Kondinin Group
ResearchReport
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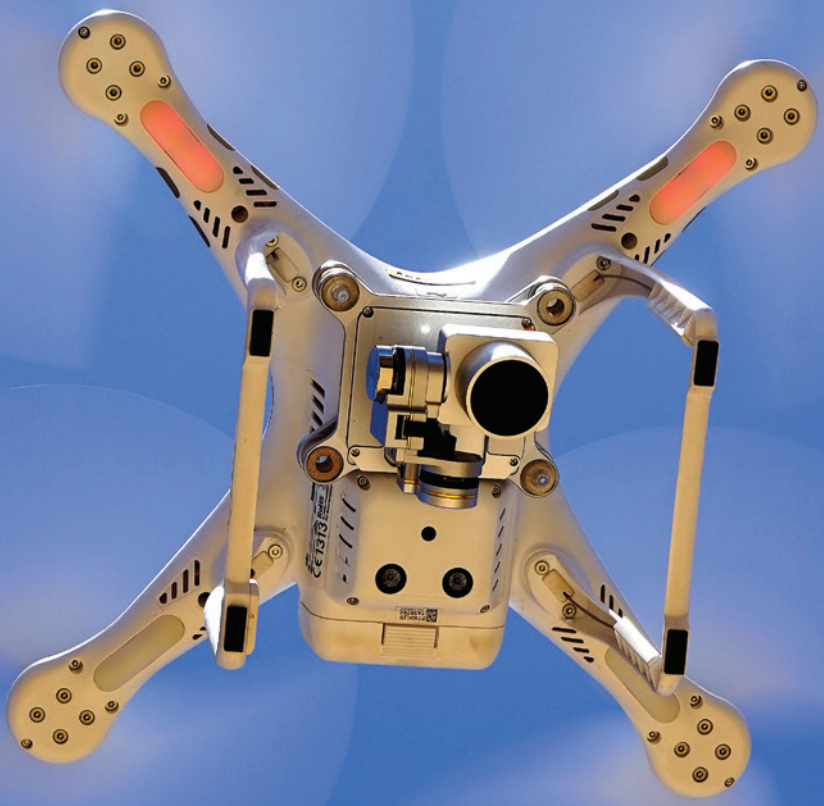
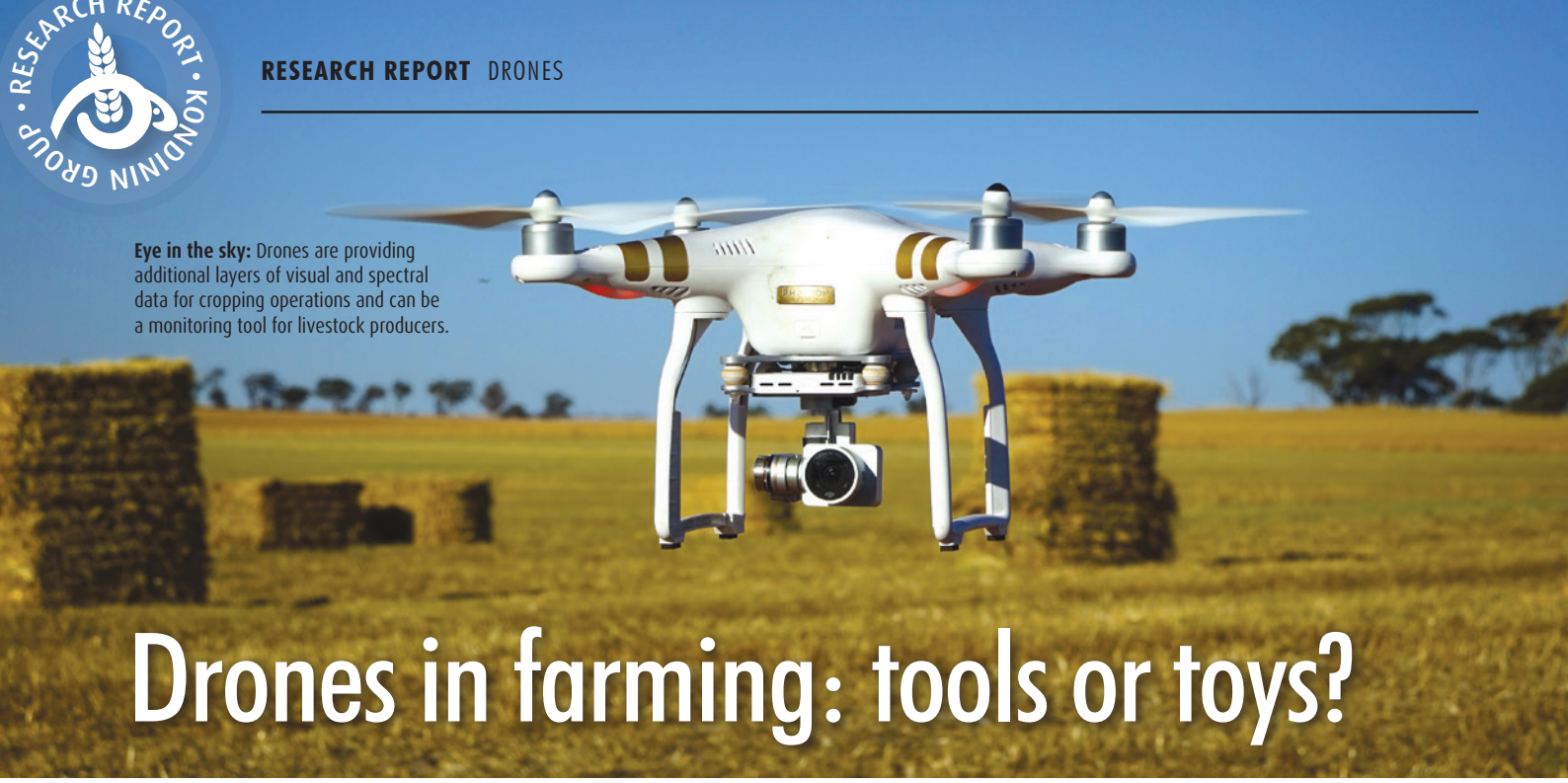


DRONES IN AGRICULTURE

TOOLS OR TOYS?



Eye in the sky: Drones are providing additional layers of visual and spectral data for cropping operations and can be a monitoring tool for livestock producers.

Drones in farming: tools or toys?

Unmanned Aerial Vehicles (UAV) or drones are becoming an increasingly common discussion point in rural and social media with some spectacular images and footage presented of farming operations. But drones may have a more serious application on-farm, allowing farmers to see things they may not have been able to previously. Kondinin Group researchers, **Ben White** and **Mark Saunders** take a look at what is available and how drones may play a role in farming.

The combination of high quality cameras and small UAV's capable of capturing images of farm operations from angles previously unachievable without the use of an expensive aircraft is both exciting and enlightening.

But there is also discussion around the purchase and use of a drone on-farm with growers asking if it is simply a justification for a recreation behind the veil of genuine application.

The general consensus is that while drones may not be used for farming operations like spraying, at least in the foreseeable future, drones arguably have a place in the future of farming as a powerful information gathering tool.

WHAT IS A DRONE?

Drones, also known as an Unmanned Aerial Vehicles or UAV's are defined more correctly by the Civil Aviation Safety Authority (CASA) as a Remotely Piloted Aircraft (RPA).

The operating weight of the drone is important from a legal perspective as it defines the UAV categorisation.

For most farmers looking to dip their toe in the water with a drone, the sub-2kg option is the most likely scenario, which under recently amended legislation does not require certification or licensing.

Higher take-off weight (2-25kg) drones may be permitted if flying on your own land.

The legalities and licensing requirements required to operate a drone are discussed in more detail later in this *Research Report*.

SKILL REQUIREMENT

Most drones will be delivered with a dedicated controller, these controllers typically have a number of buttons but most feature two joysticks used to manoeuvre the drone in altitude, heading and speed.

Unlike some of the very early drone designs, much of the highly technical aspects of flying a multi-rotor drone is now automated by the controller in many of the drones available commercially.

In the case of most multi-rotor drones, releasing the joysticks will usually see the drone stop and hover.

Most recently, DJI introduced obstacle avoidance on their Phantom 4 and 4 Pro quadcopters. Obstacle avoidance can assist the operator to avoid hitting trees or buildings with the drone when flying.

Almost all controllers utilise a smartphone or tablet screen to display vital flight data and what is known as First Person View (FPV) so the operator can visualise what the drone is 'seeing'. Alternatively, the GoPro Karma controller has an integrated high resolution and extra-bright FPV display screen.

Both the FPV vision feed and data between the drone to the controller typically operate over WiFi or a long-distance transmission frequency WiFi communication protocol. For example, 'Lightbridge' on DJI branded drones has a superior transmission range over standard WiFi.

When flying it can take some getting used to operating by both watching the screen and observing the drone, but with practice and small flights initially, confidence and skills will grow.

Considering the technology bristling in the cabin of most modern farm machinery, farmers will have no trouble operating a drone. Remember to observe CASA guidelines and fly when conditions are favourable with low winds. The software used is detailed and in many cases can be programmed to fly routes or courses over waypoints which have been pre-determined.

PROFESSIONAL SERVICES

Of course, the quality of drones varies significantly and depending on the task required, a high-cost drone armed with specialist sensors or high precision flying may be required. There is a growing number of professionals with commercial operator licenses offering their drone services to farmers.

Currently most services are related to visual and spectral imaging to assist in the determination of boundaries, production limitations, soil type observation and crop or pasture responses.

Drone-captured Normalised Difference Vegetation Index (NDVI) imagery can be used to assist in biomass analysis of crops and pastures. This might be used, for example, to determine when a specialist crop is ready for harvest.

But as sensor technology evolves, professional aerial imagery and sensing services are expected to grow significantly beyond just visual and NDVI imagery.

It is important to remember that a typical component of professional drone services often include data or image filtering, averaging and interpolating to ensure the images are both useable and accurate. FA

Sensor and software technology

Millions of investment dollars are being pumped into the development, packaging and integration of drone-mounted sensor and management software technology for precision agriculture. According to precision farming observers at agfunder.com successful examples include:

Parrot Sequoia, a combination 16 Megapixel visual camera with integrated 1.2 Megapixel near Infrared, red edge, red and green cameras for creating multispectral images. Priced at around $5400 the Sequoia can be adapted to most small drones and produce NDVI imagery with appropriate software.

The Micasense Rededge multispectral camera has five calibrated image sensors and is designed to produce a range of vegetation index images. Pricing is around $11,000 including GST.

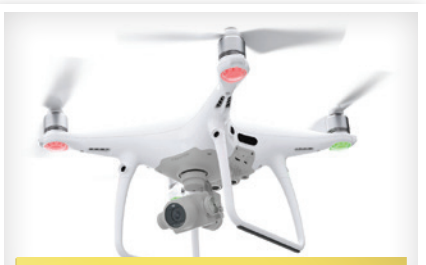
The Sentera DJI drone upgrade combines the RGB visual images captured with a DJI Inspire, Phantom 3 or 4 drones and replicates the image with a Near Infrared (NIR) layer and NDVI image generation for crop monitoring. Sentera upgrades cost between US$2000 and US$2500 depending on the drone model.

PrecisionHawk have packaged drones and software together to provide a package they claim will assist farmers to estimate crop yields, optimise inputs and improve variable rate input application. Packages vary according to drone and software package selection, but claimed package integration with common precision farming software for generating application maps is encouraging.

Drone options and configurations

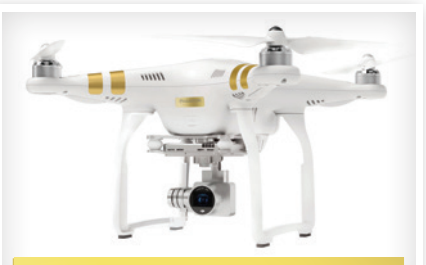
Drones come in a wide variety of designs and configurations. Some allow the fitment of specific cameras or image recording equipment while others are purchased with an integrated camera.

There are a wide range of drone designs, each with benefits and disadvantages.



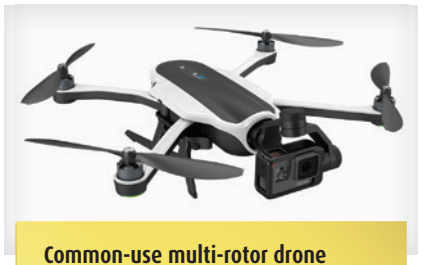
Common-use multi-rotor drone example: DJI Phantom 4 Pro

Camera: 20 Megapixel
Powered by: 4x rotors 15.2V, 5870mAh battery
Propellers: 240mm diameter
Minimum take-off weight: 1.39kg
Communication range: 3.5km (unobstructed)
Specified flight time before recharging/ refuelling: 30 minutes
Max speed: 72km/h
RRP: $2599 including GST (expected)
Extra battery: $289



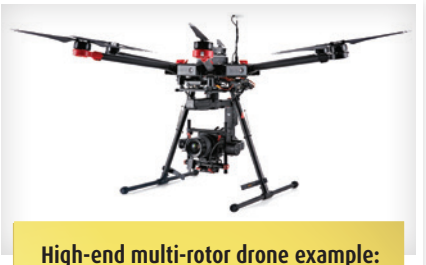
Common-use multi-rotor drone example: DJI Phantom 3 Professional

Camera: 12.4 Megapixel and 4k video
Powered by: 4x rotors 15.2V, 4480mAh battery
Propellers: 240mm diameter
Minimum take-off weight: 1.28kg
Communication range: 2km (unobstructed)
Specified flight time before recharging/ refuelling: 23 minutes
Max speed: 57km/h
Pricing: around $1700 including GST
Extra battery: $259



Common-use multi-rotor drone example: GoPro Karma

Camera: Requires GoPro Hero 4 or 5 (12 Megapixel and 4K video)
Powered by: 4x rotors 14.8V 5100mAh battery
Propellers: 254mm diameter
Minimum take-off weight: around 1.9kg including battery and stabiliser
Communication range: 3.0km (unobstructed)
Specified flight time before recharging/ refuelling: 20 minutes
Max speed: 54km/h
Pricing: Karma Drone with controller and stabiliser $1195 including GST, GoPro Hero 5 $570
Extra battery: $150



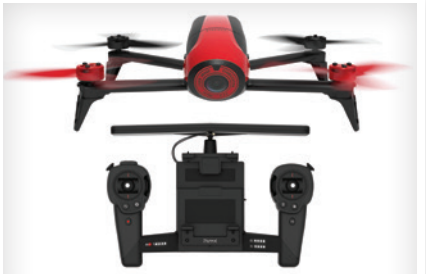
High-end multi-rotor drone example: DJI Matrice 600

Camera/sensors: Multiple options include visual, thermal and NDVI
Powered by: 6x rotors 22.2V, 4500mAh battery
Propellers: 533mm diameter
Minimum take-off weight: 9.1kg
Communication range: up to 5km
Specified flight time before recharging/ refuelling: No payload 36mins, up to 6kg payload 16mins.
Max speed: up to 72km/h
Pricing: around $7900 including GST
Extra battery: $269-$339 (high capacity)
Example optional visual camera to suit: $1700
Example optional Slantrange 2P multispectral camera: $5900

MULTI-ROTOR

Multi-rotor drones offer a vertical take-off and landing and while not as efficient as single rotor drones, meaning that their flight times are relatively short, multi-rotor units are easy to use, are readily available at a wide range of price points depending on the application.

Multi-rotor drones are relatively easy to fly and can carry larger payloads with an ability to hover making them a good choice for capturing high resolution single images.

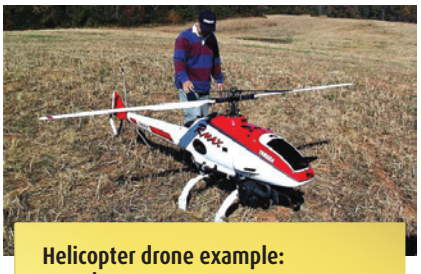


Entry-level multi-rotor drone example: Parrot Bebop2

Camera: 14 Megapixel and 1080p video
Powered by: 4x rotors 2700mAh battery
Propellers: 150mm diameter
Minimum take-off weight: 500g
Communication range: 2km (unobstructed)
Specified flight time before recharging/ refuelling: 25 minutes
Max speed: 57.6km/h
Pricing: $999 including GST
Extra Battery: $99

HELICOPTER

Single-rotor helicopter drones allow vertical take-off and landing and usually have a tail rotor to maintain heading. While running a single rotor is more efficient than multiple rotors, single-rotor helicopters are often larger and heavier, more expensive and more difficult to fly. Typically used by professionals for specific applications where larger payloads are required, examples include the Yamaha R-Max which has a main rotor diameter of over 3m and can lift up to 28kg.



Helicopter drone example: Yamaha R-Max

Powered by: 15.4kW 2-stroke 246cc petrol
Minimum take-off weight: 64kg
Communication range: Up to 400m
Specified flight time before recharging/ refuelling: 1-hour
Max speed: 40km/h
RRP: over $100,000

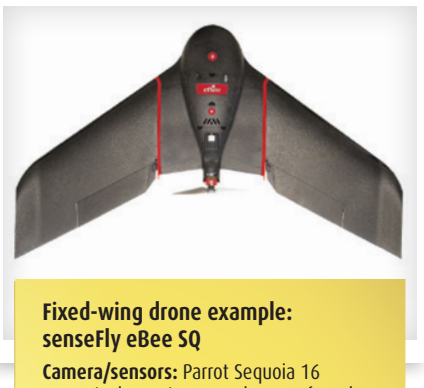
FIXED WING

Fixed-wing drones offer longer flight times and faster flight speeds resulting in an ability to cover area significantly more quickly than most multi-copters.

One of the drawbacks of fixed wing units is that they cannot take-off and land vertically so require a runway or most commonly a launch catapult to get into the air.

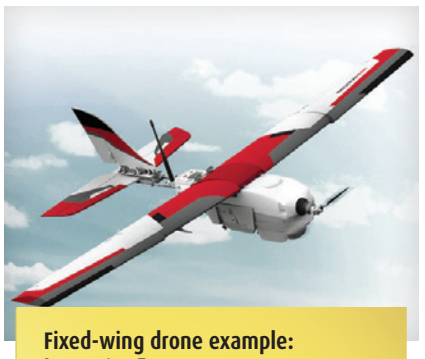
A belly landing is the common method of getting the drone back to terra-firma with replaceable skid panels on the underside of the drone.

Arguably more difficult to fly than multi-copter drones, fixed wing drones often require user training from a professional to master and ensure reliable and safe flight. Flight paths are often programmed for fixed wing drones, ensuring these grid flight paths of an area are covered efficiently.



Fixed-wing drone example: senseFly eBee SQ

Camera/sensors: Parrot Sequoia 16 Megapixel RGB, integrated near Infrared, red edge, red and green cameras all 1.2 Megapixel (for creating multispectral images)
Powered by: single rotor 11.1V 2200mAh battery
Wingspan: 1.1m
Minimum take-off weight: around 1.1kg
Communication range: 3.0km nominal up to 8km (unobstructed)
Specified flight time before recharging/ refuelling: 55 minutes
Cruise speed: 40-110km/h
Area coverage on one charge: 200ha nominal 3000ha maximum (height and resolution dependent)
Pricing: $17,308 including GST with Sequoia camera and flight planning software. Pix4D mapping software $7700 including GST
Extra battery: $264



Fixed-wing drone example: Lancaster 5

Camera/sensors: Optional Visual 18.4 Megapixel, 0.37 Megapixel thermal infrared, 12 Megapixel multispectral, LIDAR for 3D surface modelling and hyperspectral sensors.
Powered by: single rotor 7.4V 7000mAh battery
Wingspan: 1.5m
Minimum take-off weight: around 2.4kg (1.15kg payload)
Communication range: 2.0km
Specified flight time before recharging/ refuelling: 45 minutes
Cruise speed: 43-58km/h
Area coverage on one charge: 121ha at 100m altitude
Pricing: yet to be released through Ruralco

HYBRID (EG: X-WING)

Offering the benefits of a vertical take-off and landing with the endurance and speed of a fixed-wing drone, hybrid models are starting to become available as designs improve. At this stage, hybrid drones have not been used for agricultural applications, but as designs improve, expect to see them find a place.

Hybrid drone example: X PlusOne

Camera/sensors: Mount for GoPro cameras (12 Megapixel and 4K video)
Powered by: 4x rotors 11.1V 5400mAh battery
Wingspan: 825mm
Minimum take-off weight: around 1.35kg
Communication range: not specified
Specified flight time before recharging/ refuelling: 15-22 minutes
Speed range: 0-100km/h
Pricing: around $2000 depending on accessories, excluding camera and gimbal

Regulations: send in the drones

While drones or remotely piloted aircraft (RPA) can provide hours of entertainment and some advantages to farmers, there are strict regulations which cover their use.

The rules apply whether the RPA is used commercially or privately and they are overseen and enforced by the Civil Aviation Safety Authority (CASA).

For example, an RPA cannot be flown above 120m from the ground and it must be flown in line of sight at all times. A drone cannot be flown over a populous area and cannot come within 30m of anyone not involved in the RPA flight.

CASA recently made several changes to the RPA regulations, including the introduction of a new category, which is based on new take-off weight classifications. The four weight classes are:

- very small (100g-2kg)
- small (2-25kg)
- medium (25-150kg)
- large (greater than 150kg).

The new regulations are designed to make it easier for non-commercial RPA operators and also to tighten the rules for commercial use. According to CASA, the number of registered RPA users in Australia has grown from 150 two years ago to almost 800 now.

CASA has also received 1200 notifications from people wishing to use drones less than 2kg this year, so the number of drones or RPAs is growing quickly.

In line with the new CASA regulations, which came into force in late September 2016, the new operation category is known as an Excluded RPA.

An Excluded RPA must weigh less than two kilograms take-off weight. The take-off weight includes camera and battery. An Operators Certificate (ReOC) or Remote Pilot Licence (RePL) is not required when flying an Excluded RPA.

The ReOC was previously known as a UAV Operators Certificate and the RePL was previously known and a UAV controllers certificate.

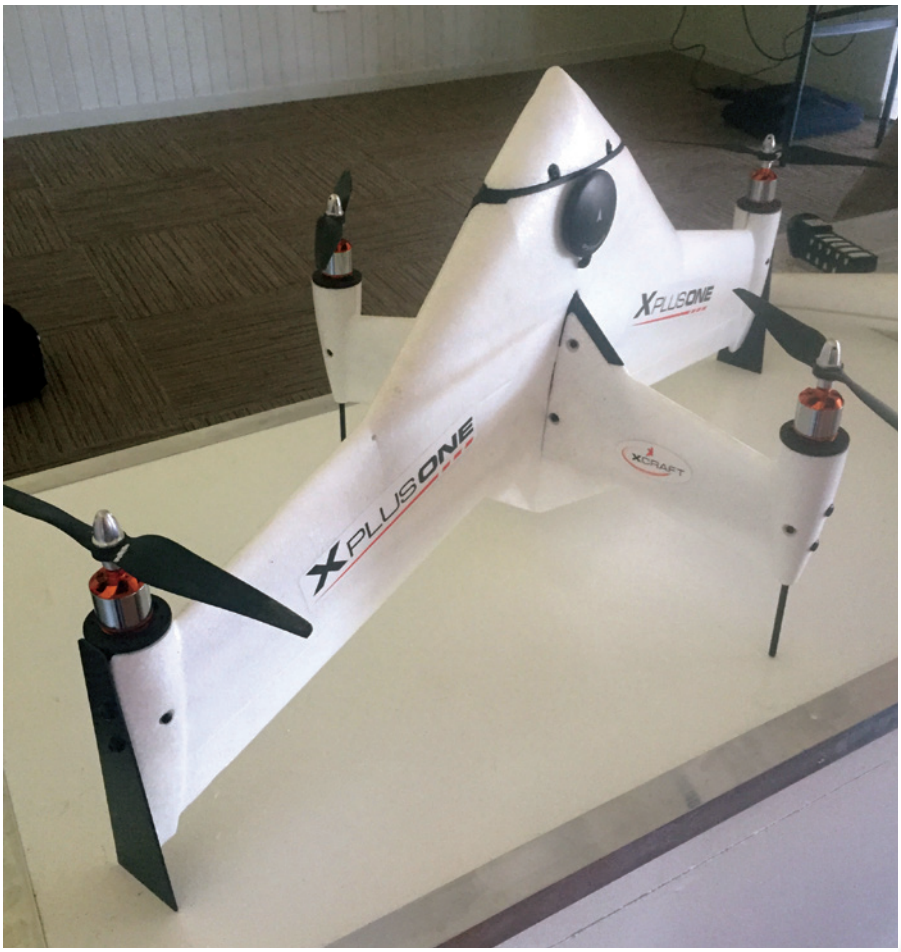
However, under the new laws, any person who intends to use an Excluded RPA for commercial purposes must register their details with CASA.

This involves obtaining an Aviation Reference Number (ARN) from CASA and the operator must notify CASA of their intention to fly commercially five days before the flight.

Heavier drones require an operator's certificate and an RPA licence and obtaining a licence will set you back close to $4000.

Another important change to the CASA regulations are new identification requirements where all Excluded RPA operators must carry ID which includes the operator's name and ARN.

For more details, visit the CASA website www.casa.com.au FA



Not so high flyer: There are strict rules governing the use of drones, or remotely piloted aircraft, for example, they cannot be flown above 120m from the ground.

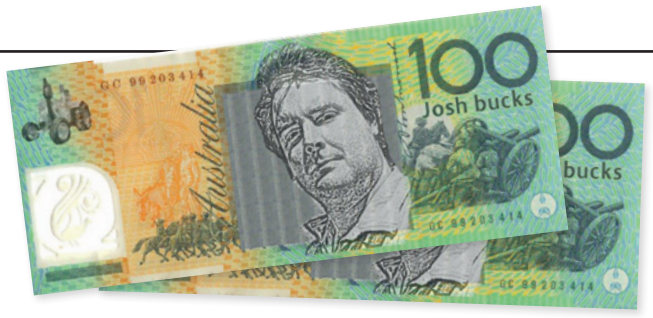
STANDARD OPERATING CHECKLIST

Source: Civil Aviation Safety Authority

All persons who fly an Excluded RPA for commercial purposes, or anyone who operates a drone, must operate within the following Standard Operating Conditions:

- ☑ Visual line of sight only
- ☑ No higher than 120 metres (400 feet) above ground level
- ☑ Not over a populous area for example a beach or sporting event
- ☑ During daytime only
- ☑ No closer than 30 metres to people not involved in the flight
- ☑ Not within 5.5 kilometres of a controlled aerodrome
- ☑ Not in an area where a Public Safety Operation is occurring. eg Bushfire or other emergency situation such as a car crash.
- ☑ Non Instrument Helicopter landing sites now have a No Fly Zone of 1000 metres (500m radius). These include rescue helicopter bases and hospital landing zones.
- ☑ Instrument Approach Helicopter sites now have a 5.5 kilometre Exclusion Zone.

Before parting with your hard earned cash, consider what you want to achieve with your investment in drone technology.



Considerations when buying a drone

Depending what the application is, farmers in the market for a drone should look for a number of features.

BATTERIES INCLUDING SPARES AND CHARGING TIME

Check the cost of replacement batteries. Having at least two batteries is recommended but battery costs can vary significantly and add considerably to the cost of the kit.

FLYING TIME

A function of battery capacity and drone style, battery life is also affected by flying speed, changes in altitude and payload. Most controllers will provide a live update of remaining flying time with some also calculating the estimated time to return to the point of take-off.

SPEED

Speed will govern the rate of image coverage area captured. Faster flying fixed wing drones can capture more area before a battery change is required.

RANGE

Operating range is typically quoted as an unobstructed figure with 2km a minimum standard across most drones. Remember that according to CASA guidelines, visual contact must be maintained.

REPLACEMENT PARTS

Crashing a drone is unfortunate and while an uncommon occurrence in drones with obstacle avoidance and intelligent flight control, access to spare parts is important for making repairs. Common brands like DJI have readily accessible replacement parts at reasonable prices.

WHERE TO BUY

We recommend purchasing from an Australian supplier. The few dollars you might save shipping internationally will be long forgotten if issues with shipping Lithium Ion batteries most drones come with are encountered.

Additionally, some drones destined for international markets are built to different specifications.

IMAGERY AND SENSOR AVAILABILITY

Depending on the intended application, image or sensor availability may influence drone selection. Aftermarket NDVI sensors like the Sequoia from Parrot or the Sentera NDVI upgrade for DJI phantom drones may suffice.

OTHER ACCESSORIES

There are an infinite number of accessories for drones, but of these, a hard case is highly recommended to protect your investment. Foam-moulded cases specific to each drone can be purchased for around $200.

KEEPING AN EYE OUT FOR EAGLES

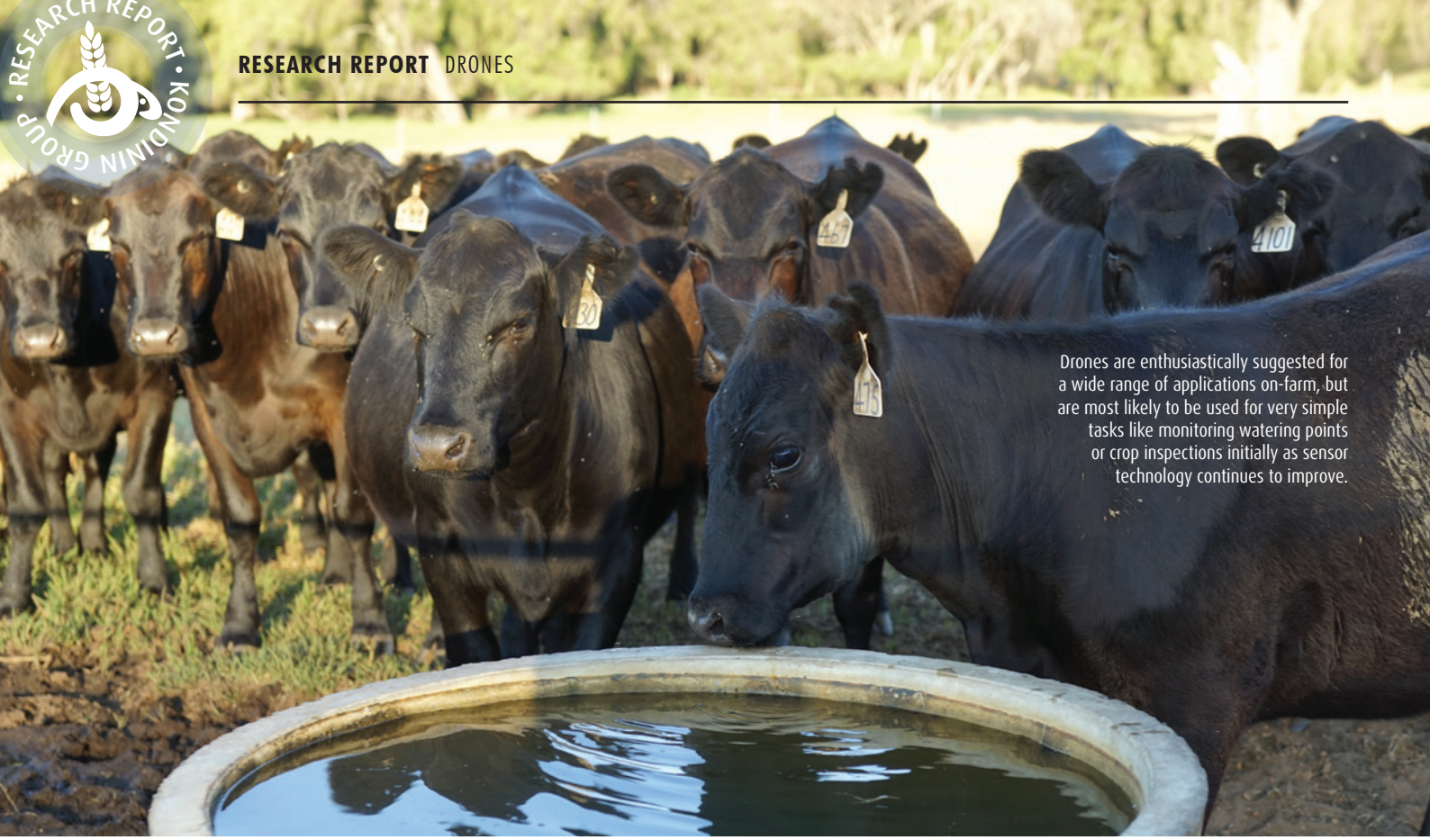
One of the in-flight risks for drone pilots are eagles who will aggressively take-down a drone operating in their territory.

The damage can be substantial, both from the powerful talons of the raptor, but also from the ungraceful fall from the sky leading to an abrupt reunification with the ground. A spotter will assist keep an eye out for eagles allowing the operator to land promptly and avoid damage.

INSURANCE

Of the three major farm insurance providers we spoke to, drones are covered for fire or flooding damage under standard household contents insurance policies, but none of the providers would cover the cost of a drone if damaged in-flight.

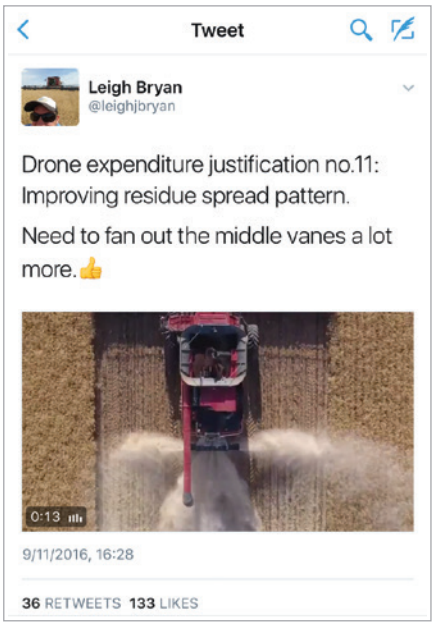
It should be noted that the drone may also need to be specified under the contents policy so coverage and exclusions should be checked with the insurer. FA



Drones are enthusiastically suggested for a wide range of applications on-farm, but are most likely to be used for very simple tasks like monitoring watering points or crop inspections initially as sensor technology continues to improve.

Applications for drones on-farm

While only 6% of Kondinin Group members are currently using a drone on-farm, according to the 2016 National Agricultural Survey, 80% of members can see application for one. Most common anticipated applications according to the survey included checking stock welfare (17%) and watering points (15%). Farmers growing crops plan to use the technology for crop monitoring (41%) and weed detection (15%) according to the survey.



Grain Producer Leigh Bryan has reported on Twitter using his drone to evaluate the uniformity of spread-pattern on the harvester and making adjustments accordingly. While the tweet was sent partly in jest, making changes like this can improve operation efficiency at seeding.

CROPPING

Agronomic uses include capturing NDVI maps indicating plant health and biomass which may assist farmers in making agronomic decisions relating to input placement.

Visual imagery can provide rapid paddock inspection superior to driving around the boundaries.

This might include plant establishment and weed observations.

While sensors like WeedIT or Weedseeker have detected green weeds on brown fallow for a number of years, researchers are working on improving the detection of green weeds within green crops.

Obviously this presents some challenges, but a COGGO-funded collaborative project between Peter Newman from the Australian Herbicide Resistance initiative and the University of Southern Queensland plans to do just that.

Capturing high resolution images of a paddock under crop and post-processing these images with high-powered computing power is hoped to to determine in-crop weed location maps and a corresponding spray application map.

LIVESTOCK

Livestock producers can use drones to remotely visually check levels at water points. Other producers and researchers have used drones to observe and rank ewe mothering behaviours to evaluate ewe performance metrics.

Evaluation of pasture biomass quantity and quality is achievable using currently available multispectral and hyperspectral sensor technology.

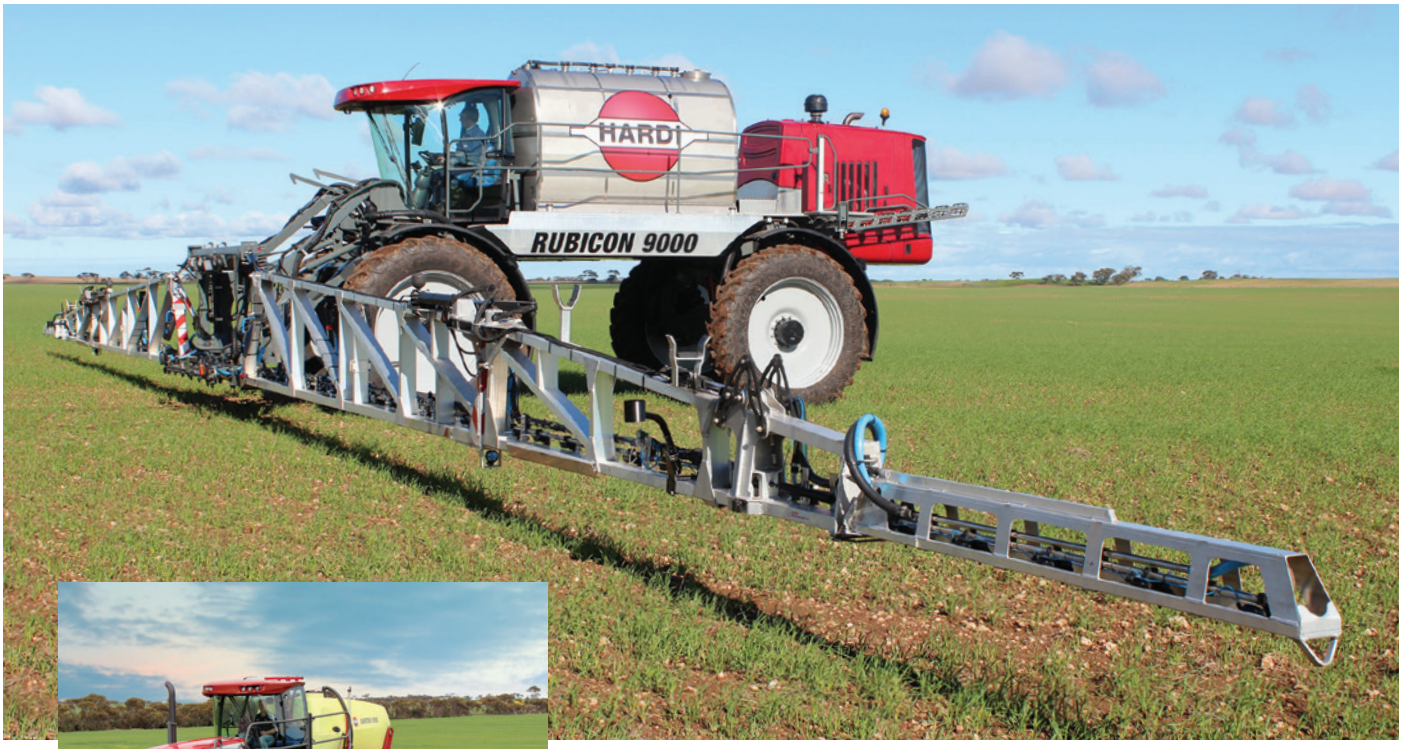
One cattle producer in Queensland has been using a drone to quickly check wild-dog baits in hilly areas around the farm, reportedly saving enough time to have recovered the cost of the drone in just 12-months.

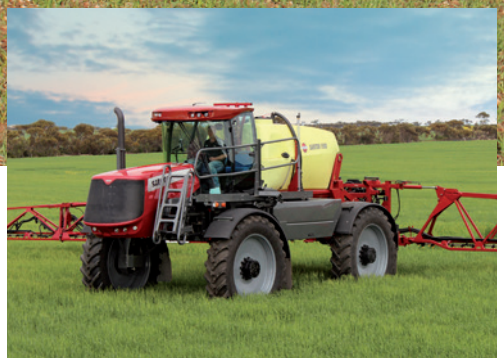
RESEARCH

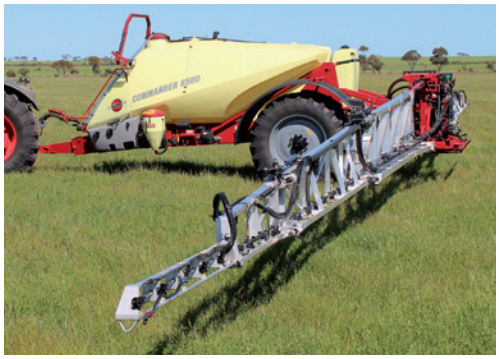
Researchers will also benefit from the application of drones in trial situations, rapid canopy management evaluation as well as plant and weed establishment population and density.

Livestock researchers have been using drones to monitor animal behaviour and grazing patterns with regular observation flights. FA

Spray More. Efficiently!







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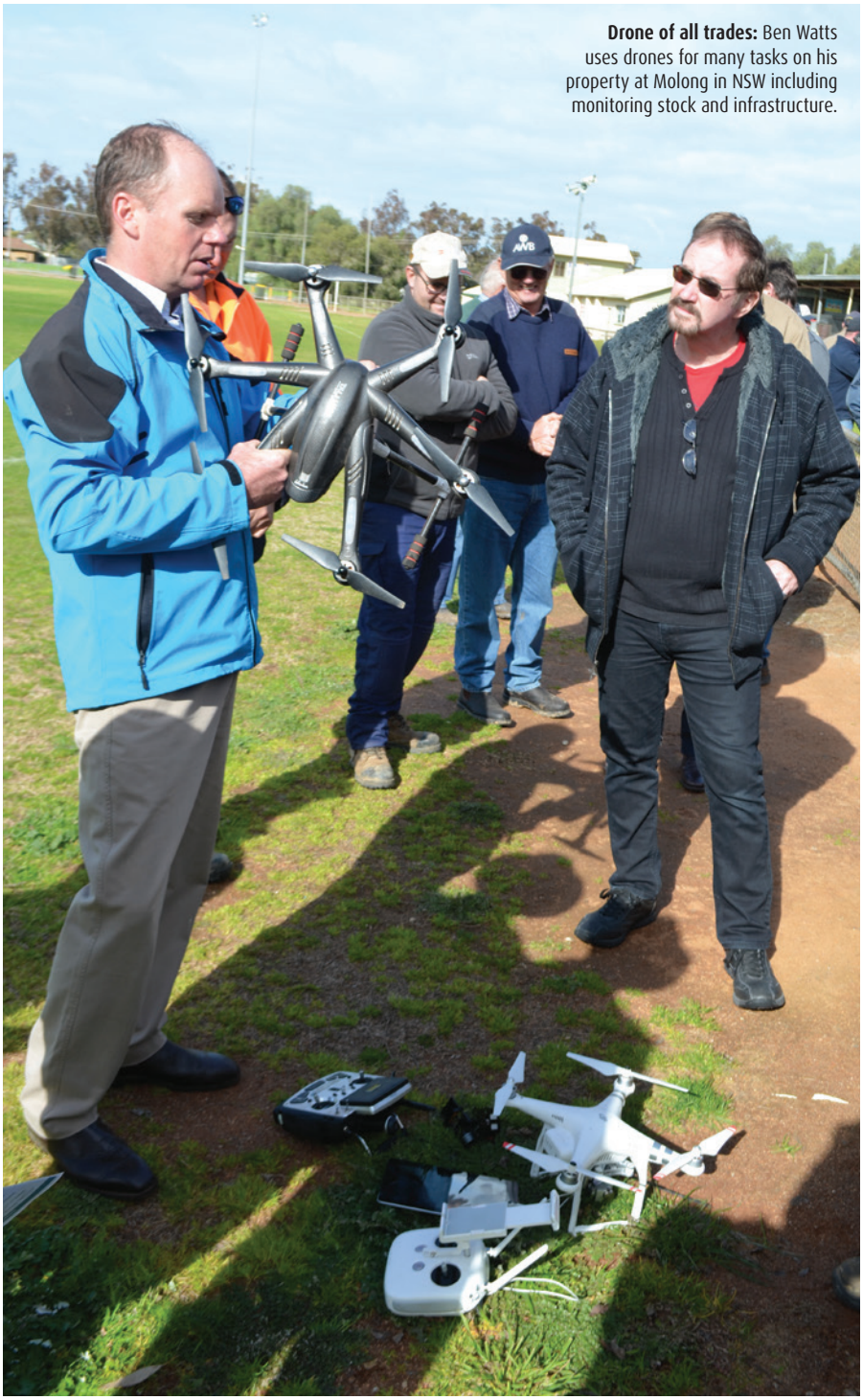
Use your drone responsibly

Livestock producer Ben Watts is an agricultural specialist user of drones or remotely piloted aircraft and cautions they need to be used responsibly.

"We use a variety of drones on our property but we make sure we always use them responsibly and stick to the guidelines," Watts said.

Watts, who runs a grazing property at Molong in New South Wales, has been using drones for about three years and being aware of industry change, particularly regulations, is important, he says.



Drone of all trades: Ben Watts uses drones for many tasks on his property at Molong in NSW including monitoring stock and infrastructure.

"It's a rapidly changing technology but that's no excuse for not keeping up to date."

Kondinin Group caught up with Watts earlier this year at a drone demonstration day held at Berrigan in NSW.

Watts had a range of drones at the demonstration, including copter style smaller units and an impressive X-wing design drone, which is capable of vertical flight using rotor blades and also flying like a fixed wing aircraft.

Whatever the drone, Watts said primary producers should consider their use before purchase.

"We mostly use our drones for monitoring stock and infrastructure but we also regularly map the property for imagery so we can make decisions on pasture growth and budgeting."

During spring, the Watts may run up to six flights a week and from those flights, generate Normalised Difference Vegetation Index (NDVI) images, for example.

"Then we know pretty accurately our plant and pasture status and we can even develop three-dimensional maps to help with drainage and the like."

But one of the simplest and most effective uses of the drone for Watts is for replacing the downtime of vehicle travel for jobs such as checking fences and water.

"We have the drones set up pretty much to work autonomously so we have a pre-programmed flight path. We can watch the drone footage live or review it at a later date."

Watts has also recently started to use the drone for mustering sheep in steep country.

"Just the faint noise of the drone will get the sheep to start to walk together, which is a great help in hard to access country."

Another important consideration for drone use is managing and paying for data. Some of the higher end software and imagery requirements can require a 20 gigabyte a month plan from an internet provider.

"And some companies who sell imagery products based on subscription will sell you a system with a 'get your first month of data free' type of offer and after that the data costs can be staggering. A single NDVI image for a paddock could be as big as one gigabyte.

"So it pays to do your homework." FA

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