Mapping of environmental weeds in native grassland. Aerial photograph interpretation and volunteer involvement

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Reinforcing Grassland Ecological Values in the Merri Valley North of Melbourne

CARING FOR OUR COUNTRY

MERRI CREEK MANAGEMENT COMMITTEE

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Acknowledgements

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Introduction

Gorse (*_Ulex europaeus_*) and Toowoomba Canary Grass (*_Phalaris aquatica_*) are two serious environmental weeds that threaten native grassland in the Merri Creek valley. To minimise off-target damage, intensive methods of weed control need to be applied within high quality native grassland where these weeds occur. This requires strategic allocation of resources that can be aided by mapping infestations before and after treatment.

Accurate, up to date mapping of these weeds at a fine scale has been used by Merri Creek Management Committee (MCMC) to plan works, select annual targets, allocate resources and finally evaluate effectiveness of weed control works. Such mapping has traditionally been expensive to carry out and is rarely conducted for routine weed control works.

Frequently updated, high definition aerial photography is a recent innovation that potentially could make mapping of environmental weeds more economical. This facility has recently been made available via the internet. In Melbourne, Nearmap™[1] provided access to such aerial imagery at low or no-cost options for non-commercial applications from late 2009 until late 2012 when full fee rates were enforced. The currency and frequent updating combine to make the product potentially valuable for environmental monitoring.

This investigation attempted to use aerial photo interpretation of Nearmap™ images to discriminate different cover classes of Gorse at a native grassland north of Melbourne.

Assessing aerial interpretation relies on comparing analysis with ground-truthed data. Ground-truthing can be time-consuming and expensive to conduct. Students from land management courses are occasionally available to work on projects of land management agencies as a part of course requirements. Exercises involving students in on-ground surveys are welcomed by teachers for fulfilling curriculum needs and providing students with real-life experience of potential workplaces. However, it is a challenge to organise activities with students that generate accurate assessments with minimal training while also providing a worthwhile learning experience.

A secondary aim of the investigation was to assess a procedure for training and marshalling student volunteers to gather the data needed to produce maps suitable for use in;

a. Evaluating the aerial photographic interpretation of Gorse infestation
b. Generating maps suitable for use in directing and assessing Gorse and Toowoomba Canary Grass eradication works.

Students and teachers were also surveyed to identify their satisfaction with the exercise.
Works were incorporated in assessment of grassland protection works at Kalkallo Common in 2011-2013 under a Caring for Our Country grant.

[1] Nearmap™ (www.nearmap.com) is a proprietary product of high resolution aerial photography provided online, covering an expanding range of areas in Australia. The company launched its Melbourne coverage in October 2009. The site provides aerial imagery which is updated at frequencies ranging from monthly to several months.

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Method

Site description

Kalkallo Common is an area of Crown land in the township of Kalkallo to the north of Melbourne (-37.528171°, 144.953568°). It consists of 9 hectares of land and is on the eastern edge of the Victorian Volcanic Plains Bioregion. The vegetation of the reserve is *Heavier-soils* Volcanic Plains Grassland Ecological Vegetation Class, (EVC) 132-61 (Dept. Sustainability & Environment 2004). The Common contains a particularly wet variant of this vegetation community with hundreds of shallow depressions. The dominant plant in the wet areas is Brown-back Wallaby-grass*, Austrodanthonia duttoniana*. In drier parts of the grassland, the vegetation is dominated by Kangaroo Grass, *Themeda triandra*. Several species of conservation significance persist in the reserve including Plains Yam Daisy, *Microseris scapigera* and Purple Blown Grass, *Lachnagrostis punicea* subsp*. punicea .*

The vegetation remains in relatively good condition and has been subject of intensive but intermittent weed control efforts for over ten years. High threat weeds at the reserve include **Ulex europaeus, *Phalaris aquatica, *Anthoxanthum odoratum, *Nassella neesiana* and **Nassella hyalina.*

In the 2010 Operational Management Plan for Kalkallo Common (MCMC 2010), the reserve was divided into 7 different zones based on management logistics and vegetation quality. The 'Eastern perimeter' of the reserve was designated as a distinct zone due to the high proportion of Toowoomba Canary Grass (**Phalaris aquatica*) and Gorse (**Ulex europaeus*). Gorse and Toowoomba Canary Grass eradication are high priority management actions identified for this zone due to their competitive impact on indigenous vegetation. These bulky weeds also produce high fuel loads. The need to treat and remove infestations close to flammable windbreak trees increased the cost of conducting ecological burns in 2012 (see Appendix 4, Figures 3 and 4).

Weed assessment with students and teachers in 2011

Arrays of temporary monitoring quadrats were created. These were aligned with fence lines as follows;

- A 5m x 5m grid was generated on the MCMC GIS across a 30x300 metre area aligned with the eastern boundary of the reserve overlying the main areas of the Gorse infestation.
- Coordinates of GPS locations along the area at 50m intervals were extracted and printed on a map of the grid.
- In the field, the map was used to place star pickets at the recorded coordinates with the aid of a GPS unit.
- 50m tapes were laid between the first two pairs of star pickets at the northern end of the survey area.
- Two 30m ropes with 5 metre graduations marked on them were unrolled and held taut between wooden stakes hammered in at the 5 metre intervals indicated by the tape measures.

Thirteen students from the first year Conservation and Land Management course at Holmesglen TAFE, Waverly Campus, were inducted into the site on 31st March 2011.

- Students were split into 6 groups (two or three each) and allocated a line in the assessment grid.

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- Training in the identification of Gorse and Toowoomba Canary Grass occurred.
- Students were trained on methods of assessing the cover percentage of a plant species within a 5 x 5m quadrat (e.g. each square metre represents 4% cover). Students were asked to nominate a percentage of cover for each quadrat. Forms (Appendix 1) were used to record data.
- Groups began assessment of individual quadrats for both Gorse and Toowoomba Canary Grass. As each line of quadrats was assessed, the hindmost rope with graduated marks was moved to the next five metre interval, creating the next line of quadrats (see photo on cover of report).
- Experienced MCMC crew members closely supervised and assisted students in the first ten assessments, to ensure identification and estimates were made consistently. A lower level of assistance for the subsequent assessments.
- Induction, training and assessments were completed between 10am and 1pm,
- In the last hour, individual groups of students were able to complete a quadrat assessment in approximately 3 minutes.
- Total effort on site on the day included 13 volunteer students and 2 Holmesglen TAFE teachers for three hours and 3 MCMC staff for approximately 4 hours creating a total effort of 57 people hours not counting travel time and preparation.

Data for each quadrat was then input into MCMC's GIS system (Mapinfo™ platform) and a thematic map generated to create a map with 6 different cover classes.

Interpretation of aerial photography for Gorse cover

Aerial photograph interpretation of cover of Gorse was carried out by an experienced MCMC staff member, (the 'assessor'), in July 2012. The 'assessor' had taken part in the on-ground survey in March but had not seen the resulting data. No attempt was made to assess Toowoomba Canary Grass.

The following steps were used to generate a map of Gorse cover using aerial photo interpretation.

- Nearmap™ aerial photos from the eastern margin of Kalkallo Grassland were downloaded into MCMC's Geographic Information System which uses a Mapinfo™ platform. The image from the 7th January 2011 was chosen due to the clarity of the image and the contrast between the dark foliage of the Gorse and pale summer-sere grasses. The Nearmap™ website has a facility (Hypertile™) to download geo-referenced images.
- The grid used for the ground-truthing survey was overlaid on the aerial photos.
- The assessor inspected images at a zoom level of 0.051 km.
- The assessor was asked to allocate a score in one of five cover classes- these were presented to the assessor in as both percentage and the nearest whole number fraction to assist with visualisation (See Table 1). The classes correspond to classes developed from the field-based assessment.

Table 1 Cover Classes used for Gorse Aerial interpretation

Percentage	**Fraction**
<16% cover	**< 1/6**
16-32%	**1/6 - 1/3**
32-48%	**1/5 - 1/2**
48-64%	**1/2 - 2/3**
68-80%+	**2/3 - 4/5+.**

The assessor noted that he examined the different parts of the survey area, in particular highest density patches to help calibrate his scoring of cover before beginning to allocate scores and that for any particular quadrat, his scoring was influenced by the score he allocated to adjacent areas.

- These scores were put into a GIS layer and a thematic map generated using the same classes and themes as the map of ground-truthed data.
- The assessor spent less than half an hour to score 240 quadrats although there had been several hours spent preparing for the assessment and subsequent analysis.

Weed Assessment with students and teachers in 2013

An on-ground assessment was conducted in 11th June 2013 with students from the Northern Melbourne Institute of TAFE, Epping campus. The method used was similar to the 2011 with the following differences;

- tape measures were used rather than marked ropes. Along with the use of marker flags this increased efficiency.
- only 5 students and two teachers were available so assessments were conducted in teams of one.
- Inadequate attention to detail by the lead author led the crew attempting to survey a 50 metre band rather than the original 30 metre band and, as a result, not all quadrats were re-surveyed. To increase the overlap of surveys, some quadrats were completed by MCMC crew members on 22/8/13.

Student and teacher satisfaction assessment

In both 2011 and 2013, the following questions were asked of students and their teachers;

1. How were you attracted to this activity? What role were you playing?
2. In what way was this a satisfying or unsatisfying activity for you?
3. Is there anything valuable you've learned from being here today?

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Results and Discussion

On ground survey

Gorse

The map showing the results of the ground truthed survey is included as Appendix 2, Figure 2. The map shows several features of the infestation of interest in planning a Gorse eradication strategy;

- The first fifty metres in the north of the 30 metre band was entirely free of Gorse. It would not require further inspection in the short term, and only quick inspection in the post-burn year to ensure this remains Gorse-free.
- Several nodes of dense Gorse infestations were visible within 30 metres of the pine tree windbreak. These would need physical removal before ecological burns
- By timing herbicide treatment so that seed was not present on the Gorse bushes, it was possible to cut and take the killed bushes into the interior of the grassland prior to the ecological burn for disposal by the fire, avoiding substantial disposal costs.
- The southernmost 50m band of the survey area was mostly in the lowest class of Gorse cover, suggesting cut and disposal of the Gorse would not need to be prioritised here.
- The distribution pattern suggested where further areas of low density Gorse are likely to be present beyond the surveyed area, in particular to the south and west.

Toowoomba Canary Grass

The 2011 map of Toowoomba Canary grass cover percentage is included as Appendix 3, Figure 5. The map shows the following features relevant to control of Toowoomba Canary Grass;

- A pattern of increasing density of Toowoomba Canary Grass close to the western perimeter probably associated with past disturbance along this boundary. This might include the legacy of weakened resistance of indigenous grassland vegetation to invasion due to 'camping' by livestock below windbreak trees in past decades. On-going seed spread from adjacent 'improved' pastures may also be occurring.
- A lower level of Toowoomba Canary Grass in the southern-most 50 metre band of quadrats appears to correspond to areas where weed control efforts were concentrated in the mid 2000's.

Comparison of Aerial interpretation with ground-truthed data

By comparing the ground-truthed survey (Appendix 2, Figure 2) with the results of the aerial interpretation map (Appendix 2, Figure 1); the following similarities are apparent;

- Virtually no Gorse was mapped in the northern-most fifty metre band of the survey area.
- The distribution of nodes of high density Gorse was very similar across the survey area.
- The estimation of higher density Gorse appeared to correspond closely with the ground-truthed data

Differences in the maps that have implications for planning include;

1. A few false positive low density Gorse patches in the northern hundred metres, perhaps associated with shadows from grass tussocks or with scattered shrubs of the native shrub, *Cassinia arcuata*
2. A false positive high density patch in the southern fifty-metre band, possibly a mis-interpretation of a shadow from an adjacent pine tree.

3. the lowest infestation class (less than 16% cover) was under-detected during aerial photo interpretation.

The small numbers of false positive readings might be addressed by weed controllers conducting a cursory inspection to eliminate the area from further patrol effort.
The second difference appears to represent a misinterpretation that might be reduced by;

- Greater experience in aerial interpretation, with opportunities to conduct comparisons of assessments with on ground conditions and training in the most likely misinterpretation scenarios.
- Comparison with multiple aerial photographs

Difference 3 would be largely allowed for by directing staff conducting weed control to patrol in sweeps or spirals out from the dense infestations which is already a standard search method.

Comparison of pre and post weed control treatment surveys

Where the surveys from 2011 and 2013 overlap, an indication of the effectiveness of weed control can be observed.

For Gorse, only the lowest level of infestation remained, with most of Gorse scores at less than 1%. Field staff reported that these consisted of gorse seedlings and small regrowth, much of which had been recently treated and still in the early stages of dying off when surveyed.

Toowoomba Canary Grass had been substantially reduced down to the lowest cover class but was still widespread through the survey area.

Despite continued presence of the weeds in the survey area 27 months after weed control began, the weed scores are consistent with both species being on target for eradication. Intensive weed control only began in the 14 months since the ecological burn in 2012 as regrowth conditions provide reduced chances for off-target damage from herbicide application. Regeneration from soil borne seed will require multiple treatments for some years to allow regeneration.

Costs and benefits of different approaches to mapping infestations

This trial provides a limited amount of data on resources needed to conduct two alternative approaches to mapping Gorse infestations for directing and assessing a treatment program. Two other approaches are typically already used by MCMC to help ensure weed infestations are thoroughly treated;

1. Do no mapping exercises and rely on field staff to patrol an entire site thoroughly and repeatedly.
2. Conduct pre-treatment mapping using a ‘mudmap’, typically an aerial photo printout. The infestation is drawn in the field, based on landmarks visible on the photograph. A Geographic Positioning System (GPS) unit might be used to accurately mark the outlines of infestations.

A very rough comparison is made between these 4 approaches, based on the 0.5 hectare area, in Table 2. This table uses timings derived from this study, feedback from field staff conducting the works and estimates by the author of using the alternative methods based on his experience. The

benefit to on-ground works was estimated based on the scenario where absolute faith is placed on the maps produced by each approach.

The costs and benefits will vary between different species. An earlier exercise in aerial interpretation by MCMC (MCMC, 2011) indicated that it could be effective in mapping Chilean Needle Grass**Nassella neesiana* within native grassland. Compared with Gorse, it is considerably more difficult to evaluate control needs from a cursory inspection of a site. Dispersal and infestation patterns are more complex and difficult to map on foot. For this species, aerial photographic interpretation potentially offers much higher efficiencies over use of mud maps or other on-ground surveys.

An important comparison to be in the table is the effect of scale. Costs of different approaches are similar at the scale used in this exercise (0.5 hectares). However, aerial photographic interpretation could have been expanded to assess several hectares of similar adjacent terrain at little additional cost. In contrast, the cost of other approaches expands much more rapidly with expansion of the area to be treated.

Table 2 Comparison of costs and benefits to 4 approaches to mapping weed infestations

Approach	Cost in time	Est. Benefit/cost to efficiency	Other benefit	Other negatives
Do nothing, rely on patrolling during eradication	• None	• Approximately 5 field staff hours unnecessarily expended patrolling areas devoid of Gorse	• Low administration costs	• No data to provide feedback on progress apart from anecdotal • Greater chance for inconsistency between control rounds- potentially increasing likelihood of re-infestation • No data to provide to funding bodies other than resources expended
Map outlines with mudmap or GPS	• Est. approx.. 8 hours in field, 2 hours in office generating map	• 5 staff hours saved by not patrolling areas devoid of gorse	• Very flexible as can be conducted without educational institution involvement and where appropriate aerial photography is unavailable	• High level of subjectivity can creep in. • Complex infestations are very difficult to map
Grid survey with student volunteers	• Approximately 8 hours with field staff • 6 hours preparation and liaison, • 2 hours mapping	• 5 staff hours saved by not patrolling areas devoid of gorse	• High level of repeatability. • Can map low level infestations • Contributes to student training • May be designed (and resourced) to fulfil community participation requirements of a funding body • Can be used with broader range of species including those without distinctive aerial signatures	• Area limited by availability of students, capacity to maintain enthusiasm and concentration of students (typically only a few hours) and logistics of organising the day.
Aerial interpretation mapping	• 2 hours pre-assessment site visit • 2 hours map preparation • 1 hour assessment and map	• 4 staff hours saved by only doing a cursory inspection of false positive points in area otherwise shown as devoid of gorse	• Not able to detect low levels of weed, therefore not useful for most post-treatment purposes. • May allow mapping of dense gorse infestations and terrains that are inaccessible on foot	• May be used to assess a much larger area of site (several hectares) for very little additional time. • Relies on availability of recent photos of appropriate quality and from appropriate season • Cost of aerial photograph access

Satisfaction with exercise by student volunteers and efficiency as a mapping method.

A goal of the project was to develop and conduct a survey exercise compatible with the capacity and needs of students of Victoria's Conservation and Land Management TAFE course.

Students from this course readily developed the identification skills for the two target weed species and skills in estimating cover percentage. The exercise successfully marshalled the students to conduct assessments efficiently. During the 2011 survey, an area of 0.6 hectares was mapped for two species concurrently over a two hour period. The 2013 survey demonstrated that the same activity can be conducted with a single surveyor per line of quadrats, 0.5 hectares was covered by 7 assessors over a 2 hour period.

Satisfaction with the exercise by students was generally high.

In 2011 the following comments were recorded in response to the question "In what way was this a satisfying or unsatisfying activity for you?"

- "It's satisfying in that it's not just toned down because I'm a student – it feels like actual helping"
- "It's unsatisfying – I feel I should be doing more of this in my course"
- "Getting to actually work for someone and generally good to be outside – exciting to be out instead of theory in the classroom."
- "It's satisfying in that I've never done this before and we were taken through the steps really well."
- "I had no idea -I thought one person would walk around and make an estimate, not this much detail."

In 2013, 7 feedback forms were received from NMIT students and teachers.

In answer to the questions "In what way was this a satisfying or unsatisfying activity for you?" and "Is there anything valuable you've learned from being here today?" 20 comments could be construed as positive or neutral and only one negative (about the weather!).

In relation to specific knowledge conveyed by the exercise;
6 nominated plant identification
4 identified survey technique
5 identified knowledge about weeds

Conclusion

From our results, aerial photograph interpretation of Nearmap™ photos appears to provide a reliable way to map different cover classes of unburnt Gorse infestations in native grasslands when coverage exceeds 16% and where the assessor has been 'trained' through a previous site visit.

Aerial interpretation is unable to reliably detect Gorse at lower densities, such as the fringes of infestations where seedling Gorse is establishing. Aerial photo interpretation should be teamed with a ground-based inspection to identify the extent of low density Gorse.

Supervised classes of first year students of Conservation and Land Management are capable of generating accurate data using a grid assessment of weed cover percentage of Gorse and Toowoomba Canary Grass. The exercise is a learning experience valued by these students and their tutors.

The mapping exercises allowed for a high level of confidence by MCMC in directing, and assessing the effect of, Gorse and Toowoomba Canary Grass treatment on the eastern perimeter at Kalkallo Common Grassland in 2011-2013.

Only one attempt to evaluate aerial interpretation was made. Several repetitions in different contexts would be needed to provide greater confidence in this result. Repetition and evaluation would also offer a means for increasing skill and reliability of this technique.

Two other approaches are currently used by MCMC to achieve confidence in eradication efforts: on ground mapping with a mud map or GPS, and reliance on patrolling without mapping. There were only minor differences in efficiency when these two approaches were compared with the two mapping approaches used in this trial. However, substantial differentials would be anticipated if a comparison were done with projects treating different species and at different scales. Significant non-monetary benefits and costs will also influence choice of approach.

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Appendices

Appendix 1. Data survey sheet

Gorse and Phalaris mapping, Kalkallo Common, June 2013

Survey data sheet

Line (circle) A B C D E F	Date:		Surveyors:	
Plot number	Live Gorse cover (%)	Dead Gorse cover (%)	Live Phalaris cover (%)	Dead Phalaris cover (%)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				

1. Record the date, and name of surveyors on your line and circle your line's letter.
2. Record the number of the plot as you move along the line.
3. Estimate the percentage cover of dead and live gorse and *Phalaris* in each plot.

Appendix 2 Gorse percentage cover as determined by Aerial Photo interpretation and ground survey

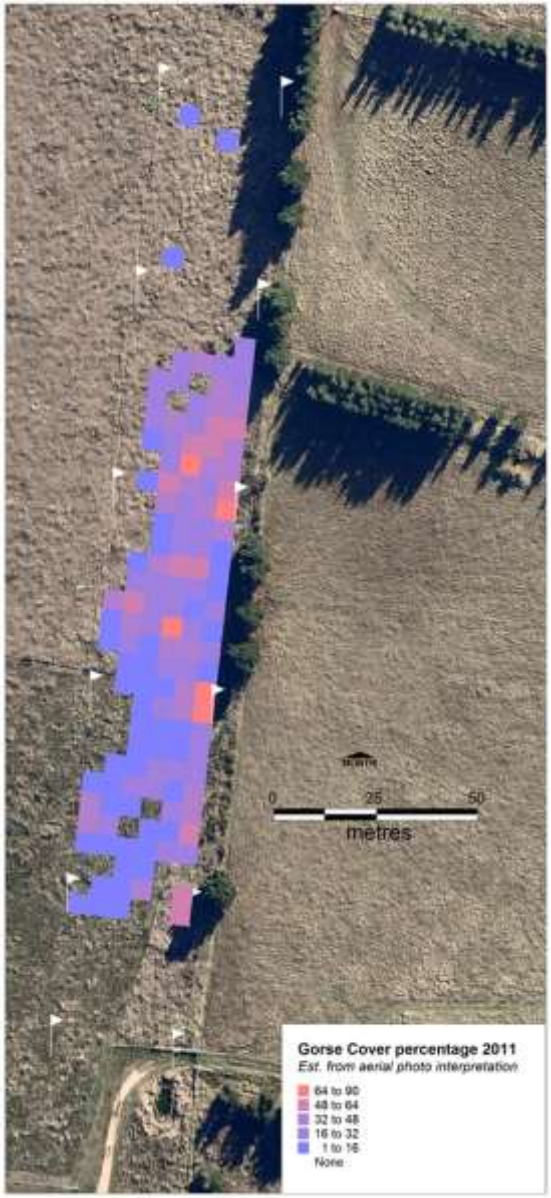

Figure 1 Estimate from Aerial photo interpretation of January 2011 aerial photo.

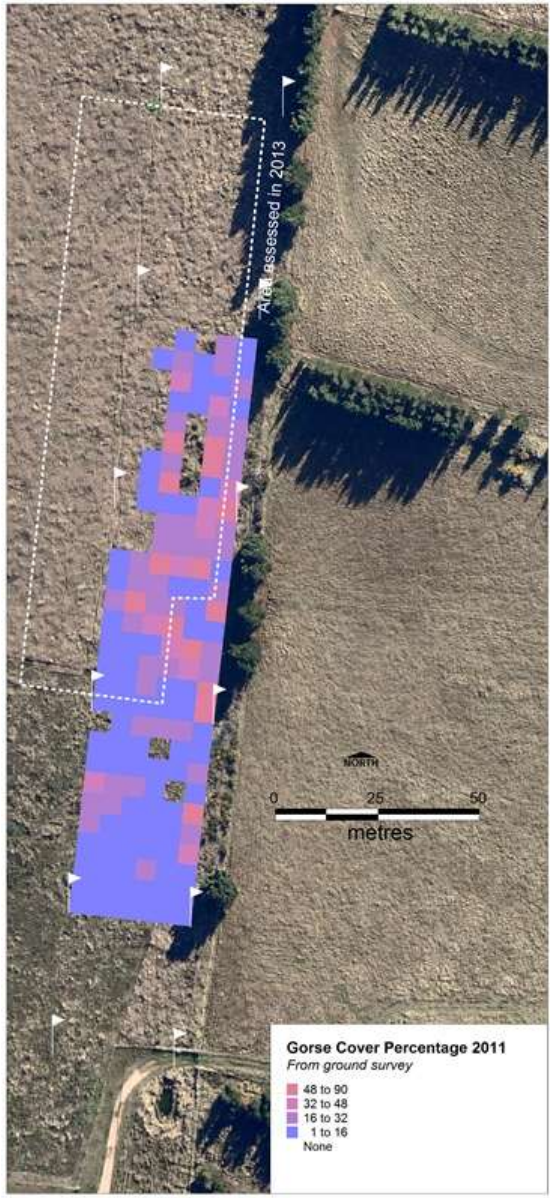

Figure 2 Cover from ground survey March 2011

Figure 3 Cover from ground survey June 2013

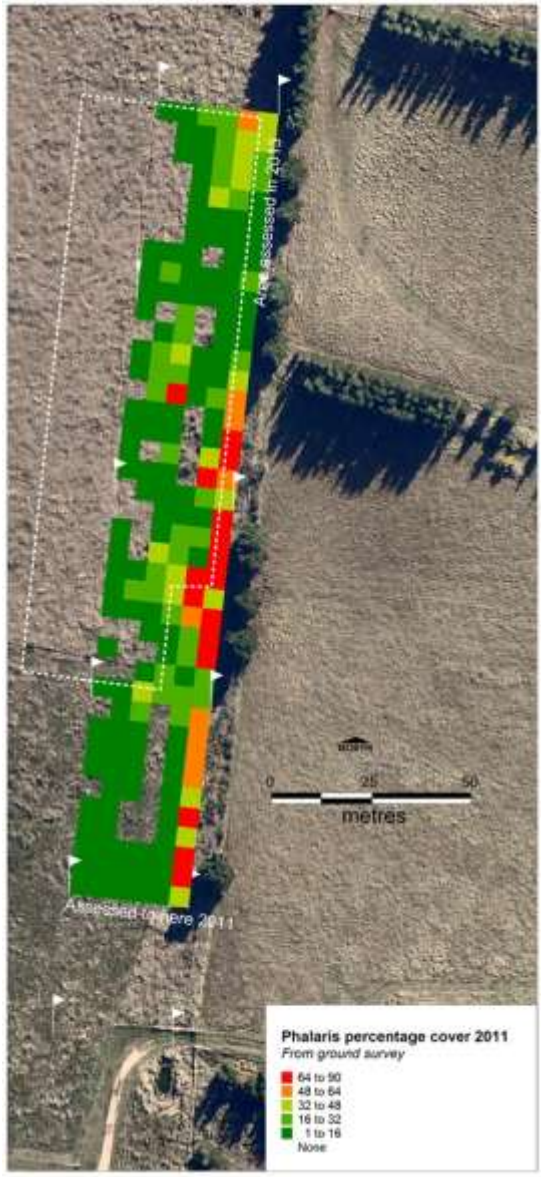

Figure 4 Percentage cover Toowoomba Canary Grass March 2011

Figure 5 Percentage Cover Toowoomba Canary Grass, June 2013

Appendix 3 Toowoomba Canary Grass percentage cover as determined by ground survey

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Appendix 4 Photographs

Pre-burn view of firebreak with heavy fuel load formed by Toowoomba Canary Grass and intermingled Gorse. Substantial clearing of Gorse had already taken place.

Ecological burn March 2012 showing extra fuel reduction that was carried out to provide insurance against flames entering canopies of windbreak trees.