THE USE OF UNMANNED AERIAL VEHICHLES (UAVs) FOR WEED CONTROL IN WESTERN QUEENSLAND

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ABSTRACT (SUMMARY)

Desert Channels Queensland and PBE Pty Ltd have been evaluating the cost effectiveness and success of weed control techniques at a range of sites with varying soil types in Western Queensland. This has included the use of unmanned aerial vehicles (UAV) for chemical application.

Initial results from spray and granular chemical application using the Yamaha RMAX, a UAV have been recorded on the two properties with specific trial sites. The two sites were chosen due to their relative geographic closeness, location on the headwaters of major watercourses, heavy infestations of a range of weed species at various growth stages, known history of weed control and variability in soil type and slope. The UAV, a visual line of sight aircraft, was selected due to payload, endurance and manoeuvrability considerations and the ability to disperse both spray and granular chemicals.

The initial focus of the UAV was on control of prickly acacia (*Acacia nilotica),* which at both sites has formed dense stands of mature trees with colonization occurring in paddocks and along adjacent watercourses. This evaluation was not developed as a chemical evaluation trial but has focused on evaluating control methodologies using the UAV and the relative cost/benefits, given its use as a novel form of control.

This paper identifies learning's, successes and constraints of the UAV control methodology and highlights the potential role for further application at both the localized and landscape scale.

Keywords: Prickly, Acacia, Weed, Control, UAV, Unmanned.

INTRODUCTION

The investment to undertake effective weed control for prickly acacia (*Acacia nilotica)* continues to increase well in-excess of the respective growth in private and public investment. This disparity means that increasingly smaller areas are able to be controlled with existing techniques, while the area affected by prickly acacia continues to expand. This poses a significant concern to land managers and government bodies to continually fund woody weed control in Australia.

As a result, Desert Channels Queensland asked PBE Pty Ltd, a company based in Western Queensland, to participate in a trial of the efficiency and effectiveness of a range of emerging weed control techniques. One of these, the use of an unmanned aerial vehicle (UAV) designed for aerial application of agricultural chemicals, occurred in Western Queensland over the months of April and May 2013. The use of the UAV is the first application of its kind in Australia and consequently required the use of innovative techniques to apply both foliar and granular chemicals to prickly acacia trial sites.

This paper highlights opportunities and limitations afforded by this emerging technology from initial flight testing to operational implementation at the trial sites. The trial aircraft used was an unmanned helicopter designed for agriculture use. The use of it in Australia for woody weed control is the first attempt using this kind of aircraft. The aircraft was chosen as it has the ability to be quickly configured for both foliar and granular application of chemicals. The aircraft is 3.9 meters long, has a take-off weight of 100 kg and an endurance of 40 minutes.

The properties used to trial the UAV are Mountain Dam and Sesbania. Both are located within the Diamantina Catchment, 2 hours north of Winton, Western Queensland and both have significant prickly acacia infestations of varying ages and densities. Both properties have had successive private and public investment aimed at control of the prickly acacia which has failed. In addition the density of prickly acacia on the properties is now affecting production and environmental values, as well as representing a potential seed source for downstream properties.

The use of the UAV is part of an integrated control program to improve the effectiveness and efficiency of prickly acacia control. Prioritisation for the UAV has been to target high and ultra-high density sites, such as along depression lines, watercourses and at water points where other techniques had either prohibitive costs or an expectation of limited success, as well as at sites that are inaccessible or had work place health and safety issues.

Emerging mapping, undertaken in conjunction with the Queensland Government, identified locations on the properties that had increasing foliar reflectance in the spectral range consistent with prickly acacia. This allowed for the development of a weed plan which prioritised sites based on density and the likely threat level. This mapping, also a first and trialled at the properties, allowed high priority sites to be easily identified. It also reduced the complexity in determining the appropriate control techniques. The mapping further allowed for detailed discussions in terms of roles and responsibilities at each of the sites, ongoing resource allocation and commitments to protect public investment into the future.

INITIATING THE UAV FOR WOODY WEED CONTROL

Planning

The properties, located in Western Queensland posed significant operational issues. Both properties are used predominantly for stock grazing and have a combined area of 60,000 acres (approximately 25 000 hectares). While the area has recently benefitted from 3 years of above average rainfall, providing the ideal conditions for prickly acacia germination and survival, the lack of recent rain and high temperatures meant that ground conditions were extremely dusty, posing additional challenges particularly at critical stages of flight such as take-off and landings.

This, combined with a variable canopy height, variance in stem and leaf density, variance in plant form and shape and the need to protect emergent native tree vegetation meant that standard flight patterning normally used had only marginal application.

Both properties also had variance in plant density across the landscape. Dense and ultra-dense sites were associated with mass germination events located in depression lines, in waterholes and break out channels along watercourses and close to man-made watering points such as dams and weirs. This variance, a normal pattern seen on all properties but which was used to determine the most applicable control technique, meant that the sites to be controlled were often widely separated. This required development of techniques and tools allowing rapid re-establishment at new sites, such as support vehicles and planned accessed routes.

Sites for the UAV were identified using the Landsat mapping and tasking was prioritised based on location, weather conditions and the chemical control to be undertaken. All sites were geo-referenced, soil type identified and hazards and risks determined for each site. Medium and high risk sites all had a completion report for future reference which outlined the chemical application undertaken, weather conditions and mitigation used to reduce the risk.

The largest site tasked for the UAV for application of granular chemicals was 24 hectares (ha) but sites were generally in the order of 5 – 10 ha and the largest area tasked for foliar application was a depression line 3 km long and covering 15 ha. Figure 1 shows an example of the mapping used to task the UAV. While the property has prickly acacia across much of the landscape, the map shows areas where increases in density and spread is occurring. Control was prioritised in these areas.

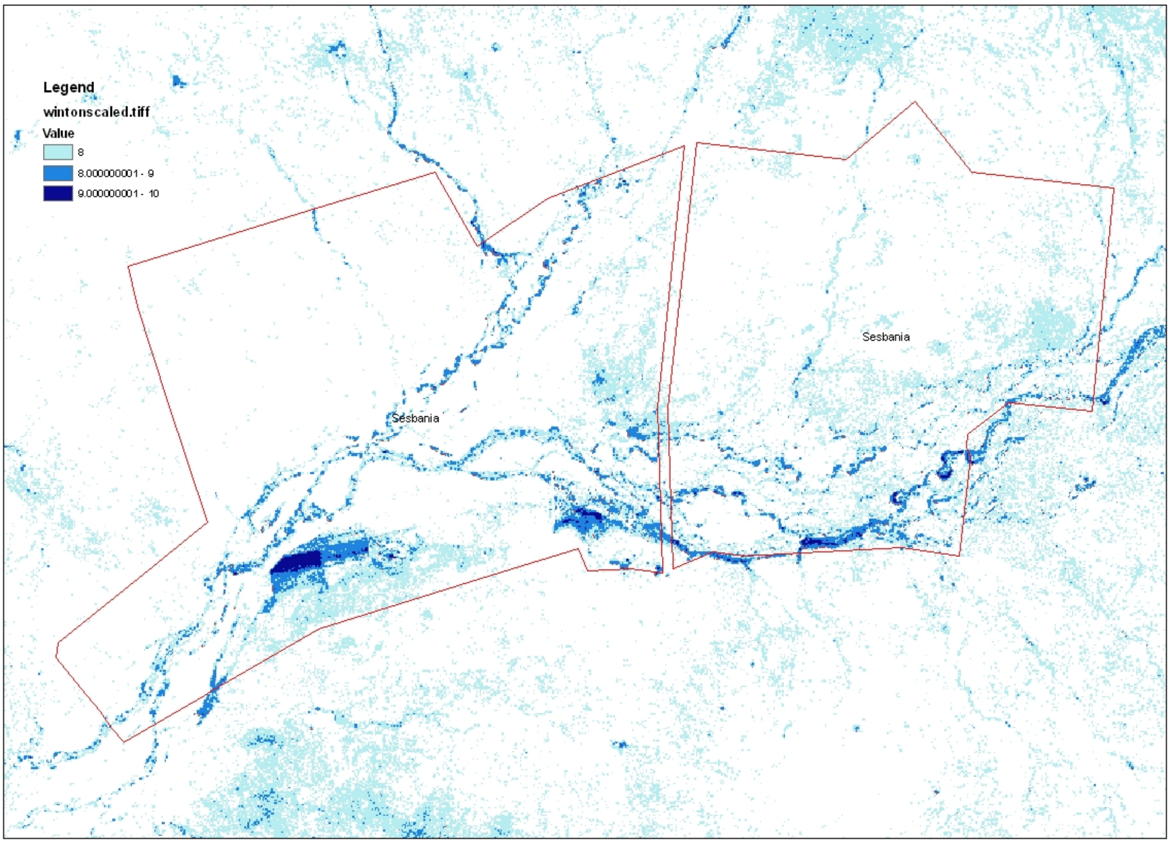

Figure 1 – UAV Tasking plan - Sesbania

These sites were tasked to the UAV for several reasons:

1. The relatively small size, density and discrete locations required application techniques that could be moved and established at new sites quickly and cheaply; and
2. The locations were often associated with hazards which precluded other application techniques such as terrain, stock and emergent native vegetation.

On other parts of the properties, particularly those where the prickly acacia density is stable other control techniques such as mechanical and hand application of chemical occurred.

Chemical Dispersal Trials

Dispersal tests for both the foliar and granular chemical application were conducted along with flight performance testing. The lack of previous applicable flight data, conversion tables and applicable load charts meant that significant time was spent setting up payloads and testing application rates before operational flight testing could be planned. This testing involved flights along known routes at measured distances to calibrate load discharge. When within the required parameters, flights were moved from calibration to operational flights.

Granular pellets were dispersed to manufacturer specifications based on soil type with dispersal rates continuously monitored throughout the application period. The highest rate of application used was 15 Kg/ha with the aircraft distributing a 6 meter swath from two distribution hoppers. The time to apply the chemicals varied depending on the amount of manoeuvring required but averaged 13 flight minutes/ha.

Foliar chemicals presented the greatest challenges. The variable canopy height, stem density and foliar density all affected chemical dispersal. Speed control along with height above the canopy was determined as the two critical flight parameters to be managed. Water sensitive paper was placed in the lower branches of test vegetation and these parameters varied until an acceptable patterning was achieved on the lower branches. As foliar chemicals were primarily used at watering points, depression lines and watercourses where emergent native vegetation occurred, significant manoeuvring was often required to ensure that non-target vegetation was protected, but the targets close to the trees were sprayed. Figure 2 shows the improvement in application density during the flight tests.

Figure 2 – Water sensitive paper used to test different application speeds and heights.

The UAV was configured to disperse chemicals from two spray booms located on either side of the fuselage. For this work the third centre spray was not used. This configuration gave a 6 meter swath using sr-5 nozzles.

As with the application of granular chemicals, the level of manoeuvring required affected the area covered. In particular, in depression lines and along watercourses the average was 20 flight minutes / ha.

Figure 3 – UAV Operated by PBE Pty Ltd configured for foliar spraying.

APPLYING THE UAV FOR WEED CONTROL

Once the tasked area was planned, application of chemicals would occur in a consistent pattern.

Using a navigator and a pilot, the UAV would fly over planned cells to undertake the control. The navigator is required to ensure accuracy of the application of the chemical and determines speed corrections required, confirms height and plans for hazards. The pattern of flying is determined to maximise flight time over the target and limit dead flying time associated with refuel or reloading.

With planned replenishment sites, a logistics officer can ensure the turnaround time is less than two minutes.

As the current legal requirement for UAV use in civilian commercial applications is limited to visual line of sight, the pilot must maintain visual control of the UAV at all times. This can present challenges in such flat terrain and at times required the pilot to be slightly elevated.

The relatively small size of each area, and the distance between each site meant that the aircraft and crew were re-establishing at new sites up to three times a day. Transport on site for aircraft, crew and chemicals require significant logistic support.

The significant number of mature, emergent native trees and the need to apply chemicals with a high degree of accuracy in close proximity in variable weather conditions required significant skill development of both the pilot and navigator. The on-board equipment has the ability to continuously monitor chemical dispersal rates and adjust for speed, monitor height and flight speed parameters but the crew are ultimately responsible for the safe operation of the machine.

By varying speed and height it was possible to apply both granular and foliar chemicals to a very high level of precision and this allowed for both the protection of native vegetation, and reducing chemical drift and risks from overspray.

As with all foliar applications, the time when this technique can be used is limited and determined by wind speed, temperature and relative humidity. In Western Queensland these parameters provide only a small window each day and by mid to late morning flight operations would transfer to granular application. The rapid reconfiguration of the UAV allows this to happen quickly.

INITIAL RESULTS FROM THE UAV

The trial occurred in April 2013 and therefore any results are only preliminary at this stage. However initial findings suggest that the application of chemicals using the UAV is effective, resulting in 99% of targets sprayed with no evidence of shadowing or missed spraying. Given the stem density at the sites the UAV was tasked this was greater than expected. Plants missed occurred due to protection from mature parent trees, rather than poor flying. Similarly, with the granular pellets, they were able to be applied consistently at their target densities.

The advantage of the UAV, when compared to other application techniques, would appear at this stage to be linked to application directly from above. In relation to foliar sprays this means application directly onto and through the canopy aided by mechanical turbulence from the rotors. From preliminary observations, this appears to be much more effective than land based misters and sprays, which often have shadow effects on the non-misted/sprayed side of the plant.

Effectiveness

While not a chemical trial, it is difficult to determine effectiveness without reviewing results at least in some context. The UAV used the aerial foliar application of Fluroxpyr with adjuvants and dye. Three age groups were tested and these were all in the dense and ultra-dense ranges (greater than 1000 stems per ha).

In the first age group (juveniles), mass germination sites associated with mechanical disturbance were sprayed as were mass germination sites associated with water inundation in depression lines. Ages were less than 2 years and there was no evidence at this stage of flowering.

Figure 4 – Initial signs of control following foliar spray over a mass germination site. Time elapsed was 21 days since treatment.

The second age group was semi mature plants along depression lines, at watering points and in watercourses. These plants were typically around 2 m, in the density range of 500/1000 stems per ha, and at the time of spraying were starting to flower.

Figures 5 – Initial signs of control following foliar spray by the UAV over dense vegetation in a depression line site. Time elapsed was 21 days since treatement.

The third group, mature plants associated with difficult to access sites that had variable densities, were at the early stages of flowering and were targeted as they represented seed trees.

Figures 6 – Initial signs of control following foliar spray by the UAV over mature watercourse vegetation. Note the native vegetation which was protected. Time elapsed was 21 days since treatment.

Long term monitoring will continue on the treated sites to determine the actual kill rate. This will be combined with monitoring of the sites treated with granular herbicide following sufficient rain.

Efficiency

In comparison to the ground application of herbicide, the results from the time trials indicated a potential four-fold efficiency gain using the UAV. In addition, a significant reduction in occupational health and safety (OH&S) issues was found, such as reduced workers interaction with spray drift and reduction in manual work.

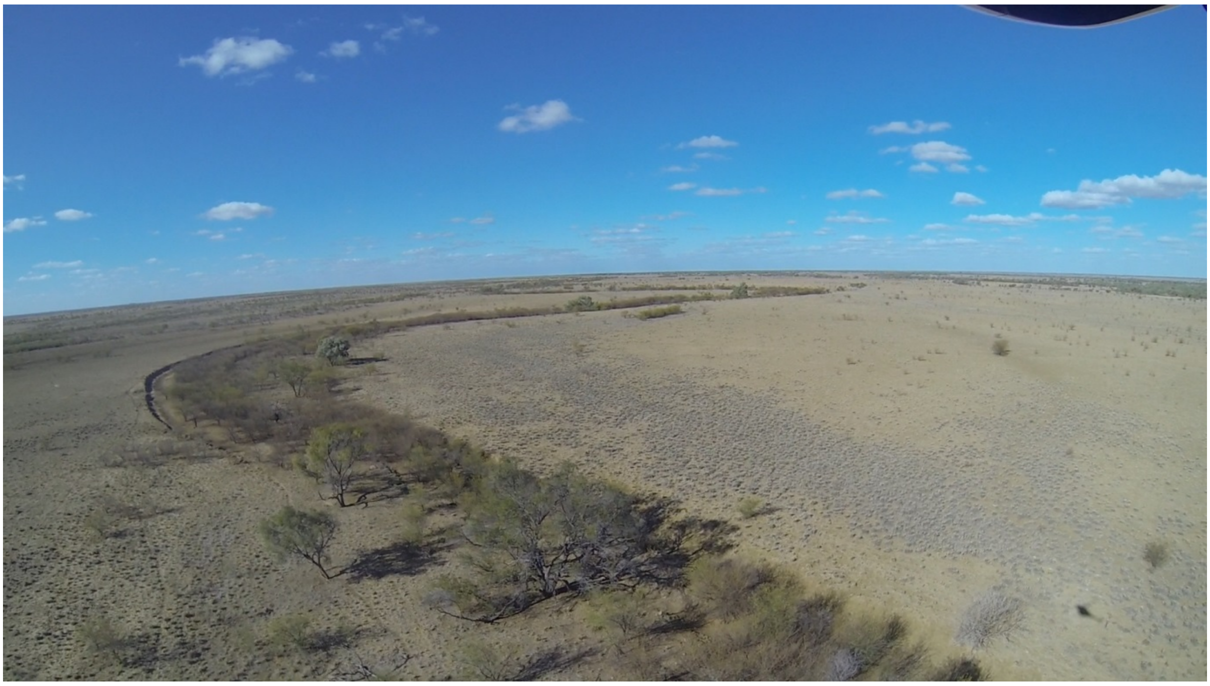

Figure 7 – Airborne photo from the UAV showing initial signs of control following foliar spray along 3 km of watercourse. Note the native vegetation which was protected. Flight time was 5 hours. Time elapsed since spraying was 21 days.

In relation to using the UAV for application of granular herbicides (Tebuthiuron), it was found that there is approximately a 10 fold efficiency improvement in ground application, as well as the reduction in OH&S issues and the use of vehicles.

The sites chosen were not applicable to mechanical control techniques due to terrain, risk or OH&S issues. It is therefore not possible to make a serious comparison.

A more valid comparison relates to alternate use of a full sized aircraft. The areas to be controlled are too small and complex in shape to allow a fixed wing aircraft with its high forward speed to operate with any degree of precision. This would not be the case for a helicopter. Speed and height above canopy would be the same for both craft to have similar efficiency however a full sized helicopter would have a larger swath and a higher payload. This would provide some efficiency gains. However, at greater than 4 times the operating costs and much higher establishment costs it is unlikely that the efficiency gains would out weigh the additional costs at these sites.

CHALLENGES AND FUTURE REFINEMENT OF UAV's FOR WEED CONTROL

There is no doubt that this type of operation will become more common in the future. There are however challenges yet to be fully overcome. These include:

1. As with all flying operations the skill and dedication of the operating staff determines outcomes and maintains the safety standards. This is still maturing and initial flight training has limited relevance to operational flying, particularly so close to the canopy and with the extensive range of hazards. Companies operating UAV's in this type of flight envelope need to establish their own specific skills development requirements based on the relevant context.

2. Operating in Western Queensland, as with all arid areas, presents its own challenges for staff and machines with extreme dust already showing signs of reducing the life of some components. These are in addition to the challenges posed by the distribution of chemicals. Equipment reliability and durability was less than expected and requires further manufacturer modification.

3. The prioritisation of the sites was undertaken by Desert Channel Queensland and supported by their mapping staff. While under continuous refinement it already allows for a much more strategic approach to weed control and the simultaneous use of multiple machinery types and control techniques.

CONCLUSION

The ability of the UAV to operate with such precision, to turn on and off distribution of chemicals so easily, its high manoeuvrability and low noise levels, all make this type of craft appealing for weed control. The use of the UAV will be trialled on other weed species in a range of environmental conditions and in the surveying for weeds, such as the invasive cacti of Wester Queensland, in difficult and hazardous sites.

This paper will be updated within 6 months on kill rates achieved and relative costs for controls undertaken. If you would like further information contact Desert Channels Queensland, Longreach.