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USE OF AN ELECTRONIC GUIDANCE SYSTEM IN TOPDRESSING PINE FORESTS

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Abstract

Since 1970 an increasing annual programme of aerial topdressing of forests has been carried out. In the past uneven spread of fertilisers has been a major problem, causing substantial waste of fertiliser and uneven tree growth.

Since 1979 most of the areas that have been fertilised have been topdressed by a helicopter fitted with a Decca Flying Flagman electronic guidance system. Use of this system has resulted in much more accurate flying and more even spread of fertiliser enabling fertiliser application rates to be reduced. Further reductions are probable when fertiliser spreading rates and ground speeds can be monitored more accurately.

Keywords: pine forest, fertiliser, aerial application, electronic guidance

BACKGROUND

Large-scale establishment of pine plantations began in New Zealand in the 1920's; a major part of these (mainly radiata pine *(Pinus radiata))* were on the pumice soils of the central plateau of the North Island. Here cobalt deficiency had resulted in 'bush sickness' and the abandonment of pastoral farming; in contrast these soils proved to be excellent for tree growth and large areas of highly productive forest were quickly established.

The success of pine plantations on pumice soils led to the expectation that radiata pine would be able to grow well on any soil found unsuitable for agriculture; in particular, no-one considered that on some soils even pine trees might require the addition of fertiliser before acceptable growth rates could be achieved. However, in the early 1950's severe ill-thrift, dieback, and mortality were very obvious in the plantation on a 'gumland' clay soil in Riverhead Forest just north of Auckland. Small experimental plots were treated with superphosphate and the results were so dramatic (Weston 1956) that within a few years the first experimental aerial topdressing operations had been carried out (Conway 1962).

During the 1960's quantities of fertilisers used in forestry were small but there was a growing awareness of the need for fertilisers in pine plantations on a wide range of soils in all parts of New Zealand. It was found that tree growth in several forests was severely retarded by deficiencies of nitrogen, phosphorus, or boron. The 1970's saw a very sharp rise in the application of fertilisers to forests (Will 1981) (Fig. 1). Aerial topdressing was the major means of application; hand application at time of planting, and ground spreading in thinned stands on flat country, accounted for much smaller proportions.

Even before the expanded programme of aerial topdressing in the 1970's, it was realised that standard aerial topdressing operations were not giving an acceptable pattern of fertiliser distribution over forests (Ballard & Will 1971). The unevenness of spread and its consequent effects on tree growth are illustrated in Figures 2 and 3.

Similar irregular distribution patterns are known to occur in agricultural operations but it is thought by many that these are counteracted by (1) re-topdressing each year, (2) fertility transfer by animals, and (3) the ability of

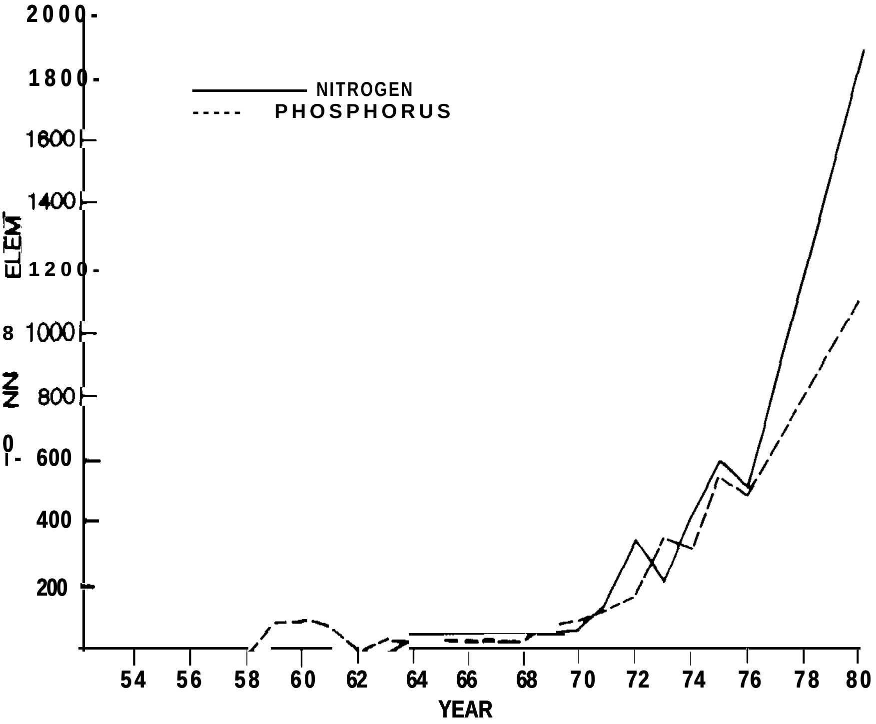

Figure 7: Increases in the use of nitrogen andphosphorus fertilisers in New Zealand forestry (Will 198 1).

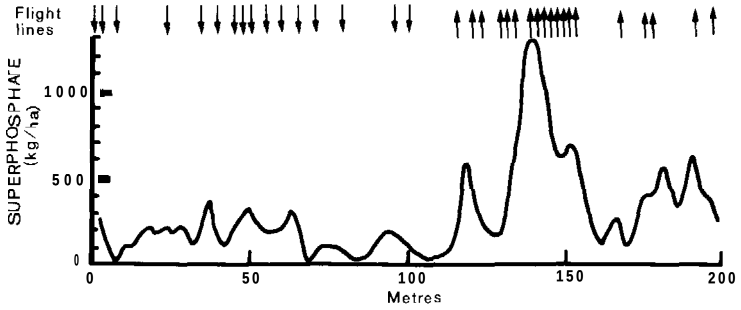

Figure 2: Distribution of standard superphosphate applied by fixed wingaircraft, Maramarua Forest, 7969. Note the variability in the spacing of the flight lines and in the fertiliser distribution patterns (adapted from Ballard & Will 1971).

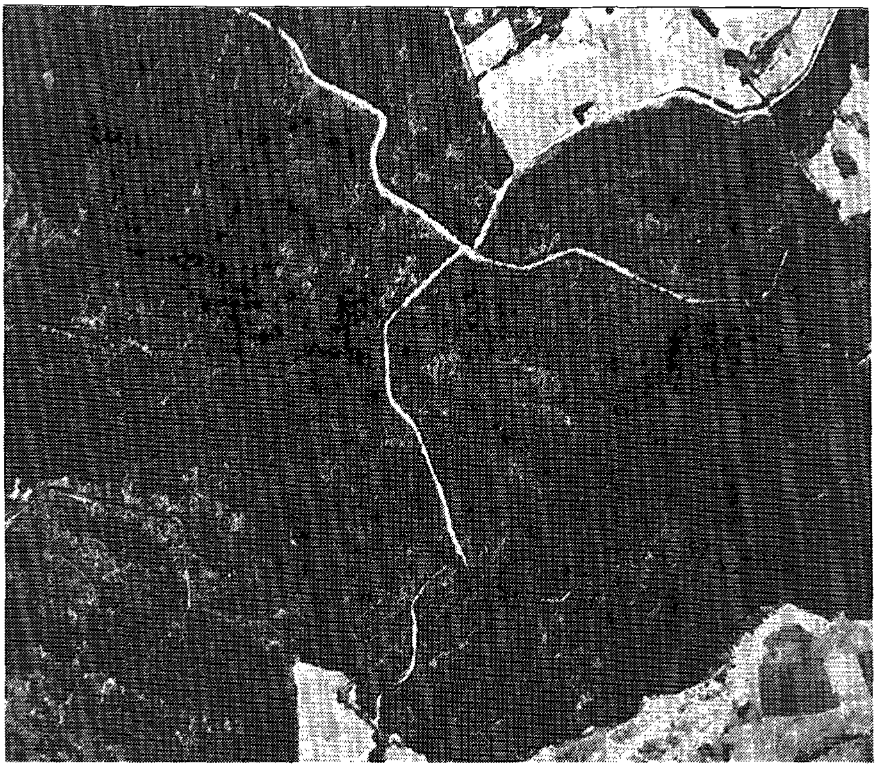

Figure 3: Part of Riverhead Forest aerially topdressed in 1959. The uneven growth response – the strip effect – evident in this photograph taken in 1969 has been largely caused by uneven fertiliser distribution.

animals to move and graze in proportion to pasture growth. In forestry, top-dressing is infrequent (5-10 years), there is no fertility transfer by stock, and it is vitally important to have every plant (tree) growing at as near the same rate as possible. All forest operations such as thinning, pruning, logging and sawmilling, individually and collectively, are most cost-effective when dealing with trees and logs of uniform size.

At a symposium in 1977 on 'Use of Fertiliser in New Zealand Forestry' the consequences of failing to achieve even distribution of fertiliser were recognised (Mead & Gadgil 1978) but it was not until 1979 that positive steps were taken to improve flight patterns. In that year, the Auckland Conservancy of the New Zealand Forest Service, when advertising aerial topdressing tenders, took the bold step of stating that preference would be given to operators of aircraft fitted with a guidance system. Marine Helicopters *were* the successful tenderer and over the last three years they have operated their Lama helicopter fitted with a Decca Flying Flagman electronic guidance system.

This paper briefly describes the developments and the results achieved.

THE DECCA FLYING FLAGMAN SYSTEM

The components and operation of the system are as follows. A master transmitter/receiver and a computer are installed in the aircraft (fixed wing or helicopter). At the start of an operation two transponders are placed one each on two points of high ground in line of sight of where the aircraft will be topdressing. Radar signals from the transmitter are picked up by the transponders and sent back to the receiver. The times taken for the signal to return are then used by the computer to calculate the aircraft's position (Fig. 4). When this position varies from the predetermined flight path, a light bar on the console indicates to the pilot the direction and extent of the deviation. Position updates are given at 0.5-second intervals; these can be recorded on tape by the computer and later used to print out the overall flight pattern for an operation. Printouts are not only records of pilot performance and areas treated, but they also provide the forest manager with an accurate basis for the future evaluation of tree response.

The system also incorporates a push-button device which allows operation boundaries and 'material-out positions' (MOP) to be recorded: the 'distance-to-go' to these positions is then displayed so the pilot knows precisely when and where to cease or resume spreading fertiliser.

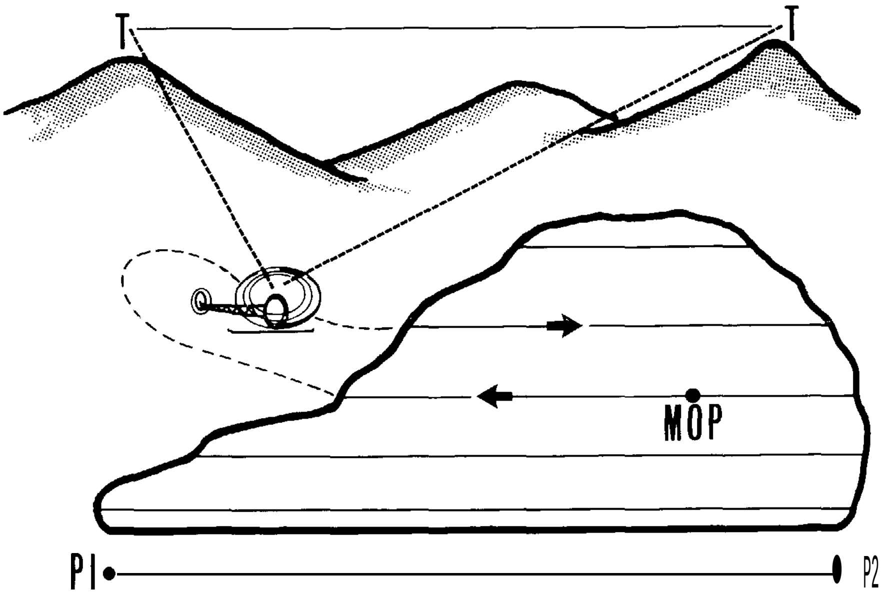

***Figure 4:** The Decca Flying Flagman System in use. At the start of the operation the pilot must fly a course which intersects a straight line between the two transponders (T) and then fly from one selected point (P_1) to another (P_2) to establish a baseline. Successive flight lines can then be calculated by the System's computer and will be parallel to the baseline and a pre-determined distance apart.*

EXPERIENCE WITH THE SYSTEM

In the initial operations the pilot found it very difficult to adjust to flying by the Decca System: his reaction was to distrust the light bar on the console when it indicated a flight path that was different to the one he would have normally flown using judgement based on experience gained in visual flying. It was only after 100 or more hours' experience with the Decca System that the pilot reached the stage where he had confidence in the system and could react efficiently to the light bar (N .Barrow *pers. corn).*

Printouts of the early operations showed that flight lines were not particularly straight or evenly spaced. With experience flight patterns improved and those from two operations have been published (Hedderwick & Will 1982; Forest Research Institute 1982). The flight pattern from one of the latest operations is shown in Figure 5. It can be seen that a pilot experienced in the use of the system is able to achieve a high degree of accuracy in flying parallel, evenly spaced lines.

The need for experience with the system must be stressed as the Decca or similar systems have been tried in forest operations overseas but sometimes soon abandoned as impractical or of no advantage (J.Eyre *pers. comm.).*

Figure 5: Printout of aerial topdressing flight patterns, Tairua Forest.

Here in New Zealand three year's experience shows that, once familiar with and able to fully utilise the capabilities of the system, a pilot can fly very accurately. An example of this overall accuracy is given in Figure 6 where the same section of forest was flown twice. However, besides the good agreement between the generally accurate flying on both occasions two examples of errors which may still occur should be noted in these flight patterns. Flight line 12 was flown three times -- an apparent error in switching the computer to the next flight path. It also appears that the second flights on lines 6 and 7 were at a lower altitude and partially out of line of sight of the transponders – no position updates are recorded for most of the second half of the lines and at the end of the lines the flight path was out by at least a swath width.

While Figures 5 and 6 show the accuracy of aircraft navigation that can be achieved by a pilot experienced in the use of the Decca Flying Flagman navigation system, it must be pointed out that this in itself does not guarantee uniform

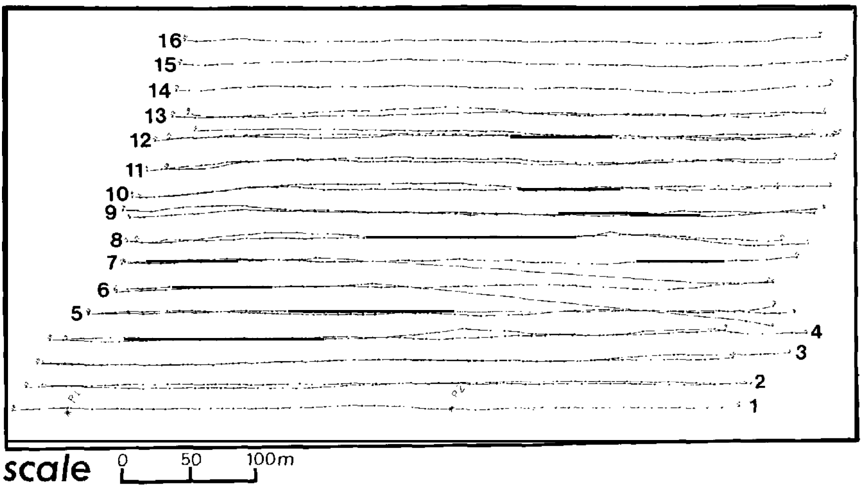

Figure 6: Printout of aerial topdressing flight patterns, Maramarua Forest.

fertiliser distribution. The other factors which must be taken into account are:

(1) Dust free fertilisers are essential to minimise the effect of wind in distorting the distribution pattern (Hedderwick & Will 1982; Forest Research Institute 1982).

(2) An efficient spreader must be available to give the calibrated output in a uniform swath.

(3) An accurate ground speed indicator is needed to ensure constant speed.

Considerable work has been done on the first of these, current work involves the second, and it is hoped that the Decca system can be modified to give accurate ground speeds.

Before the introduction of a guidance system fertiliser application rates had been substantially increased to try to counteract uneven spread. The standard rate of application was about doubled to 1200 kg/ha (applied once every 5-10 years) in an attempt to ensure that all parts of a plantation received at least 600 kg/ha. With the introduction of the Decca system the standard rate was initially reduced to 1000 kg/ha and is now 900 kg/ha. This has been done on the basis of proven improvements in ground spread. When the three aspects listed above are optimised, further reductions to 600-800 kg/ha, depending on soil type, are probable.

CONCLUSIONS

Current experience with the Decca Flying Flagman System has shown that, used in conjunction with well-granulated fertilisers and efficient spreaders, it can ensure that aerial topdressing over forests achieves even fertiliser distribution which in turn will ensure even tree growth. Rates of application can also be reduced.

This experience gained in the use of an electronic guidance system in topdressing forests may well be used to advantage in some agricultural topdressing operations.

ACKNOWLEDGEMENTS

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