Forest Audit Program: 2011-12 reporting period
Module 7 audit of coupe regeneration and finalisation

Report on the potential use of aerial photography in coupe regeneration and finalisation audits

June 22, 2012

Department of Sustainability and Environment

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1 Introduction

Sinclair Knight Merz (SKM) was commissioned by the Department of Sustainability and Environment (DSE) to conduct an audit of logging coupe regeneration and finalisation as part of its Forest Audit Program (FAP). This particular audit considers regeneration and finalisation activities for harvesting and thinning operations managed by VicForests in State forests in eastern Victoria. It applies audit tools from the FAP's Module 7 for coupe regeneration and finalisation [1].

The objective of the audit is to assess whether forest regeneration, thinning and coupe finalisation processes are appropriately conducted to achieve sustainable forest management and are managed in accordance with relevant legislation, regulations, policies and practice guidance, particularly the *Code of Practice for Timber Production* 2007 (the Code [2]) and *Native Forest Silviculture Guidelines* (NFSGs; numbers 10, 13 and 14 [3-5]). The audit is conducted as a statutory environmental audit under the auspices of the *Environment Protection Act 1970* (EP Act).

The overall audit project commissioned by DSE included four main components, one of which involved revising Module 7 of the FAP Toolbox and its associated work books [1]. Those revisions included:

- Inclusion of a review of VicForests own assessments of regeneration in logging coupes and residual stocking and damage in thinning coupes and its finalisation reporting to DSE. This assessment considers evidence of coupe regeneration and stocking adequacy in all thinning and regeneration coupes that were proposed for hand back to DSE and enables a high level assessment of the suitability for hand back of all coupes. A more detailed assessment on 10% of coupes was undertaken to confirm that VicForests reporting is consistent with the underpinning stocking and post-thinning survey data.
- Modification of the workbook used to assess compliance of with the Code in coupe regeneration and finalisation in harvesting coupes and in native forest thinning operations. This provided an improved set of audit criteria for regeneration coupes and adapted Code prescriptions to thinning coupes to enable Code compliance to be audited.
- Development of a field survey methodology to audit VicForests regeneration coupe stocking surveys. The intention was to develop a methodology to validate VicForests surveys, rather than re-survey the coupes and extend the audit coverage within the limited FAP resources.

The updated Module 7 process was trialled with coupes proposed by VicForests for handback in 2011-12 [7].

The overall audit project included a trial in the use of high resolution aerial photography in assessments of regeneration coupe stocking adequacy to determine if at least some elements of the field auditing of regeneration coupes may be replaced by remote sensing analysis. The trial, which is reported here, was undertaken to determine whether it was possible to make further economies in the field auditing component and avoid unnecessary (and often physically challenging) ground-based surveys of well-stocked coupes.

2 Methodology

2.1 General approach

Aerial imagery for this trial was sourced from VicMap's Coordinated Imagery Program. Two sets of aerial photography were selected:

- 15 cm resolution imagery for State forest areas in Central FMA. The imagery was acquired in 2009 and used to assess stocking in two coupes that had been regenerated in 2007;
- 50 cm resolution imagery that covered large areas of State forest in East Gippsland FMA. This imagery was acquired in 2010 and was used to assess coupes that were regenerated in 2005 (2 coupes), 2007 (two coupes) and 2008 (1 coupe).

The first step was to set up a consistent sampling approach that would replicate the standard established seedling survey (ESS) approach for regeneration coupes described in NFSG #10 [3]. The approach established an 80×20 m grid (the basis of standard ESSs) across the entire state of Victoria. It then located 2.27 m radius sampling plots at each grid point (as per the 4 mill-acre plots used in ESSs). A GIS tool ('Generate sample locations') was developed for this purpose (see below).

The second step involved assessing whether sampling points located within target coupes were 'stocked' with eucalypt regrowth and summarising the survey results. A second GIS tool ('Summarise sample results') was developed to process the survey results (see below).

The assessment was undertaken by a remote sensing analyst, following 'training' by a member of the field audit team. Several rounds of review and reassessment were undertaken to ensure the accuracy of the assessment.

It was originally proposed that this trial would investigate the use of both high resolution multispectral (MS) satellite imagery and aerial photography. Eight band Multispectral WorldView2 imagery was ordered for an approximately 100 km^2 area of native forest containing some of the coupes included in the field audit component of the project. However, due to persistent cloud cover in the target area and competition for the use of the satellite, no suitable imagery could be obtained within the available timeframe.

2.2 GIS tools

Two new GIS tools were designed and developed for this trial using Python 2.6 for ArcGIS 10, namely:

- Generate sample locations – the objective of this script was to generate a consistent 80×20 m sampling grid for the entire state of Victoria, with a single numbering system. The grid is in the GDA 94 VicGrid coordinate system. The origin is the north-west corner of Victoria and set at 2,259,400E-2,827,200N. The columns progress in an easterly direction and are spaced 80 m apart. The rows progress in a southerly direction and are spaced 20 m apart. Each grid point is assigned a unique code based on the column and row. To reduce the number of unnecessary points being assessed, only locations which are within the defined gross coupe boundary[1] are presented to the operator.

  Sampling plots are established at each grid point. A circle with 2.27 m radius is created around the sample point by the script. The radius can be adjusted by the operator.

- Summarise sample results – once the assessment of sample locations is complete for a particular coupe, this script is run to determine whether the coupe meeting NFSG #10 [3] standards for coupe stocking, namely at least 65% of productive sample plots in the harvest area are stocked and that there must be no

[1] The coupe boundary used initially in harvest planning. The area actually harvested is reduced from this area (often significantly so) as a result of the application of forest management zoning and Code and other prescriptions.

more than 1 contiguous hectare of unstocked plots within the coupe. The initial assessment of the imagery confirmed that it would not be possible to assess against the requirement that the regeneration coupe retain at least 10 individuals of the species present pre-harvest.

The 1 ha requirement was assessed on the basis of there being no more than six adjacent unstocked plots (plots that shared a common boundary) within the coupe. The user can modify the target area for unstocked plots, for example if an uneven-aged coupe was to be audited (2 ha is the standard maximum unstocked area).

3 Application of the methodology

3.1 Assessment process

A series of images are reproduced below to illustrate how the methodology was applied in the seven coupes included in this trial.

Assessing regrowth in the harvested area

In the following image (Figure 1), the 80×20 m sampling grid was established over a logging coupe. Plots were assessed to be stocked if regrowth was observed within the 2.27 m radius circle. Image resolution was adjusted, where necessary, to ensure an accurate assessment. Plots assessed as stocked were coded 'Y' and their borders are coloured green.

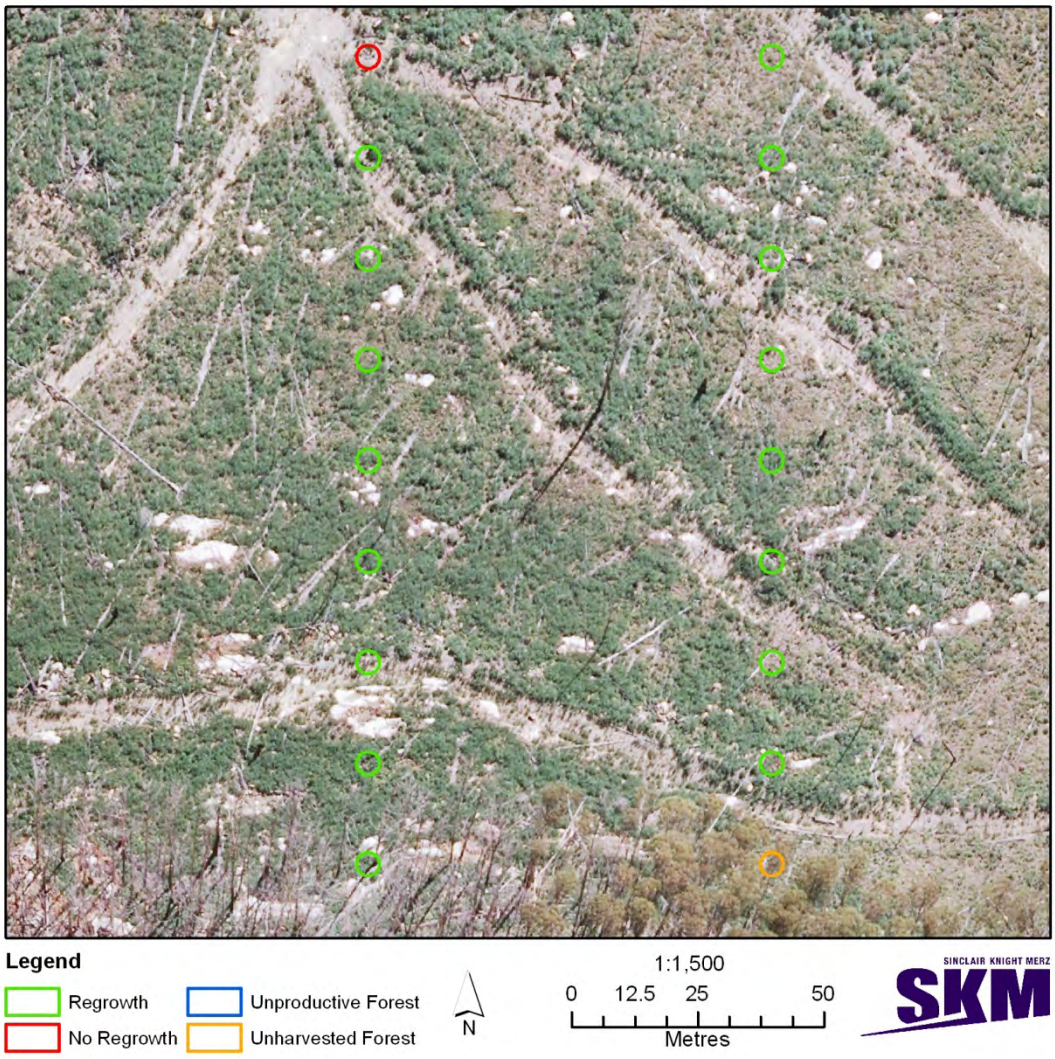

Figure 1 Identifying regrowth in a harvested coupe: 2009-15 cm resolution aerial photography for a coupe regenerated in 2007.

Unstocked plots

Figure 2 shows a series of plots in which regrowth is not present. Such plots are coded 'N' and their borders coloured red. The second plot from the top in this image includes shadows from nearby plants, but was assessed to be unstocked.

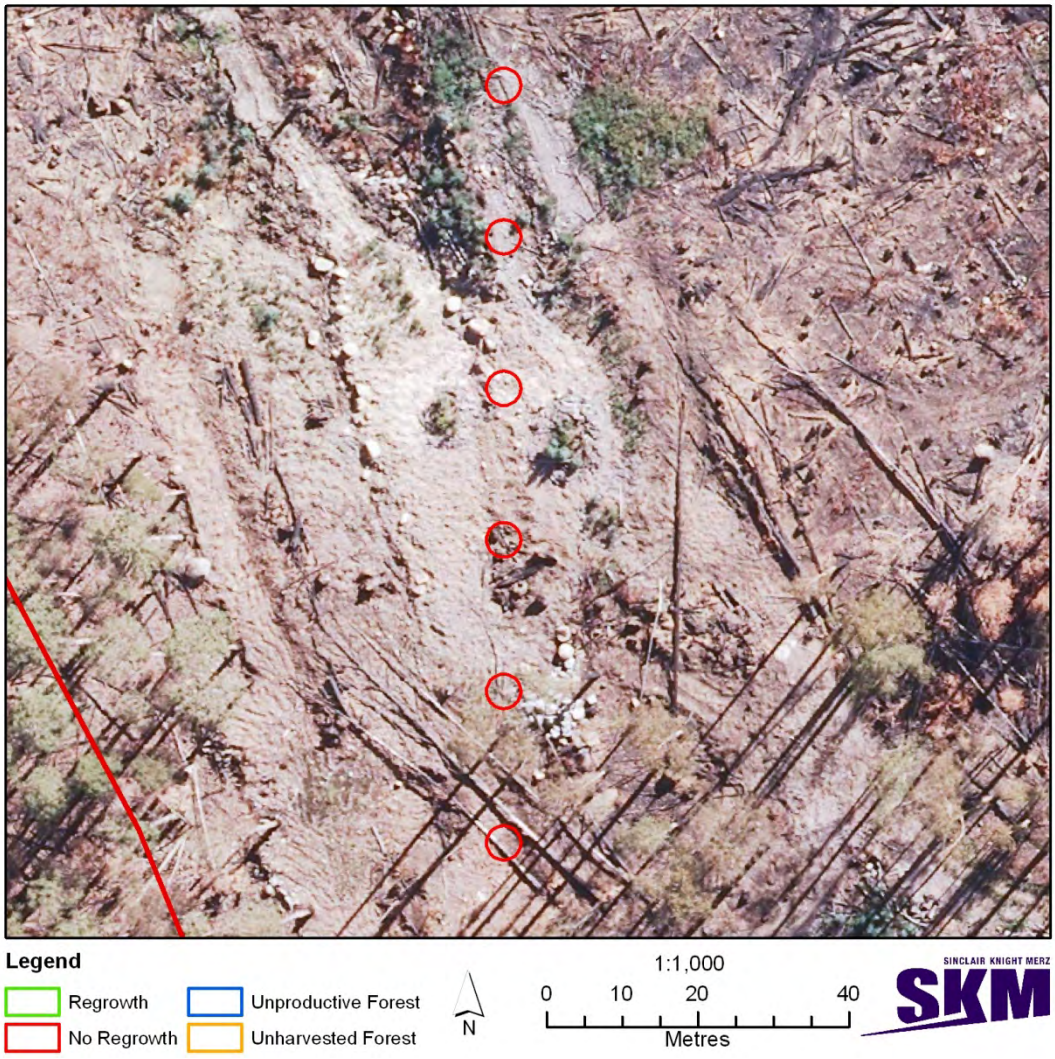

Figure 2 Identification of unstocked plots: 2009-15 cm resolution aerial photography for a coupe regenerated in 2007.

Actual harvest coupe boundary

The script uses the polygon for the gross coupe boundary to clip the sampling grid. However, the area actually harvested and regenerated is often significantly smaller. Sampling points that are located within unharvested forest are coded 'Z' and appear as dark yellow (Figure 3).

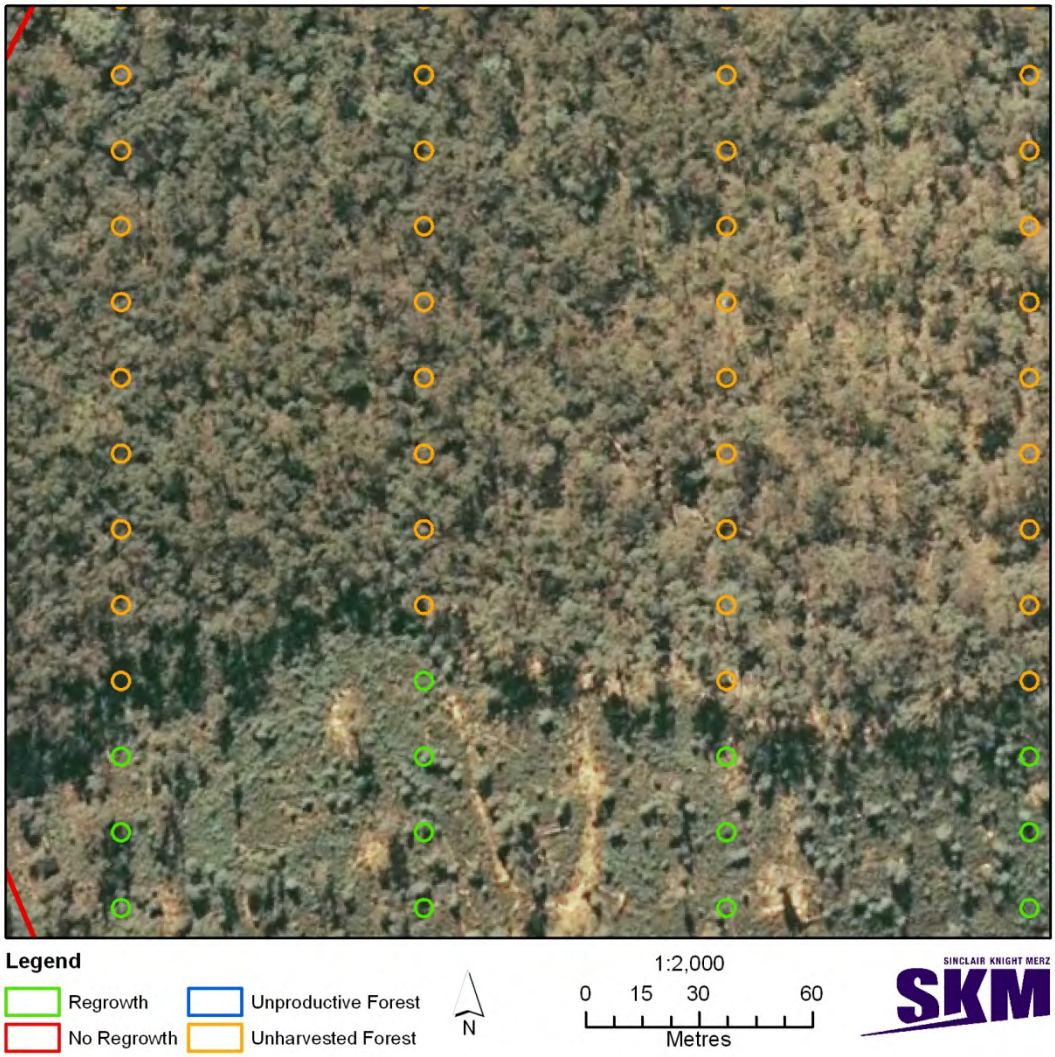

Figure 3 Assessment of unharvested areas within gross coupe boundary: 2010-50 cm imagery for a coupe regenerated in 2007.

Unproductive plots

Areas within the coupe that are unproductive and cannot be expected to regenerate can be identified using the imagery (Figure 4). Such coupes are coded 'Q' and plotted in blue. In Figure 4, the blue plot is unproductive due to the presence of granite rock at the surface.

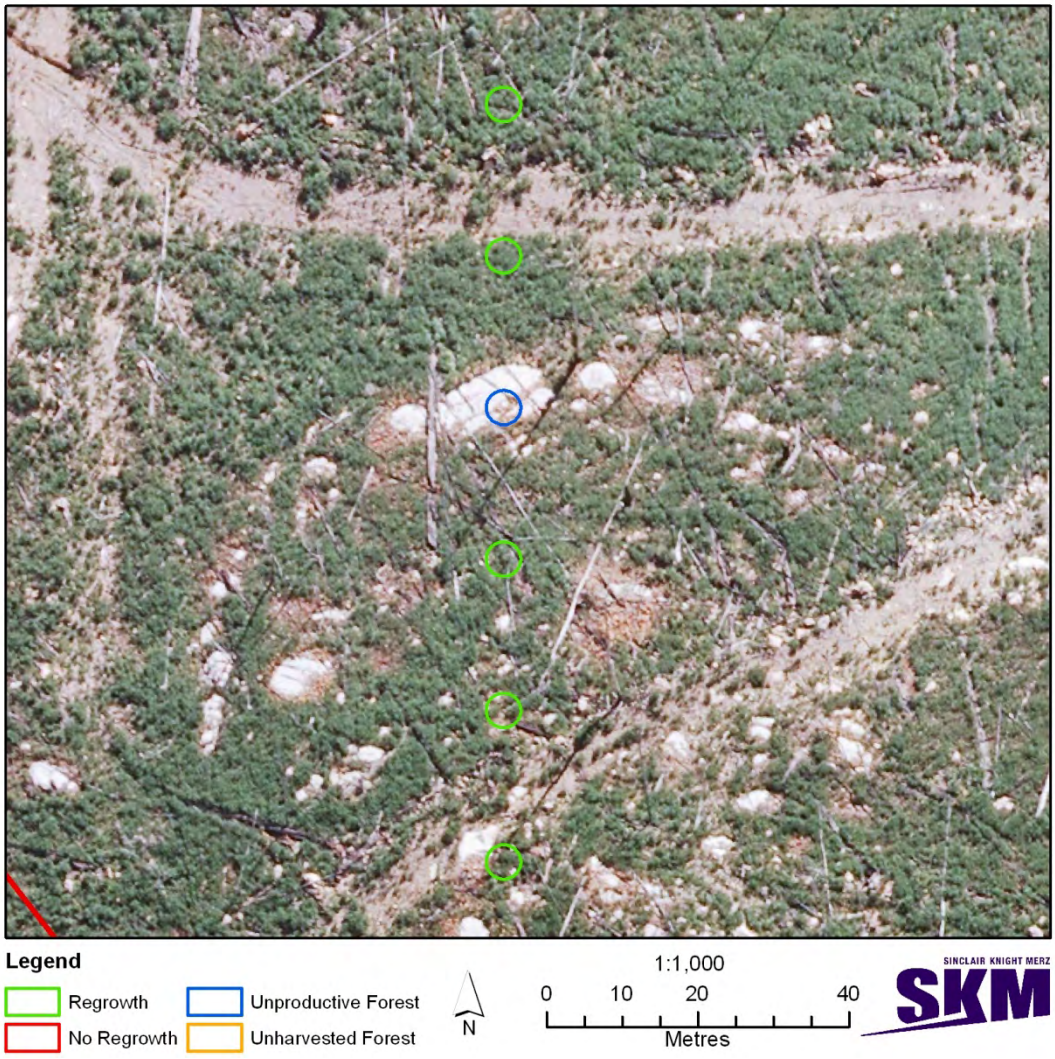

Figure 4 Unproductive plots in a regenerating coupe: 2009-15 cm imagery for a coupe regenerated in 2007.

Completed coupe assessment

An example of a completed coupe assessment is given in Figure 5. This example shows two adjacent coupes, only one of which was assessed. The red boundary is the original gross coupe boundary. The actual net, harvested coupe boundary is somewhat different. The coupe includes 11 unstocked, productive plots (red) and one unproductive plot (blue). The remaining plots were either stocked (green) or not located in the harvest area (dark yellow).

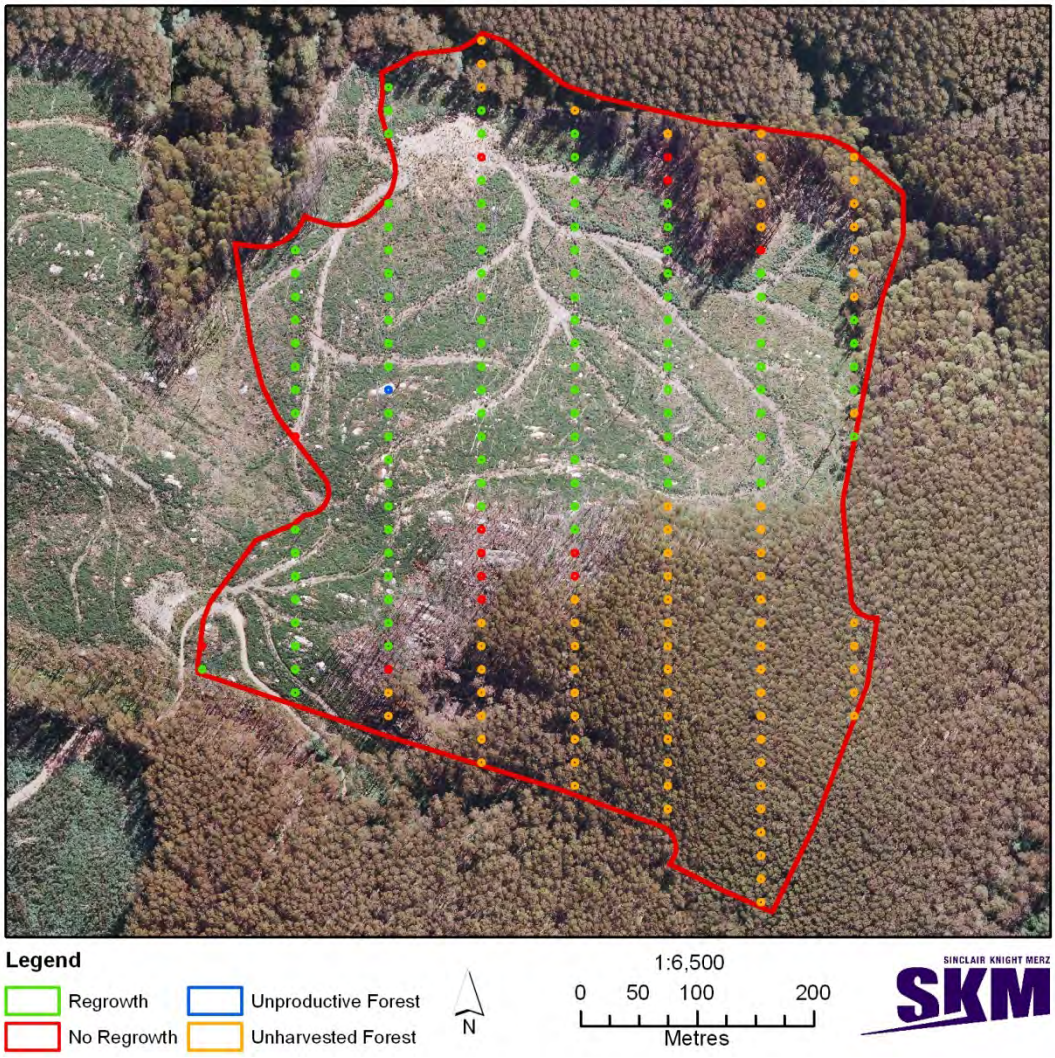

Figure 5 Completed coupe assessment: 2009-15 cm imagery for a coupe regenerated in 2007.

Identify contiguous unstocked areas

The centres of the sampling plots are the centre points 80×20 metres grids. A script is run to identify locations where unstocked, productive plots are adjacent to each other (Figure 6). At most, only six contiguous cells were identified, so in this case the coupe does not have any unstocked areas exceeding 1 ha.

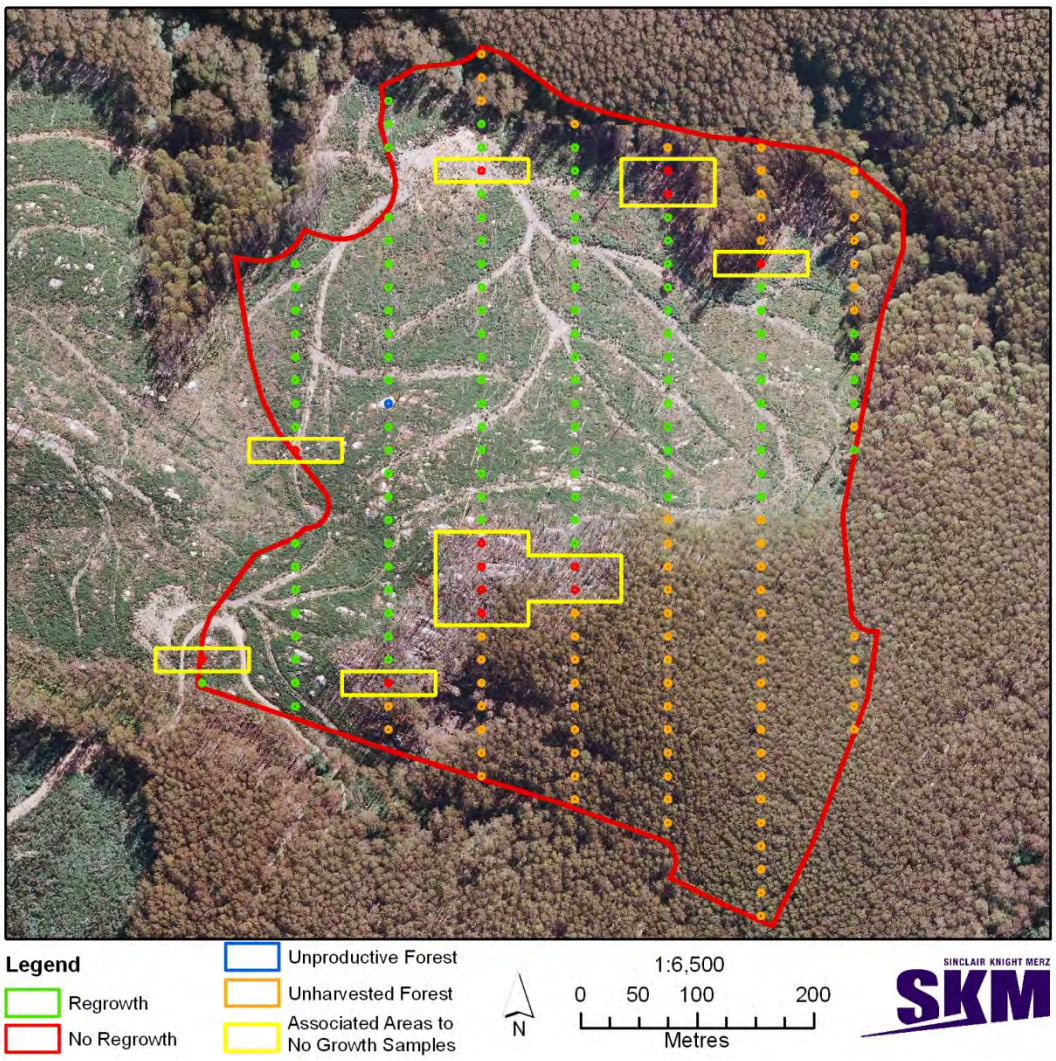

Figure 6 Identification of adjacent unstocked plots: 2009-15 cm imagery for a coupe regenerated in 2007

Statistical assessment

The 'summarise sample results' script is run to report on the number of plots in each state, namely:

- Regrowth in harvested area (stocked);
- No regrowth in potential productive plot within harvest area (unstocked);
- Unharvested area;
- Unregenerated, but unproductive area (unproductive);

Equation 1 is used to determine the percentage of unstocked plots in productive areas with the harvested part of the coupe.

$$\%\ with\ no\ regrowth = \frac{\sum(Sample\ with\ No\ regrowth)}{\sum(Sample\ with\ No\ regrowth)+\sum(Sample\ with\ Regrowth)} \quad (1)$$

If the percentage of unstocked plots (i.e. with no regrowth) is greater than 35% (i.e. coupe stocking is less than 65%), then the coupe is considered not to have been successfully regenerated.

The script also generates summary statistics about the assessment, as follows:

- Number of plots of each of the four categories (above)
- The percentage of plots with no regrowth (unstocked)
- Pass or fail on the requirement that there be no more than 6 adjacent unstocked plots (i.e. no more than 1 ha unstocked).

These output statistics are saved into a text file for later reference.

3.2 Trial results

Results of this trial into the use of aerial photography as a coupe regeneration auditing tool are summarised in Figure 7**Error! Reference source not found.**. The aerial stocking survey generally gave a higher average coupe stocking value than both the full VicForests survey and the field assessment undertaken as part of the FAP audit of coupe regeneration and finalisation. In four of the seven coupes included in the assessment, the VicForests survey results were within the 90% confidence intervals of the average for the aerial stocking survey.

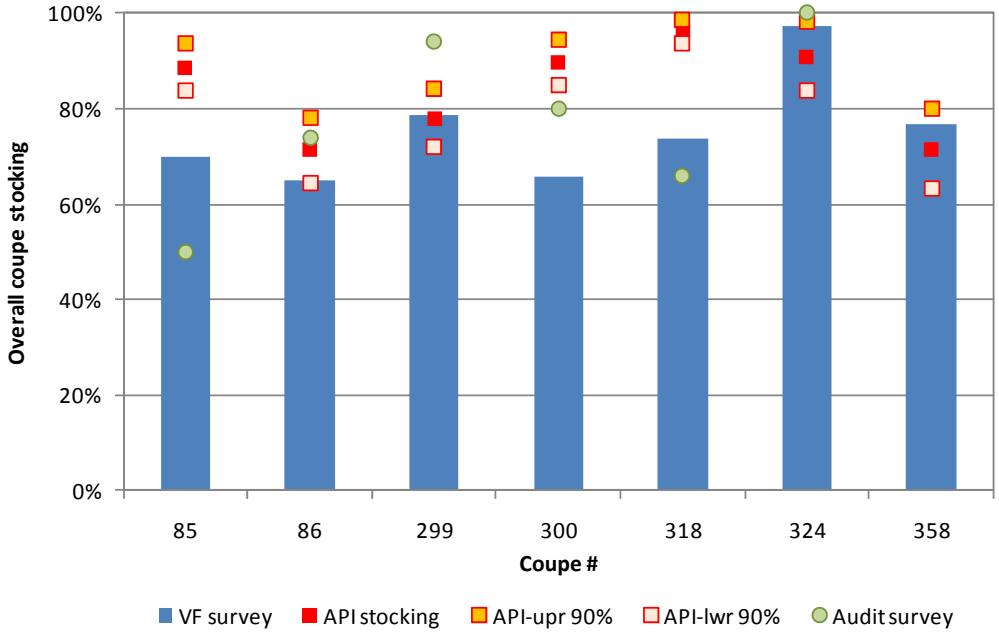

Figure 7 Results of trial into the use of aerial photography as a coupe regeneration auditing tool. Graph shows results from VicForests' coupe stocking assessments (VF survey), the survey conducted as part of the audit of coupe regeneration and finalisation (Audit survey) and the outcomes of this assessment (API stocking). Confidence intervals were calculated using the formula for calculating confidence intervals for stocking surveys in NFSG #10. No audit survey was conducted for coupe 358.

Two of the coupes were identified as having unstocked areas greater than 1 ha (086 and 358). One of these (coupe 086) was identified to have an unstocked area greater than 1 ha in the VicForests survey (and audit field assessment).

Coupe 085

This coupe is located in Central FMA and was regenerated in 2007. The 15 cm resolution aerial photography (Figure 8) was captured in 2009. Overall, 71% of plots were assessed to be stocked, compared with 70% in the VicForests survey and 50% in the audit field assessment. The low stocking result from the audit field assessment reflected a concentration of sampling points in the vicinity of the poorly stocked area highlighted in Figure 8.

No unstocked areas greater than 1 ha were identified with the sampling grid used, however the cluster of unstocked plots towards the southern boundary of the harvested coupe marks the area identified by the VicForests survey as being unstocked.

This coupe had a dense cover of wattle regrowth, which could not be distinguished in the aerial photograph from eucalypt regrowth. This may have contributed to overall coupe stocking being overestimated. Despite this, the aerial survey did identify the same poorly stocked area as identified in the ground-based surveys.

The initial gross boundary for coupe 085 did not align well with the actual harvested area.

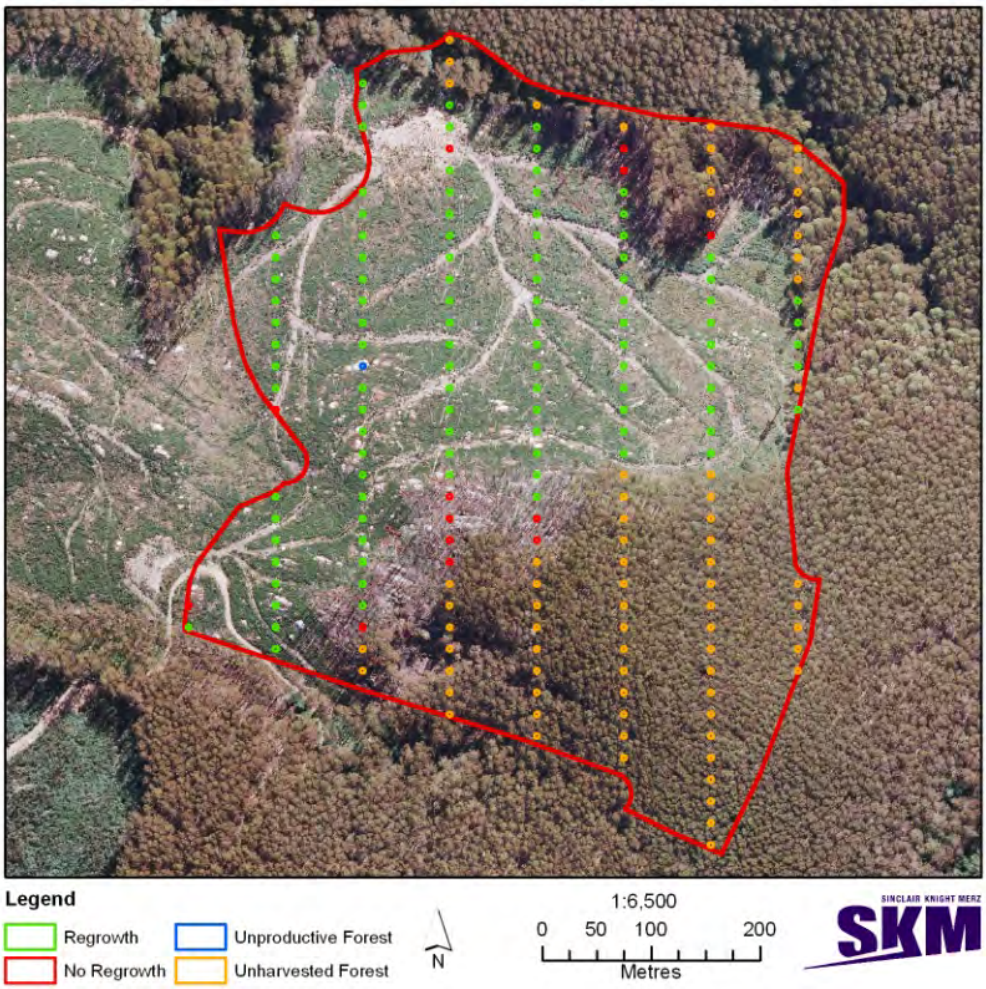

Figure 8 Aerial stocking survey for coupe 085

Coupe 086

This coupe is also located in Central FMA and, like coupe 085, was regenerated in 2007. The 15 cm resolution aerial photography (Figure 9) was captured in 2009. Overall, 89% of plots were assessed to be stocked, compared with 65% in the VicForests survey and 74% in the audit field assessment.

The aerial survey identified two unstocked areas greater than 1 ha, one along the coupe's northern boundary, with the other extending into the coupe from the western boundary. These areas were identified in the VicForests survey as being poorly stocked, but with their sampling grid the there were not more than 6 adjacent unstocked sampling points.

Alignment of the initial gross coupe boundary and the actual harvested area was better than for coupe 085.

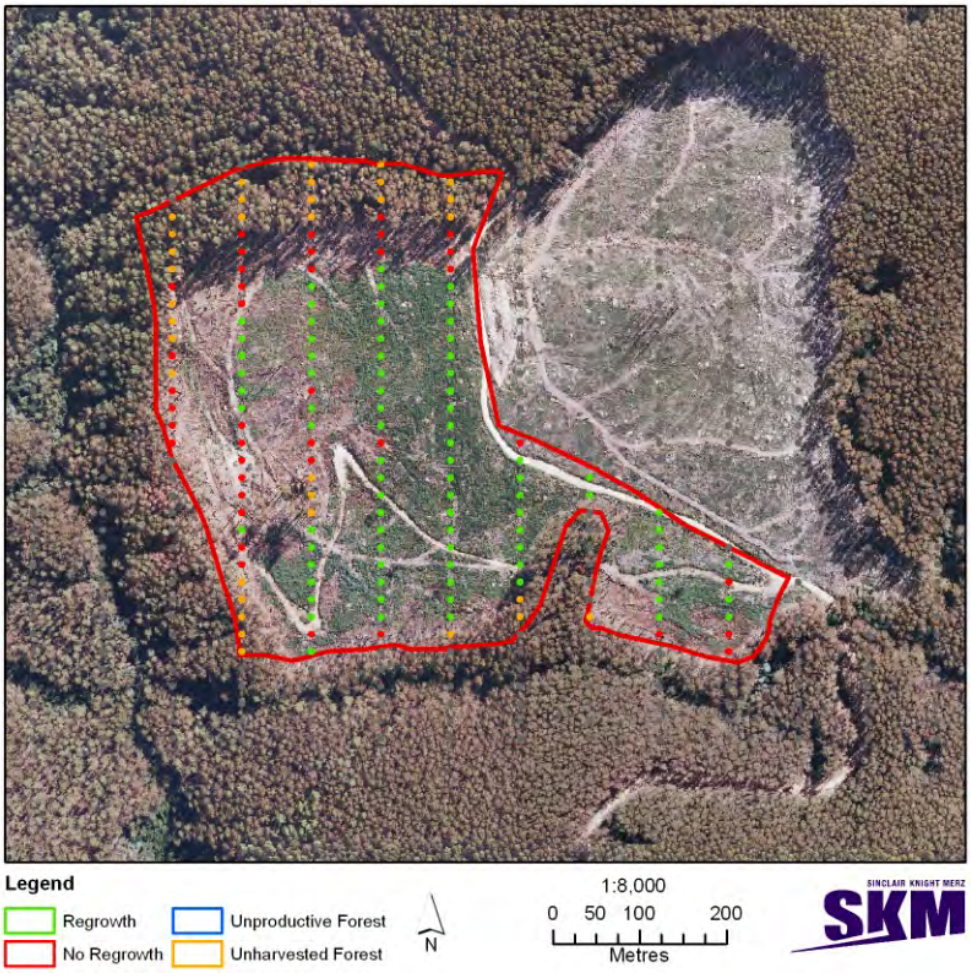

Figure 9 Aerial stocking survey for coupe 086

Coupe 299

This coupe is located in East Gippsland FMA and was regenerated in 2007. The 50 cm resolution aerial photography (Figure 10) was captured in 2010. Overall, 78% of plots were assessed to be stocked, compared with 79% in the VicForests survey and 94% in the audit field assessment. None of the surveys identified unstocked areas greater than 1 ha.

The resolution of the imagery would not allow plots that were stocked with non-eucalypts to be differentiated from those that were stocked with eucalypts. The resolution was adequate to assess stocking, but only marginally so.

Alignment of the initial gross coupe boundary and the actual harvested area was good.

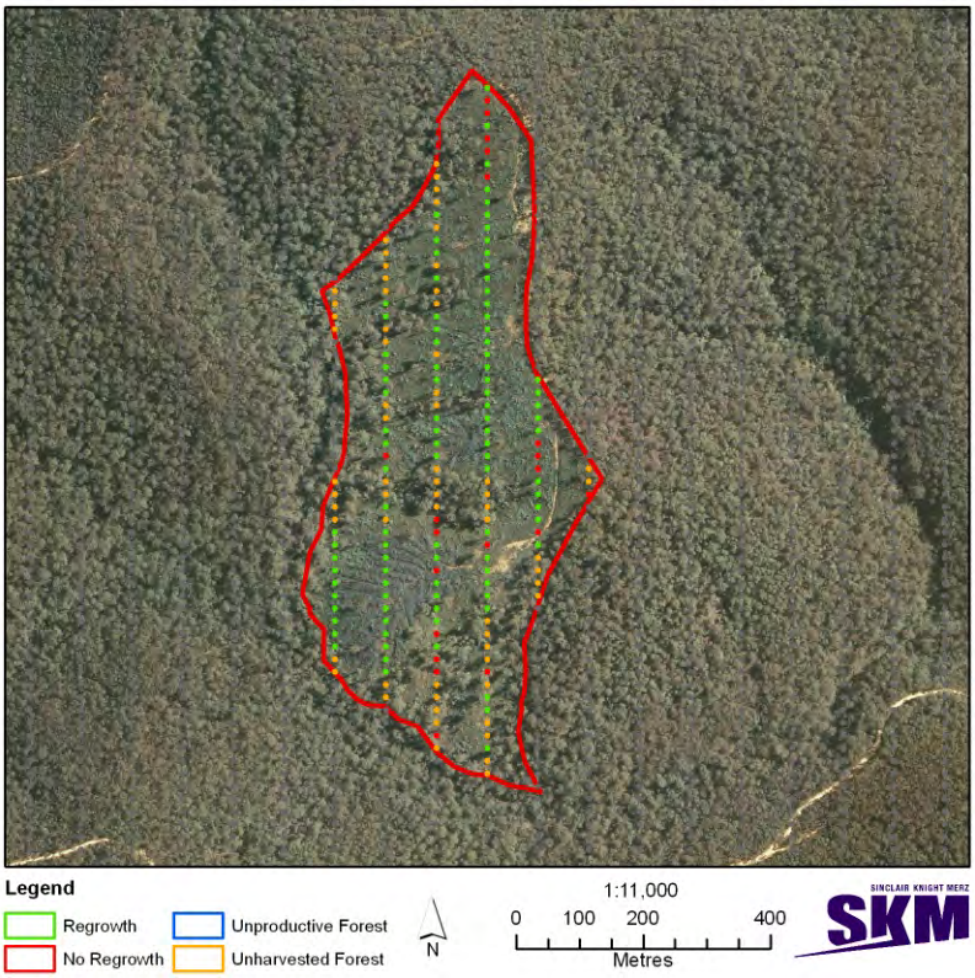

Figure 10 Aerial stocking survey for coupe 299.

Coupe 300

This coupe is located in East Gippsland FMA and was regenerated in 2005. The 50 cm resolution aerial photography (Figure 11) was captured in 2010. Overall, 90% of plots were assessed to be stocked, compared with 66% in the VicForests survey and 80% in the audit field assessment. None of the surveys identified unstocked areas greater than 1 ha.

Alignment of the initial gross coupe boundary and the actual harvested area was reasonable.

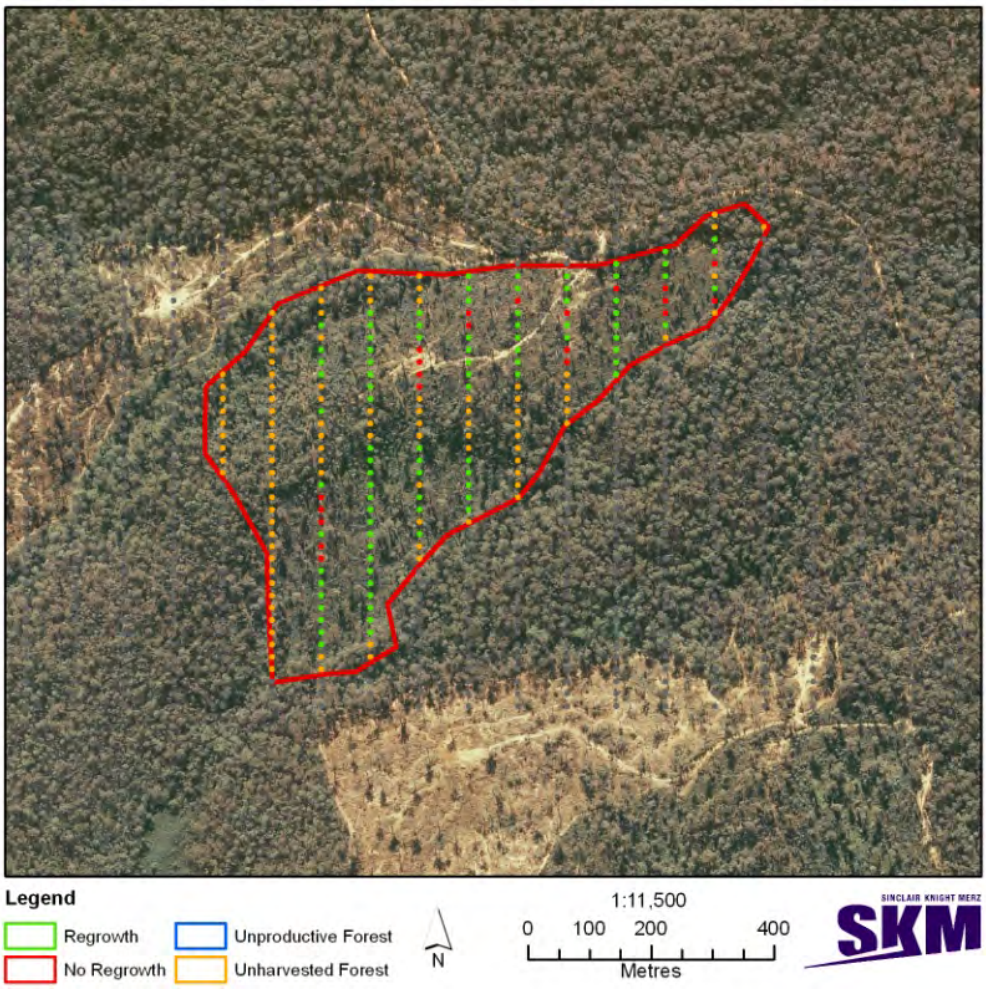

Figure 11 Aerial stocking survey for coupe 300.

Coupe 318

This coupe is located in East Gippsland FMA and was also regenerated in 2005. The 50 cm resolution aerial photography (Figure 12) was captured in 2010. Overall, 96% of plots in the harvested area were assessed to be stocked, compared with 74% in the VicForests survey and 66% in the audit field assessment. Unstocked plots in the aerial survey were associated with landings and access roads.

None of the surveys identified unstocked areas greater than 1 ha. At the time of the aerial photography, the landing in the centre of the coupe did not appear to have been regenerated successfully.

Alignment of the initial gross coupe boundary and the actual harvested area was poor.

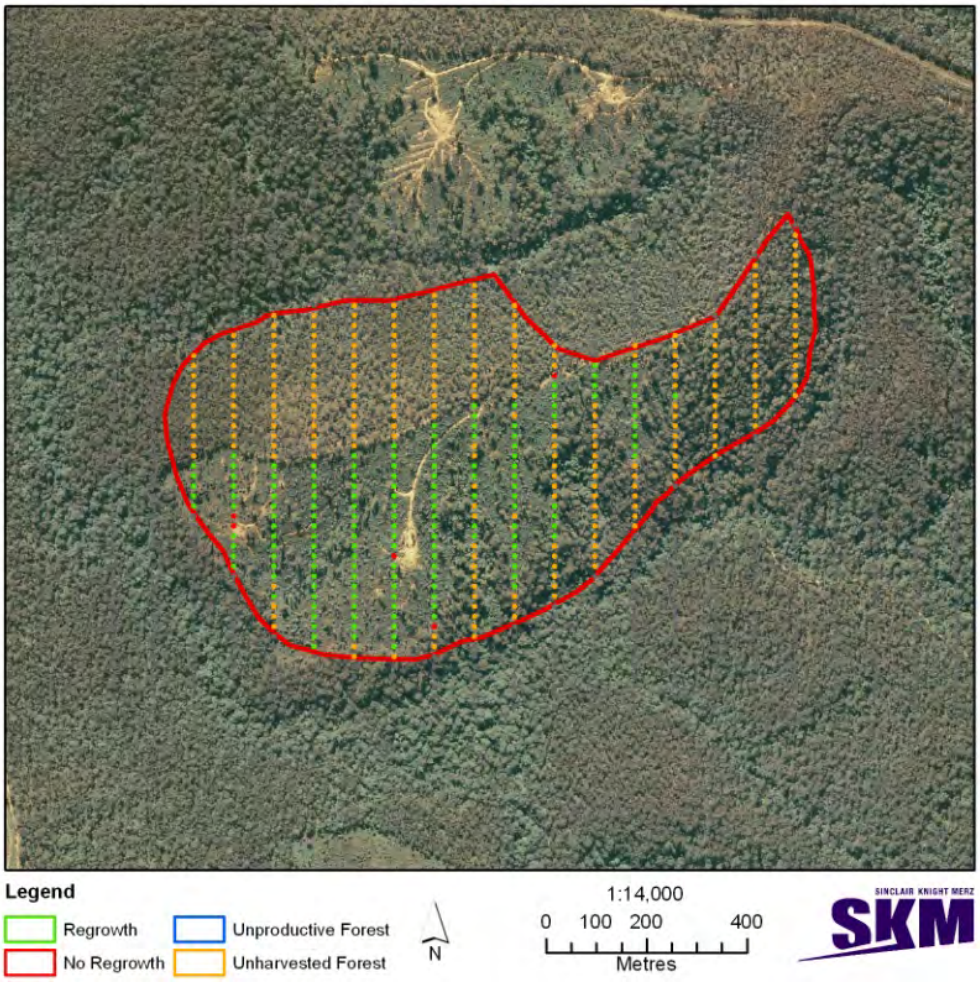

Figure 12 Aerial stocking survey for coupe 318.

Coupe 324

This coupe is located in East Gippsland FMA and was regenerated in 2007. The 50 cm resolution aerial photography (Figure 13) was captured in 2010. Overall, 91% of plots in the harvested area were assessed to be stocked, compared with 97% in the VicForests survey and 100% in the audit field assessment. The main unstocked area in the aerial survey was associated with a log landing.

None of the surveys identified unstocked areas greater than 1 ha.

Alignment of the initial gross coupe boundary and the actual harvested area was poor in this case.

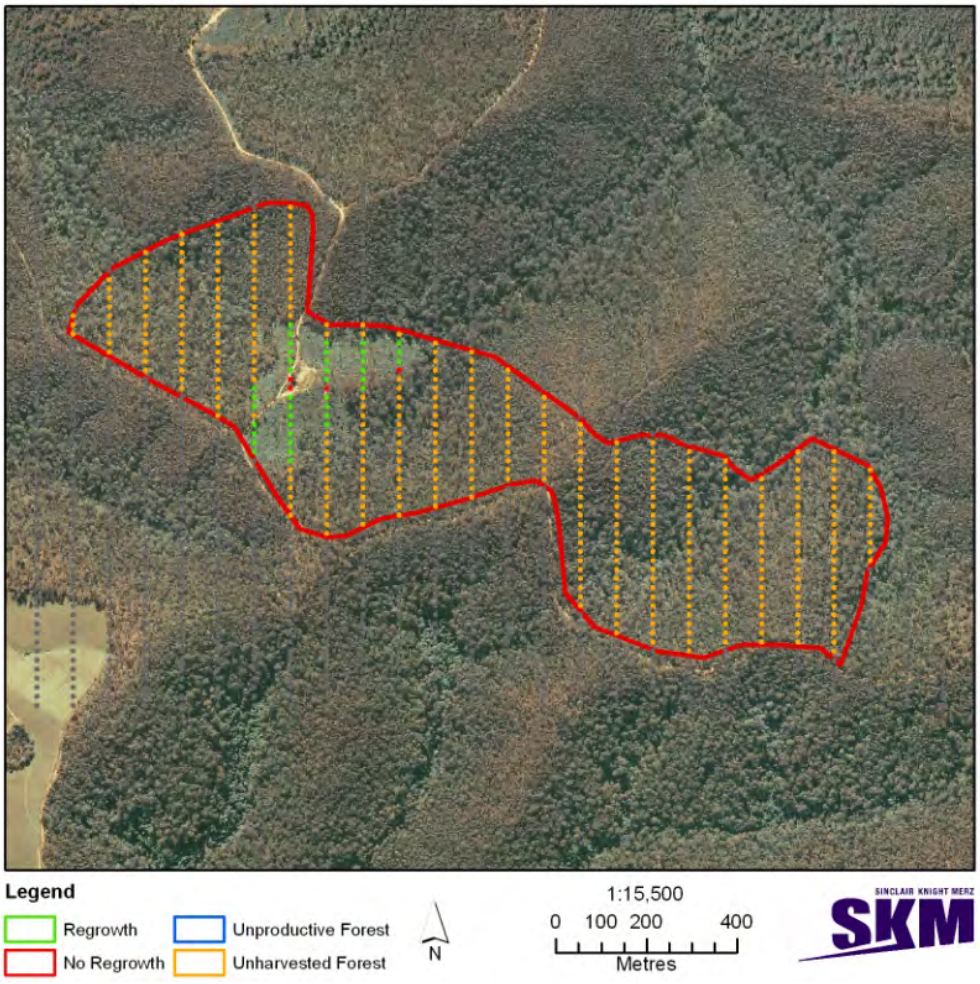

Figure 13 Aerial stocking survey for coupe 324.

Coupe 358

This coupe is located in East Gippsland FMA and was regenerated in 2008, making it the 'youngest' coupe to be included in the survey. The 50 cm resolution aerial photography (Figure 14) was captured in 2010. Overall, 72% of plots in the harvested area were assessed to be stocked, compared with 77% in the VicForests survey. This coupe was not included in the audit field assessment. None of the surveys identified unstocked areas greater than 1 ha.

Alignment of the initial gross coupe boundary and the actual harvested area was also poor in this case.

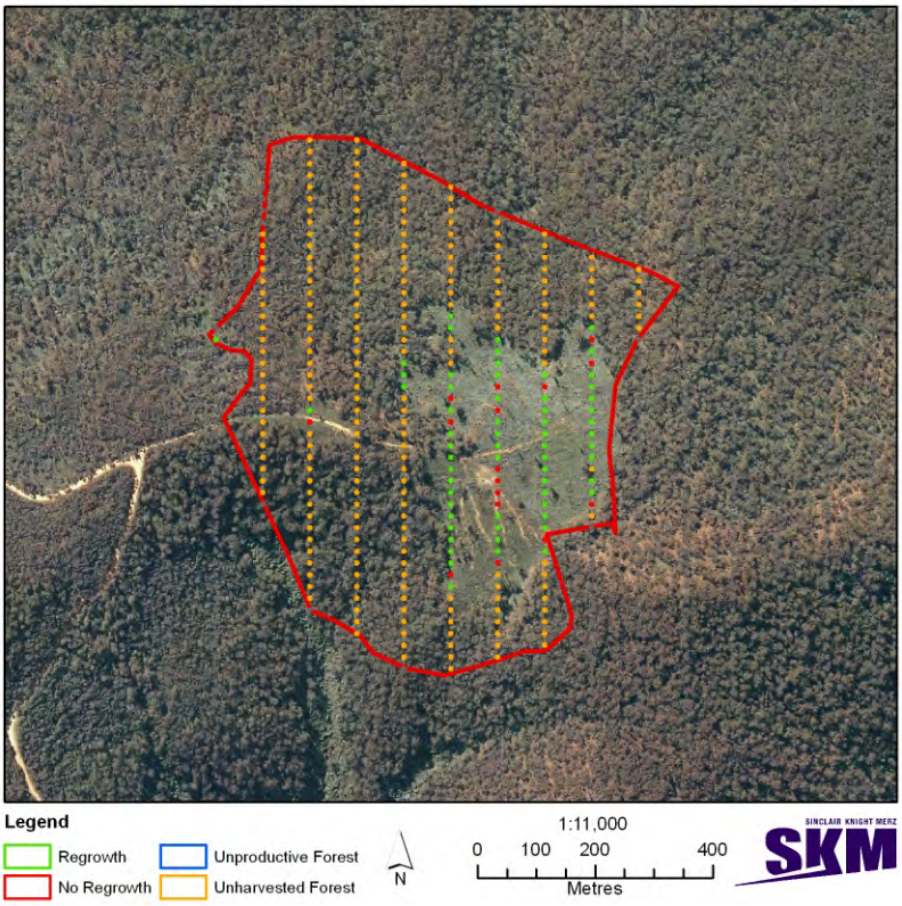

Figure 14 Aerial stocking survey for coupe 358.

4 Discussion

4.1 Image resolution

The trial enabled an assessment of two different levels of imagery resolution. The 15 cm resolution imagery was significantly easier to interpret and allowed more detailed analysis than the 50 cm resolution imagery (Figure 15 and Figure 16).It provided greater confidence in assessments that sampling plots were either stocked or unstocked. It also enabled unproductive areas (e.g. because of rock outcrop) to be identified, which would not have been the case for 50 cm imagery. The higher resolution imagery also provided a superior view below the canopy of seed or habitat trees that were retained within the coupe.

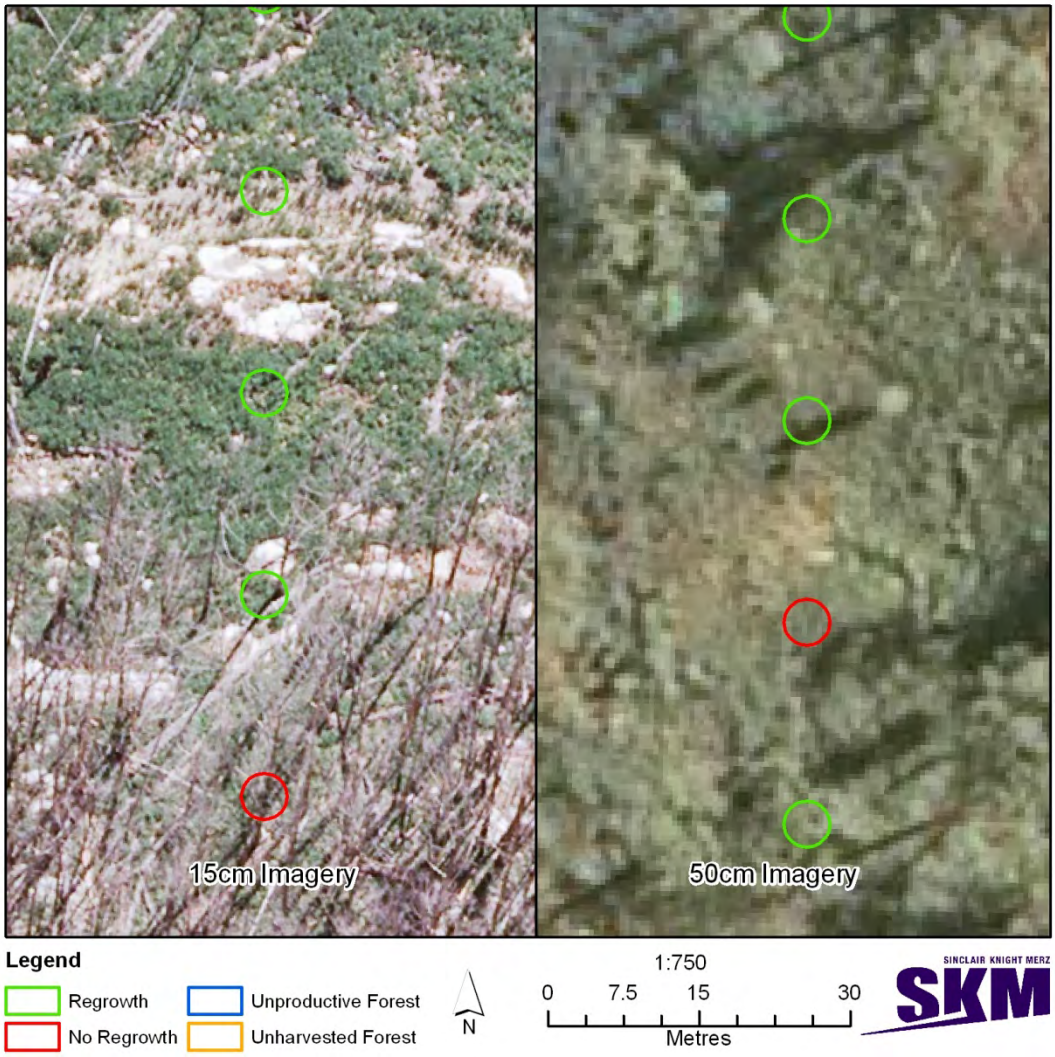

Figure 15 Comparison of 15 cm and 50 cm resolution imagery at the 1:750 scale.

The limit of resolution for the 50 cm imagery was reached at about 1:750 scale, whereas the 15 cm imagery was still interpretable at 1:250 scale (Figure 15 and Figure 16). Unfortunately even the higher resolution imagery could not distinguish between eucalypt regrowth and that of wattles or other shrub or tree species.

Figure 16 Comparison of 15 cm and 50 cm resolution imagery at the 1:250 scale

4.2 Time since regeneration

The trial included coupes that were regenerated between two and five years prior to the imagery being acquired. Both images for the 15 cm resolution imagery were acquired for coupes that had only been regenerated for two years. Regrowth of that age was adequate for assessment with that scale of imagery. Aerial photography with 50 cm resolution was trialled on coupes that had been regenerated for 2, 3 or 5 years. While an assessment on two year old regrowth, confidence was relatively low. For this scale of imagery, particularly on slower growing coupes in East Gippsland, a minimum of three years would be required, post-regeneration, before an aerial survey was undertaken.

It might be expected that allowing additional since regeneration before conducting a ground or aerial survey would lead to high levels of overall coupe stocking. This is hypothesised on the basis of slow to regenerate areas gradually increasing in stocking over time.

The trial (Figure 17) supports this hypothesis, at least up to about 5 years post-regeneration. For at least the VicForests and aerial surveys, there is a broad trend for stocking to increase with time to about 5 years. It is unclear if the lower stocking levels identified after 5 years is a sampling artefact or evidence of reductions in stocking after that time.

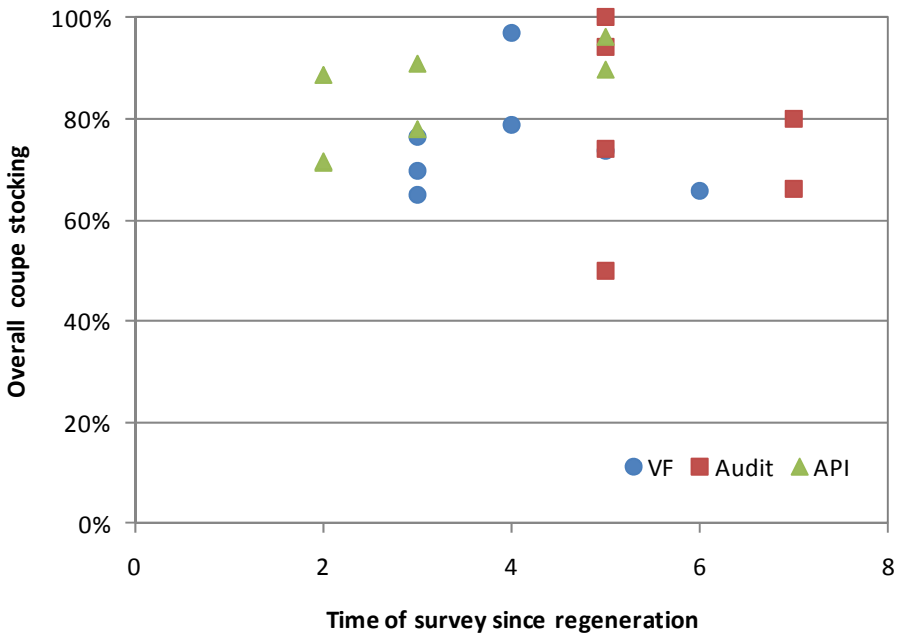

Figure 17 Plot of overall coupe stocking with time of survey since regeneration for three stocking survey methods: VicForests survey, following NFSG #10 (VF); Audit survey, following Module 7 (Audit) and aerial survey based on a 80×20 m grid (API)

4.3 Evaluation of the use of aerial survey techniques in regeneration coupe auditing

Even the high resolution aerial photography used in this trial would not be suitable as a replacement for ground-based surveys to assess whether stocking meets standards set in NFSG #10. Colour photography with 15 cm resolution does not enable the interpreter to distinguish between eucalypt and non-eucalypt (especially Acacia) regrowth or between eucalypt species. It would therefore not be possible to assess whether plots stocked with regrowth were actually stocked with acceptable eucalypt seedlings or whether the species present in the stand prior to harvest were present in the regenerating stand. While aerial photography, particularly at 15 cm resolution, is very useful in identifying areas with no regrowth, it would classify unstocked wattle thickets as stocked.

Aerial surveys also assess stocking on a slightly different basis to NFSG #10. A stocked plot must have the stem of an acceptable seedling within 2.27 m of the plot centre. Since the aerial survey sees only the crown of regenerating plants, a plot is assessed as stocked if part of the crown of a seedling is present. This might contribute to a slight overestimation of the actual stocking rate.

While aerial surveys (of the type considered here) cannot replace VicForests' current ground-based survey program, they may have a role in providing the evidence base for audits of coupe regeneration and finalisation. Where there is already evidence from ground-based surveys of acceptable stocking with eucalypt seedlings, aerial survey could be used as a check on stocking and the presence of unstocked areas larger than 1 ha. It would need to be supplemented by (limited and rapid) ground-based assessments of regrowth composition, which could be undertaken when assessing field-based audit criteria to assess compliance with the Code.

If aerial photography is already available, taken at least two years post-regeneration and of suitable resolution (i.e. at least 15 cm), it provides a low cost and rapid assessment tool to support auditing of coupe regeneration. Once the imagery is acquired and incorporated into the GIS work environment, it is possible with the scripts developed for this trial to complete an assessment in 15-30 minutes. This compares with 1-2^{+} hours for a ground-based survey, not including travel time.

Acquiring imagery specifically for this purpose may not be cost-effective, as the audit considers a random selection of coupes scattered across large areas of forest. However, if suitable imagery is available, it could be used instead of ground-based rapid assessment proposed following the review of methods used in the 2011-12 coupe regeneration and finalisation audit [7].

In any future work of this nature, it is recommended that shapefiles with the net harvest area be used to guide the aerial survey rather than the gross coupe area shapefile that was used in coupe planning.

4.4 Alternative approaches

There are a range of emerging remote sensing technologies that might enable aerial surveys to play a greater role in coupe regeneration auditing and even in regeneration coupe stocking assessments.

Small unmanned aerial vehicles (UAVs) can be used to produce very high resolution imagery. They can be programmed to acquire imagery over specific areas, such as harvest coupes, and support the type of grid-based image analysis undertaken in this trial. UAVs can safely reach inaccessible areas within coupes and potentially provide imagery with 2-3 cm resolution. Imagery with this level of resolution may enable eucalypt and non-eucalypt regrowth to be distinguished and potentially allow some eucalypt species to be discriminated.

Depending on the level of investments, different UAVs can be used to facilitate such auditing programs. Some UAVs can be easily operated by the field team and the images would be available at the end of the exercise. The UAVs can be pre-programmed to fly only over the specified coupes and take off and land automatically.

The most basic equipment consisted of a simple camera controller circuit mounted on a semi autonomous helicopter system (Figure 18). At the higher end of the scale is a fully autonomous helicopter and ground control system (GCS), capable of auto take off and landing, auto waypoint navigation and data capture.

It was originally intended that high resolution satellite imagery be acquired as part of this trial of the use of remotely sensed images in auditing harvest coupe regeneration. The imagery that was to be acquired has a spatial resolution of about 50 cm. The inclusion of 8 spectral bands may have enabled discrimination between species – at least of eucalypts and non-eucalypts. However, based on the experience of this trial, the 50 cm resolution would be barely sufficient to confidently interpret stocking. It is not recommended that this alternative be reconsidered at this stage.

Figure 18 Rotor wing UAV (Neural Robotics inc., USA) and imagery acquired.

5 Conclusions

A trial was undertaken to determine the potential role of aerial surveys using high resolution imagery to audit harvest coupe regeneration as part of an audit of logging coupe regeneration and finalisation under DSE's Forest Audit Program. Aerial survey techniques were considered to offer the prospect of improving the cost-effectiveness and coverage of the FAP's coupe regeneration and finalisation audit.

Two sets of aerial imagery were acquired from VicMap's Coordinated Imagery Program: 15 cm resolution imagery from parts of Central FMA (flown 2009) and 50 cm resolution imagery from much of East Gippsland FMA (flown 2010). GIS scripts were developed to set up a consistent sampling approach and support data capture analysis. Stocking of regrowth in 2.27 m radius plots on an 80 ×20 m grid was assessed on seven regeneration coupes, two using the 15 cm resolution imagery and five using the 50 cm imagery. Time elapsed between coupe regeneration and image acquisition ranged between 2 and 5 years.

The coupe harvest area, infrastructure (landings, snig tracks etc) and retained seed and habitat trees were clearly distinguishable in both sets of imagery. Regenerating trees could be readily distinguished in 15 cm resolution imagery only 2 years after regeneration. While regeneration could be detected in 50 cm resolution imagery, even at 5 years post-regeneration, it was sometime difficult to distinguish. In neither form of imagery was it possible to separate eucalypt from non-eucalypt regrowth or to distinguish between different eucalypt species.

Results from the assessment of regeneration coupe stocking were broadly similar to those obtained from VicForests' ground-based surveys using the same grid size (but different directions and starting points). In four of the seven coupes included in this trial, results from the VicForests' surveys were within the 90% confidence interval of the aerial survey results.

The aerial surveys typically (although not always) overestimated coupe stocking, compared with VicForests' ground-based surveys. This most likely reflects the inability of the imagery to distinguish between sampling plots stocked with non-eucalypts only and those stocked with eucalypts. The aerial surveys proved to be effective in identifying areas with no eucalypt (or other) regrowth within the coupes.

Even with 15 cm resolution imagery, it is not possible for an aerial survey to replace ground-based surveys of stocking to assess whether coupes have meet the standards required by NFSG #10. Key criteria require eucalypt and non-eucalypt regrowth to be distinguished and each eucalypt species present in the coupe to be identified: 15 cm resolution imagery cannot do this.

As part of an overall audit approach that draws on multiple lines of evidence, including VicForests stocking survey results, aerial survey techniques could contribute to audit processes for coupe regeneration and finalisation. Where it can be demonstrated from a ground-based survey or rapid appraisal that a regenerating coupe is dominated by eucalypt rather than non-eucalypt regeneration, aerial survey could be used to provide a rapid, low-cost and safe means of auditing stocking (including the presence of large unstocked areas within the coupe). While both forms of imagery could be used for this task, 15 cm resolution imagery (or better) is recommended.

Use of high resolution aerial photography in regeneration and finalisation audits is likely to be opportunistic, in that it will not be cost-effective to acquire it solely for auditing purposes. If it is available, it should be used to supplement the ground-based rapid survey technique proposed in the coupe regeneration and finalisation audit methodology that was developed following the experience of the 2011-12 audit program.

The use of UAVs to acquire very high resolution imagery from logging coupes should be evaluated to determine if they are able to replace ground-based surveys currently undertaken by VicForests.

6 References

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