LOGGING INDUSTRY RESEARCH ASSOCIATION

LIFT RESISTANCE OF STUMPS

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INTRODUCTION

Stumps are the most common form of anchor in cable logging systems and may be used as attachments for skylines, guylines, or the hauler itself. The holding strength of the stumps is of critical concern to the effectiveness and safety of the system. To date in New Zealand, there has been no recorded testing of stumps' lift resistance.* In many instances there has been no real requirement for such testing as large secure stumps have been available.

Within the future New Zealand cable logging industry, we can expect a trend towards smaller stumps, more difficult soil conditions, and haulers supported by fewer guylines. Under these circumstances, testing stump holding strength is considered timely and this Report describes the results of initial trials.

ACKNOWLEDGEMENTS

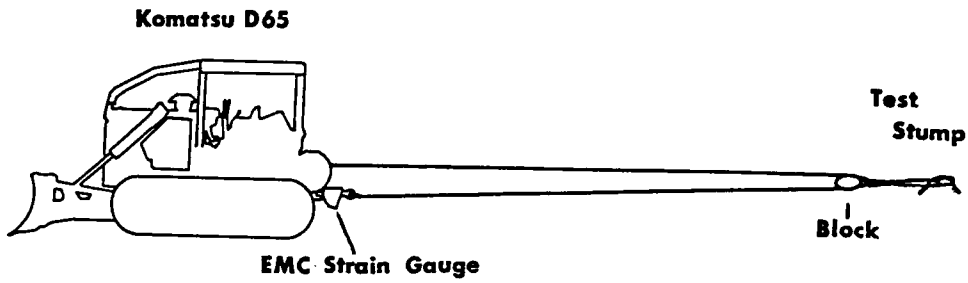
LIRA acknowledges the assistance of New Zealand Forest Service, Golden Downs, and in particular, George Bonner, in providing equipment, personnel, and advice for the trial, and Lotus Enterprises for the loan of their load measuring equipment.

METHOD

(1) Stumps for testing were selected, the criteria being that they were in locations typical of guyline or skyline anchors.

(2) After grooving the stumps at ground level, the diameter was measured (inside bark) in two directions - parallel and perpendicular to the prevailing slope.

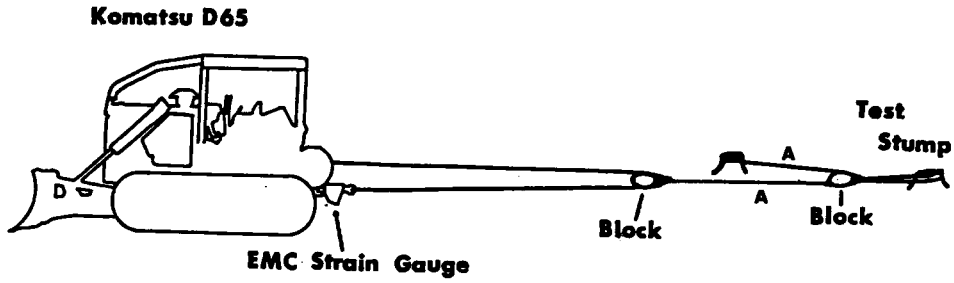
(3) A tractor and strain gauge were rigged in one of two systems necessary to keep the line tensions within the tractor's traction limit.



2 : 1 PURCHASE

System 1 : Tension on stump assumed to be twice strain gauge reading (the two parts of the winch rope remained sufficiently parallel for this to be correct to within 1%).

* A study by Somerville (1979) considered the overturning resistance of young (11½ year old) trees in the windprone Eyrewell forest. Somerville, A. 1979 "Root Anchorage and Root Morphology of Pinus Radiata on a Range of Ripping Treatments", N.Z. J.For.Sci. 9 (3) : 294-315.



4 : 1 PURCHASE

System 2 : "Burton" purchase system. Line tensions on the stump could be up to four times the strain gauge readout with all ropes parallel

(4) The direction and inclination of the pull on each stump was measured. Where the two parts of rope A diverged significantly , the angle of divergence was also measured.

In all cases, the resultant pull direction was parallel to the ground surface.

(5) With all equipment in place and the tractor "bedded" in, the stump was steadily winched until it failed. Rope tensions were recorded by instruments attached to the strain gauge, which provided a chart trace for later reference.

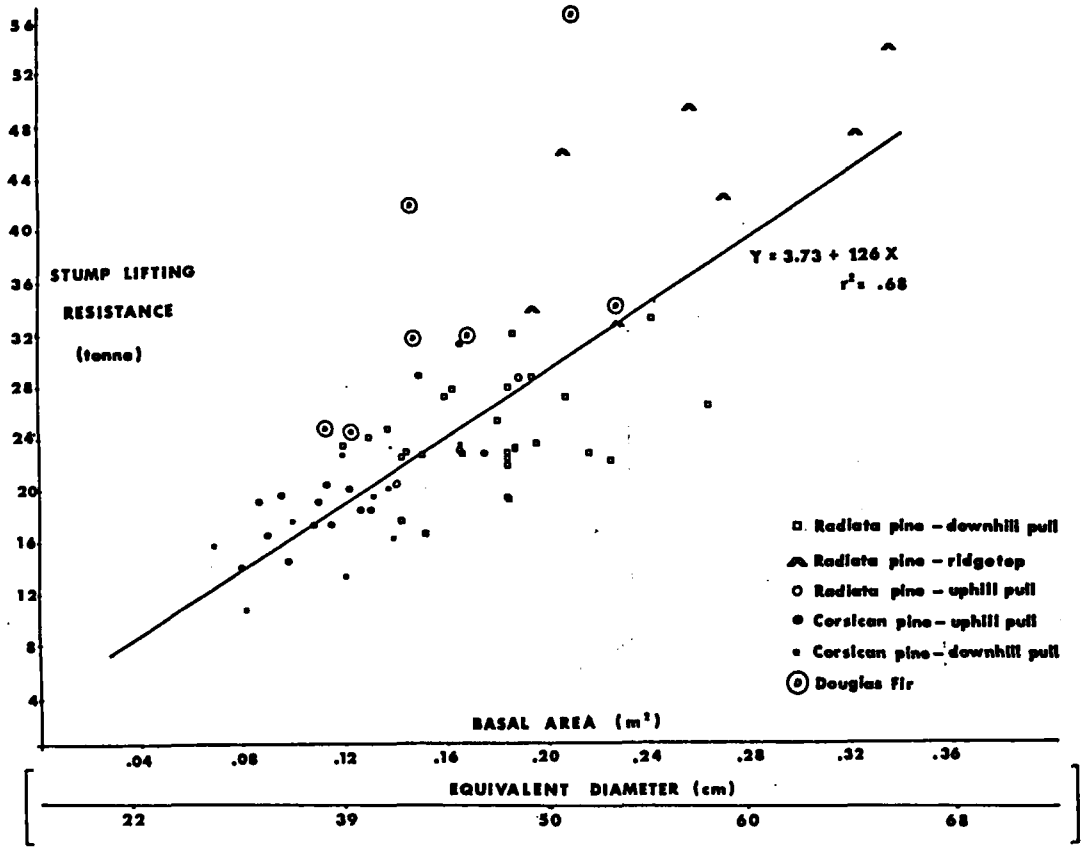
RESULTS

The following table describes the distribution of the tests :

Species	Direction of pull	Characteristic of anchor for:	Number of stumps tested	Diameter range (cm)	Range of Maximum lift resistance (tonnes)
Radiata	Downhill	Skyline	27	40 - 58	16.8 - 32.0
Radiata	Ridgetop	Skyline Guyline	7	50 - 65	32.8 - 53.6
Radiata	Uphill	Guyline	2	42 - 49	20.6 - 28.6
Corsican	Downhill	Skyline	9	30 - 46	10.8 - 23.6
Corsican	Uphill	Guyline	17	32 - 47	14.0 - 31.0
Douglas Fir	Uphill	Guyline	8	35 - 54	17.8 - 56.4

Lift resistances for all stumps tested are plotted for comparison on the following graph. The different symbols used correspond to the different test circumstances described above. The vertical axis represents maximum tension applied before stump failure. Basal area of the stump is shown on the horizontal axis.

Graph showing increase in stump lifting resistance with an increase in basal area



The following linear regression was fitted to the combined data for the Radiata and Corsican pine :

(stump lifting resistance) = 3.73 + 126 x (stump basal area)

The r^2 value for this equation was 0.68, meaning that the mathematical relationship accounts for 68% of the variation in resistance about basal area. This is reasonable, given that the resistance could be expected to vary with a variety of other factors discussed below.

The Douglas Fir stumps have not been included in the regression as they appeared to follow a different trend. With three of these, the wire rope sheared through the tops of the stumps before they uprooted. Insufficient Douglas Fir stumps were tested to justify further regression analysis.

DISCUSSION

As might be expected from an initial trial, a number of questions are raised :

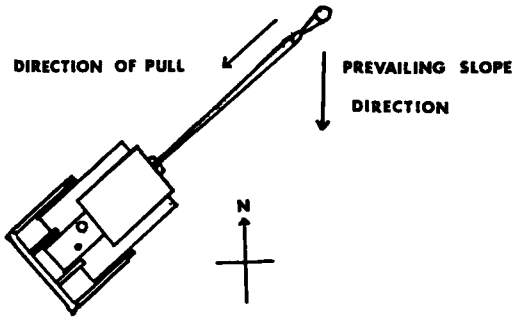
- What is the effect of variation in soils? Four soil samples taken from beneath stumps during the trial were analysed by the Forest Research Institute, and the results were :

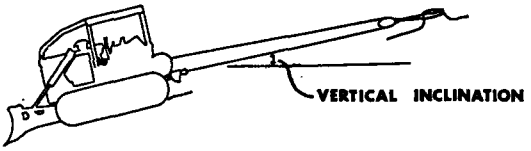
		% sand	% silt	% clay	
Sample 1	ridge	59.4	24.5	16.1	sandy loam
Sample 2	hillside	42.7	17.4	39.9	clay loam
Sample 3	hillside	45.7	19.6	33.7	clay loam
Sample 4	ridge	45.7	23.6	30.7	clay loam

In such soil, all uprooted Radiata and Corsican pine stumps had a fairly narrow and shallow root pad. The radius of most pads ranged from 1.2 m - 1.8 m and showed no clear relationship with stump diameter. Soils which allow better root development should lead to increased stump lifting resistance.

During the week prior to the tests, there had been very heavy rain and soil moisture was consequently high. This is likely to have reduced the stump holding strength. Better knowledge of the weakening effect of soil moisture will be important as stumps are used in all weathers.

- The testing showed almost no discernible differences in stump lifting resistance with different angles of pull. The direction of applied tension could be described by two angles - a horizontal bearing, and a vertical inclination as shown below :

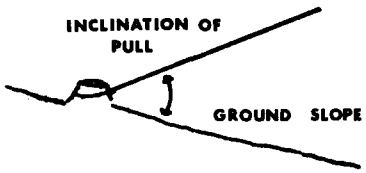




To test the effect of the direction of pull, multiple regression analysis was used to relate the tension at failure to three variables; stump basal area (as before), the angle between the direction of pull and prevailing slope direction, and the vertical inclination.

Including the horizontal angle in the mathematical relationship improved the fit only marginally from an r^2 of 0.68 to an r^2 of 0.70. The result of including the vertical inclination was insignificant.

The vertical inclination may prove significant if an angle is created between the line inclination and the ground slope as illustrated. This was a situation that could not be tested with the equipment available - in all tests the pull was parallel to the ground surface. Since skylines, and especially guylines, are not commonly parallel to the ground surface, further testing of this effect is required.



- Further testing may also resolve the importance of :
  - Intermittent or cyclical loading. With repeated rocking, the stump may work loose, reducing its lifting resistance.
  - Height attachment. In principle, the effect of raising the height of attachment of ropes up the stump should be predictable. This requires an analysis of the torque on the stump which in turn requires identification of the point about which it rotates during failure. Field testing will be essential to confirm such an analysis.
  - Stand stocking. Root competition within the stand may mean that the number of stems per hectare has an important effect. Conversely, during the tests one tree with marked edge tree characteristics (asymmetric crown and lean) proved to have a higher than normal lift resistance.

CONCLUSIONS

- The results from the Radiata and Corsican stumps show that the maximum resistance of a stump is linearly related to the area of its top - in other words, the maximum tension is directly proportional to the square of the stump diameter.
- Stump failure was fairly rapid once the maximum tension was reached. In general, no plateau was observed in the tension traces as the stump lifted. No useful reaction time would be available to the operator in which to drop his lines. This is in contrast to deadmen where failure is prolonged.
- In those stumps where some root damage was evident (resulting from tractor grousers or bladework), stump failure occurred at significantly lower tensions. The practical implication is clear : stumps, with even minor apparent damage, should not be used as anchors.

LIRA would welcome the co-operation of other logging organisations in continuing this work.

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