Precision Agriculture - using Technology to Improve Water Use Efficiency (8256)
Precision Agriculture: using Technology to Improve Water Use Efficiency

• A suite of measurement and control technologies based around the ability to spatially locate our actions.
• PA is now at an inflection point where the rules are rapidly changing and this has direct parallels with other industries. We are becoming data driven.
• This change is creating many challenges for us which will be common to the surveying industry. A lot of it revolves around managing end user expectations around data and data visualisation.
First yield map I completed in 1991, who can remember selective availability?

Hyperspectral imaging technology used 25 years later.
Technology Acceleration Curve

- **Linear**
- **Exponential**
- **Shift**

Technology Acceleration Curve is no aberration
- Aviation (WW II)
- Media/Communications (TV, Cell Ph)
- Info Tech (PC, Internet)

Exponential Shift requires intersection of:
- Demand/Political Will
- Adequate Base of R & D
- Capital

Bye Energy

Terrigriffith.com
Innovation cycle times are being reduced.

Technological Acceleration

- Cellular
- Internet
- VCR
- Radio
- Television
- Electricity
- Telephone
- Automobile

% Penetration vs YEARS

IBM UPward (University Programs worldwide – accelerating regional development)
PA is at an inflection point.

- PA developed through spatial technologies, ability to locate and sense, then use that information to better control or inform operational management. Improved strategic management.
- That is what I would term GEN 1.
- PA is now about data, and this is what I would term GEN 2.
- Multiple scale, multiple time, multiple source data, the internet of things etc.
- The speed and scale of the change seems to be escaping most people, we are not well equipped to deal with it.
Innovation Cycle: Rapid development. UAVs

Dramatically shortening: UAV’s as an example of very rapid technical innovation.

- Got going 5 years ago, Craft have changed, usability has improved very rapidly, improving access.
- Commercial services now available for most industries. Kiwi fruit, forestry, viticulture, agriculture.
- Research organisations, maybe a couple up to play until recently but generally failing to keep up.
- Research organisations have had very little impact in the development of UAV services for NZ.
Applications of UAV Sensors Trimble UX5 System
A “typical” vegetation spectral signature changes with a number of biochemical and biophysical plant properties…

**Biophysical** properties such as growth stage, disease, plant density

**Biochemical** properties such as leaf nutrient concentrations

Atmospheric water, light angle and light intensity are a few of the factors that can vary the reflectance of a scene without any change from the target.
FIG Working Week 2016
CHRISTCHURCH, NEW ZEALAND 2–6 MAY 2016

Recovery

Spectral bands
High-grade optical filters deliver precise information specially targeted to agricultural applications.

Typical Plant Reflectance

<table>
<thead>
<tr>
<th>Wavelength (nm)</th>
<th>Blue</th>
<th>Green</th>
<th>Red</th>
<th>Red Edge</th>
<th>Near Infrared</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>50%</td>
<td>40%</td>
<td>30%</td>
<td>20%</td>
<td>10%</td>
</tr>
<tr>
<td>500</td>
<td>50%</td>
<td>40%</td>
<td>30%</td>
<td>20%</td>
<td>10%</td>
</tr>
<tr>
<td>600</td>
<td>50%</td>
<td>40%</td>
<td>30%</td>
<td>20%</td>
<td>10%</td>
</tr>
<tr>
<td>700</td>
<td>50%</td>
<td>40%</td>
<td>30%</td>
<td>20%</td>
<td>10%</td>
</tr>
<tr>
<td>800</td>
<td>50%</td>
<td>40%</td>
<td>30%</td>
<td>20%</td>
<td>10%</td>
</tr>
<tr>
<td>900</td>
<td>50%</td>
<td>40%</td>
<td>30%</td>
<td>20%</td>
<td>10%</td>
</tr>
</tbody>
</table>

Key
- D4_mosaic_clip.tif
- NDVI
  - 0.2 - 0.53 (Low)
  - 0.54 - 0.67 (Med)
  - 0.68 - 1 (High)

Platinum Partners:
- Trimble
- esri

Diamond Partner:
- (Land Information New Zealand)
Hyperspectral Data

- Hyperspectral sensing and imaging has a long and proven track record in many fields.

- This is no longer an experimental technology we are bringing it out of the laboratory to the real world.

- We had to progress from sensing to imaging.

- It is difficult to see the limits of where this can be applied.

- **Further Applications:** effective farming area, weed and disease management, horticulture, forestry (various applications), grazing management, animal health. Environmental management, identifying sustainable land management practices, nutrient attenuation. Crop and pasture, species-cultivar identification, plant health and moisture management, yield estimation, insurance loss adjustment. Erosion monitoring, land capability classification, hydrological modelling, etc etc.
FIG Working Week 2016
CHRISTCHURCH, NEW ZEALAND 2–6 MAY 2016

Recovery
from disaster

[Diagram showing reflectance (%), wavelength (nm), and various absorption bands and wavelengths, including VIS, NIR, SWIR, reflection peaks, and absorption bands for chlorophyll, red edge, water content, leaf bio-chemicals, protein, lignin, cellulose, and atmospheric water absorption bands.]

Adapted from: http://www.markelowitz.com/hyperspectral.html
Push-broom hyperspectral imaging

- **Flight Line**
- **Single Pixel**
- **Spatial Pixels**
- **Spectral Bands**
- **Pixel Spectrum**
- **Intensity**
- **Wavelength**

**Single Sensor Frame**

**Series of Sensor Frames**
Hyperspectral Imaging: Fenix Airborne Sensor
We can now describe our environment in a lot of detail.
RGB Visualisation of farm
Nitrogen concentration in pasture
The new data economy

3 transects samples per 3,000ha
(and then interpolate observations in terms of previous rules, how robust?)

4,500,000 data points per ha. (4.5M)
13,500,000,000 data points per 3000 ha farm.
Speed and Scale of Change

- Millimeter scale, 450M data points per sqm. Individual plant, phenomics etc.
- Operational scale, 0.5m to 24m.
- Field scale, information to inform growing or animal performance for example.
- Farm, orchard, herd scale
- Catchment scale, Regional Scale National Scale
- Aggregation of data, across sources and locations.
- Multi-temporal data

Each level of scale has a community of users.
Data Fear

• A lot of negative terms being applied to data:
  • Data lakes,
    – Fear of drowning
  • Data Graveyard,
    – Fear of death,
  • Data redundancy,
    – Used to old model where data was expensive.

Big Data: Wrong term, does not convey the level and scale of change.

Digital Agriculture, Horticulture, Forestry, Viticulture
FIG Working Week 2016
CHRISTCHURCH, NEW ZEALAND 2–6 MAY 2016
Recovery from disaster
Ground based imaging

The same Fenix imaging system can be used close up to scan an object producing a detailed hyperspectral image of that object. Spatial resolution just over 1 mm. 1 Million points per m².

High speed imaging, takes two minutes to complete a scan.

Rotary stage, allows the Fenix to rotate and take an image of a vista.

Closer view than aerial, flexibility, possible to mount on a mobile robot actuator for example.

This opens up all sorts of inspection opportunities for biosecurity purposes for example.
Conclusions

- Managing water is an important element in our precision agriculture.
- Sensing and imaging are making huge strides in terms of describing our environment.
- Data is growing at an exponential rate.
- How do you turn data into information.
- Visualisation of data is an extremely important element.
- Even hyperspectral imaging is becoming more accessible and can be used from multiple platforms.