Monitoring barley grass in broad acre paddocks

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Location
Minnipa Ag Centre, paddock S4
Rainfall
Av. Annual: 324 mm
Av. GSR: 241 mm
2019 Total: 254 mm
2019 GSR: 234 mm
Paddock history
2019: Scepter wheat
2018: Volga vetch
2017: Spartacus barley

Location
Minnipa Ag Centre, paddock N5S
Paddock history
2019: Self-regenerating medic pasture
2018: Scepter wheat
2017: Self-regenerating medic pasture

Location
Minnipa Hill
Rainfall
Av. Annual: 324 mm
Av. GSR: 241 mm
2019 Total: 237 mm
2019 GSR: 233 mm
Paddock history
2019: Self-regenerating medic pasture
2018: Scope barley
2017: Mace wheat

Location
Yaninee
Rainfall
Av. Annual: 233 mm
Av. GSR: 226 mm
Paddock history
2019: Scepter wheat
2018: Mace wheat
2017: Self-regenerating medic pasture

Key messages

- **UAV imagery with skilled specialist analysis has the potential to identify weed issues in paddocks.**
- **It was easier to identify grass weed patches in legume and pasture crops than cereal crops.**
- **Data capture and analysis for analytical purposes such as grass weed mapping in individual paddocks will be beyond most farm enterprises unless farmers have a special interest in this area.**
- **Grass patches were more reliably identified using UAV data captured at higher resolutions.**
- **Barley grass resistance to Group A herbicides has been detected several times throughout the project, so be aware it may be present in current farming systems.**

Why do the trial?

Barley grass continues to be a major grass weed in cereal cropping regions on upper Eyre Peninsula (EP). The use of unmanned aerial vehicle (UAV) technology to identify and assess barley grass populations in paddocks and monitor potential resistant populations may be a useful tool for farmers. This approach was tested in three paddocks on upper EP Minnipa Agricultural Centre (MAC), Minnipa Hill and Yaninee using a UAV during the 2017, 2018 and 2019 growing seasons at three different timings, with paddock transects conducted to verify grass weed density in paddocks. In 2019 grass weed escape paddocks were targeted at MAC and Condada in the final flights.

The aim of the research was to determine if the UAV imagery could monitor the grass weed populations across seasons in crops and pastures, if resistant weed patches were continually in the same area of the paddock and if the information could be useful for farmers to adopt this method to better target grass weed control.

How was it done?

In-crop paddock monitoring for grass weed populations

Grass weeds were assessed in crop or pasture at eight paddock-marked GPS points, and in 2018 and 2019 the sites were also marked in the paddock with a large corflute sign visible in the imagery, with six or more counts taken at each sample point and each timing during the season. This was used to verify the UAV data captured at two times during the cropping season. Extra sampling points in the paddock were targeted if more information was needed to verify the imagery. The paddock photos were captured on an iPad with 'Avenza Maps' linked to the location in the paddock.

In 2019, grass weed assessments were undertaken on:

- North's Minnipa Hill Pasture Paddock (self-regenerating medic pasture) 4 June, 16 June
- MAC S4 (Scepter wheat) 3 June, 16 June, 6 August
- Yaninee (Scepter wheat) 4 June

Location
Condada
Rainfall
Av. Annual: 224 mm
Av. GSR: 209 mm
Paddock history
H12
2019: Self-regenerating medic pasture
2018: Sown grazing cereal
2017: Self-regenerating medic pasture
H5
2019: Lentils
2018: Mace wheat
2017: Self-regenerating medic pasture
Soil types
Red loams
Plot size
Paddock monitoring

- MAC North 5 South (self-regenerating medic pasture) 27 August
- Condada (lentils) 28 August
- Condada (self-regenerating medic pasture) 28 August

UAV imagery

UAV data were captured twice in each paddock during the 2019 cropping season. The UAVs used were either a DJI Matrice 100 with both NIR and RGB sensors or a Mavic Pro with RGB sensors. In 2019 the UAVs were flown at a height of 120 metres and a smaller 10 ha area at 40 metres to increase the detail of the information captured. Due to the low barley grass weed numbers in the paddocks the final flight targeted paddocks with barley grass weed escapes in pulse and pasture paddocks.

'Training features' were created which highlighted areas of high weed infestation within the image. These areas were identified by matching photos from the ground with the aerial imagery. Originally, training features also aimed to identify other features such as clean crop areas, but the training process was found to be more accurate when a single type of weed pixel was the focus of analysis. This currently needs to be done separately for each image flown, which is a labour-intensive process.

Data analysis of UAV imagery

To analyse weed locations at a whole paddock level using the UAV imagery, geospatial analysis tools were used to automate the selection of likely weed infestation areas. A map of the paddock with the UAV coverage was generated from ArcGIS Desktop as a geo-pdf to enable collection and analysis of field data. This is a map file which can be used in a range of devices. With this file loaded to the 'Avenza Maps' app on a tablet, photos and comments with GPS locations were collected. This data was then added to ArcGIS and used to interpret the UAV mapping.

The Spatial Analyst extension within ESRI's ArcGIS Desktop software was used to carry out a 'Maximum Likelihood' spatial classification. This classification uses small parts of the image selected by the user as 'training features' for deciding which category each pixel of the image most likely fits into. This classification method is based entirely on the spectral (colours through different bands of light) characteristics of the imagery. Training features were created which highlighted areas of high weeds, low weeds/crop features and bare ground.

What happened?

In 2019 the initial paddocks monitored were two cereal crops and one self-regenerating medic pasture at North's block on Minnipa Hill. The self-regenerating medic pasture initially had high grass weed numbers.

A paddock at Yaninee was wheat sown on 7 May with Scepter wheat @ 60 kg/ha and 18:20:0:0 at 50 kg/ha, and pre-emergent herbicides of 1 L/ha Treflan and 800 ml/ha Ultramax. Post emergent herbicides were MCPA LVE @ 400 ml/ha, 5 g/ha Ally and ZMC micromiz chelate @ 3 L/ha. The wheat was harvested on 12 November and yielded 1.5 t/ha at H1 grade.

MAC paddock S4 was sown on 14 May with Scepter wheat at 70 kg/ha and 50 kg/ha of Granulock Z fertiliser. Pre-emergent herbicides applied were of 1.2 L/ha Roundup DST, 40 ml/ha Hammer, Jetti Duo @ 1.8 L/ha and Ester 680 LVE at 450 ml/ha. The seed was pre-treated with 0.105 L/t Gaucho and 0.084 L/t of Vitaflo. Post emergent herbicide of Tigrex @ 750 ml/ha was applied on 17 June.

At Minnipa the 2019 growing season rainfall was 234 mm, decile 4 (below average), with the crop yielding 2.14 t/ha due to timely September rain which maximised grain fill.

UAV flights were conducted on the dates shown in Table 1. MAC S4, North's Minnipa Hill and Yaninee were flown early. The pasture was flown again after a grass herbicide application but with only low grass weed numbers and grasses dying, so only the two flights were undertaken in these paddocks in 2019. As a result of the low grass weed numbers the final flights in August targeted paddocks in which grass weed escapes were visible at Condada (lentils and pasture) and MAC North 5 South (pasture) to capture and identify the grass weed escapes.

Analysis of UAV imagery in 2019

'Training features' were created which highlighted areas of high weed infestation within the image. These areas were identified by matching photos from the ground with the aerial imagery (example Figure 1 a-c). For each site imaged at higher resolution (drone flown at 40 m height) patches of likely barley grass where identified and marked using cross referencing with photos taken on the ground. Grass patches within a measurable distance from fixed points such as fence posts were also identified.

Table 1. UAV image capture flights conducted at 40 m and 120 m above the ground in 2019.

Location	Crop	Flights		
North's Minnipa Hill	Medic pasture	4 June	16 June	
MAC S4	Scepter wheat	3 June	16 June	6 August
Yaninee	Scepter wheat	4 June		
Condada	Lentils			28 August
Condada	Medic pasture			28 August
MAC N5S	Medic pasture			27 August

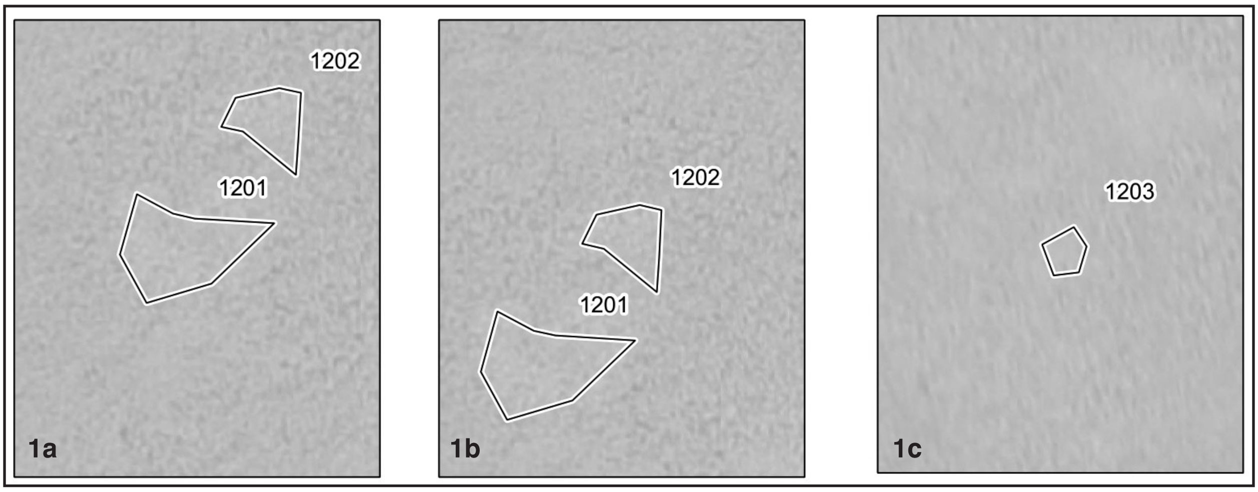


Figure 1 (a, b and c). Training 'features' (area with barley grass) in North's Minnipa Hill pasture paddock sample sites flown at 40 m above ground level, 2019.

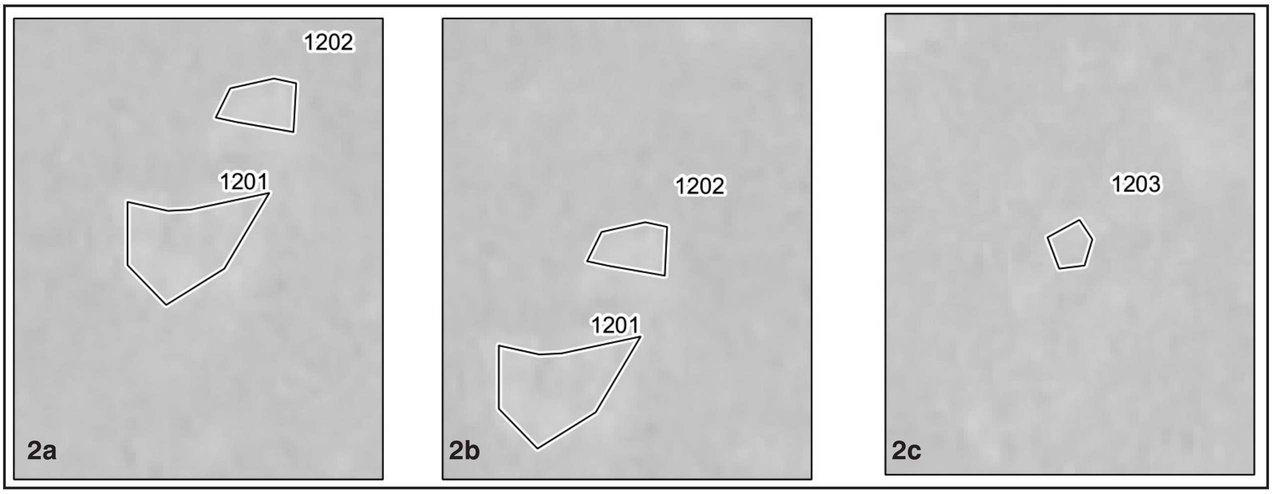


Figure 2 (a, b and c). North's Minnipa Hill pasture paddock sample sites flown at 120 m above ground level, 2019.

In the higher resolution imagery these patches were easily identified. Cross referencing these with the medium resolution imagery (drones flown at 120 m height), the same patches of grass were marked using comparative features in the imagery (example Figure 2 a-c)).

The initial analysis was then run, and a representative sample area was compared for each set of images. The black layer in the images below (example Figure 3) shows the initial "Maximum Likelihood" analysis output, or the increased likelihood of grass weeds being present.

2019 North's Minnipa Hill pasture paddock

Imagery was collected from Norths on Minnipa Hill on 7 August 2019 at both 40 m and 120 m heights.

Sample sites were selected from the 40 m imagery and replicated in the imagery flown at 120 m as show below (Figure 1-4).

Condada – lentil paddock

A paddock at Condada was imaged at both 40 m and 120 m on 28 August 2019.

Overall the North's Paddock (Figures 1-4) and the Condada paddock (Figures 5-8) sample comparison analysis output based on the 40 m samples and the 120 m samples does have some overlap, however they appear to be producing highly dissimilar results, with less detail and detection of grass weeds in the 120 m analysis.

Condada pasture paddock

A pasture paddock at Condada was flown at both 40 m and 120 m heights on 28 August 2019.

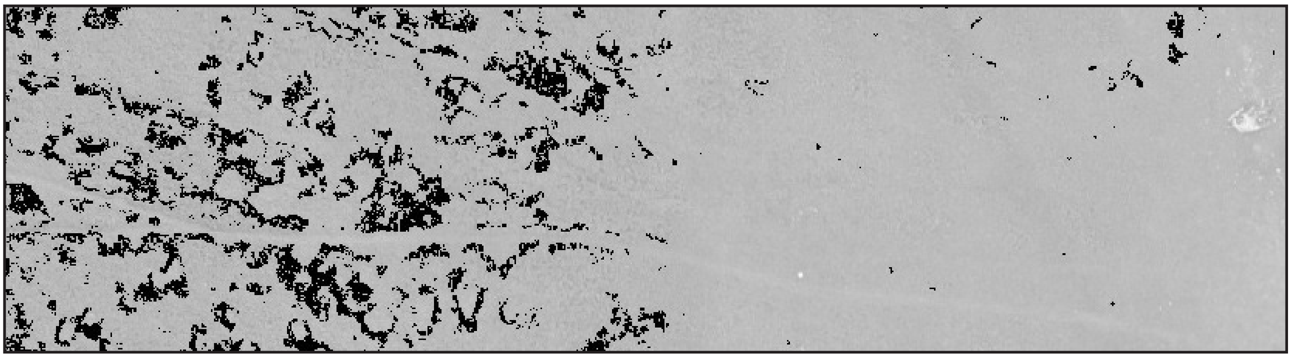


Figure 3. North's Minnipa Hill pasture paddock, sample output strip flown at 40 m above ground level, 2019.

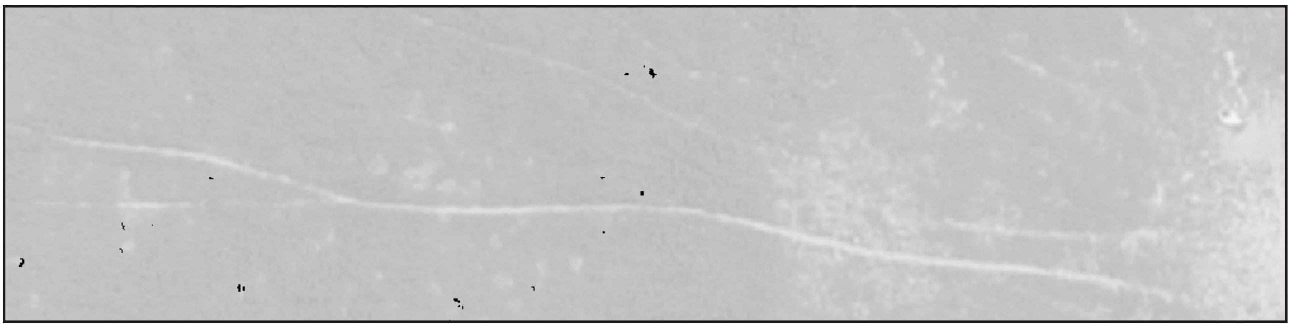


Figure 4. North's Minnipa Hill pasture paddock, sample output strip flown at 120 m above ground level, 2019.

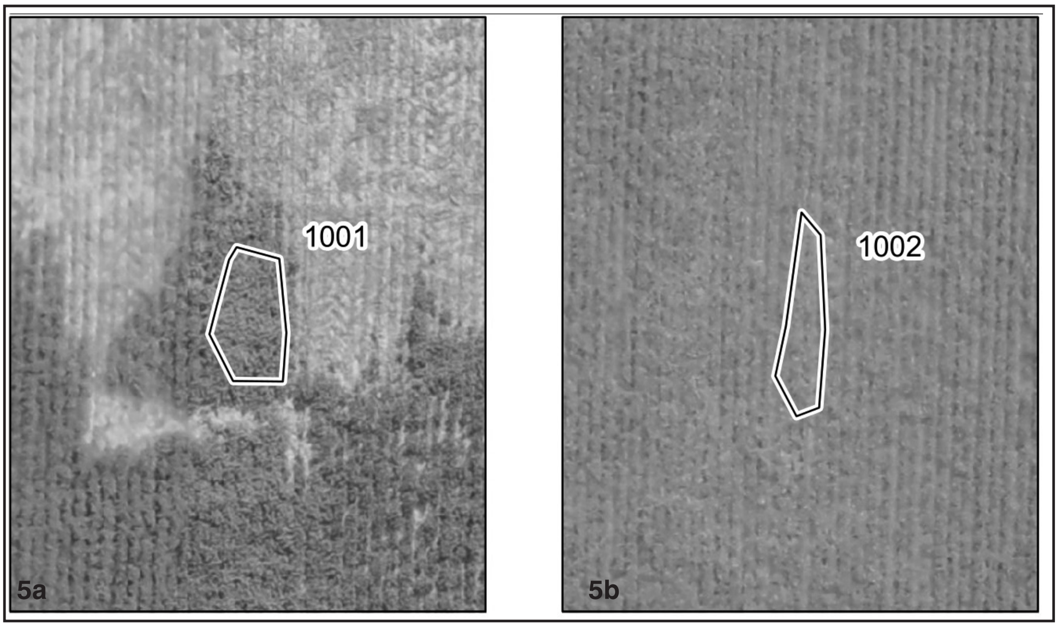


Figure 5 (a and b). Training 'features' (a - lentils and b – barley grass) in Condada lentil paddock imagery flown at 40 m above ground level, 2019.

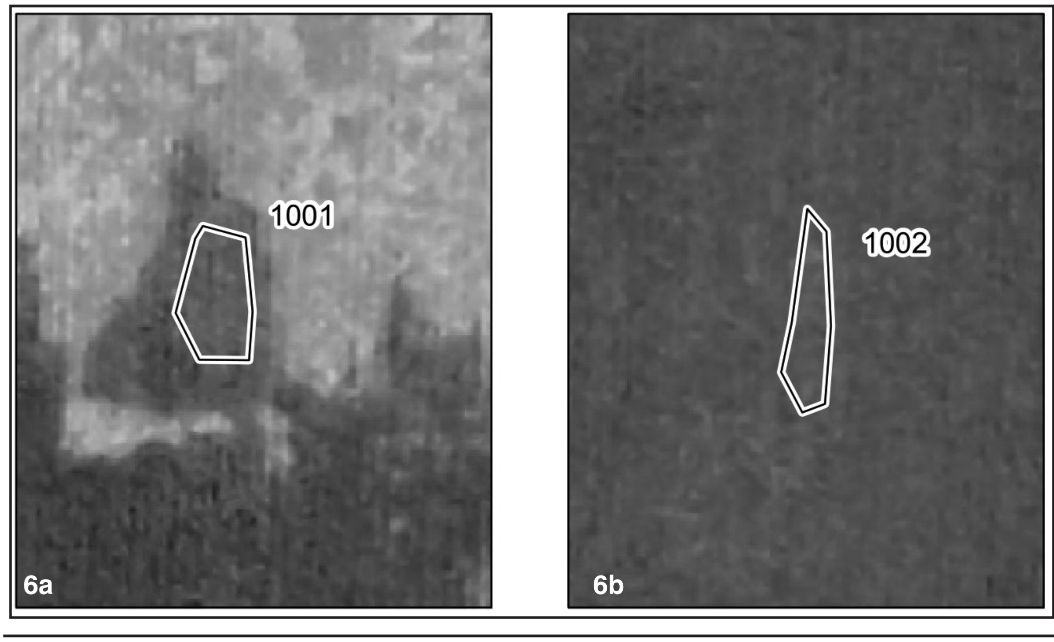


Figure 6 (a and b). Condada lentil paddock imagery flown at 120 m above ground level, 2019.

Weeds

Figure 7. Condada lentil paddock, sample output strip flown at 40 m above ground level, 2019.

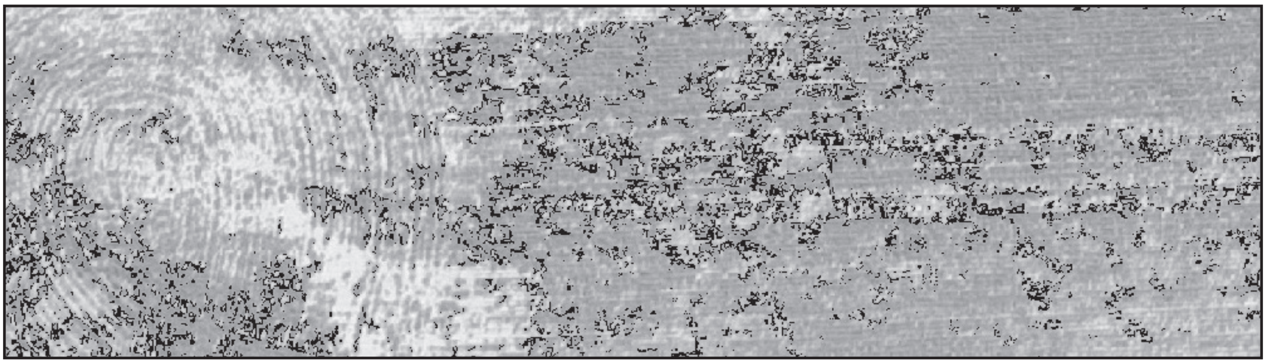


Figure 8. Condada lentil paddock, sample output strip flown at 120 m above ground level, 2019.

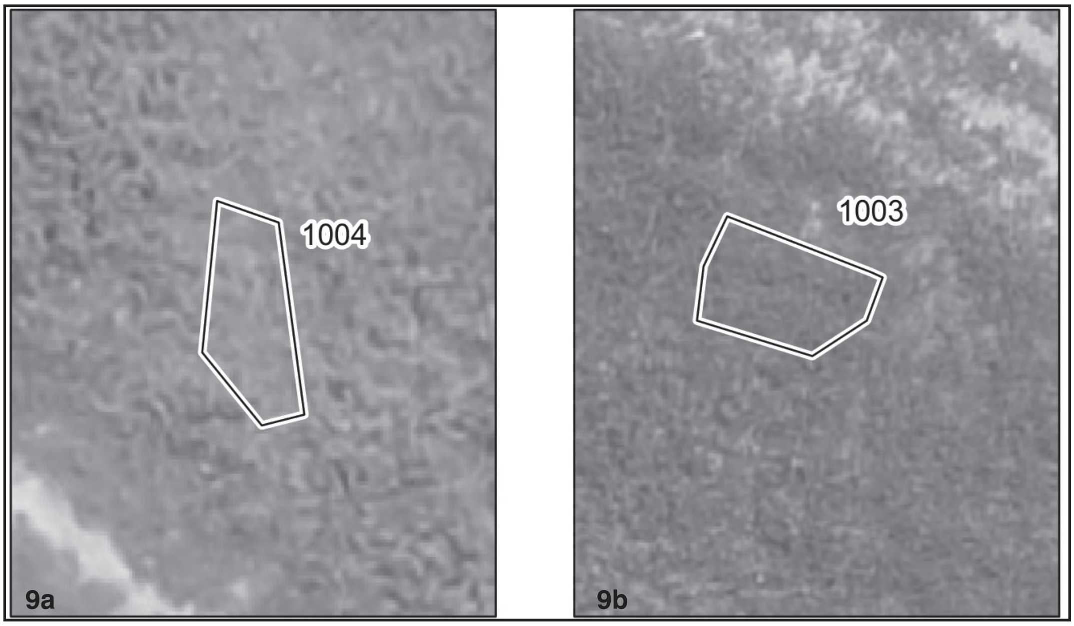


Figure 9 (a and b). Condada pasture paddock imagery flown at 40 m above ground level in 2019.

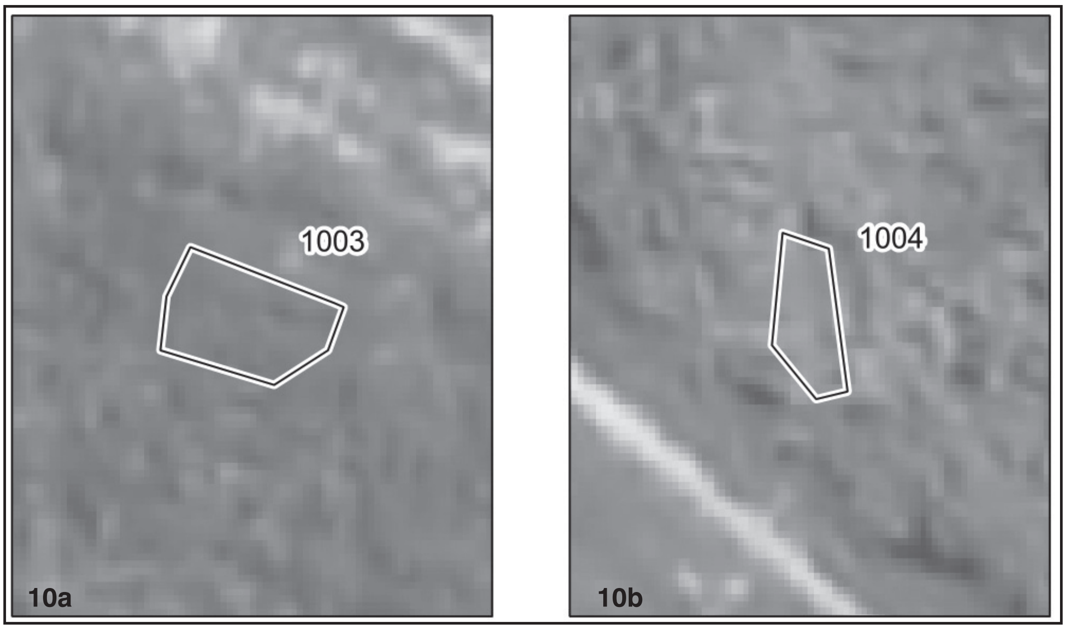


Figure 10 (a and b). Condada pasture paddock imagery flown at 120 m above ground level, 2019.

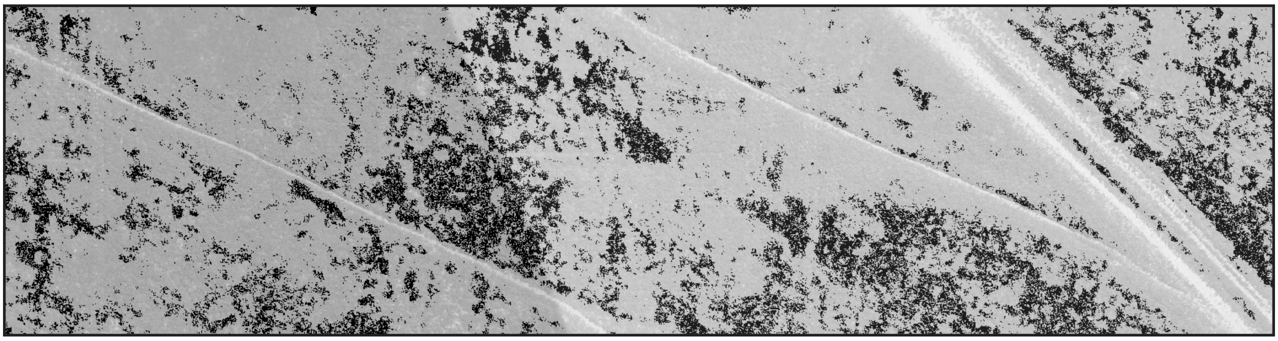


Figure 11. Condada pasture paddock, sample output strip flown at 40 m above ground level, 2019.

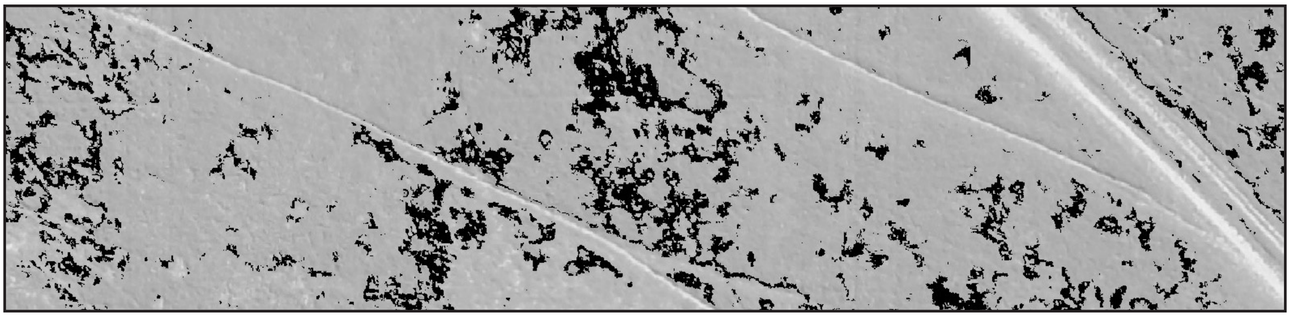


Figure 12. Condada pasture paddock, sample output strip flown at 120 m above ground level, 2019.

The Condada pasture paddock 2019 sample comparison of the analysis output based on the 40 m samples and the 120 m samples appear to be producing similar results. There are differences, but the broad scale pattern similarity looks to repeat in other areas of the imagery.

Overall sample comparison

It was investigated if the 120 m resolution flight could produce the same outputs as the imagery flown at 40 m, which would allow a greater paddock area to be covered at lower cost for the data capture. The initial comparisons of the two flight resolutions at North's Minnipa Hill and Condada lentils did not show a reliable pattern, with the 40 m resolution being more accurate in detecting the grass weeds. At the Condada pasture site the comparison of different resolutions yielded similar results. Further comparisons will be carried out with varying input parameters, however the initial comparisons do not seem promising at the lower resolution imagery taken 120 m above ground level.

The MAC S4 paddock, which has previously shown resistance to Group A herbicides, had large areas of barley grass weed patches survive herbicide applications, and some smaller circular patches in the southern end in 2018 (Figure 13 (a, b and c)).

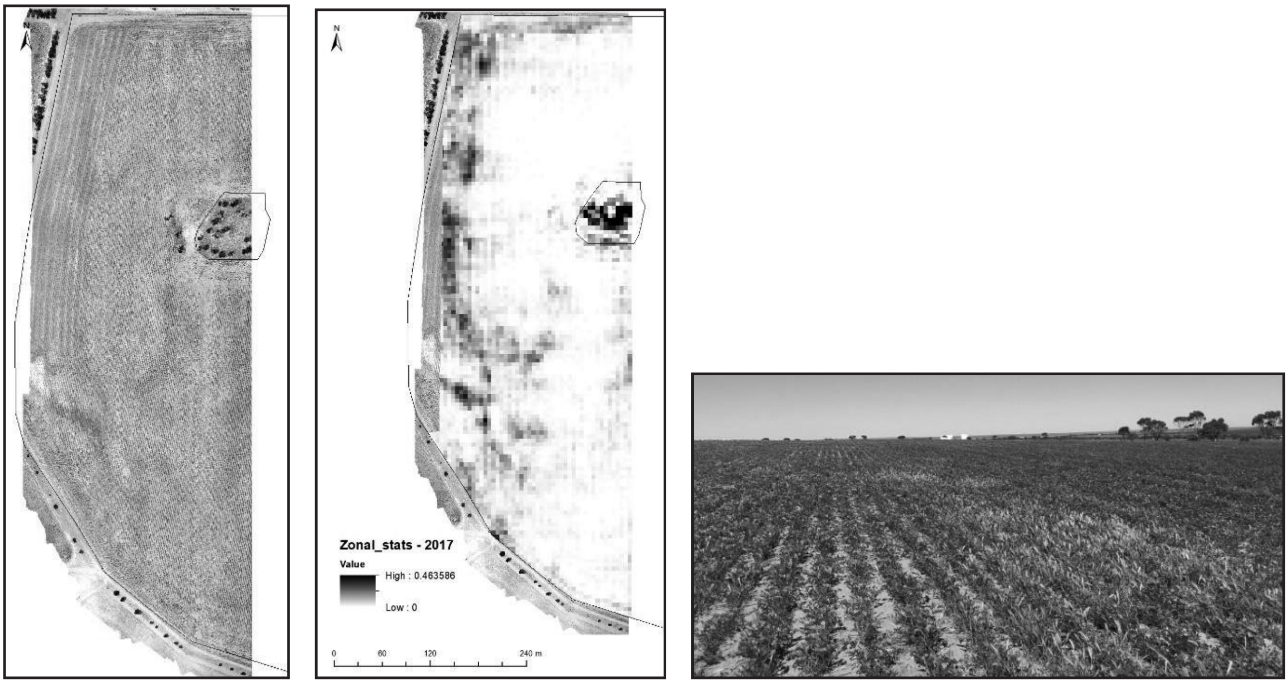
Comparing the barley grass weed density map in MAC S4 in 2019 (Figure 14) higher grass weed infestation can be observed along the western boundary, matching the patterns observed in 2018 (Figure 13 b).

A comparison of the 2017 weed map area in MAC S4 was made with the 2018 maps and the western half of the paddock was imaged both years so these are compared. Some similarities in occurrence patterns can be observed, but differences in crops sown, barley in 2017 and vetch in 2018 may also have an impact. The vetch crop in 2018 may have been less competitive with weeds. The area of heaviest weed growth in the 2017 imagery has been cut for vetch hay in the 2018 image, indicating the area is likely to have been higher in weeds in both seasons. For the 2019 season the same pattern can be mostly observed. Some drift in infestation, along with some reductions can be seen in the top corner of the image, potentially highlighting movements in weed infestation between seasons.

The maps used in the analysis can be accessed at http://wisdomdata.com.au/sagit-weeds-project/.

What does this mean?

UAV imagery may provide an opportunity to assist in targeted grass weed management. Current UAV technology is cheap to purchase and has high resolution. However the time and effort of collecting data over large paddock areas, the size of files, and the expertise required for overlaying the images and analysing the data, and variable image quality may limit the adoption by farmers. If farmers personally have the time and the interest to acquire these skills, or are willing to pay for the data capture and analysis, the technology may be used for targeting grass weed management and monitoring grass weed areas. The cost of the data capture and analysis was approximately $6,000 per paddock.



13a 13b 13c

Figure 13 (a) MAC S4 paddock in 2018 and (b) the barley grass weed density map. Figure 13c Photo of 2018 Group A resistant barley grass patches, September 2018.

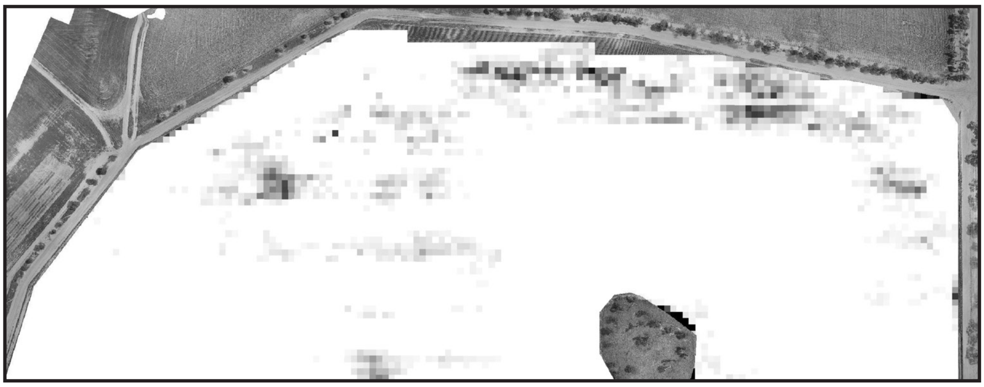


Figure 14. MAC S4 paddock barley grass weed density map 2019 (Landscape view).

In 2018 and 2019 the UAV flights captured data over a smaller area at 40 m height to provide a higher resolution strip to compare to 120 m lower resolution analysis of the paddock. The 40 m higher resolution data capture provided greater detail and more accurate barley grass weed densities compared to the 120 m medium resolution.

The capture of barley grass weed density was easier within legume break crops than cereal crops. The escape barley grass weeds were highly visible in the legume crops in late spring, however were still hard to identify in 40 m resolution image without knowledge of the paddock and where heavier weed infestations were.

The MAC S4 paddock has shown resistance to Group A herbicides and had large areas of barley grass weed patches survive herbicide applications in 2018 in a vetch crop. These resistant barley grass weed patches were able to be detected in similar areas in 2019, but at a lower density. This analysis could be converted to spray mapping information to target these areas in future seasons.

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