The use of Unmanned Aerial Vehicles (UAV) to measure pasture biomass

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The project

Most of the technology in remote sensing of pasture is used for qualitative analysis, that is, where are "high" and "low" areas of pasture productivity within a paddock. This project aimed at quantitatively measuring pasture i.e. putting a value to the high and low areas of pasture productivity, using existing technology in the industry. The application for this is aimed at grazing management and feed budgeting decisions, for example, identifying farm pasture on offer to help establish a "feed wedge" of paddocks, if post-grazing residuals are being achieved or to identify feed deficits or surplus on farm which can help decisions on daily herd requirements or for locking up paddocks for silage/hay.

The UAV or drone and camera

The drone used for this project is commercially available and used in the mining, environmental, surveying and agricultural industries. It has a fixed wing design, rear facing propeller and weighs less than 1kg. Almost all aspects of the drones operation are automatic making it easy to use. The camera used is an "off-the-shelf" digital camera that has been converted for use in the drone. Instead of capturing normal images in the visible spectrum of light (red, green, blue), light captured in blue has been replaced by the capture of light in near-infrared or NIR from the non-visible section of the spectrum. The benefit of NIR is that it behaves differently with respect to green vegetation compared to other surfaces such as roads, water, or buildings. Green vegetation is highly reflective of light in the NIR whereas it is highly absorbent of light in the visible section, namely for photosynthesis. We can use this relationship to extract useful information about plant health and vigour using vegetation indices.

Vegetation indices (VI)

Vegetation indices use a combination of wavelengths of light to identify certain properties of vegetation or crops. The most common and well known is the Normalized Difference Vegetation Index (NDVI) which uses red and NIR wavelengths and can be an indication of crop health, biomass and vigour. One aspect of this project was to test a series of common VI ability to measure pasture biomass. A rising plate meter (RPM) was also used to measure pasture biomass as a benchmark to base results off. Figure 1 illustrates the results. R^2 values are indication of the explanatory power of the relationship between VI and pasture biomass, the higher the R^2 values the better the VI is at explaining the variation of pasture in a paddock. The RPM was found to have the highest R^2 at 0.66 or the RPM explained 66% of the variation in pasture biomass within the paddock. Results for the VI were lower with the highest being 0.421 or 42.1% of the variation in pasture biomass explained by the Difference Vegetation Index (DVI). The performance of VI was rather consistent with no stand out performers. Some indices were shown to be poor performers compared to others such as the Green Difference Index (GDI) and VI in grey were found to have non-significant relationships with pasture biomass.

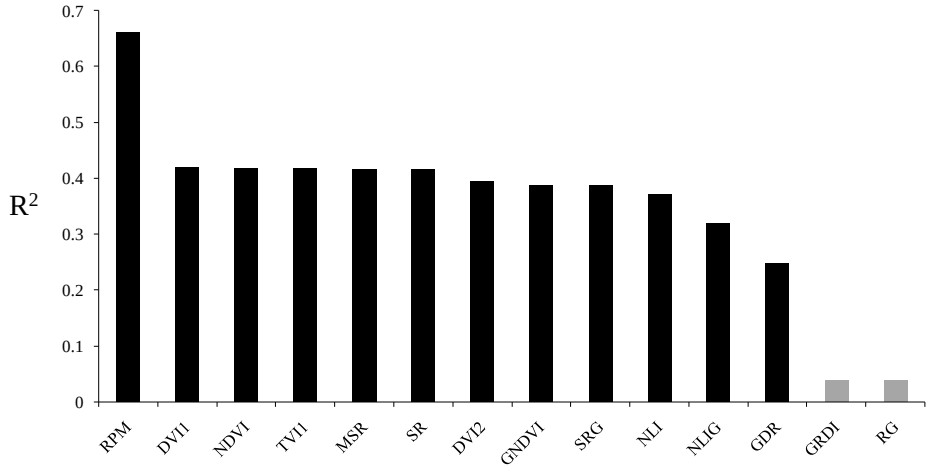

Figure 1: Results of testing a range of common VI to measure pasture biomass benchmarked against a current method of pasture measurement (RPM). Higher R^2 values indicates higher explanatory power of VI or RPM to predict pasture biomass. Bars in black: significant, bars in grey: non-significant.

Qualitative Vs. Quantitative

This section is aimed at highlighting the benefits of having quantitative measures of pasture biomass as compared to qualitative analysis. Figure 2 shows two maps of the same paddocks, on the left is an NDVI and on the right a pasture on offer map. NDVI is a good indication of "high" and "low" areas of pasture productivity or biomass but implementing that into decision making could be hard as deciding when to graze based on how much pasture is available is hard to distinguish without making a trip to the paddock. The pasture on offer map is able illustrate the variability and quantity of pasture is present within the paddock from which grazing decisions can be made. Feed allocation can be determined more accurately based on information about herd daily requirements and pasture on offer.

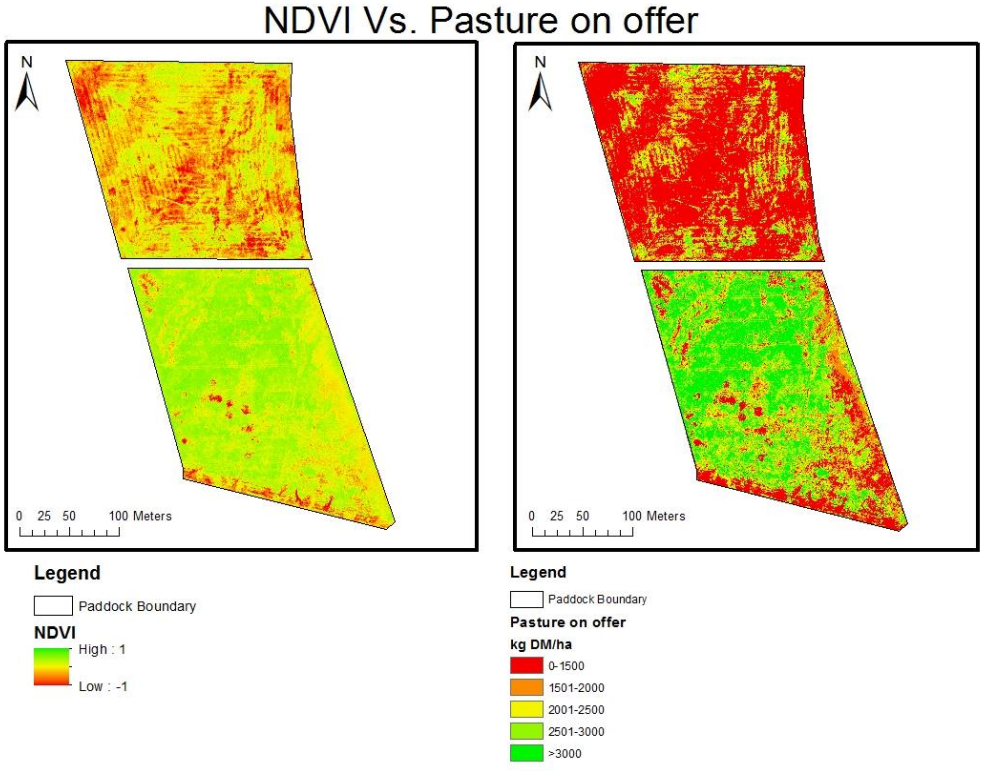

Figure 2: Qualitative NDVI map compared to that of quantitative pasture on offer map.

Applications

The applications of this can be further shown in figure 3 where criteria can be established to rank paddocks in terms of their "readiness" to be grazed or if post-grazing residual targets are being achieved.The first map has been created with the criteria that paddocks over 2600 kg DM/ha (green) should be grazed. The bottom paddock is clearly ready to be grazed with the lower performing red areas around the edges most likely due to effects of the tree line. An intermediate range of 2200-2600 kg DM/ha was used to illustrate the identification of paddocks soon to be grazed for future planning of paddock rotations for example. If such maps were applied to whole farm scenarios the "feed wedge" concept could then easily be applied.

The post-grazing residual maps provides a basis for determining grazing intensity or the whether herd daily requirements are being met. If stocking rates are too high cows maybe grazing too hard due to insufficient feed resulting in lower residuals than the 1500-1600 kg DM/ha target. This can have future implications on pasture regrowth and recovery. In regard to daily herd requirements, post-grazing residual maps can be an indication if feed rations are optimal. Cows grazing too hard or too light can be indication of how well supplement feeds in the dairy are meeting daily requirements.

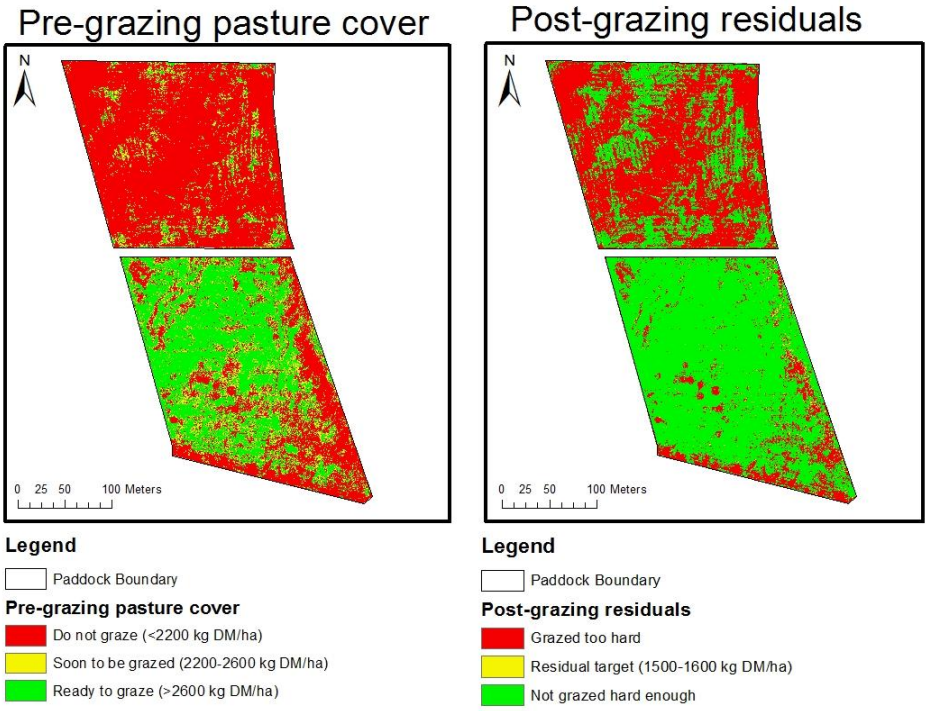

Figure 3: Demonstration of the potential application that pasture biomass maps can over to aid in grazing management and feed budgeting decision.

Summary

- Overall the RPM performed better than vegetation indices to measure pasture biomass, this was probably due to the inherent nature of using a low-end, "off-the-shelf" camera sensor
- Lower-end sensors are more likely to be used as qualitative analysis tools rather than quantitative but future improvements in sensors will entail more accurate results
- Considering the limitations of the sensor, the use of drones to produce pasture biomass maps has been shown to have a wide range of applications when it comes to grazing management and feed budgeting decisions