AIRBORNE IMAGERY

Airborne imagery is the taking of photographs of the ground and crops from a direct-down position. Platforms for airborne imagery for agriculture include satellites, fixed-wing aircraft, unmanned aerial vehicles (UAVs or "drones").

Airborne map images available are generally full colour, four band CIR (Colour Infrared), or manipulations of the CIR spectrums such as NDVI (Normalised Difference Vegetative Index) or SVI (Standard Vegetation Index), and can provide good information about crop growth and health.

All these images are available in digital format from an increasing range of suppliers of precision agriculture services.

Airborne Images – features

Full Colour Images

Full colour paddock maps are produced with high resolution digital cameras. The images produced are often composites of many images 'stitched' together with specialised software. Full colour maps can be produced from images collected by aircraft or drones. There are a number of service providers who will receive images and produce a single paddock map rectified for camera angle, luminosity, and optical distortion.

Four-Band Images (CIR)

Four band colour maps are mostly obtained using a specialised two camera setup, one which records full colour spectrum (Red, Green, Blue) and another which records the Alpha or Near Infrared band. The images are digitally combined and known as Colour Infrared (CIR).

A natural or full color image displays color as it would appear to human eyes under normal conditions. Conventionally, a CIR image is set up to display the infrared band data with a red tone. Red wavelengths will appear green, and green wavelengths will appear blue. Blue wavelengths are not displayed. Because the healthy green vegetation will appear to be bright red, a CIR image is also known as a "false colour" image.

CIR provides a path to a range of other indices used in agriculture, most of which are derived from manipulation of digital CIR spectral data. These are used as indicators in plant and crop analysis such as water stress, biomass, and chlorophyll content. Some common indices are:

- Normalised Difference Vegetation Index (NDVI),
- Standard Vegetation Index (SVI)

CIR and these common indices are especially useful because healthy plants reflect near infrared wavelengths. Chlorophyll in plants reflects green wavelengths; this is why healthy plants appear green. In addition, the reflected infrared is more reliable in monitoring plant health than the reflected green wavelengths. CIR tends to penetrate atmospheric haze better than natural color, and it provides sharper imagery.

NDVI images, for example, show a bright red color indicating healthy vegetation. Variations in the red color can indicate stressed vegetation. These stresses can include:

- A lack of fertility
- Insect infestation
- Soil deficiencies
- Water stress from over or under watering

NDVI can also be used for:

- Determining paddock zones for fertiliser application
- Monitoring fertiliser applications and yield estimates
- CIR can also help analyze soil properties, such as permeability, salinity, and erosion. (Source USDA, four band digital imagery, 2011)

CIR has also been used in aerial environmental surveys looking at:

- "After-flood" mapping - mapping water soaked soil or water leaks
- Wildfire mapping
- Environmental refuse volumes
- Monitoring of dump sites
- Blue-green algae outbreaks requiring daily monitoring

Attributes	Airborne Platform		
	Drone/UAV	Aircraft	Satellite
Resolution (pixel size)	4 cm – 2 m	10 cm – 2 m, depending on altitude	50 cm – 50 m
Images format	Full Colour CIR Thermal	Full Colour CIR Thermal	CIR
Image data quality control	Low to high	Good to very high	Very high
Time series interval	As required	As required, or as per package requirement	7 – 16+ days, depending on satellite flight path frequency
Turnaround time for processing image	24-48 hours	24-48 hours	24-48 hours
Image processing	Upload to web for processing or, Service provider package	Service provider package	Service provider package
Flight image area capture (approx.)	40 -150 ha	10 000+ ha	10 000 000+ ha
Limitations	Weather conditions, especially wind, flight time	Weather conditions, four hours flight time per day	Cloud cover
Cost per hectare imaged	Highest		Lowest

Comparison of features and limitations of airborne image platforms

NDVI (Normalised Difference Vegetation Index)

NDVI is an index of plant "greenness" or photosynthetic activity, and is one of the most commonly used vegetation indices. Vegetation indices are based on the observation that different surfaces reflect different types of light differently. Photosynthetically active vegetation, in particular, absorbs most of the red light that hits it while reflecting much of the near infrared light. Vegetation that is dead or stressed reflects more red light and less near infrared light. (Source Normalized Difference Vegetation Index []).

The NDVI figure is in the range from 0 - 1, and the closer to 1 the NDVI figure, the greater the level of photosynthetic activity in the vegetation.

A time series over a season or years of NDVI derived from satellite data is a useful tool for monitoring vegetation condition. NDVI can also be obtained from special single spectrum cameras.

SVI (Standard Vegetation Index)

SVI is similar to NDVI but has a higher saturation threshold (accounting for very favourable growing conditions) and is less impacted by soil colour. Low SVI value indicates poor vegetation conditions (including moisture shortages and flooding or extreme temperatures). It can also highlight delays during seeding caused by dry conditions or wet soils that can cause setbacks in vegetation (crop) condition early in the growing season.

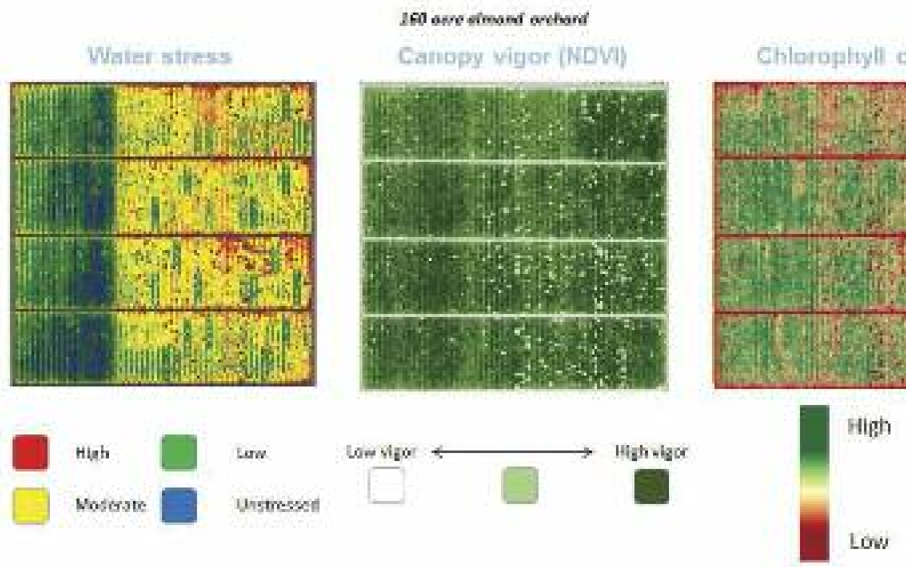
Each SVI pixel is a comparison of "vegetation greenness" over a multi year period only at that location. Vegetation at a pixel location can only be compared with the condition of vegetation at that same location (pixel) in the other years. (Source: http://www.casde.unl.edu/imagery/svi/index.php)

Thermal Imagery

Plant water stress can be measured by a plant's level of transpiration (plants that are under water stress transpire less). Transpiration is measured by using thermal imagery to expose the variation between canopy (plant) temperature and ambient temperature.

Getting started? What to consider before investing in airborne imaging:

- What's your MUM (Minimum Unit of Management)? This will determine the resolution of the images you can use. For example: If the sprayer is a 30 m sprayer with no section control do you need 0.5 m * 0.5 m pixel size? Cost is proportional to resolution - smaller pixels give more data but cost more
- What land area requires mapping? Is it best measured rone or plane or satellite?
- Do you need full colour images or NDVI or SVI or another index?
- What information do you need about your crops? Growth rates, plant health, stress, soil plant interactions, yield estimates, or insect infestations. Will these maps provide this?
- How will you use these maps to make operational decisions for your property?
- Do you have the hardware to make use of these maps?
- How often do you need the area mapped?
- Are you looking for trends over time?
- How good is your internet access for uploading or downloaded large volumes of data?
- Who can help setup the capability to use these maps and information effectively?
- What are the costs per ha? UAV>Planes>Satellite. Prices are changing quickly.
- Can I get full access to the raw data (four band array) for alternate post processing if required?



Source: Ceres Imaging. Water stress measures transpiration (related to stem water potential), chlorophyll content is related to nutrition/nitrogen, vigour is an index of leafy biomass.

Case study

Century Orchards

Farm location
Loxton, South Australia

Farm size
640 ha

Crops
100 ha Wine Grapes and 540 ha Almonds

Rainfall
Loxton, long term:
270 mm annual rainfall,
172 mm growing season rainfall

Century Orchards is a private company which started in 1998 with 50 ha of wine grapes, the following year 137 ha of almonds were planted. Currently they are removing the vineyard and replanting with Almonds. Total plantings in 2017 will be 600 ha of Almonds.

Why are Century Orchards using airborne imaging?

Currently converting sprinkler orchards to drip irrigation and installing a new automatic system through South Australian River Murray Sustainability Program (SARMS) funding. Ceres Imaging produces water stress, canopy vigour (NDVI) and thermal images which allows us to identify any issues earlier that arise with a new system;

- Malfunctions – filter/pressure/irrigation programing issues
- Poor irrigation design – drainage concerns resulting in wet feet diseases, tree death
- Wet/dry areas – help with irrigation scheduling for different soil types.

Future

Yield mapping is currently under investigation by·

- Using GPS to yield map (yield is estimated by measuring height of almond windrows).
- Layering Ceres Imaging a nd yield map will allow identification of possible correlations to hopefully lead to bigger and better yields.

Justification of the cost of Imaging

- Efficiency – inputs continue to rise whilst prices usually don't – maximise yield per area.
- Imaging allows more efficient irrigation/fertigation
- Optimal yields from each area.
- Locate possible disease pockets; wet/high humidity areas
- $30 - 50 per ha, which requires an extra 5 - 13 kg almonds per ha.

Airborne Imaging Service Providers

Below is a brief list of Australian and international companies working in Australia, currently offering a range of services including· mapping properties or paddocks by aircraft or drones, acquisition of satellite maps or processing of map images. Prices for services or packages are constantly changing and are largely dependent on resolution required, the method of acquisition and frequency of time series needed. Many providers offer packages regularly supplying maps to requirements of nominated areas. Weblinks were current on 30 September 2016.

www.precisionag.com.au
Precision Agronomics Australia

Benefits and limitations of the various images available.

Benefits	Limitations
Full colour maps	**Full Colour Maps**
• Can be used to map gross paddock differences – broad soil types: sand, rock, blowouts, water movement, stock areas, erosion potential • Used on paddock scale with drones for identification of changes in weed areas early in the growing season • High resolution images possible with quality equipment • Price of capable and suitable drones is reducing • Relatively rapid turnaround time for production of paddock maps for rapid in-paddock response	• No real plant health information • Need for fast internet upload for remote (web) processing of multiple images from drones • Requires ground-truthing or knowledge of paddock
CIR (NDVI and SVI)	**CIR, (NDVI and SVI)**
• Production of false colour maps for indication of stressed areas from • Fertility • Insect infestation • Soil deficiencies • Soil moisture • Plant health • Low chlorophyll • Satellite image maps are very cheap per unit area • Satellite maps have high levels of quality control	• Timeliness of images can be compromised by cloud cover at satellite fly- over, delays timely production of images • Some regions and years experience significant cloud cover through winter growing season resulting in extended periods between satellite images • Requires ground-truthing to fully determine reasons for poor or high growth signatures • Satellite maps are generally lower resolution than aircraft or drone maps, using larger pixel size – 10m * 10m, but high resolution is available at a price.

Ceres Imaging conduct eight imaging plane flights over the property during the almond growing season, checking for evenness of irrigation, growth rates, areas of water stress (from over or under watering). Image acquisition flight timings are as follows·

Timing	Purpose and function
1x October	Peak Fertigation season – check for evenness of irrigation
1x November	Critical irrigation time for nut fill and tree growth (setting the trees up for next season's fruiting wood).
2x December	Critical timing for nut fill – biggest yield reductions if stress at this point.
2x January	Before Deficit and after Deficit irrigation – wet/dry areas become more obvious due to orchard under stress.
1x March	After Nonpareil harvest.
1x April	After harvest – checking for pruning plan and any wet areas.

Source· Century Orchards, Water stress thermal image. Red = water deficit stress, Blue = low water stress

Source· Century Orchards, NDVI biomass map.

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Growing Solutions
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Ceres Imaging
www.specterra.com.au
SpecTerra Airborne Remote Sensing

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