Sustainable Agro-ecosystems (SAE): An OLW aligned programme

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Sustainable Agro-ecosystems Programme

- Knowledge & tools that enhance productivity & resilience of primary industries while reducing their environmental footprint to meet community and market defined limits.
  - Improve sustainable production
  - Improve water quality & availability
  - Reduce GHG, adapt to climate change
  - Inform policy and practice
  - Enable market access
  - Grow export earnings

- Diverse range of partners:
  - FAR, Zespri, DairyNZ, HortNZ, IrrigationNZ
  - MPI, NZAGRC,
  - OLW & Deep South NSC

- Current funding:
  - SSIF (Core) = $4.5 M
  - Industry/Policy aligned = $3.2 M
SAE programme – Aligned to OLW NSC
(Focus on Soil, Arable, Horticultural & Environmental Science)

**OLW Objective:** To enhance primary sector production and productivity while maintaining and improving our land and water quality for future generations

### Three Major Themes

- **Land use capability to suitability:** Knowledge & tools to better match land use & mgnt with productive potential & environmental constraints of land.
- **Productive plants for the environment:** Crops & mgt practices that deliver greater value to industries from better environmental performance of farm systems.
- **Future Farming Systems:** New production systems and technologies that enhance the productivity, profitability and environmental performance.

### Outcomes

- Improved understanding of impacts, risks & trade-offs of land use & mgt decisions
- Position primary industries to respond to changes in community define limits, climate, resource allocation (e.g. water) and market values.
Land use capability to suitability

Outcome objectives:

• Knowledge and tools to better match land use and management with the productive potential and environmental constraints of the land.

Research focus:

• Soil/Land attributes/constraints (with LCR)
  – Sustainable production of different land uses (resistance / resilience)
  – Risks of adverse environmental impacts (N, P, sediment, fecal bugs)
  – Addresses gap in the OLW LUS programme (beyond LU capability)

• Understanding and managing
  – Soil organic matter stock & services (Aligned to OLW Suitability)
  – Soil physical properties & biophysical processes (Aligned to OLW Suitability)
  – Water & solute transport, storage and attenuation (Aligned to OLW Sources & Flows)
Understanding and Managing Soil Organic Matter

Improving predictions of N mineralisation

- N mineralised from SOM: important N source; difficult to predict
- Existing methods are poor predictors N mineralisation
- Better prediction → improved fertiliser forecasting
- Improved NUE and reduced risk of N losses
- Can we identify practical, dependable methods?
- N mineralisation – soil potential, in field actual
- What are the key soil fractions or sources?
- Hot water soluble organic N

<table>
<thead>
<tr>
<th>Method</th>
<th>Dryland</th>
<th>Irrigated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured</td>
<td>45 ± 7</td>
<td>71 ± 15</td>
</tr>
<tr>
<td>Predicted</td>
<td>41 ± 6</td>
<td>70 ± 14</td>
</tr>
</tbody>
</table>

Curtin, Beare et al 2017 SSSAJ
Irrigation, soil organic matter & ecosystem services

• Agricultural intensification
  – Irrigation expansion on soils of low natural capital (shallow, stony, sloping)
• How does irrigation affect SOC storage & turnover?
  – Enhanced SOC storage assumed, but true?
  – What are the consequences for ecosystem services?
• Soil water repellency and irrigation (with MVI)
  – Most soils are sub-critically repellent
  – Even at low irrigation rates water will bypass much of matrix
  – Managing SC repellency could increase irrigation efficiency

![Diagram showing cumulative infiltration and repellency index](image)

Mueller, Thomas Carrick
Soil physical constraints to crop/pasture productivity

Different forms of constraints (Inherent vs dynamic):
- Shallow top soils (subsoils affect water storage/drainage)
- Structural breakdown and consolidation from loss of SOM
- Soil compaction (wheel trafficking, livestock treading)

Soil compaction
- How prevalent is soil compaction? (soils, systems)
- How does it affect soil function? (water, nutrients)
- What are the costs? (loss of production, input costs etc)
- How can we represent the effects in crop system models?

% of paddocks with PR greater than 2.5 Mpa (PR normalised to 35% v/v)

<table>
<thead>
<tr>
<th>Land use</th>
<th>0-15 cm</th>
<th>15-25 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pastoral Sheep/beef</td>
<td>26</td>
<td>19</td>
</tr>
<tr>
<td>Dairy</td>
<td>36</td>
<td>30</td>
</tr>
<tr>
<td>Cropping Mixed arable</td>
<td>13</td>
<td>21</td>
</tr>
<tr>
<td>Intensive arable</td>
<td>12</td>
<td>29</td>
</tr>
<tr>
<td>Intensive vegetable</td>
<td>41</td>
<td>38</td>
</tr>
</tbody>
</table>
Crop dry matter (silage harvest)

Heavy Compaction
4.5 t DM/ha

Controlled Traffic
19.2 t DM/ha
Plants for the Environment

Productive plants with enhanced environmental traits

Outcome objective:

• Crops & mgt practices that deliver greater productivity, profit, and/or policy compliance to primary industries from better environmental performance.
• Includes crops to address specific yield or quality gaps and environmental impacts and crop rotations to enhance resource use efficiency and farm system resilience.

Research focus:

• Critical plant traits
• Optimising the mix and management of plant traits
• Advanced modelling tools to predict productive and environmental outcomes
Plants for the Environment

Productive plants with enhanced environmental traits

Beneficial attributes may include:

• Improved nutrient acquisition
  – Winter active & deep rooted plants to mop up excess N
  – Enhanced uptake of P (roots, adsorbed P)

• Root characteristics that:
  – improve soil structure formation
  – Enhance access to plant available water
  – Penetrate or reverse soil physical constraints

• Biological Nitrification Inhibition:
  – Focus has been on grasses
  – Some crops also have high BNI activity (species, cultivars)
  – What plants are most effective and under what conditions?
  – Can we manage the outcome?

![Graph showing amount of NO₃⁻-N leached with different plant species.]

(Urine at 1,000 kg N/ha in May)

Malcolm et al. (2014)

25% lower loss
Catch Crops to reduce NO$_3$ leaching ex grazing

**Oats sown in winter yielded 6-12 t DM/ha and reduced soil N**
Future Farming Systems

Outcome objective:
• New production systems and technologies that enhance the productivity, profitability and environmental performance of primary industries

Research focus:
• Smarter irrigation and nutrient management systems
• Adaptive management for drought mitigation
• Precision (spatial & temporal) management
• Advanced modelling tools to predict productive and environmental outcomes
Multi-crop models to test variability in outcomes

Example of variability for a June N load of 400 kg/ha with mid-July cover crop

Simulated leaching reduction estimates:
- **Good years**: 11 to 16% (best 5 of 20 years)
- **Most years**: 7 to 10% (10 in 20 years)
- **Bad years**: -2 to 6% (worst 5 of 20 years)
Irrigation, land use change & ecosystem services

- Managing Irrigation to mitigate N losses
  - Keeping soils wet = high N$_2$O emissions
  - Maintaining deficits (less frequent irrigation) reduces risk of large N$_2$O emissions and N leaching

- How do soil physical properties affect process?
  - PSD, pore connectivity and diffusivity
  - Effects of soil compaction & structural consolidation

- Are there trade-offs between N gaseous emission and N leaching?

- Can develop rules & tools to manage these interactions to enhance WUE and mitigate nutrient losses?

Uncompacted

Compacted
Thank You