Bottom Line Benefits of Building Resilience
• Natural sequence farming (Peter Andrews)
• Keyline Contours (Yeoman)
• Compost in contours
• Leaky weirs
• Adaptive grazing
Martin Royds, Jillamatong, Braidwood, in front of one of his weirs, with the hills that were burnt out by the recent bushfires in the background. Helicopters fighting the fires, filled up from the weirs every 40 seconds.
Entomopathagenic Fungi

*Cordyceps variabilis.*
Credit Roger Heidt.

*Beauvaria bassiana*
White muscardine disease

*Metarhyzium spp*
Green muscardine disease
Gut microbes:

– Make us grow

– Regulate our health

– Provide vitamins, enzymes etc

– Help our whole body to function

– Disruption of gut flora linked to disease
Gut microbiome & health

Acne, Asthma/Allergies, Anxiety and PTSD, Arthritis, Autism, Autoimmune diseases, Cancer, Crone’s, Depression, Diabetes, Eczema, Inflammation, Longevity Motor Neuron, MS, Obesity, Parkinsons, Sleep issues, Tooth Cavities....and more....
We’ve blown the microbial bridge
We’re doing the same to our soils

They have indigestion, constipation, gas, dehydration and diarrhoea
The US loses 6.9 billion tonnes of soil each year (Pimentel, 2000)
Microbes are everywhere!
Disturbed vs Healthy Soils

5000 species

Disturbed Soil

= Biomass in kg/ha
10’s of thousands of signalling molecules in soil

- Proteins, hormones, enzymes, elicitors
- Plant defence molecules;
  - salicylic, jasmonic acids chitinase, proteinase
Quorum Sensing

- Bioluminescence
- Insects; ants and honeybees
- Quorum quenching – switches biology off

- A little goes a long way... parts per trillion
Quorum sensing

New discoveries between plants and bacteria

- Aromatics, exudates, hormones, pheromones, enzymes, vitamins, sugars, amino acids & proteins...
Optimising biological diversity and biomass is CRITICAL

~80% of plant health and nutrition is driven by biological functions

Diverse communities = more signals = increased resilience to stress = crop health and quality
Hormones primed: jasmonic (JA), ethylene (ET), salicylic acid (SA) abscisic acid (ABA), and the peptide prosystemin (PS)
Healthy rhizosphere

- Plant protection
- Nutrient uptake
- Plant growth
- Feeds microbes
- Carbon building
- Resilience
- Buffer – temp, pH
SEED DRESSING - Encourage root development and thick rhizosheath
Rhizophagy

30% of nutrients to a seedling come from the absorption of bacteria.
Two neighbouring orchards

**Integrated system**

No compost application, herbicided rows, irrigation,

$\rightarrow 5.3 \, \text{# C/y}^2 \, (\text{top 4"})$

**Biological system**

Compost application, pasture in rows, no irrigation,

$\rightarrow 8.4 \, \text{# C/y}^2 \, (\text{top 4"})$
Macro-pores enhance the mixing of nutrients and contaminants

= better buffering of nutrients and filtering of contaminants
Integrated managed system

Largest, connected system of pores: 8.8% of the total macroporosity
Biologically managed orchard

Largest, connected system of pores: 79% of the total macroporosity
NPK
168° F at 1/5” depth

Worm extracts
90° F
What is putting a drag on your farming system?
The 5 M’s

SOIL HEALTH
Bacteria and archaea

• Oldest, simplest, most numerous organisms
• Involved in: disease suppression, nutrient retention, form soil micro-aggregates
Bacteria are essential. However,

- Bacterial dominance can lead to compaction
- High bacteria and low predators tie up nutrients
  - Increases nitrates in plants

- Germination signal for many “weeds”
What (who) makes it rain?

- 40-100% of ice crystals contain bacteria
- *Pseudomonas syringae* – ice nucleating bacteria
  - frost
Reducing the frost factors

- *Reduce free nitrates*
- *Higher sugar (brix)*
- *Biological activity on leaves & in soil*
- *Pseudomonas fluorescens*

Protect from frost damage as low as -6 °C for up to two months.
Frost and biology
Fungi

- Disease suppression
- Retain nutrients
- Decomposers
- Form soil macroaggregates
- Hold soils together
- Yield
Fungi release nutrients bound on rocks

Pinzari, F et al (2016). Routes of phlogopite weathering by three fungal strains. Fungal Biology. 120.
Recombine minerals to create new elements

Carbon sink

Weddelite ($\text{CaC}_2\text{O}_4\cdot 2\text{H}_2\text{O}$)

Calcite ($\text{CaCO}_3$)

Moolooite
Calcium oxalate
Fungi:Bacteria ratios

• As F:B ratio increase, C accumulation increase
• NMSU showing F:B ratios are more closely related to production than NPK
• Low F:B ratios increases low quality ‘weed’ species
Fungal Foods

Fungi require more complex carbons “brown materials” e.g. ‘brown’ grass, cellulose, lignin, chitin, stubble, straw, fish hydrolysate, humates, biochar, wood chip...
Case Study Canada

35,000 acres growing wheat, barley, canola & peas.

Av precip 12 to 19” (incl snow)
Why change?

- Top 1% of producers in region
- Market signals
- Declining soil health
- Want to be the best!
Soil Concerns

- Tight compacted, poor soil structure
- Water logging /drought
- Low functional humus,
- Low biological activity, low AMF,
- high Mg, low trace elements,
- low sodium
1st year program Wheat

<table>
<thead>
<tr>
<th>Down the slot</th>
<th>Seed treatment</th>
<th>Foliar</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Gypsum 35 #</td>
<td>• AMF, Trichoderma</td>
<td>• 2.4 litres 10 10 10 (NPK)</td>
</tr>
<tr>
<td>• Humate 25 #</td>
<td>• P-solubilising bacteria</td>
<td>• 300mls Fulvic acid</td>
</tr>
<tr>
<td>• Sea minerals 4 #</td>
<td></td>
<td>(1 kg 21% B in peas)</td>
</tr>
<tr>
<td>• Boron 0.6 #</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Zinc 0.35 #</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Copper 0.5 #</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Nitrogen

- 2016 - 110lbs actual N
- 2017 - 30 lbs actual N
- With no yield drop!
Buffer chemicals with Carbon

- Fulvic/humic lift cell wall permeability by 30%
- Fulvic acid (600mls/ha) with glyphosate
- Reduce herbicide use by 30%
Year One results

• Only 34mm rainfall!
• Roots through hardpan
• Awesome healthy crop and good yield
## 2016

<table>
<thead>
<tr>
<th>Date Sampled</th>
<th>Lab Number</th>
<th>Nitrogen (%)</th>
<th>Nitrate Nitrogen (%)</th>
<th>Sulfur (%)</th>
<th>Phosphorus (%)</th>
<th>Potassium (%)</th>
<th>Magnesium (%)</th>
<th>Calcium (%)</th>
<th>Sodium (%)</th>
<th>Boron (ppm)</th>
<th>Zinc (ppm)</th>
<th>Manganese (ppm)</th>
<th>Iron (ppm)</th>
<th>Copper (ppm)</th>
<th>Aluminum (ppm)</th>
<th>Chloride (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016-08-04</td>
<td>2210017</td>
<td>4.25</td>
<td>0.62</td>
<td>0.22</td>
<td>2.42</td>
<td>0.76</td>
<td>0.85</td>
<td>0.08</td>
<td>3</td>
<td>24</td>
<td>125</td>
<td>225</td>
<td>125</td>
<td>4</td>
<td>54</td>
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</tr>
<tr>
<td>Normal Range</td>
<td></td>
<td>2.00</td>
<td>0.16</td>
<td>0.20</td>
<td>1.50</td>
<td>0.17</td>
<td>0.20</td>
<td>0.17</td>
<td>6</td>
<td>15</td>
<td>35</td>
<td>35</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Actual Ratio</td>
<td></td>
<td>6.9</td>
<td>1.8</td>
<td>0.4</td>
<td>91</td>
<td>3.2</td>
<td>107</td>
<td>0.6</td>
<td>243</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expected Ratio</td>
<td></td>
<td>8.9</td>
<td>1.1</td>
<td>1.3</td>
<td>88</td>
<td>7.2</td>
<td>460</td>
<td>1.3</td>
<td>194</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

### Nutrient Sufficiency Ratings

- **Very High**
- **High**
- **Sufficient**
- **Low**
- **Deficient**

## 2017

<table>
<thead>
<tr>
<th>Date Sampled</th>
<th>Lab Number</th>
<th>Nitrogen (%)</th>
<th>Nitrate Nitrogen (%)</th>
<th>Sulfur (%)</th>
<th>Phosphorus (%)</th>
<th>Potassium (%)</th>
<th>Magnesium (%)</th>
<th>Calcium (%)</th>
<th>Sodium (%)</th>
<th>Boron (ppm)</th>
<th>Zinc (ppm)</th>
<th>Manganese (ppm)</th>
<th>Iron (ppm)</th>
<th>Copper (ppm)</th>
<th>Aluminum (ppm)</th>
<th>Chloride (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017-08-01</td>
<td>2230055</td>
<td>3.54</td>
<td>0.41</td>
<td>0.23</td>
<td>1.86</td>
<td>0.26</td>
<td>0.56</td>
<td>0.02</td>
<td>9</td>
<td>19</td>
<td>44</td>
<td>123</td>
<td>12</td>
<td>12</td>
<td>51</td>
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</tr>
<tr>
<td>Normal Range</td>
<td></td>
<td>2.00</td>
<td>0.16</td>
<td>0.20</td>
<td>1.50</td>
<td>0.17</td>
<td>0.20</td>
<td>0.20</td>
<td>6</td>
<td>15</td>
<td>35</td>
<td>35</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Actual Ratio</td>
<td></td>
<td>8.7</td>
<td>1.9</td>
<td>0.6</td>
<td>118</td>
<td>6.7</td>
<td>426</td>
<td>2.8</td>
<td>637</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Expected Ratio</td>
<td></td>
<td>8.9</td>
<td>1.1</td>
<td>1.3</td>
<td>88</td>
<td>7.2</td>
<td>460</td>
<td>1.3</td>
<td>194</td>
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<td></td>
</tr>
</tbody>
</table>

### Nutrient Sufficiency Ratings

- **Very High**
- **High**
- **Sufficient**
- **Low**
- **Deficient**

---

**Note:** The data represents nutrient analysis results for the years 2016 and 2017. The tables show the percentage of nitrogen, nitrate nitrogen, sulfur, phosphorus, potassium, magnesium, calcium, sodium, boron, zinc, manganese, iron, copper, aluminum, and chloride along with their respective normal ranges. The actual and expected ratios are also provided. The nutrient sufficiency ratings are visually represented in the charts.
Year One results

- 60% reduction spend
- Roots through hardpan
- Awesome healthy crop and good yield
  - Wheat 70 bushels/acre
- All on only 5” rainfall!
- Cover crop failures
• Maintaining yield
• Decreasing costs
• Water infiltration increase 5-10x
# Increases in Profitability

<table>
<thead>
<tr>
<th>Passes</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Pesticides</td>
<td>• 95%</td>
</tr>
<tr>
<td>• Herbicides</td>
<td>• 40%</td>
</tr>
<tr>
<td>• Fuel</td>
<td>~ 20%</td>
</tr>
<tr>
<td>• Fertilizer/inputs</td>
<td>• $50/ac (year 1-3)</td>
</tr>
</tbody>
</table>
Ian & Di Haggarty
44,000 ac, sheep and cropping
5 properties in WA, 8 inches “average” annual rainfall
Program

Post grazing- seed drilled with vermi-liquid @ 0.5 gal/ac.
On new rehab land - 12 gal compost extract
Low rate glyphosate pre-emergent
Year round ground cover

Year 1: Button grasses
Kerosene grass
Windmill grasses
(Early successional grasses)

Year 2:
Serratia spp
Native C4 palatable grass
Modern Ag puts farmers into an arms race

- Herbicide - over 300 weed spp now resistant
- Pesticide – over 500 pests spp
- Antimicrobial resistance

ALL ARE ON AN EXPONENTIAL RISE

Dr. Ian Heap, WeedScience.org 2016
Herbicide resistance in ryegrass

Chemical rate

Glyphosate

Prospect

Resistant

Trifluralin

Prospect

Resistant

Glyphosate

Trifluralin

0 0.5X 1X 2X
What signal are you sending?

- Optimise plant brix (photosynthesis)
- Ensure year round cover
- Increase root mass
- Lift above/below diversity & biomass
- Address limiting factors
  - air, water, decomposition?
“Regenerative Agriculture is the way of the future; indeed without it there is no future for Western Australia”

Alannah Mactiernan,
WA Minister for Ag and Food
An Enriched Future

Getting fit for a better world is key.

We have identified five elements that are crucial to making that happen.

1. A regenerative mindset: thinking about what we can regenerate in our ecosystems.

2. A Taiao approach, and we talk about that in more detail below.

3. Our commitment to ethical production systems.

4. Delivering outstanding products for discerning consumers around the world.

5. We need to make the most of our New Zealandness in everything we do.
In 2005, Barry Marshall and Robin Warren were awarded the Nobel prize in Physiology.
Where do you see for the future Agriculture?

• Complicated, mechanical fixes?
• Deep, ecological, complex and adaptive solutions that address root causes?
How do we transition profitably?

By repairing and regenerating the microbial bridge
Feed your underground workforce
• Lift plant brix (photosynthesis)
• Is there a trace element or mineral holding you back?
• Avoid bare ground and overgrazing at any cost
• Improve plant root systems through species selection and above-ground management
Keys for success

• Identify major limiting factors
• Take action
• Tickle the system
Indreland Angus
Concerns:

- Low Brix (13), Brix same thru day
- Low N, P, low trace elements; B and Mn
- High insect pressure
2 alfalfa treatments

- Bio Block
  - 2 gal fish hydrolysate
  - 10 Lbs trace element (based on soil/forage test)
  - 8 oz humic acid
  Cost $20/ac

- Conv fertility
## Forage tests

<table>
<thead>
<tr>
<th>DM Basis</th>
<th>‘Supreme’</th>
<th>Bio Alfalfa</th>
<th>Control Alfalfa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude Protein</td>
<td>&gt;22%</td>
<td>29.7</td>
<td>21.9</td>
</tr>
<tr>
<td>NDF</td>
<td>&lt;34</td>
<td>28.5</td>
<td>37.5</td>
</tr>
<tr>
<td>TDN</td>
<td>&gt;62</td>
<td>70.1</td>
<td>62.4</td>
</tr>
<tr>
<td>RFQ</td>
<td>&gt;180</td>
<td>222</td>
<td>155</td>
</tr>
</tbody>
</table>
Results

• Brix lifted to 20
• Faster recover after grazing/hay
• Minimal insect damage
• Crop yield improvements
• 1 T/ac crop
A tale of 2 soils
120 years of management

South Side
- 120 years under degrading irrigation system
- Cut for hay
- Horse grazing

North Side
- Under tall sage >30 years
- 30 years Holistic management
- Good irrigation practices
24 mins 1” water infiltration
80% unpalatable plants, 80% non-mycorrhizal
1 min 2” water infiltration
<5% unpalatable species

10x humus
Humus holds 7 X weight in water= 70x more water holding capacity
South Side
- Flagellates 297 > 10,000
- N potential: 100 lbs/acre
- AMF 9% > 10%
- 16% root feeding nematodes

North Side
- Flagellates 16,441 > 10,000
- N potential: 300+ lbs/acre
- AMF 14% > 10%
- 5% root feeding nematodes
2018 program

• Direct drill 7 spp mix
With 30kg vermicast

Foliar application:
• fish hydrolysate,
molasses, humic,
redmonds salt
2 lazy 2 Ranch, Billings, MT

- 12” rainfall, 40” pan evaporation
- 3200 – 3800’ elevation
- Started Holistic Management in early 1990’s
- Early success - lifting stock numbers. <5 day moves
Concerns

- Animal health
- Bare ground
- Poor diversity
  - Sage and crested wheat
- In 1993 25 years of holistic management
2 lb vermicast as extract/acre
• 1 lb vermicast as extract/acre
What is the purpose of Ag?
Many agricultural scientists deny that there is any link between human health and what happens on-farm, however...
70 YEARS OF SOIL DEPLETION

The reduction in average mineral content of fruits and vegetables since 1940.

<table>
<thead>
<tr>
<th>MINERAL</th>
<th>VEGETABLES</th>
<th>FRUITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>-49%</td>
<td>-29%</td>
</tr>
<tr>
<td>Potassium</td>
<td>-16%</td>
<td>-19%</td>
</tr>
<tr>
<td>Magnesium</td>
<td>-24%</td>
<td>-16%</td>
</tr>
<tr>
<td>Calcium</td>
<td>-46%</td>
<td>-16%</td>
</tr>
<tr>
<td>Iron</td>
<td>-27%</td>
<td>-24%</td>
</tr>
<tr>
<td>Copper</td>
<td>-76%</td>
<td>-20%</td>
</tr>
<tr>
<td>Zinc</td>
<td>-59%</td>
<td>-27%</td>
</tr>
</tbody>
</table>
% Changes in beef nutrient density 1940-1991

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>1963</th>
<th>1991</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca</td>
<td>-20</td>
<td>-41</td>
</tr>
<tr>
<td>Fe</td>
<td>-36</td>
<td>-54</td>
</tr>
<tr>
<td>Mg</td>
<td>-5.9</td>
<td>-10</td>
</tr>
<tr>
<td>P</td>
<td>-16.7</td>
<td>-28</td>
</tr>
<tr>
<td>K</td>
<td>-3.4</td>
<td>-16</td>
</tr>
<tr>
<td>Vit A</td>
<td>0</td>
<td>-100</td>
</tr>
<tr>
<td>Thiamine</td>
<td>0</td>
<td>-52.5</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>0</td>
<td>-5.63</td>
</tr>
<tr>
<td>Cu</td>
<td>0</td>
<td>-24</td>
</tr>
<tr>
<td>Niacin</td>
<td>0</td>
<td>4.19</td>
</tr>
</tbody>
</table>
3 cattle operations


2. Certified organic grassfed, nil inputs

3. Feedlot, grain fed, balanced ration
Beef with different feeding regimes and trace elements (US data)
Beef with different feeding regimes and CLA (US data)
NZ data comparing beef under different fertilizer/feeding regimes

Omega 3 to Omega 6 Ratio

Biological
Acidic Fert
Grain Fed