



Potential of airborne video for updating forest maps

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Abstract

A procedure is described in which airborne video was used to update an existing forest map. With the aid of image processing (IP) software, three Super-VHS format video images were captured as digital data files and georeferenced using a forest map stored in a Geographic Information System (GIS). The linework was revised according to the information shown on the underlying image then exported back to the GIS. Two transformation options were used for rectification of the images and the influence of terrain steepness on their effectiveness in this application is discussed. The video procedure is likely to take longer than the conventional aerial photography and simple transfer instrument method. However, the lower marginal cost of acquiring video, the greater number of days on which suitable video images can be obtained compared to aerial photography, and the wider versatility of the video system are all significant advantages.

KEYWORDS

Aerial photography, airborne video, forest maps, GIS, IP.

Introduction

Accurate maps are a necessity for sound forest management and most forestry companies have a regular programme for keeping them up-to-date. This task is frequently carried out using small format aerial photography and a simple optical transfer instrument (e.g. Sketchmaster² or Zoom Transfer Scope³). However, because the weather conditions in New

Zealand restrict the number of days suitable for aerial photography, and because of the imprecise and subjective nature of the map revision process when using this type of instrument (Spurr, 1960), there is a need for a speedier and more objective technique. This is becoming increasingly important as forest management requires its areal database to be updated more frequently than the quarterly or annual revision currently undertaken by most companies.

Airborne videography is emerging as a versatile remote sensing tool, now available to resource managers (Myhre, R.J. *et al.*, 1991, Pywell, 1994). When used with an appropriate IP capability, it appears to offer some potential as a tool for updating forest maps in New Zealand. Three main reasons for this are:

1. Suitable imagery can be obtained over a wide range of weather conditions, e.g. cloud free; continuous high cloud; and certain situations in between (Pywell, 1994). This is possible because the image quality can be controlled in real time by adjusting the camera gain setting and iris control. High-quality aerial photography, on the other hand, can usually only be obtained on cloud-free days with high sun angles. The video option therefore offers a distinct advantage over aerial photography when the need to update a map is urgent.
2. The cost of obtaining additional video imagery (i.e. the 'marginal' cost) is lower than for film; a video cassette is cheap, can store large numbers of images, and is reusable.
3. Images from the video system can be easily converted to digital format for computerised IP.

In this paper we describe a procedure in which an airborne video system was used in conjunction with IP software to update part of a forest map. Results are presented using two different mathematical transformations for georectifying of images of flat, undulating and steep terrain.

It is the authors' view that, due to the inherent inaccuracies of using 'best-fit' methods for map updating (particularly for steep areas where relief displacement

is present), a rigorous scientific evaluation of the two options (i.e. photography and simple optical transfer instruments versus airborne video and image warping techniques) would be difficult and probably unwarranted. However, a subjective comparison of the relative merits of the two systems is likely to be of value to current practitioners.

Study Area

The study was carried out on a strip of land in a New Zealand forest where recent logging activity had taken place. Terrain covered by the strip progressed from flat to undulating ground (6° average slope) and ended as a steep hillside (20° average slope). The total elevation range was approximately 240 m. A number of roads and tracks crossed the area and a variety of vegetation types were represented including wetland, grass and trees.

Method

Three years prior to the commencement of this study, colour aerial photographs (scale 1:15,000) of the forest had been taken and used to produce a digital map of the roads, main vegetation boundaries and a wastewater pipeline network. The map was produced using an AP190 analytical stereo-plotter⁴ linked to a GIS, (TerraSoft^{TM5}).

For this study, images of the site were acquired with a Panasonic Super-VHS video camera (model WV-F250E), from an altitude of 1500 m above the mean ground elevation, giving a coverage (swath width) of 1.2 km.

After viewing the video tape, three individual frames were selected and converted to digital format using a TARGA^{TM6} 'capture' board under the control of the IP system, TNTmips^{TM7}. The frames were chosen because they were contiguous and because the terrain covered by each fell into one of the three terrain classes, predominantly flat, undulating and steep.

In order to implement the process of map updating, the existing GIS map of the study area was converted to AutoCAD Drawing eXchange Format (DXF). This enabled it to be imported into the TNTmipsTM georeference module as a computer-aided draughting (CAD) 'reference

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² A product of Carl Zeiss, Inc., Oberkochen, Germany.

³ A product of Bausch and Lomb, Rochester, NY, USA.

⁴ A product of Carto Instruments Inc., Corvallis, OR, USA.

⁵ A product of Essential Planning Systems, Victoria, BC, Canada.

⁶ A product of Truevision, Indianapolis, IN, USA.

⁷ A product of MicroImages, Inc., Lincoln, NE, USA.

object'. The TARGA™ files (captured raster images) of the three sites were then also brought into the georeference module as 'input objects'.

Six well-spaced ground control points (GCPs), clearly visible on both the input object and the reference object, were identified by the operator. The TNTmips™ georeference procedures were then used to effect an overlay of the CAD map onto the video images, by obtaining a 'best-fit' of the two sets of GCPs, according to a linear (affine⁸) mathematical transformation (see Fig. 1) and a non-linear (2nd order polynomial⁹) transformation (see Fig. 2). This enabled the effectiveness of the two registration methods to be compared. (See Hoffer, [1993] or Novak, [1992] for a discussion on GCP location and choice of transformations.)

The 'goodness of fit' of the resulting overlays was evaluated by comparing the magnitude of the root mean square (RMS) errors of the fit of the GCPs. RMS values represent the mean distance between a selected GCP and its location predicted by the TNTmips™ software using a transformation equation. The fit was also evaluated by subjectively noting how well the feature boundaries, visible on the video image, corresponded to the superimposed CAD linework.

The TNTmips™ CAD module was then used to revise the linework. The georeferenced images were selected and displayed as 'background' raster objects and the CAD line drawing tool used to 'trace' around new features and record their coordinates. Figure 3 shows the revised linework for a recently clearfelled compartment, with new roads and landings, mapped from the steep country image.

The completed linework was exported, in AutoCAD DXF format, from TNTmips™ and imported into the original TerraSoft dataset. A simple edit process was used to integrate the new linework with the existing GIS dataset.

Results

The RMS error of the fit of the GCPs used

⁸ The TNTmips™ affine geometric transformation uses at least three GCPs to orientate and scale the original image. Different scale factors may be applied in the x and y directions. Although there may be an acceptable fit at the GCPs (because the residuals are small) undulations in terrain between GCPs could create errors due to relief displacement.

⁹ The 2nd order polynomial geometric transformation uses a minimum of six GCPs to orientate, scale and warp the original image. To implement the warp process, the image is resampled. As with the affine transformation, areas between GCPs remain subject to relief displacement errors.

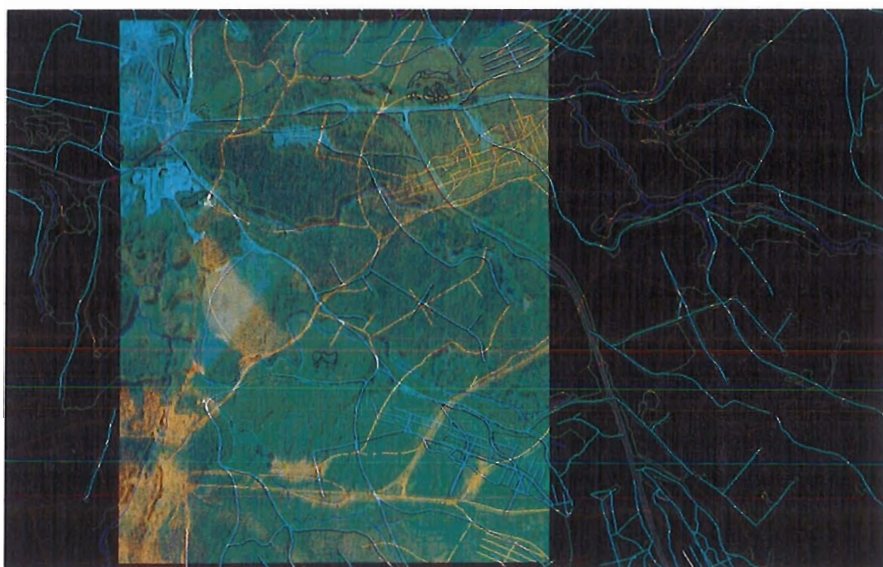


Fig 1. Airborne video image of flat terrain georeferenced to GIS linework using a linear (affine) transformation.



Fig 2. Airborne video image of steep terrain georeferenced to GIS linework using a non-linear (2nd order polynomial) transformation.



Fig 3. Revised linework 'traced' from georeferenced video image.

to georeference the images of the three terrain types is given in Table 1. The figures show that the errors increased with an increase in the average slope of the terrain. The trend was similar for the subjective assessment of the 'goodness of fit' of all the linework features. For flat and undulating terrain, there was little or no difference between the two transformations. For the steep country, however, there was a 4 m decrease in the RMS error when the 2nd order polynomial was applied.

carry out a small map-updating task (e.g. inclusion of a new logging road) using airborne video with IP, is compared in Table 2 with the time required to carry out the same task using an aerial photograph and a simple transfer instrument (authors' estimates throughout).

The figures given in Table 2 will vary according to operator experience and the characteristics for each job, but the assumption that the simple transfer instrument method is likely to take less time

cluded that a S-VHS Panasonic video camera, in conjunction with TNTmips™ IP software, could be used to update a GIS-based forest map. However, the following issues need to be considered:

1. Because the mapping principles employed in the video/IP and aerial photograph/simple transfer instrument methods are similar, the overall accuracy of the end result will also be similar.
2. The rectification transformations used for the georeferencing did not apply a rigorous (photogrammetric) approach to the restitution process. The final accuracy of any updated linework will therefore be strongly influenced by:
 - i) the transformation algorithm used for rectification,
 - ii) the number and location of the GCPs,
 - iii) the magnitude of the relief displacement on the images.
3. The time required to carry out a simple map updating task is likely to be greater with airborne video and IP than with traditional optical transfer methods. This could be offset by the additional time required to process photographic film. Video footage is immediately available for viewing.
4. If a digital elevation model is available, it can be used to orthorectify the video image (i.e. to differentially correct the image for displacements due to camera tilt and terrain relief). This offers potential for improving the accuracy of airborne video and IP for map-updating.

The results of this evaluation suggest that airborne video, used in conjunction with IP, is worthy of consideration as a technique that can facilitate the production

Transformation algorithm used for georectification	Terrain type					
	Flat		Undulating		Steep	
	RMS error (m)	Subjective assessment	RMS error (m)	Subjective assessment	RMS error (m)	Subjective assessment
Linear (affine)	6	good	9	good	16	poor
Non-linear (2nd order polynomial)	6	good	8	good	12	fair

Table 1. Mean RMS error of the predicted fit of the GCPs using two georeference transformations, and a subjective assessment of the match of the GIS linework to the video image.

When it is considered that a pen-line thickness on a typical 1:10,000 compartment map represents a ground width of about 3 m, the magnitude of the RMS error values in the table can be put into context. For the flat and the undulating terrain, the results would probably be acceptable for updating forest map features such as stand boundaries. For the steep terrain, the errors might be large but would still compare favourably with those achievable using a simple transfer instrument.

If a simple transfer instrument is used to update a map of steep terrain, the operator will usually divide the aerial photograph into segments and re-orientate the instrument for each one. This does not usually take long and has the effect of reducing the overall error. An attempt was made to use the same principle of updating the video image segment by segment. Unfortunately there were insufficient clearly identifiable control points to enable this procedure to be carried out.

Although accuracy is important when comparing one map updating method with another, the time taken to carry out the various procedures also needs to be considered. The approximate time required to

than the airborne video method will probably be correct in most instances.

Discussion

As a result of this evaluation, it was con-

Airborne video method		Transfer instrument method	
Task	Estimated time (minutes)	Task	Estimated time (minutes)
Select and capture video image	5	Set up transfer instrument	15
Import linework from GIS as a CAD object	10	Revise map	10
Georeference video image to CAD object	30	Digitise new linework into GIS	35
Revise the linework	35		
Export revised linework to GIS	10		
TOTAL	90		60

Table 2. Comparison of time required to update a compartment map using airborne video/IP and aerial photograph/simple transfer instrument methods.

of frequently updated map records.

References

- Hoffer, R.M., 1993. Airborne Video Automated Processing: Final Report. Methods Application Group, U.S. Forest Service, pp. 5/23-5/27.
- Myhre, R.J., C.W. Sumpter, and L.A. Graham. 1990. Airborne Videography – A Potential Tool for Resource Managers. Proceedings of Resource Technology 90 Symposium, Washington, D.C. pp. 590-594.
- Novak, K., 1992. Rectification of Digital Imagery. Photogrammetric Engineering & Remote Sensing. Vol. 53(3), pp. 339-344.
- Pywell, H.R., R.J. Myhre. 1990. Monitoring Forest Health with Airborne Videography. Proceedings of Resource Technology 90 Conference, Washington, D.C. USA.
- Pywell, H.R., 1994. Airborne Videography: Remote Sensing Applications in Natural Resources. Proceedings of Resource Technology 94 Conference, Melbourne, Australia, pp. 274-285.
- Spurr, S.H., 1960. Photogrammetry and Photo-interpretation. Chapter 12. Ronald Press Co. USA.

Gall wasp on *Eucalyptus botryoides* and *Eucalyptus saligna* and possibilities for biological control

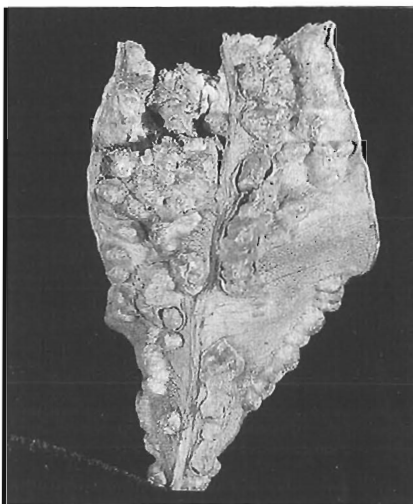
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During 1987, in Wellington, a well-established specimen of *Eucalyptus botryoides* was found to be suffering from severe leaf abscission. An entomologist from the Forest Health Group, NZFRI, examined the tree and found that it was severely infested with robust, spherical galls. These galls were found to contain the larvae of a small wasp. The adults of the wasp (3-4 mm in length) were indistinguishable, with present taxonomic knowledge, from a gall wasp, *Rhynopeltella eucalypti*, already present in New Zealand. The tree was cut down because of its poor health status.

Specimens of the adult insect were sent to the Entomology Division of CSIRO Australia, the acknowledged experts in the taxonomy of Australian Chalcidoidea (the superfamily to which these wasps belong). The reply from Australia identified the insect as *Ophelimus eucalypti*. The entomologists at NZFRI adopted this designation for some time. However, on examining a recently published key of Australian Chalcidoidea we found that *Rhynopeltella eucalypti* was now *Ophelimus eucalypti*. What we believed to be a recent introduction was identified as a well-established NZ exotic insect. This presented us with a problem, not only was the taxonomy of this group extremely difficult, even for the experts, but also it confounded any future research we could devise.

We were fairly sure from the size and shape of the galls that this was a different, but closely-related, species. Also some of the species of eucalypts affected by the former *Rhynopeltella eucalypti* were never recorded as being infested with this gall type. Another confounding factor was the variation in reports from field officers on the severity of infestation by the wasp, and the amount of damage caused. During 1991/92 the Ministry of Forestry still

operated a Declaration of Infested Area on the west coast of the North Island, from Wellington north to Ohakea. The western boundary of this area ran along a line delimited by the foothills of the Tararua Range. A more rigorous survey by NZFRI staff demonstrated that the insect was much more widespread than first thought and that it was in most regions of the North Island. The Declaration of Infested Area was lifted. More recently (1995) the wasp has been found in Picton on the South Island and has spread to forests in the north of the South Island, where it is well established.



The insect can complete its life cycle in abscised leaves. Eulophid galls on fallen leaves. *Eucalyptus botryoides*, Otari Plant Museum, Wellington, March 17, 1988.

Our problem was to determine, by means other than classical taxonomic methods, whether this was indeed a different but closely-related species of gall wasp. We also had to determine whether it was an insect pest of potential economic importance. If it was found to be causing tree death or loss of growth increment it was also important to determine which of

the affected species was the primary host. This would assist us in locating possible regions to search for a biological control agent if it was necessary.

The first stage in all new pest introduction investigations is to determine if the insect is causing enough damage to warrant control. The two tree species most often attacked, and most severely affected were *Eucalyptus botryoides* and *Eucalyptus saligna* – both special-purpose species. *Eucalyptus botryoides* is considered to be especially good for effluent and land-treatment areas. These species are very closely related taxonomically and would be expected to have similar foliage chemistry. However, the primary host of the wasp would be affected most as the insect and tree would have closely coevolved over millennia.

One site in Waikanae and one site in Foxton, were chosen for an experiment in 1992/93. Both sites had well-established populations of the gall wasp and were colonised by the wasp around the same time. The sites differed in exposure and soil type. The Waikanae site was on a very exposed hill slope with colluvium soils. The Foxton site was very sheltered with mature macrocarpa and pines surrounding the stands of eucalypts and was planted on a sandy loam.

Diameter at breast height (DBH) was measured on 50 trees at both sites at the beginning and end of the year's work. The foliage of all these trees was sampled and scored for level of infestation.

The primary experiment was laid out in the Foxton site. Two hundred and fifty seedlings consisting of *Eucalyptus botryoides*, *E. saligna* and *E. nitens* were planted in five Latin square arrangements in the infested site. Half of the *E. botryoides* and half of the *E. saligna* seedlings were protected with regular spraying of an insecticide. This would allow us to identify lack of vigour due to site factors and

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