Using SATELLITE IMAGERY *to* INFORM ADAPTIVE MANAGEMENT

Upper North Farming Systems

Breezy Hill Precision Ag Services

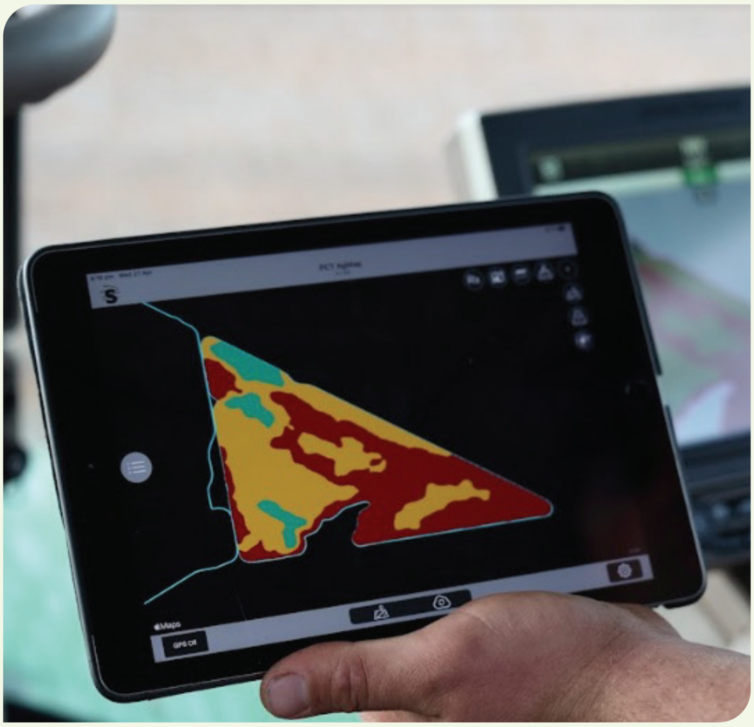
mla MEAT & LIVESTOCK AUSTRALIA

pct

Author: Jessica Koch, *Breezy Hill Precision Ag Services*

INTRODUCTION

Satellite technology in agriculture has become a widely adopted method of viewing and analysing broadacre crops, giving new insights into variability across and between fields. As time has gone on, accessibility to satellite imagery has become higher in resolution, faster and more affordable for growers. Agronomists have satellite imagery available in their software programs, and the maps can even be viewed in machinery data services such as John Deere Operations Centre. Despite this fact, the practical uses for the maps are still not widely known or adopted. In low rainfall environments, the opportunities for changed management using the maps and information from the imagery are huge. Data can offer increased confidence when making tough decisions in harder drought years. We will explore four very different case studies throughout the Upper North, and how the growers made profitable management decisions through understanding variability.

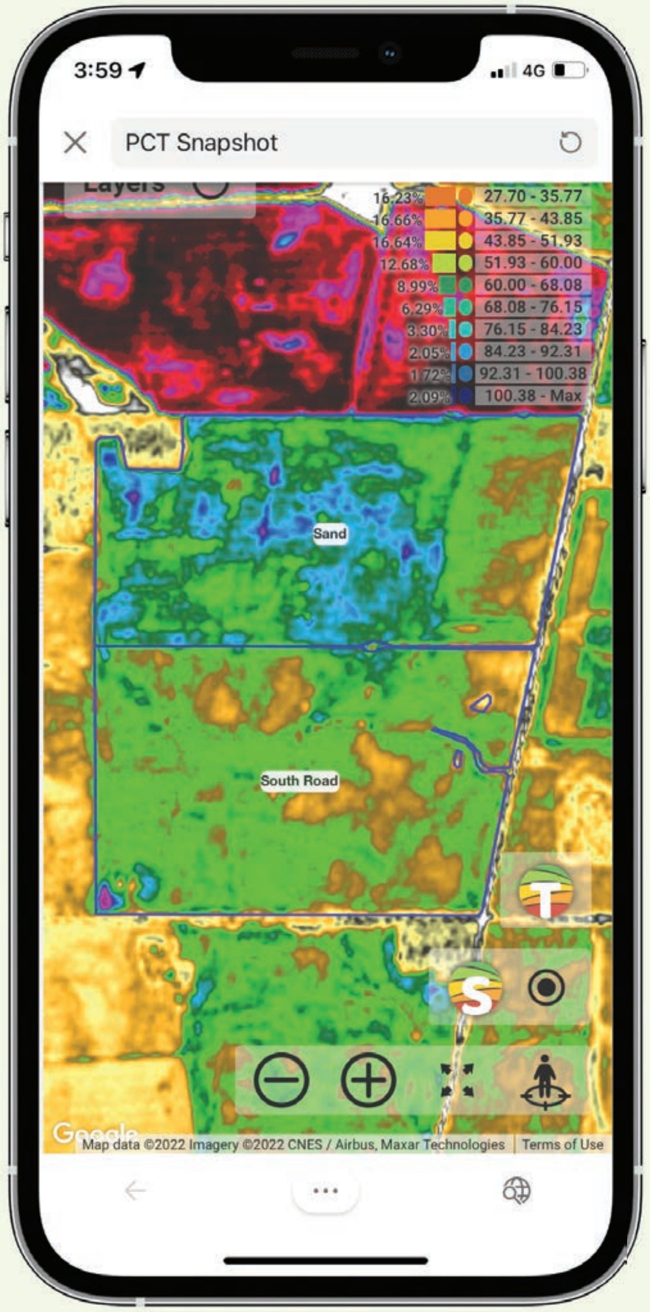


SATELLITE IMAGERY USES:

- Crop Scouting – gain insights into the crop variability before visiting the field. Often variability shows up that isn't visible from the ute cab
- Change Detection – Comparing images over time to view the changes in crops within a season or between seasons. Very important for management of both abiotic (eg - heat stress, drought, chilling stress, salinity) and biotic (eg - disease, pest) crop stressors
- Harvest Order Management - As a crop grows its amount of green leaf area increases. As it senesces the green leaf area begins to decrease. This effect shows clearly on the imagery and can be very helpful in targeting desiccation timings and harvest operations
- Crop Effect - Hail/Storm/Herbicide Damage/ Overspray assessment
- Fallow Selective Spot Spraying – In a summer spray scenario, spraying outcrops of weeds in stubble
- In Crop Selective Spot Spraying – Fungicide application for example – spraying product based on the density of the crop canopy
- Frost Management – finding and defining frost affected zones to make harvest decisions – cutting for hay or selective harvesting
- Targeted Insect Inspections – Pests tend to congregate in thicker biomass zones, nutrient or moisture deficient/excess areas. Crop inspections can be targeted accordingly
- Soil Performance Zoning - soil types and soil condition delineation (soil capability and capacity)

ABOUT SATELLITE IMAGERY

Most agricultural satellite imagery is derived from two satellites – LANDSAT 8 and Sentinel-2. Landsat 8 provides data with a spatial resolution of 30 m, while Sentinel-2 of 10, 20 or 60 m (depending on the band), Planetscope of 3 m and SkySat of 1 m. The temporal resolution (time between availability of images) is in most cases regular. For example, Landsat 8 is available every 16 days, while Sentinel-2 is available every 3 to 5 days Planetscope and Skysat have a daily resolution. The regular passage of the satellites determines the availability of the data in several phases of the growing season, but it is also important to understand that during the satellite transit, where the area under examination is covered by clouds, the data is not usable.



WHAT ARE VEGETATION INDICES?

A vegetation index (also called a vegetative index) is a single number that quantifies vegetation biomass and/or plant vigor for each pixel in a remote sensing image. The index is computed using several spectral bands that are sensitive to plant biomass and vigor. The index we are most familiar with in agriculture is NDVI (Normalised Difference Vegetation Index). Similar to NDVI, the Satamap Vegetation Index (SVI) exposes variability in vegetation by exploiting the difference in reflectance in the red and near infrared bands. SVI also uses the green band to help mitigate the effects of soil colour.

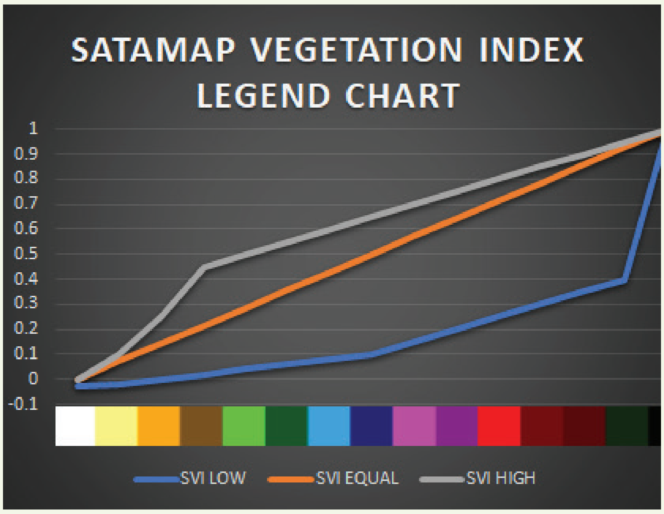
The Satamap Vegetation Index (SVI) offers three colour scales to represent the information: Equal, Low and High. SVI Equal distributes SVI values evenly across the colour scale, whereas SVI Low gives bias to low biomass crops and SVI High bias to high biomass crops. This allows maximum information to be extracted from the imagery. Many would be familiar with this colour scale in programs like Agworld.

VEGETATION INDICES:

- **NDVI** - Normalised Difference Vegetation Index
- **SVI** - Satamap Vegetation Index
- **PCD** - Plant Cell Density
- **CCC** - Canopy Chlorophyll Content

OTHER INDICES:

- **RGBI** – Red Green Blue Index
- **MSI** - Moisture Stress Index
- **NDRE** - Normalised Difference Red Edge



USING THE 'MOISTURE STRESS INDEX' TO MAKE STRATEGIC GRAZING DECISIONS

THE GROWERS:
David, Chloe, Ian & Sue Clarke

FARMING ZONE:
Booleroo Centre, SA

PADDOCK LOCATION:
Amyton 'Shed Paddock'

ANNUAL RAINFALL:
290mm

With farms spread up to 80km apart, and cropping country well north of Goyders Line, David Clarke has turned to satellite imagery to assist in proactively making grazing and harvest management decisions differently.

THE PROBLEM

- Below average rainfall in July/August 2021 meant a strategic decision had to be made on a moisture stressed barley crop.

THE QUESTIONS

- How can we make an informed decision on whether to graze this paddock? If the answer is yes, when?
- Should the paddock be harvested after being grazed?

Amyton is traditionally a marginal cropping zone, and after an extended dry period throughout July and August in 2021, David chose to be proactive in his crop scouting methods using satellite imagery to guide him. This case study focuses on the 'Shed' paddock at their 'Brindinna' property.

THE SOLUTION

David used a map called MSI (Moisture Stress Index) to help him crop scout his barley. The crop had a solid start with good opening rains but follow up rains were sparse. The crop was beginning to struggle from moisture stress but it was clear that the affect of the moisture stress was variable throughout the paddock. The decision to graze the paddock needed to be made swiftly and logically, to maximise the use of the crop as feed, and still allow the option to harvest it.

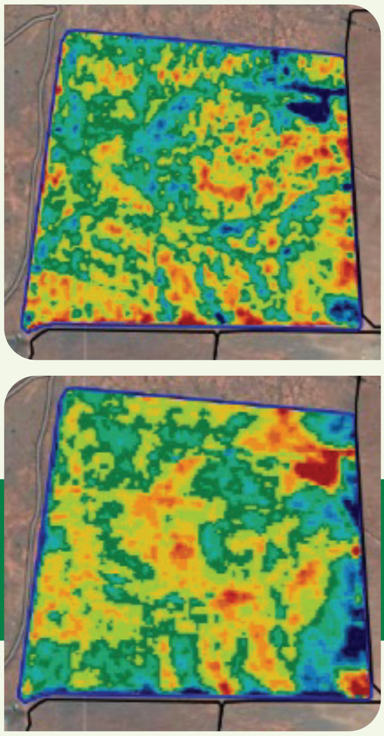


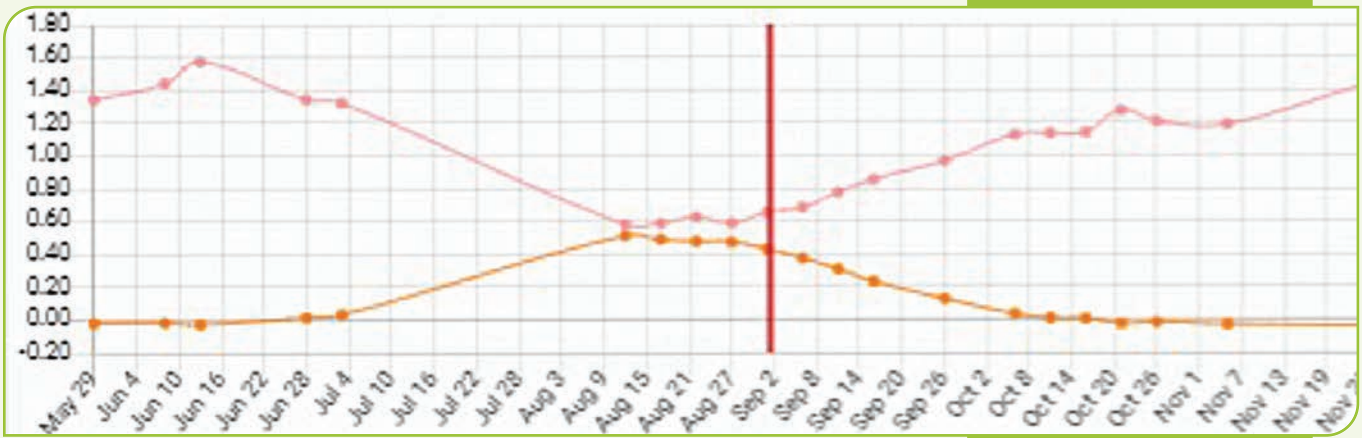
__Fig 1__ – An SVI biomass satellite image from the 1st of September 2021 on the top and a MSI (Moisture Stress Index) map on the bottom. The maps are generally the inverse of one another, explained more below.

WHAT IS A MOISTURE STRESS INDEX (MSI) MAP?

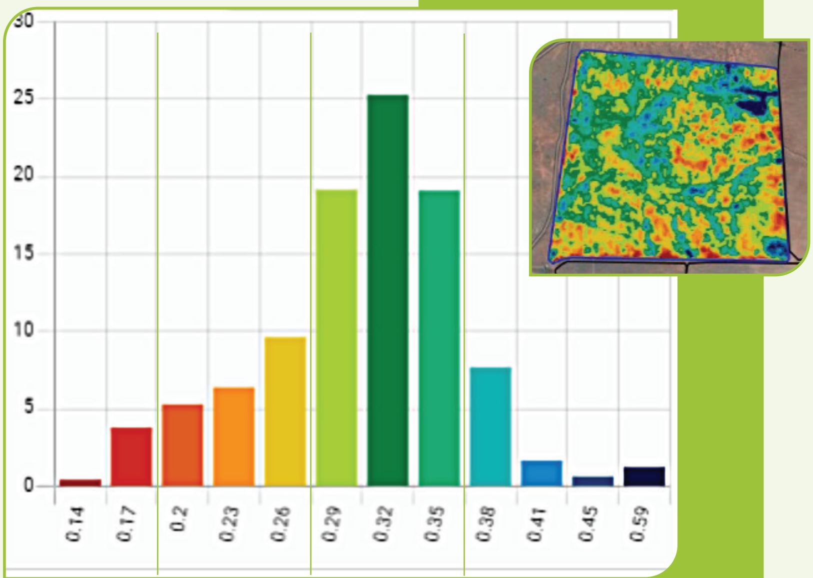
The MSI is an estimation of leaf water content. Near Infrared (NIR) is derived by shortwave infrared (SWIR). SWIR will reflect more as leaf water content decreases. NIR reflectance is not directly impacted by water content and is therefore used as a reference. Like Plant Cell Density (PCD), MSI is not normalised so we cannot know exactly what the range will be, but generally we see values from 0.4 to 2.

It is important to note that the values are inverted to a normal vegetation index. A high value indicates low water content/high plant stress.

***Fig 2** – The correlation between moisture stress and biomass imagery was evident on the 1st of September. The MSI (pink) vs SVI (Orange). As the crop greenness diminishes, the moisture stress increases – a typical relationship.*



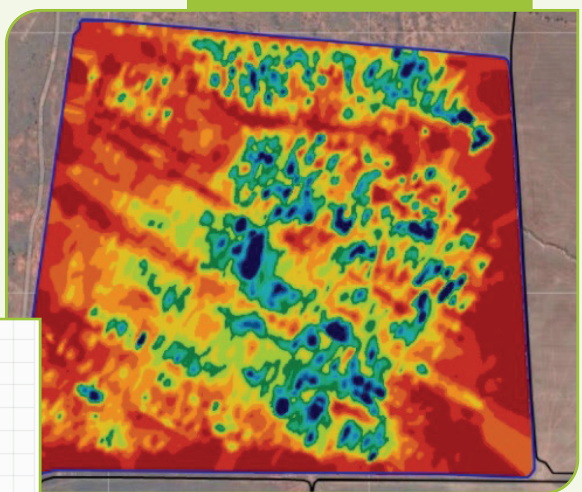
The SVI image from the the 1st of September was divided up into four zones (right) based on SVI value. David also noted the area of each of the four zones. This map was downloaded as a KMZ file, so that it could be used as a layer with cellular GPS on his tablet. He then drove to each of the zones and made a correlation assessment. The decision was made to graze the paddock immediately.



THE RESULTS

David was excited to have successfully used his imagery to make an informed, evidence based decision. He is keen to use the methodology in this case study in other areas of his crop management. ***The main outcomes to note were:***

- The satellite imagery indicated a moisture stress problem well in advance of physical assessment from a ute inspection
- The sheep grazed the poorer zones of the paddock, saving the higher biomass areas to be taken through to harvest, which added to the grazing benefit
- The sheep cleaned any volunteer wheat out of the barley as they grazed
- An extra 8 weeks of feed gained; other feed sources that would otherwise have been used were saved
- The barley crop was still worth harvesting and due to late spring rain David does not believe there was a yield penalty to this field despite the fact it was grazed



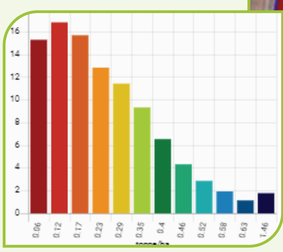


***Fig 3** - The 2021 barley yield map*

USING SATELLITE IMAGERY TO **SELECTIVELY SUMMER SPRAY** WITH **SECTION CONTROL**

THE GROWERS:
Scott and Luke Clark, Clark Forest View

FARMING ZONE:
Jamestown, SA

PADDOCK LOCATION:
Belalie

ANNUAL RAINFALL:
450mm

Satellite imagery helped the Clark Brothers cut their chemical bill by up to 87%, by selectively spraying weeds.

THE PROBLEM

In March 2021 the Clarks discovered volunteer canola had germinated where they had renovated shallow limestone patches in two of their paddocks – 'Bears West' and 'Back Paddock', the rest of the paddocks were relatively clean upon inspection. Scott and Luke turned to Satamap Vegetation Index (SVI) imagery in AgWorld to compare the map with what they were seeing in inspections. It was evident that the areas of the paddock that had germinated with canola were clearly defined in the satellite imagery.

THE SOLUTION

Scott and Luke could see potential in selectively spraying the weed areas given they were only affecting a small percentage of the paddock. They reached out to a precision ag consultant to create the prescription file. The boundary for the paddock was imported from John Deere Operations Centre to PCT AgCloud. PCT AgCloud uses the same Satamap enabled SVI imagery as Agworld, however there is the option to select a cloud free satellite map capture from your date of choice and download it for other applications. An SVI image from the 4th of April had the best correlation with what was seen in Agworld and in the paddock, so this was downloaded. At this point, a prescription could be created.

A spray prescription design was created for both Bears West and Back Paddocks, spraying 1.5 L/ha of Glyphosate on the canola patches. The self propelled boom spray had standard section control (11 sections), which was more than adequate for this operation.

THE RESULTS

'The concept worked well as the imagery picked up the weed affected areas very accurately, meaning we only sprayed 13% of one of our paddocks and 30% of the other. This spray run hit the big weeds we were targeting which means we could do our pre sowing spray at a lower rate, chemical saving for both passes, a win win.' - Luke Clark

***Fig 4 (left to right)** – The Agworld SVI Image, the PCT AgCloud SVI Image, and the prescription made in PCT AgCloud. The green areas were sprayed and the red was left unsprayed.*

USING **SOIL COLOUR INDICES** AND **STRATEGIC SOIL TESTING** TO HELP DETERMINE **MANAGEMENT ZONES**

THE GROWERS:
Joe and Jessica Koch, Breezy Hill Ag

FARMING ZONE:
Booleroo Centre, SA

PADDOCK LOCATION:
Wepowie/Morchard

ANNUAL RAINFALL:
300mm

With the input prices soaring, farming in a low rainfall environment meant that nitrogen decisions had to be made strategically and precisely. RGB Soil Colour Maps made available through satellite imagery helped identify soil types in this zone.

THE PROBLEM

The 'Ruin' paddock at Breezy Hill is in a low rainfall zone, north of Goyders Line. Urea applications are made strategically, and usually in one singular pass. In 2021, the field was in a wheat rotation on the back of a 'vetchola' (vetch/canola) mix in 2020, which had been spray topped and grazed. It was hard to calculate the nitrogen fixation from the vetchola crop given that one of the crops is nitrogen (N) fixing and the other has a large nitrogen requirement.

The questions to answer for the 2021 wheat crop were:

- How much N (in the form of urea) is required to meet the yield potential of the wheat crop?
- Is a variable rate map an appropriate option given the paddock has significant historical yield variability?

THE SOLUTION

Step 1 – *Determine representative zones to test*

The soil types in this field are largely driven by topography. There are three distinct ridges that are heavily eroded, this is confirmed by a landscape change map layer (created from the elevation map). A simple 'Google Earth' image also gives clarity to the two distinct soil zones. It was decided that two Deep N tests should provide enough information to answer the question.

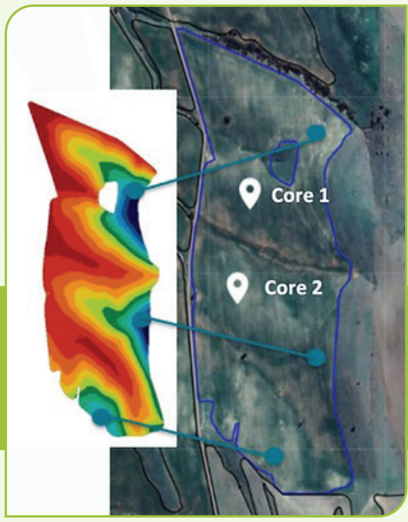


***Fig 5** – The landscape change map on the left. The calcareous outcrops are evident on Google Earth as they are in the landscape change map as indicated by the blue markers. The two chosen soil core sites were placed in two representative zones.*

Step 2 – *Identify the yield potential for each zone*

The yield potential in the paddock for 2021 was 5.2 t/ha, as calculated through the Angus and Sandras model (updated French and Scultz). Realistically though, it is not common to achieve yields this high due to various environmental limitations.

When considering seasonal rainfall to date, the long-term season forecast, and the historical yield in each zone, it was decided that the yield potential was not the same at core 1 as it was at core 2. The core 2 site historically yields higher, so this was given a yield potential of 3.5 t/ha. Core 1 was matched to a yield potential of 2.5 t/ha, due to hostile soil conditions.

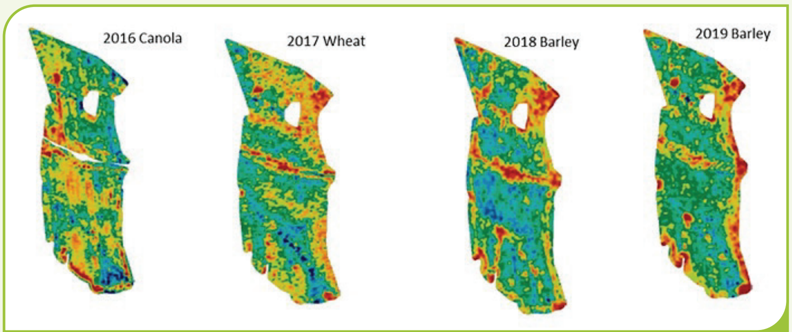


***Fig 6** – The historical yield maps for Ruin paddock. The distinct zones and their yield potential are evident (blue/green – 3.5 t/ha, Red/Orange Zone 2.5 t/ha wheat yield potential for 2021)*

Core 1 Yield Potential: 3.5 t/ha | **Core 2 Yield Potential:** 2.5 t/ha

Step 3 - *Calculate units of N already available in the soil*

The Deep N results provided the information for this part of the equation. It's important to consider the available nitrate in the upper and lower horizons and pair this with crop rooting depth.

Core 1: 0-30cm = **7 mg N/Kg** 30-60cm = **12 mg N/Kg** | Core 2: 0-30cm = **9 mg N/Kg** 30-60cm = **9 mg N/Kg**

Step 4 - *Estimate mineralisation for the rate of the season*

Factors that fed into the mineralisation calculation, included; the organic N within the soil, soil organic carbon, soil temperature, previous crop rotations and moisture availability. The information was fed into a program called Back Paddock, which calculated the estimated N mineralisation at each depth at each core.

	Core 1		Core 2	
Analyte	***0-30cm***	***30-60cm***	***0-30cm***	***30-60cm***
Nitrate mg/kg	7	12	9	9
Estimated N Mineralisation	41	42	34	56

Step 5 - *Calculate remaining N requirement to meet the yield potential*

The last step was to calculate the gap between the amount of available N in the soil, and the requirement to meet the yield potential at each core site.

The N requirement at Core 1 (yield potential 3.5 t/ha) is 52 kg of N. With 83 kg of N available between the two depths, the urea requirement to meet yield potential at this site was 0 kg/ha.

The N requirement at Core 2 (yield potential 2.5 t/ha) is 37 kg of N. With 90 kg of N available between the two depths, the N requirement to meet yield potential at this site was 0 kg/ha.

	Core 1		Core 2	
Analyte	***0-30cm***	***30-60cm***	***0-30cm***	***30-60cm***
Nitrate mg/kg	7	12	9	9
Estimated N Mineralisation	41	42	34	56
Estimated Remaining N Requirement	***52 kg/ha***	***52 kg/ha***	***37 kg/ha***	***37 kg/ha***

SO, TO ANSWER THE QUESTIONS....

How much urea was required to meet the yield potential of the crop in 2021?

0 kg/ha - Through our four step calculation process we could determine the soil N requirement was adequate to meet the yield potential of the crop at both core site's, therefore no urea was applied.

Was a variable rate map an appropriate option given the field has significant yield variability?

In 2021, a variable map was not required, given that the total N requirement to meet the yield potential in each zone had already been met through fixed N. However, what the exercise did highlight, was that the yield potential in the different zone varies, as does the amount of available N. A variable rate N application will certainly be considered in the future to confirm this hypothesis. After the decision was made to not spread the ruin paddock in August, the season began to shut off with the next significant rainfall event coming in late October. Despite the dry finish, and no top dressed N applied, the Koch's were able to produce a wheat crop that averaged 2.94 t/ha. In the future, the Koch's will utilise the knowledge gained from this exercise to spread from an N removal map, using the protein and yield maps from the harvester.

USING **SATELLITE MAPPING** TO **SUPPORT GRAZING DECISIONS** AT A **MIXED SPECIES PASTURE DEMONSTRATION SITE**

THE GROWERS:
Alison Henderson, Hendowie Poll Merinos

FARMING ZONE:
Caltowie, SA

PADDOCK LOCATION:
Caltowie/Appila

ANNUAL RAINFALL:
370mm

PADDOCK NAME:
AB17 'Sambells' block

Having a true understanding of the feed on hand is the key to unlocking grazing efficiencies. Through satellite imagery and trialling the performance of their flock grazing mixed species vs single species pastures, Alison and the team at Hendowie Poll Merino's could gain better insights for their management decisions

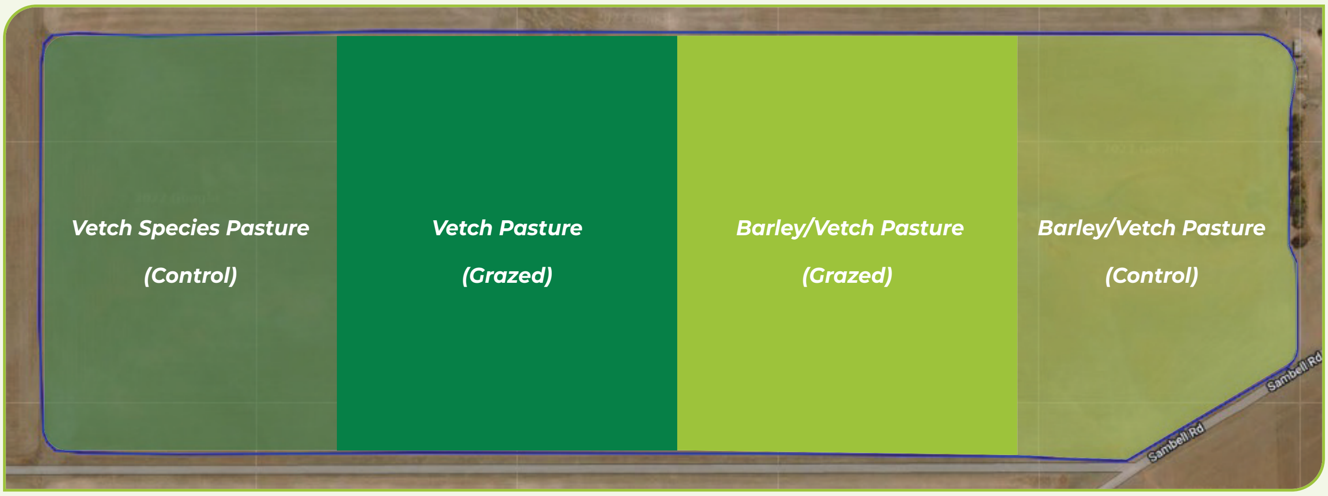
THE QUESTIONS

Will the performance (in terms of average weight gain) be improved on a multi species vs single species pasture?

Aim: Improve the pasture management systems using satellite Imagery to have a better understanding of the feed on offer.

THE PROCESS

To investigate these ideas, a pasture demonstration site was set up in a 50ha paddock on the Henderson's farm, with a fence running north-south through the centre. The concept was to put a mob of 96 sheep on each of the two pasture types for a one-month period, leaving a control zone on the outside(s).



The pastures were:

Single Species (Rasina vetch)

- to the left of the centre fence

Mixed species (Kraken barley/Rasina vetch)

- sown on the right of the centre fence

Both pastures were dry sown on April 23rd and germinated in June after an opening rain on the 30th of May. Prior to the sheep entering the paddock, the mixed pasture showed higher amounts of biomass using the satellite imagery. This is evident in the pre-graze image figure 8, below. The paddock had a large outcrop of Ryegrass and Medic present. The mobs were weighed and then put onto the respective demonstration sites on the 2nd of August, and then removed on the 29th of August and weighed again.

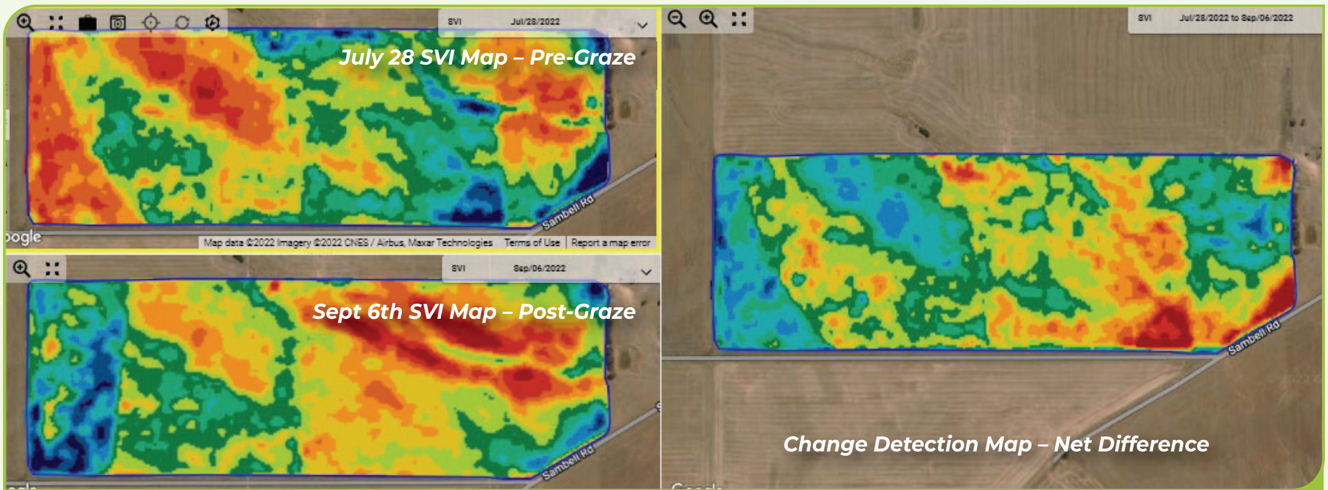


Fig 8 *– 'Change Detection Map' – Above right, shows the net difference in pasture vegetation over the grazing time – the mixed species was grazed more evenly. The vetch single species was more harshly grazed where there was an accumulation of ryegrass in a strip, explained more below.*

THE RESULTS

The key learnings from the demonstration site:

- Alison Henderson observed that the mixed species was grazed more evenly than the singles species. The change detection map highlights this.
- The animals on the mixed species (vetch/barley) gained an average of 1.25 kg more per animal over the grazing period (see figure 9)
- There was less variability in the average weight results across the mixed species mob compared to the single species
- The sheep from both pasture compositions were condition scored and weighed after the grazing period ended on the 29th of August, and the condition scores were higher for the mixed species mob - which is consistent with the weight gain results
- The Feed Tests confirmed that the dry matter (DM)% in the mixed species was 30.4% vs 26.3% in the vetch only, meaning the mob on the single species had to consume more pasture volume to obtain the same DM content

Vetch			Vetch/Barley		
Daily Weight Gain g/hd	Start Weight kg	End Weight kg	Daily Weight Gain g/hd	Start Weight kg	End Weight kg
146.87	46.22	50.01	266.38	47.47	55.4

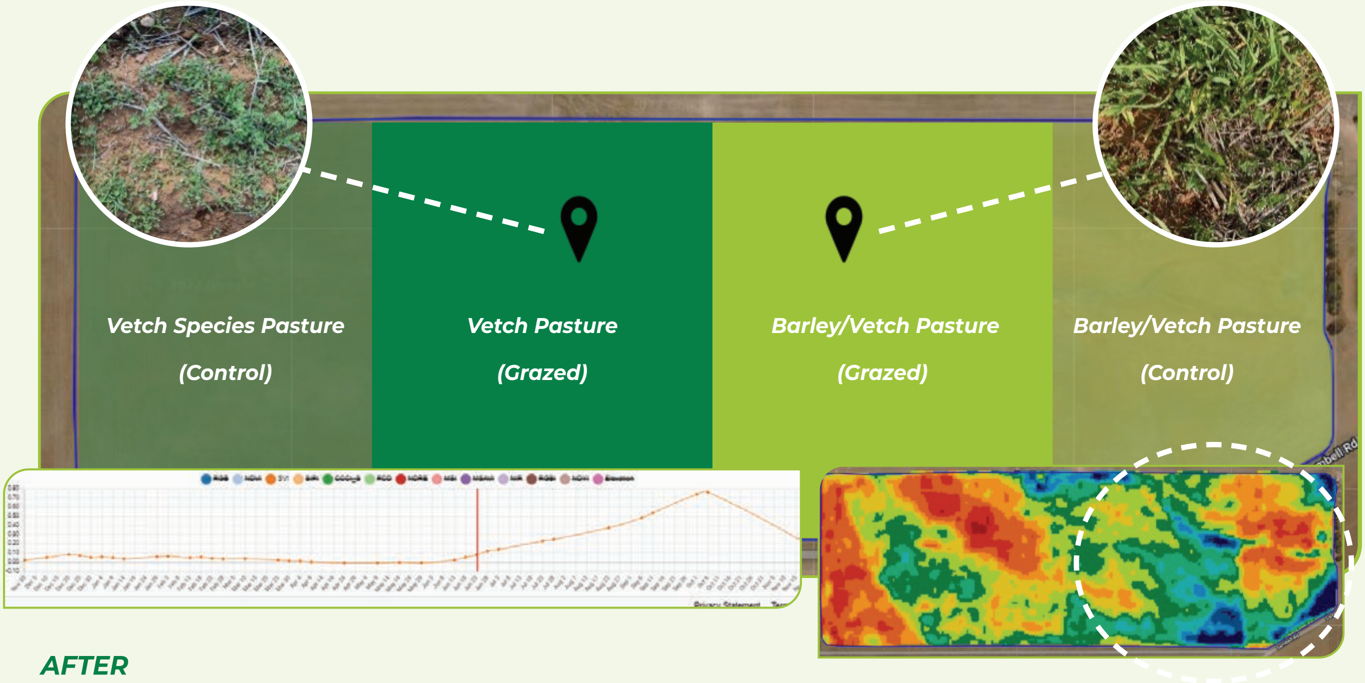
***Fig 9 –** A summarised table of the weight gain of the mob on the vetch single species pasture, vs the vetch/barley mixed pasture*

PASTURE CUT OBSERVATIONS

Pasture cuts were taken pre-graze on the 1st of August and post-graze on the 14th September.

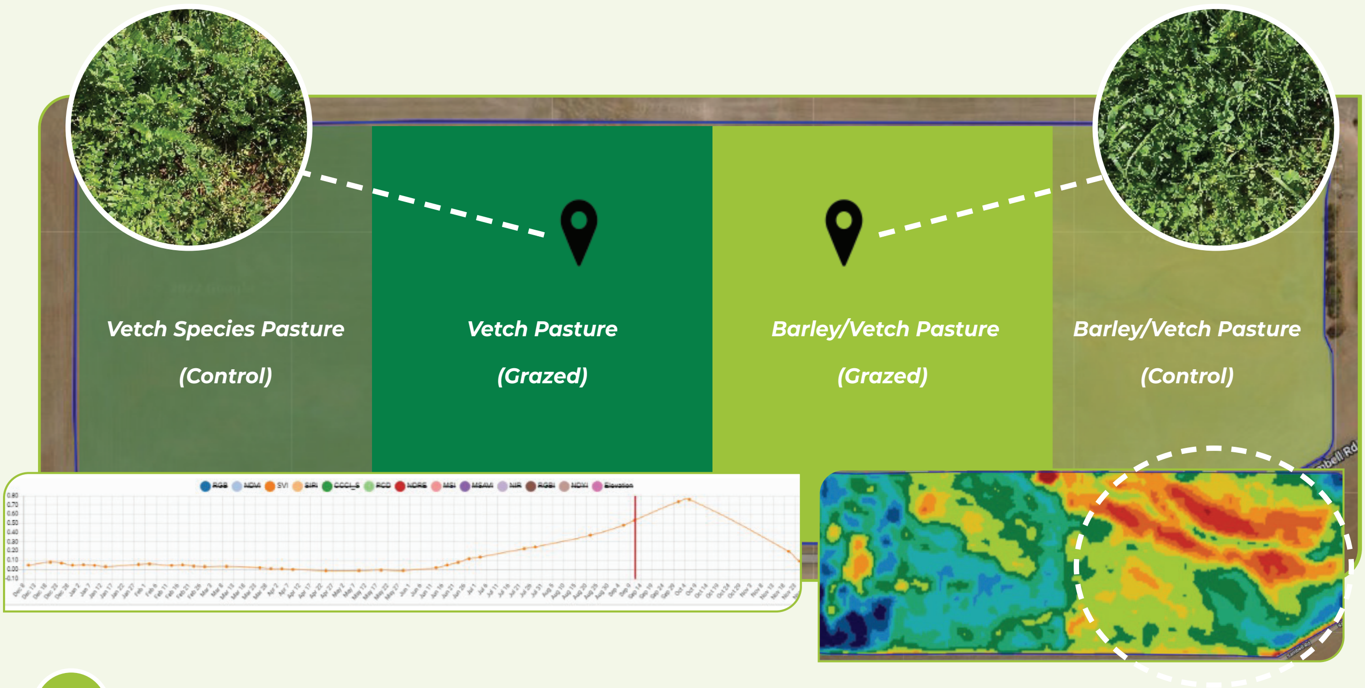
BEFORE

Prior to the graze (July 29th) the mixed pasture through the SVI satellite imagery indicated thicker or greener canopy cover than the single species. The pasture cuts from the two sites at this earlier date confirmed this through ground truthing.



AFTER

As the pasture demonstration zones were grazed, the mixed species pasture showed a more even grazing pattern. It also highlighted the effect of different soil types on the vigour of the pasture as the root systems ventured into the subsoil.



GROWER OBSERVATIONS

Alison observed that sheep grazed the mixed species side of the trial very uniformly. In contrast, the single species vetch pasture was slow to gain biomass at the beginning of the season, seen on the SVI image captured the 29th of July. Once livestock were added to the monoculture vetch pasture, sheep congregated throughout the middle of the paddock (the diagonal trend you can see in the SVI image from the 6th of September, see figure 8). They were selectively grazing this strip as there was ryegrass through this zone of the paddock they were seeking out. The patches with less ryegrass and more vetch were left to accumulate biomass, as sheep did not move out to these sections to graze the zone to its boundaries.

Summary

- In the mixed species pasture sheep were able to gain more weight in contrast to the mob in the vetch monoculture, as they were taking advantage of feed throughout the entire available pasture zone and hence had more 'feed on offer'. Conversely, the mob on the vetch were concentrating their grazing to a smaller section of their zone. This meant there was less feed for this mob and hence they gained less weight. This is reflected by the average weight gain values.
- There is a greater spread in the data for the mob on the vetch monoculture when considering the average weight gain. It appears selective grazing in this zone on the ryegrass patch led to a disadvantage for the 'shy feeders' in the mob, resulting in them gaining less weight.

'We are trying to achieve "Regenerative Grazing" which is ultimately about rotating animals through pastures at the right time. Satellite imagery will be a powerful tool to help make these decisions. The flow on effects of this information may also assist us manage pasture recovery and soil cover.' – Alison Henderson

REFERENCES

Agricolus - https://www.agricolus.com/en/technologies/satellite-imagery/#:~:text=Spatial%20and%20temporal%20resolution%20of,)%2C%20Planetscope%20and%20Sky%20Sat.

L3Harris Vegetation Indices - https://www.l3harrisgeospatial.com/docs/vegetationindices.html

Geospatial Technology – What does vegetation index mean in remote sensing technology - https://mapasyst.extension.org/what-does-vegetation-index-mean-in-remote-sensing-technology/

PCT AgCloud - https://pct.ag/learning-centre/

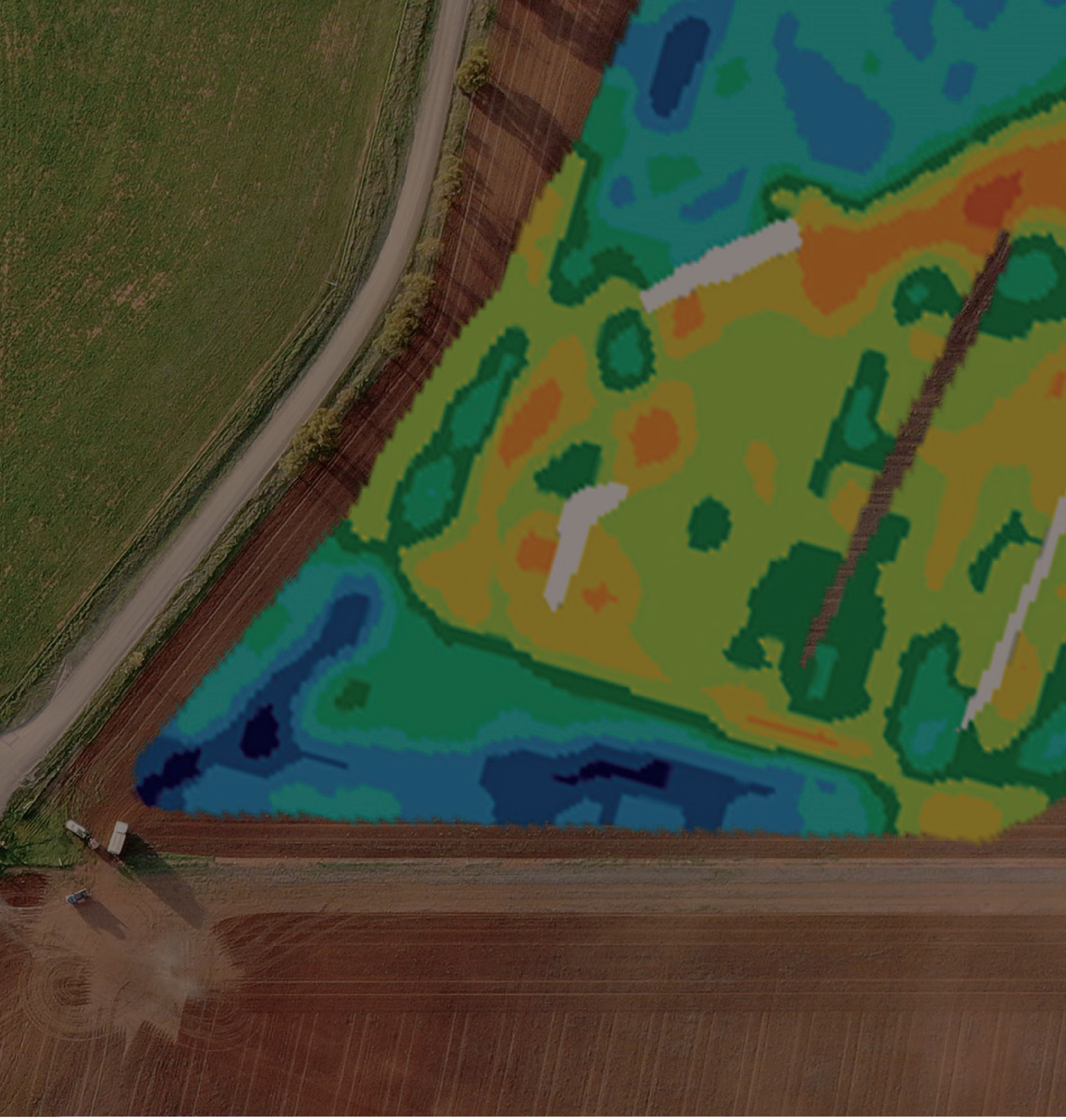
Satamap - https://www.satamap.com.au/features#:~:text=Similar%20to%20NDVI%2C%20the%20Satamap,%3A%20Equal%2C%20Low%20and%20High.

ACKNOWLEDGEMENTS

This fact sheet is part of the 'Using Satellite Imagery in the Growing Season to Inform Adaptive Management' Project' and the 'Pasture Demonstration Sites' funded by the SA Drought Hub, as an initiative of the Upper North Farming Systems.

The data and analysis were compiled and written by Jessica Koch of Breezy Hill Precision Ag Services together with Rachel Trengove, Upper North Farming Systems and Bethany Humphris, Elders Jamestown, with review from the Upper North Farming Systems committee and staff. Morgan McCallum conducted the plant counts and compilation of statistics.

A special acknowledgement to the growers – the Clarke, Clark, Koch and Henderson families for being generous with the use of their data and their input with interpretation and analysis.



Australian Government
Department of Agriculture, Fisheries and Forestry

Future Drought Fund

SA DROUGHT HUB

This program received funding from the Australian Government's Future Drought Fund

UNFS
Upper North Farming Systems

Breezy Hill Precision Ag Services

pct

mla
MEAT & LIVESTOCK AUSTRALIA