THE USE OF TOPOGRAPHIC MAPS BASED ON AERIAL PHOTOGRAPHS IN LOGGING PLANNING

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Summary

Topographic base maps prepared from aerial photographs are essential for logging planning to facilitate layout of operations. At present, some deficiencies are still apparent but a thorough understanding of the objectives, advantages and limitations of these maps minimises errors.

A topographic map is essential for advance planning of large scale logging operations as it reduces the time spent on ground reconnaissance and enables the successful integration of the various phases of logging. In the past, planning for logging was non-existent or was a haphazard reconnaissance by crew bosses. This method limited accurate observation to the visual range at any given moment and these visual pictures were difficult to correlate. Only occasionally were topographic maps available. Usually these maps showed a fifty foot contour interval, which is too small a scale for detailed logging planning. In the post-war years, aerial photographs came into general use as an aid to ground reconnaissance. These were most effective in stereoscopic pairs but the area viewed was small and correlation difficulties still existed. At Kaingaroa, in 1953, some topographic maps for logging were prepared from ground survey. Grid lines, ten chains apart, were traversed and visual ten foot contours sketched in the field books.

The resultant maps at 1″ = 2.5 ch. scale were a great aid to planning but had disadvantages. Although accurate on the grid lines, considerable error occurred between lines due to the limited view of the surveyor through the trees in broken country. Much skilled labour was required for survey and tedious map preparation forced costs to about five shillings per acre.

At present, in Kaingaroa Forest, topographic maps plotted from aerial photographs are used extensively for the planning of logging operations. They do not eliminate ground reconnaissance, but do pinpoint critical areas and show those where cursory checks are sufficient. Using these maps, a large percentage of layout work is accomplished in the office. Road location, skid sites and hauling boundaries are then checked in the field.

Preparation of Topographic Maps

The flying and photography for Kaingaroa Forest was completed by Aerial Mapping Ltd., Hastings. Originally, two distinct plotting methods were used.

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(a) A map was plotted with a "Multiplex" from photographs scaling approximately eight chains to one inch. In this machine a series of transparent photo positives were set up and adjusted for tip and tilt. Filters were fitted to each projector and coloured glasses were worn by the operator to see the photographic image clearly. The stereoscopic view of two adjacent photos was projected on a movable plotting table which was raised or lowered to enable a floating dot indicator to merge with the level of ground cover. Once the height required was set, the contour could be traced out by moving the plotting table along the contour.

(b) A map was plotted with a "Wilde A6" using twenty chain to the inch photographs. The "Wilde" projected two photos, which were adjusted for tip and tilt, into an eyepiece, where a floating dot was set for various heights. Plotting was accomplished by moving the dot along the appropriate contour which traced out its path on the plan.

Trial maps, prepared by each of these methods, were tested for accuracy, presentation of ground features, and application to logging planning. A check line was traversed and the results graphed (Fig. 1).

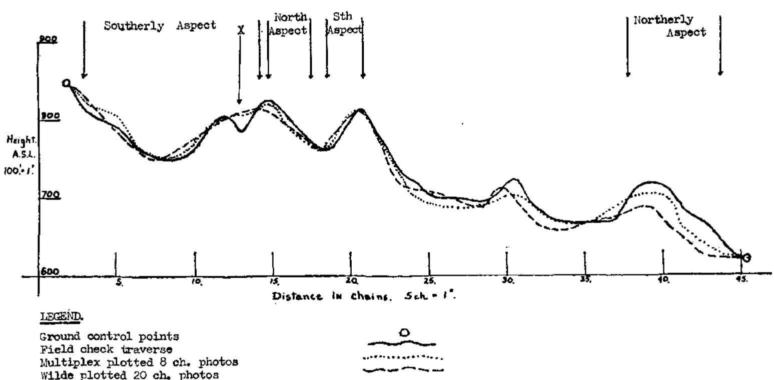

Fig. 1.—Comparison of vertical profiles.

The map based on eight chain flying was more accurate and presented a slightly better picture of ground conditions. However, the expense involved in the extra flying photography and ground control was twice that of the twenty chain flying which cost three shillings per acre. Both maps had similar errors and tended to smooth out detail, obliterating some small gullies and saddles. (See Fig. 1.)

Some system of ground control was necessary for computation of compensating adjustments for the plotting machine to achieve planimetric and vertical accuracy. A network of ground control for these topographic maps was established by theodolite survey after suitable points had been picked out from the photos themselves. For efficient control, four points were required on every second photo of alternate runs. Each point was common to three photos of its own run and also to photos of the adjacent run. Additional control for the adjacent run could be established by the plotting machine where necessary. A trial system of pre-marking control points was tried. The marks showed up distinctly in the photographs but were rarely in good locations for photo overlaps, therefore this system was abandoned.

Objectives of Topographic Map for Logging Planning

The objective of a topographic map for logging is to present a picture of the terrain from which logging management can plan operations economically. The relative relationships of topographic features are generally of more importance than the height of these features.

To accomplish this objective a topographic map must show:

(a) Contour lines wherever possible and form lines within compartments where correct contour heights cannot be ascertained. A twenty foot contour interval is suitable for logging purposes. Contour heights should be indicated and representative spot heights shown. The latter are particularly advantageous on knolls which may be up to nineteen feet above the nearest contour.

(b) Creeks and main drainages. The positions of these may be readily deduced from the contours, but they are necessary, as these maps are used by personnel with little training in topographic interpretation.

(c) Compartment or bush edges. Understocked areas, regeneration, or gaps in the crown cover of mappable size should be indicated. These often enable the field man to fix his position on the ground. Volume estimations based on older maps often erred because blanks were not considered.

(d) Rock outcrops, cliff faces, swamps and any other features that may affect log hauling or roadmaking. These govern hauling methods and usually affect changes from tractor to hauler operation.

(e) Trig stations, survey or ground control pegs and other features that can be recognised on the ground for use in local survey. A twenty-five chain grid superimposed over the map is essential for calculating the positions of these features from coordinates.

The only feature of logging importance that cannot be shown is soil condition, which has to be checked thoroughly during road location. Legend shown is minimised to sheet and map reference numbers. Often it is necessary to join two or more adjacent maps to get the overall picture.

Advantages of using Topographic Maps

These maps eliminate unnecessary reconnaissance trips and confine thorough investigation to the more difficult areas. Trial road lines can be drawn in the office and roughly calculated to give balanced earthwork. The map indicates the most direct routes on the best alignments for road location and the proximity of any obligatory points for log extraction to these routes. In most cases, ground investigations have proved these trial lines correctly located. Grades can be calculated and the road line altered to meet the grade limitations of the equipment available. The map indicates immediately where grade is too steep, thus eliminating the necessity for probably several explorative grade traverses. However, these maps only demonstrate the feasibility of any grade; a profile traverse is still necessary for any calculation of earthwork involved.

An area can be subdivided into settings suited to different types of extraction by perusal of the map and the number of logging crews needed to harvest the area can be calculated. Division in this way is important when replacement of machines or initial purchases are being considered. Stand acreages and duration of work on each setting can be calculated, enabling proper differentiation of road standards between summer and winter areas.

The maps are particularly useful for cable-hauling methods of extraction. The longest haul distances can be seen immediately and the maximum length of rope required for hauling calculated, with rope sag, pole height and slope given due consideration. In some cases, calculated haul length may exceed machine capacity so that another method of working or a different machine may be necessary. From good topographic maps clearance over intermediate obstacles such as ridges can be calculated. If necessary, the profiles of critical or doubtful haul lines can then be traversed.

Some Distadvantages of the Present Type of Map

It must be realised that these maps, being compiled from photographs of mature forests, are not perfect and correct contour levels are difficult to ascertain. Considerable experience in map reading is necessary for the observer to be aware of likely errors. These maps minimise field work but do not eliminate it, thus ground checks of all roadlines, skid sites and hauler backlines are still necessary.

Errors are mainly due to miscalculation of tree height and to the presence of features obscured by the crown canopy. Since the plotter depends on his estimate of tree height to position form lines correctly, he is liable to error because of different sites and aspects within compartments. Originally, the plotter establishes his height by checking at a firebreak or road. A height corresponding roughly with crown closure is used rather than top height which is difficult to pick easily on photos. Errors can be classified into two major divisions; mapping errors and interpretation errors.

Mapping Errors

Most mapping errors are due to miscalculation of tree height by the plotter. The main sources of this type of error are:

(a) Differences in site quality which affect tree height. The plotter, who generally has no forestry experience, has difficulty in detecting these.

(b) Edge trees are unrepresentative of compartments as a whole, being usually eight to ten per cent. shorter than internal trees. The plotter tends to establish crown height from these trees.

(c) Local fluctuations in tree height make it difficult to trace a form line within a compartment. Accuracy depends largely on the power of concentration of the individual plotter. Plotted form lines sometimes cross even where great care is exercised. Interpolation is required to overcome these personal errors.

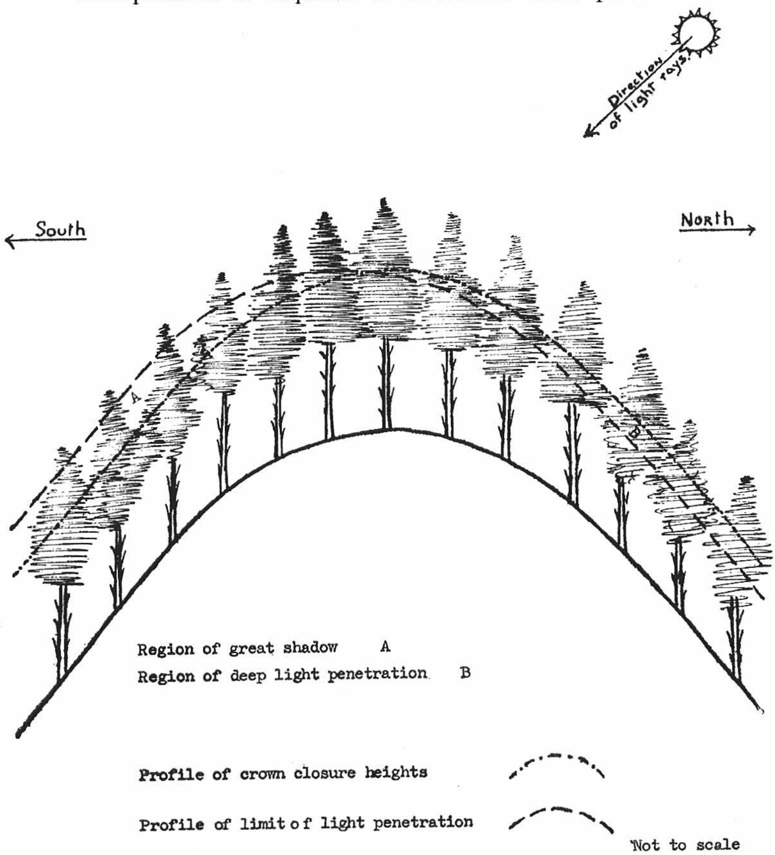

Fig. 2—Section through a knoll or ridge to show effect of light penetration.

(d) Thin spots in the crown cover occur. A *Sirex* infested patch or a few windfalls tend to lower the crown closure and therefore the plotted height. Stocking is an important factor affecting total height and crown closure.

(e) Variation in light penetration into the crowns displaces form lines. Light penetration on northern aspects is greater allowing the floating dot of the plotting machine to find a lower level in the crown cover and still appear to be on the surface. Conversely, on shaded southern aspects, penetration is less. This effect increases the further the sun is from its zenith at the time of flying. This error is illustrated on the ground check graph (Fig. 1), where the tendency is for southerly aspect heights to be lower and northerly aspect heights higher than the check line. This effect tends to position ridges and plateau edges slightly to the south of their actual position. Originally this factor caused some confusion in mapping ground surveys. Hauler skids sites when plotted on the map showed off the edge of adjacent slopes. (This effect is illustrated in Fig. II.)

(f) The height of scrub cover in firebreaks varies from one to fifteen feet, thus causing errors in the calculation of ground level. Crown heights may be estimated from the ground levels of roads, which unknown to the plotter may be on fills or in cuttings.

Apart from errors due to tree height miscalculation, other mapping errors may occur.

(a) Obscured features, such as rock ledges and outcrops, may be missed. An example of tree cover obscuring a rock ledge is down in Fig. III. Detail and the contours under leaning trees

Fig. 3—Crown cover obscuring rock ledge 20′ high. (Mature *P. radiata*, Kaingaroa Forest)

on steep faces are obscured, particularly on south facing slopes. This effect tends to show trees further down a steep slope than they actually are. The resultant exaggerated steep area may then be planned for some cable hauling system where a tractor could easily accomplish extraction.

(b) Exaggeration of planted areas occur due to delineation of compartment boundaries on the photographs from the crowns of edge trees, many of which are leaning. Areas calculated from topographic maps tend to be larger than the original planted area because of this error.

Many of these mapping errors can be reduced if the plotter is supplied with all the existing maps showing known artificial or natural features.

Map Reading Errors

In addition to the errors listed above, several features occur on flattish or undulating ground that cannot be shown on the map.

In map-reading, the grade between contours appears constant, therefore one must be alert for stepped country. A steepish drop equal to nearly two contour intervals may not be readily discernible. (Fig. IV.)

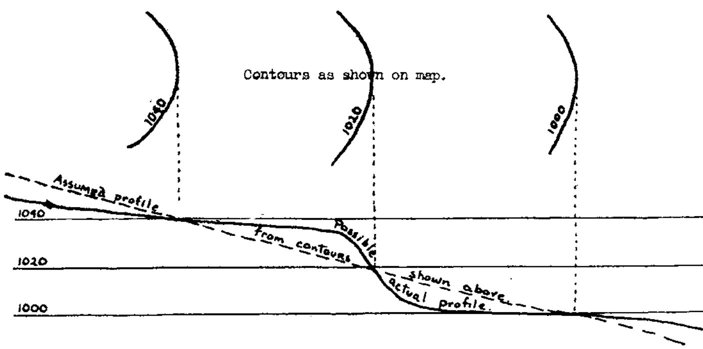

Fig. 4—Diagram to show stepped country that may not be indicated by contours.

Road lines must be carefully checked, particularly in undulating country, to ensure that the route does not include unavoidably large cuts or fills not shown on the topographic map which may be important for delineating tractor skidding areas and altering road lines.

Correction of Errors

There are three possible methods of reducing errors and achieving better results from the use of topographic maps.

A table, indicating tree height variations within the different age classes due to stocking, site and aspect could be prepared. Considerable research would be required for this remedy, particularly as crown closure heights have not been dealt with in any existing data. Obscured features would still be a problem.

The long term answer is to do the photography when the height of ground cover is least, i.e., before, or shortly after, planting. At this stage, detail is visible, contours can be easily followed, and the survey marks used in establishment layout are available for use as ground control. In areas of mature forest, cutover areas should be photographed within five years of harvesting.

Meantime, the answer for more efficient usage is to train the map-user to understand map limitations and sources of error. To achieve consistency in plotting it is important that the mapping of any particular working circle be carried out by one man.

Logging Planning from Topographic Maps

In 1954 these maps were first used for logging planning in the Murupara Working Circle of Kaingaroa Forest. The first cutting section, comprising some 6,000 acres of *P. radiata,* was planned in that year. Since then, most of that Working Circle and the Waipa Working Circle have been planned using similar methods.

The main areas of timber to be logged are delineated on the topographic map and a picture of the timber and topography is established from a reconnaissance. Economic egress from these areas by arterial logging roads is then planned and investigated. These routes are located on the top of ridges in steep country and near the gully bottoms in undulating areas. Side hill locations in steep country are avoided wherever possible. The locations of these routes are checked in the field for alignment, grade and ease of construction.

The forest is subdivided topographically into logging areas of convenient size, each area having a common outlet on to an arterial logging road. These areas are treated individually with a pattern of spur roads and skid sites being drawn on the office map according to the limitations and operating ranges of the equipment to be used. In difficult areas alternatives may be sketched in for investigation on the ground.

The locations of these planned roads and skid sites are then checked in the field. Where necessary road alignments or skid locations are altered to suit ground features and a choice made between alternative locations. All hauler back lines, as indicated by the plan, are checked for blind spots and suitable tie back stumps. During this work additional features such as obscured rock outcrops or ledges, swamps and drainage features are marked on the map. Arrows indicating tree lean, which affects felling operations, are added during this phase.

Final locations of all roads, skid sites and stand boundaries are plotted and the area is divided up into staggered settings. Acreages and volumes are calculated. From this information a schedule of logging crew movements is drawn up so that winter and summer logging can be carried out in suitable areas. The whole of this information is presented with the maps in the final logging plan.

Conclusion

Topographic maps prepared from aerial photographs are invaluable in the planning of large scale logging operations. They are economically justifiable in the extensive saving in reconnaissance and survey. They are essential to the economic planning of operations so that each area is worked to the best advantage by the methods and machines available.