Framework

- Climate change
  - Impacts on receiving environments
    - Sediment loss
    - Phosphorus loss
    - E coli
    - N leaching
  - Soil attributes
    - Land suitability (biophysical)
  - Pasture quality
    - Dairy production
  - Yield
    - Maize

- Land suitability (biophysical+social)

- Management

- Adaptive capacity (farmers)
  - SLMACC

- Grape
Hypothesis-driven research to fill gaps

<table>
<thead>
<tr>
<th></th>
<th>Production</th>
<th>Receiving environments</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Droughts &amp; extreme events</strong></td>
<td>GAP</td>
<td>GAP!</td>
<td>DSC focus</td>
</tr>
<tr>
<td><strong>Long-term effects</strong></td>
<td>Some CCII outputs (kiwifruit, maize, pasture)</td>
<td>GAP</td>
<td>OLW focus</td>
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Flow diagram for proposed work

- **Climate scenario**
  - Drought occurrence analysis
  - Production
    - Tier 1: bioclimatic indices: Impact on phenology, crop cycle
    - Tier 2: Biophysical model: relate climatic indices to indices of potential production and quality (APSIM, biomeBGC)
    - Tier 3: Upscale to regional scale (APSIM), and national scale (biomeBGC)

- **Model class**
  - RCP scenarios
  - Long-term effects
  - Long-term climate variables analysis
  - Receiving environments
    - Drought index: impact on nutrient loss
    - Biophysical model: relate climatic indices to water demand, runoff, nutrient loss
    - Empirical model: relate climatic indices to sediment loss
Climate attributes impacts on production

<table>
<thead>
<tr>
<th>Climate attribute</th>
<th>Impact</th>
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</thead>
<tbody>
<tr>
<td>Seasonal temperature</td>
<td>Flowering, plant growth</td>
</tr>
<tr>
<td>Seasonal GDD</td>
<td>Plant growth</td>
</tr>
<tr>
<td>Number of hot days</td>
<td>Plant growth, pollination, animal welfare, fruit quality at harvest</td>
</tr>
<tr>
<td>Number of frost days</td>
<td>Flowering, crop establishment, harvest</td>
</tr>
<tr>
<td>Soil moisture deficit</td>
<td>Balance between vegetative/fruit growth</td>
</tr>
<tr>
<td>Length of dry season</td>
<td>Plant production (non-irrigated crops)</td>
</tr>
<tr>
<td>Frequency of successive droughts</td>
<td>Cumulative effect on on-farm pasture production and access to supplements</td>
</tr>
<tr>
<td>Wind speed</td>
<td>Crop damage, animal welfare</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>Risks of plant pests and disease, faecal eczema</td>
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</table>
Climate attributes impacts on receiving environments

<table>
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<tr>
<th>Climate attribute</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Rainfall high intensity</td>
<td>Mobilisation of contaminants (f(soil))</td>
</tr>
<tr>
<td>Cumulative drought and wet periods</td>
<td>Overland flow of hydrophobic contaminants (reactive P, <em>E coli</em>) or leaching (nitrate)</td>
</tr>
<tr>
<td>Soil temperature</td>
<td>Soil mineralisation of C and N, risk to N leaching</td>
</tr>
<tr>
<td>Number of wet days</td>
<td>Risk of soil pugging</td>
</tr>
<tr>
<td>Extreme winds</td>
<td>Wind erosion</td>
</tr>
<tr>
<td>Solar radiation</td>
<td>Reduction in plant uptake, risk to N leaching</td>
</tr>
</tbody>
</table>
CCII: impact of climate change on irrigated maize production and adaptation

Assumption: RCP8.5, model

CCII output: Kiwifruit suitability

Bay of Plenty focus area

Scenario = RCP8.5

With Hydrogen cyanamide

Without Hydrogen cyanamide

Now
Sheep Model Ensemble

2046-2065

RCP 2.6
RCP 4.5
RCP 6.0
RCP 8.5

2081-2100

Legend:
- < -15%
-14.9% - -10%
-9.9% - -5%
-4.9% - 0%
0.1% - 5%
5.1% - 10%
10.1% - 15%
15.1% - 15%
> 20.1%
Sheep/Beef Model Ensemble

Next: Examine drought events in each RCP x downscaled climate model.
Work Plan: Drought & Long-term Change...

Drought effects

RCP scenarios

Long-term effects

Appropriate Use of Tier 1, 2 & 3 models: including visualisations for engagement.

Production

Pastoral sector

Cropping sector

Horticultural sector

Drought effects

APSIM: Impact on potential yield at farm to regional scale
Biome-BGC: Impact on potential yield at national scale (+ test on C3/C4)

APSIM, bioclimatic indices: Impact on potential yield at regional scale

Bioclimatic indices: Impact on phenology

Receiving environments

APSIM: Impact on water demand, runoff, nutrient loss
Erosion model: sediment loss

Biome-BGC: spatial/temporal patterns of plant nutrient excess

Impact on water demand

Decision pathways in Hawkes Bay

Appropriate Use of Tier 1, 2 & 3 models: including visualisations for engagement.
Conclusions
If DSC failed the $40B primary sector:

What happened? (risks = worst case!?)

• Dialogues bit off bite-sized pieces but avoided:
  – primary sector’s scale and complexity
  – consistent involvement of scientists engaged with sector
  – managing risk from a production and value-chain perspective

• I&I LUS project under-engaged due to $$, fixed plan relative to original vision
  – couldn’t package climate change into everyday decisions
  – ‘scare mongering’: simple models overstate negative impacts

• OLW LUS framework useful but not implemented by water reforms; decreasing interest in water impacts.

• ESM did not better inform NZ land sector, relative to other ESMs, observations, and need to downscale well.