NEW HAULERS SUITABLE FOR LOGGING NEW CROP

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ABSTRACT

Recommended specifications for skyline haulers and swing yarders are outlined. Prices range from $500,000 - $750,000 for skyline haulers and $750,000 - $1,200,000 for swing yarders.

Payload calculations show that these new machines have more than double the capacity of existing technology machines in New Zealand.

Cycle times from study data of existing machines in New Zealand and new machines in the PNW are compared and increases in productivity recorded with the PNW haulers. Man related element times are generally slower in the New Zealand operations.

It is concluded that these new machines will be economically viable in new crop provided high productivity can be maintained.

INTRODUCTION

Few people will dispute that a significant increase in cable logging will be required to harvest New Zealand's new crop resource. Some have even been brave enough to put a figure on this proportion and estimates of around 44% have been suggested (Tustin, 1983). Along with this increase in volume to be harvested by cables, is a similar increase in the degree of difficulty the terrain will impose on harvesting systems. Areas such as Mangakahia in Northland, Whangapoa in Coromandel, Mangatu and Ruatoria on the East Coast and Queen Charlotte Forest in Marlborough, are examples of this more difficult terrain.

These areas have features which will impose restrictions on the harvesting options, including:

- The broken nature of the terrain with convex slopes and intermediate ridges limiting the systems that can be used.
- Sensitive or unstable soils, particularly on the East Coast of the North Island.
- Irregularities in setting boundaries with extremes of age classes (and species changes) adjacent to each other.
- Environmental restrictions imposed by catchment authorities which may have implications for harvesting methods.

To compound the problems outlined above, the new crop resource will have different characteristics to old crop radiata. Mean tree volume for example is expected to fall from $4.5m^3$ to about $2.2m^3$ as the typical clearfelling age drops from 45 to 28 years (Manly, 1986, Nicholls, 1986). Stocking levels will also reduce as the silviculturally tended stands come on stream and live volumes per hectare will go from $1200m^3$ to around $600m^3$ depending on age class. The nett result is fewer smaller trees with lower overall volume per hectare.

All of this is going to require low harvesting costs so that these areas can be economically viable.

In this paper I propose to describe the type of haulers our research has shown will be most suited to logging new crop. These predictions will be supported by results from study data collected during a recent Jubilee Scholarship trip[1].

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[1]*The Jubilee scholarship is an award granted annually by Elders Resources NZFP to assist persons undertaking study and research in forestry or forestry related industries either in New Zealand or overseas.*

WHAT IS REQUIRED

The traditional cable logging methods used in New Zealand will not be suitable for handling a large proportion of the new crop areas. The customary two-drum haulers with 27m towers (e.g. Madill 009) will have limited application in these areas because they are not matched to the smaller wood and lower volumes per hectare. The main disadvantages with the large 27m tower machines are: the inflexibility of the systems they can use (i.e. no slackpulling), their relative lack of mobility when it comes to frequent machine shifts, the requirements for anchoring them and the quality and size of roads and landings necessary for them to operate on.

Systems Required

The increasing difficulty of the terrain will mean a decrease in road densities per hectare and a reduction in landing size to save on construction costs and the impact on the site. Cable systems will have to reach out over 400m and occasionally extend out to 600m to reach small inaccessible pockets.

The broken nature of the terrain and sensitivity of soils will require the use of suspension systems for most of these areas. Skyline haulers with mechanical slackpulling facilities to optimise payloads will be an essential part of these systems. In extreme situations multi-span may be necessary where it is not possible to get a road or track in to the setting. Swing yarders will have an application in areas where the terrain is even and road and landing construction has to be kept to a minimum e.g. parts of Mangatu and Ruatoria on the East Coast. Highlead, scab skyline and Shotgun systems are also likely to be common practice where ground conditions permit. The "ideal" machine therefore will need to be able to efficiently operate the following systems:

(i) Highlead
(ii) Shotgun
(iii) Scab skyline
(iv) Slackline
(v) Northbend
(vi) MSP carriage systems

A comprehensive manual describing the various systems, the type of haulers required for them and planning and operational procedures is published by LIRA (Liley, 1983).

Machine Specifications

Skyline haulers will need a minimum of five drums (four working drums and a strawline) to enable them to operate the above systems. Ideally they would have the drum capacities listed in Table 1.

Depending on operating position, a minimum of 4 guylines would be necessary with these haulers.

Expected engine power would need to be between 200 and 300kW, to provide the above line pulls.

Line speeds would want to be between 400 and 600m/min for mainrope and slackpuller, and up to 1000m/minute for the tailrope drum. Note that manufacturers specifications are sometimes misleading as they quote line pulls on a bare drum at stalling speed, and line speeds on a full drum at no load.

In my view the tower should be an integral part of the hauler and should have an operating height of about 20m. Being able to move with the tower vertical will be a big advantage when shifting between landings. For the machine to be able to operate a scab skyline system, the tailrope sheave should be above the mainrope sheave in the top of the tower. It stands to reason also that the skyline sheave should be above the mainrope sheave for shotgunning.

The key to success with these machines is to utilise their mobility and move them into positions where the most efficient system can be used. To do this it is best if the base carrier is self-propelled. If machine shifts over short distances are anticipated and a high degree of manoeuvrability or traction are necessary, the hauler should be track mounted. Rubber tyre mounting is better for situations where shifts over longer distances are expected.

Swing yarders will need a minimum of four drums, including strawline, and be able to operate the running skyline system. They should have the capacity to log out to 450m with rope sizes of 19-26mm.

TABLE 1 : DRUM CAPACITIES FOR NEW CROP HAULERS

Drum	Rope Size	Capacity	Linepull (mid drum)
Skyline	26mm - 32mm	450 - 600m	20,000kg - 35,000kg
Mainrope	19mm - 22mm	500 - 650m	8,000kg - 12,000kg
Tailrope	16mm - 19mm	1200 - 1400m	Braking capacity will be more important than linepull
Slackpuller	13mm - 16mm	550 - 700m	3,000 - 5,000kg

Linepull and engine power requirements will be similar to the skyline hauler specifications above. Obviously higher line speeds would be expected with these interlocked machines. Minimum tower height for swing yarders should be 15m and the guyline configuration such that the machine is supported during the swinging action. With the boom inclined to 15^0 (during operation) a minimum of 2 guylines are required.

PAYLOAD ANALYSIS

The easiest way to justify the predictions made above is to use an example. Figure 1 is a ground profile taken from a setting in a new crop stand in the Hawkes Bay district. The total distance from the landing to the back of the setting was 452m.

Using LOGGERPC analysis (Oregon State University, 1987) payload calculations have been made for a Madill 071 with 26mm skyline (an example of current technology) and a Madill 171 with 28mm skyline (a new machine that would satisfy the above requirements). The logging system envisaged is tree length extraction to a rubber tyred front end loader. The analysis (see Appendix 1) shows that with a 6m tail tree at terrain point 19, and using a live skyline system, the 171 could haul an average payload of 4594 kg compared to 2010 kg with the 071 - a 128% increase.

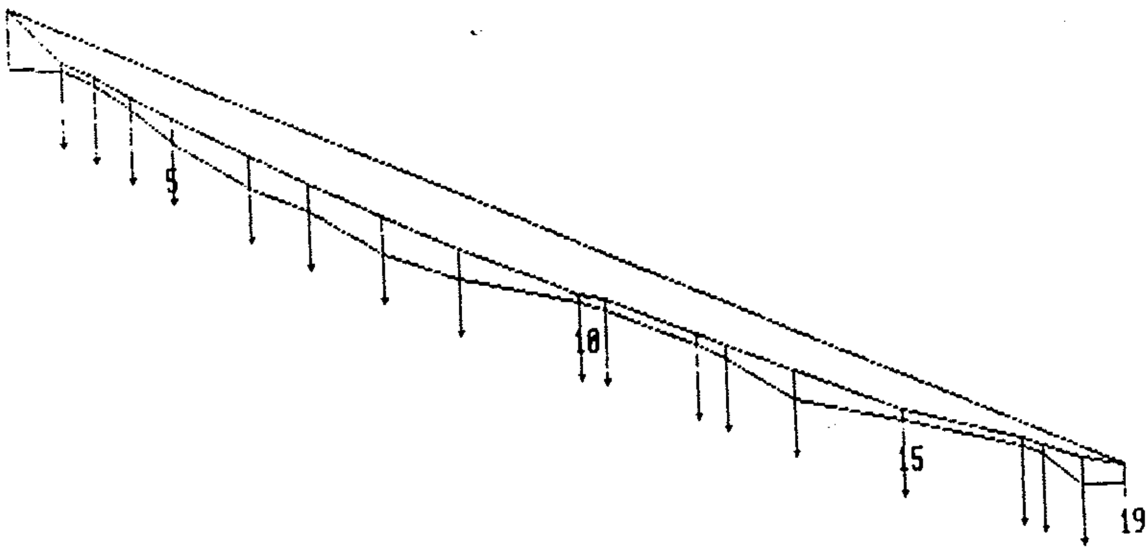


Figure 1 : Ground profile from Hawkes Bay Forest

Over 67% of this extra payload is due to the larger mainrope and skyline. The maximum payload over the critical point at terrain point 12 was 1595 kg for the 171 and 411 kg for the 071 i.e. nearly four times the 071's payload at that point. Note that although the LOGGERPC analysis tends to underestimate payloads, the difference is still significant.

The above comparison is based on one example and just considers payload analysis according to rope strength. If the faster mainrope drum speed of the 171 is taken into account (13% higher) the advantages of the new machine are likely to be greater.

An independent analysis done by a Tasmanian contractor (Morgan pers comm) showed that he could reduce his multispan rigging by 40% if he changed from the 071 to a 171. Similar investigations have been done by Timberlands districts on the East Coast (Drummond pers comm) and they estimate a $3.00/m^3$ saving in hauling costs with the 171.

Doing the same analysis as above with swing yarders and comparing a Washington 88 (current technology) with a Thunderbird TSY 255 (new technology) an average payload of 980 kg is calculated for the 88 and 2143 kg predicted for the TSY 255. Once again a significant increase (119%). These machines have comparable linespeeds, but the 255 has greater linepulls and more capacity than the 88. As with the comparison of skyline haulers, the payload at the critical point was twice as much with the new machine.

WHAT IS AVAILABLE?

A list of all skyline haulers that meet the outlined specifications is shown in Table 2. The table only considers machines that are currently being manufactured or are able to be manufactured.

Table 2 does not consider large 27-30m tower haulers or modifications that may be made to existing machines (e.g. fitting a 20m tower to a Westminster hauler).

TABLE 2 : SKYLINE HAULERS FOR NEW CROP LOGGING

Machine	Power	Tower Height	No. of Drums	Skyline Size	Skyline Capacity	Mainrope Size	Mainrope Capacity	Cost NZ$*
Thunderbird TMY70	317kw	21m	5	28mm	610m	22mm	640m	$730,000
Madill 171	298kw	21m	5	28mm	610m	22m	610m	$670,000
Berger C19	390kw	18m	5	28mm	680m	22mm	767m	$750,000
Edco Wildcat III	335kw	23m	5	28mm	732m	22mm	823m	N/A
Bellis	201kw	23m	4**	28mm	612m	22mm	850m	$470,000
Steyr KSK 20	236kw	22m	5	24mm	700m	16mm	650m	$725,000
Lotus SIV***	261kw	18m	4	26mm	405m	22mm	500m	$480,000

*Cost is NZ$ based on March 1989 prices, a US - NZ exchange rate of NZ$1.00 = US$0.61 and including NZ$50,000 to ship the hauler to New Zealand.

**The current Bellis hauler has 4 drums but a 5th drum could be added for approximately $30,000.

***Note that these are basic specifications for the Series IV and increases in the No. of drums, rope capacity and tower height can be made for little extra cost. Price includes $30,000 for a second hand truck.

TABLE 3 : SWING YARDERS FOR NEW CROP LOGGING

Machine	Power	Tower Height	Mainrope Size	Mainrope Capacity	Tailrope Size	Tailrope Capacity	Cost NZ$*
Madill 123	343kw	16m	22mm	715m	22mm	1349m	$1,025,000
Madill 122	298kw	16m	22mm	427m	22mm	884m	$ 920,000
Thunderbird TSY255	313kw	15m	22mm	610m	22mm	1220m	$ 960,000
Thunderbird TSY355	317kw	18m	22mm	701m	22mm	1403m	$1,025,000
Washington 88	227kw	14m	19mm	534m	19mm	1068m	$ 747,000
Washington 188	336kw	17m	22mm	701m	22mm	1403m	$1,030,000
Cypress 6280	336kw	18m	22mm	610m	22mm	1220m	$ 935,000
Cypress 7280	392kw	21m	22mm	519m	22mm	1250m	$1,200,000

**Prices calculated as for Table 2. These particular figures (in Table 3) are list prices which is a starting point for negotiation. Eventual purchase price could be as much as NZ$80,000 lower.*

Table 3 records all of the swing yarders that would meet the suggested specifications.

Information on the Lantec swing yarders has not been included as it is uncertain whether they are still being manufactured.

MACHINE STUDIES

With the assistance of a Jubilee scholarship award, production studies were conducted on two skyline haulers and a swing yarder operating in the State of Oregon, USA. The Skyline haulers were: a Madill 171 rigged with an Interstate dropline carriage, and a Thunderbird TMY70 using a slackline, (live skyline) system. The swing yarder was a Thunderbird TSY 255 set up as a running skyline with a MSP (Mechanical Slack Pulling) carriage.

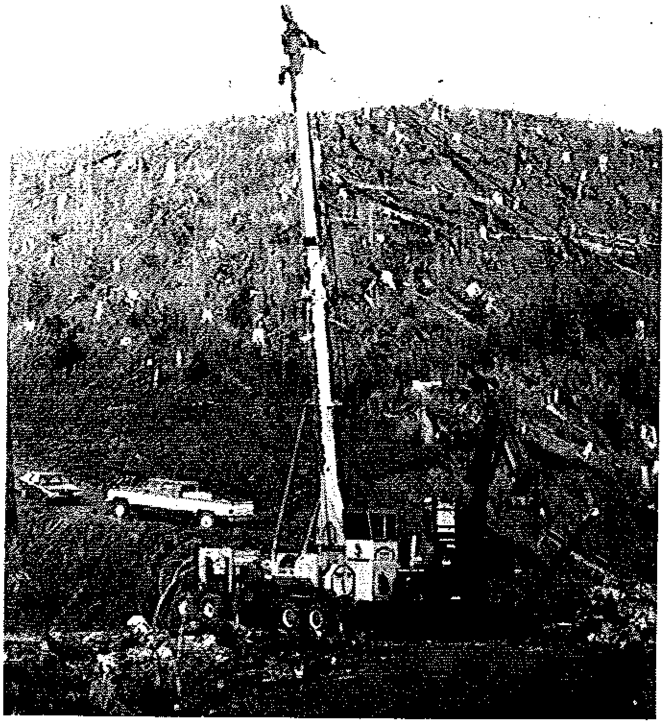
In each operation a 30 - 35 tonne hydraulic knuckleboom loader was used for fleeting and loading at the landing. Extraction was all log length with four to six segregations being made. The crew size for both skyline haulers was six men excluding the fallers. (This was done on a sub-contract basis). Generally there were two or three breaker-outs in these operations. An eight man crew was operating the swing yarder with four, and occasionally five breaking out.

Results

Data from the production studies are summarised in Table 4. Readers are cautioned not to draw direct comparisons between these machines because there were significant differences in extracted log size and the logging systems were different. For convenience all haul distances have been standardised to 200m.

Table 4 shows that under the conditions studied, all three machines were capable of producing between 275 and 310m^3 per eight hour shift. Similar operations in New Zealand might produce 140 to 200m^3 per shift (Galbraith, 1987). While piece size has some influence on productivity it is not necessarily the sole factor in determining performance. Take for example the small piece size in the 171 operation which resulted in an average payload well under the machines capacity and yet hourly production was still competitive.

It should be noted that this data includes a complete machine shift in both the 171 and the TSY255 operations, and a system change in the TMY70 operation. The extra non-productive time may have artificially inflated the delay times, although frequent machine shifts and system changes are common in the Pacific Northwest.



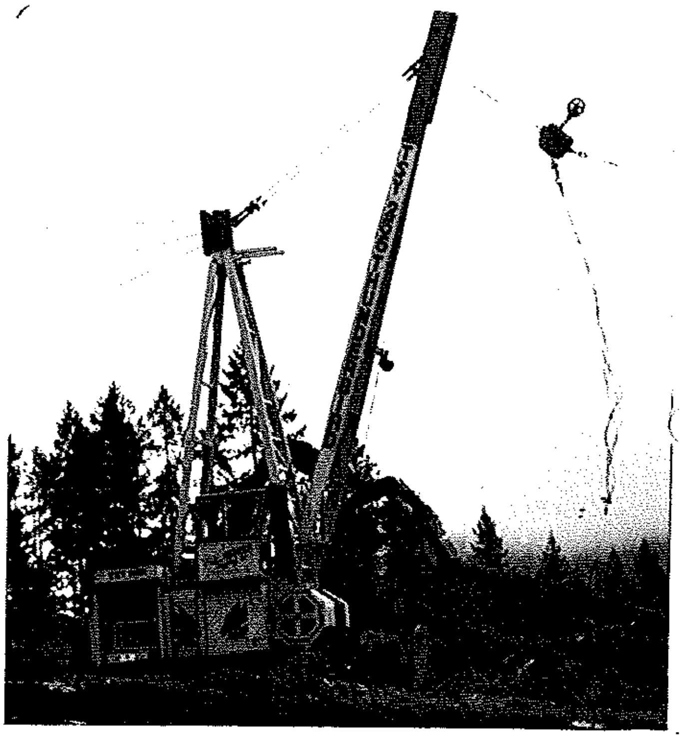


Figure 2 : Examples of the skyline haulers and swing yarder studied in the PNW.

TABLE 4 : RESULTS FROM PRODUCTION STUDIES IN THE PNW

Element	Madill 171	Thunderbird TMY70	Thunderbird TSY255
Delay free cycle time	3.68 min	5.70 min	4.76 min
Delays	1.90 min	2.19 min	1.86 min
Total cycle time	5.58 min	7.79 min	6.62 min
Prices/cycle	3.83	3.55	3.89
Vol/piece	.84m^3	1.42m^3	1.05m^3
Ave drag size	3.22m^3	5.04m^3	4.08m^3
Production/hour	34.6m^3	38.8m^3	37.0m^3

While it is unwise to directly compare these results with studies done on New Zealand cable operations, it is possible to use them as indicative of machine performances and look at differences in element times to see where any productivity losses might originate from. The studies can be best analysed on a system basis as follows:

1) **MSP System on Skyline Haulers**

Data from a recent study on an 071 Madill operating in Douglas fir in Kaingaroa (Mythen and McConchie, 1987) can be put alongside the 171 study results to see where differences in element times occur. The 071 was using a Danebo MSP carriage in a log length operation with a 30 tonne hydraulic knuckleboom loader on the landing. Results are shown in Table 5.

Table 5 shows that although the 071 was hauling a larger average payload, cycle times were almost twice as long. Machine related elements were much slower in the 071 study (3.63 min compared to 1.87 min) with "Outhaul" and "Inhaul" being 76 and 126% (respectively) longer.

TABLE 5 : CYCLE TIMES FROM STUDIES OF 071 AND 171 MSP SYSTEMS

Element	*Madill 071*	*Madill 171*
Sample Size	*99*	*125*
Raise rigging	*.40*	*.20*
Outhaul	*.88 (200m)*	*.50 (200m)*
Position	*.36*	*.44*
Hook on	*3.09*	*1.01 (3.83 pcs)*
Breakout	*.47*	*.26*
Inhaul	*1.72 (200m)*	*.76 (200m)*
Lower rigging	*.16*	*.15*
Unhook	*.70*	*.36*
Delay free Total	*7.78*	*3.68*
Production delays	*.46*	*.04*
Landing delays	*.06*	*.08*
Rigging	*1.31*	*1.69*
Other	*1.24* (1)	*.09* (2)
Total cycle time	*10.85*	*5.58*
No. of pieces	*4.00*	*3.83*
Ave piece size	*1.06*m^3	*.84*m^3
Ave drag size	*4.24*m^3	*3.22*m^3

(1) The other element includes social delays, access, preparation etc.

(2) This crew did not stop for smoko breaks.

Man related elements such as "Hook on" and "Unhook" were nearly three times longer in the 071 cycle. There is no obvious reason for this because average piece size was bigger and the same number of breaker-outs were being used.

2) **Live Skyline Systems**

The same 071 used in the MSP study was also evaluated using a live skyline (shotgun) system (McConchie and Mythen, 1987). While shotgunning is not exactly the same as slacklining (because no tailrope is used) the basic principles of raising and lowering the skyline for breakout and unhooking still apply. In this light, parallels can be drawn between the 071 and TMY70 data. Results are summarised in Table 6.

As would be expected the "Outhaul" element with the 071 shotgunning was faster than in the TMY70's slackline system but "Inhaul" times were much slower. The machine related elements in the cycle and the larger average payload indicate that the TMY70 had considerable advantages over the 071 in terms of hauling capacity.

Once again man related elements took longer in the New Zealand operation (4.49 compared to 2.32 min) with no apparent explanation for the difference.

TABLE 6 : CYCLE TIMES FROM STUDIES OF 071 AND TMY70 LIVE SKYLINE SYSTEMS

Element	Time, minutes Madill 071	 Thunderbird TMY70
Sample Size	75	93
Raise rigging	.24	.29
Outhaul	.51 (200m)	.67 (200m)
Position(1)	.60	.96
Hook on	3.43 (4.3 pcs)	1.90 (3.55 pcs)
Breakout	.28	.31
Inhaul	1.54 (200m)	.91 (200m)
Lower rigging	.24	.24
Unhook	1.06	.42
Delay free total	7.90	5.70
Production delays	.13	.15
Landing delays	.35	.05
Rigging	.67	1.31
Other	.99	.58
Total cycle time	10.04	7.79
No. of pieces	4.24	3.55
Ave piece size	.87m^3	1.42m^3
Ave drag size	3.69m^3	5.04m^3

(1) Position includes move in and lower strops in the bush

3) MSP System on Swing yarders

Data from the TSY255 study can be matched with results from a study on a Washington 88 using a Young MSP carriage in Kaingaroa transition crop (Prebble, 1988). This operation was based on log length extraction but discrepancies in specification and length resulted in long landing delays while these errors were corrected. Results are summarised in Table 7.

Machine related elements were actually quicker with the Washington 88 but smaller drags were being extracted. Man related elements were comparable with the TSY255 data although production and landing delays were longer. Actual "hook on" time per piece was .19 min in the 88 study and .16 min in the TSY255 study.

Indications are that the Washington 88 could have been more productive if longer "Hook on" times were accepted and a larger payload hauled (the report concludes that the drag size in the Washington 88 study was well below the machine's capacity). The question as to whether a logger should spend $750,000 on a Washington 88 as opposed to

TABLE 7 : CYCLE TIMES FROM STUDIES OF WASHINGTON 88 AND TSY255 MSP SYSTEMS

Element	Time, minutes Washington 88	Thunderbird TSY255
Sample size	101	70
Raise rigging	.11	.45
Outhaul	.50 (200m)	.56 (200m)
Position	.53	.61
Lateral out	.24 (8.6m)	.21 (6.7m)
Hook on	.91 (4.7 pcs)(1)	.63 (3.89 pcs)
Breakout	.42	.36
Inhaul	.87 (200m)	1.05 (200m)
Lower rigging	.20	.33
Unhook	.92	.56
Delay free total	4.70	4.76
Production delays	.10	.04
Landing delays	.84	.09
Rigging	.33	.86
Other	.81	.87
Total cycle time	6.78	6.62
No. of pieces	4.6	3.89
Ave piece size	.50m^3	1.05m^3
Ave drag size	2.30m^3	4.08m^3

(1) Logs were pre-stropped in this study

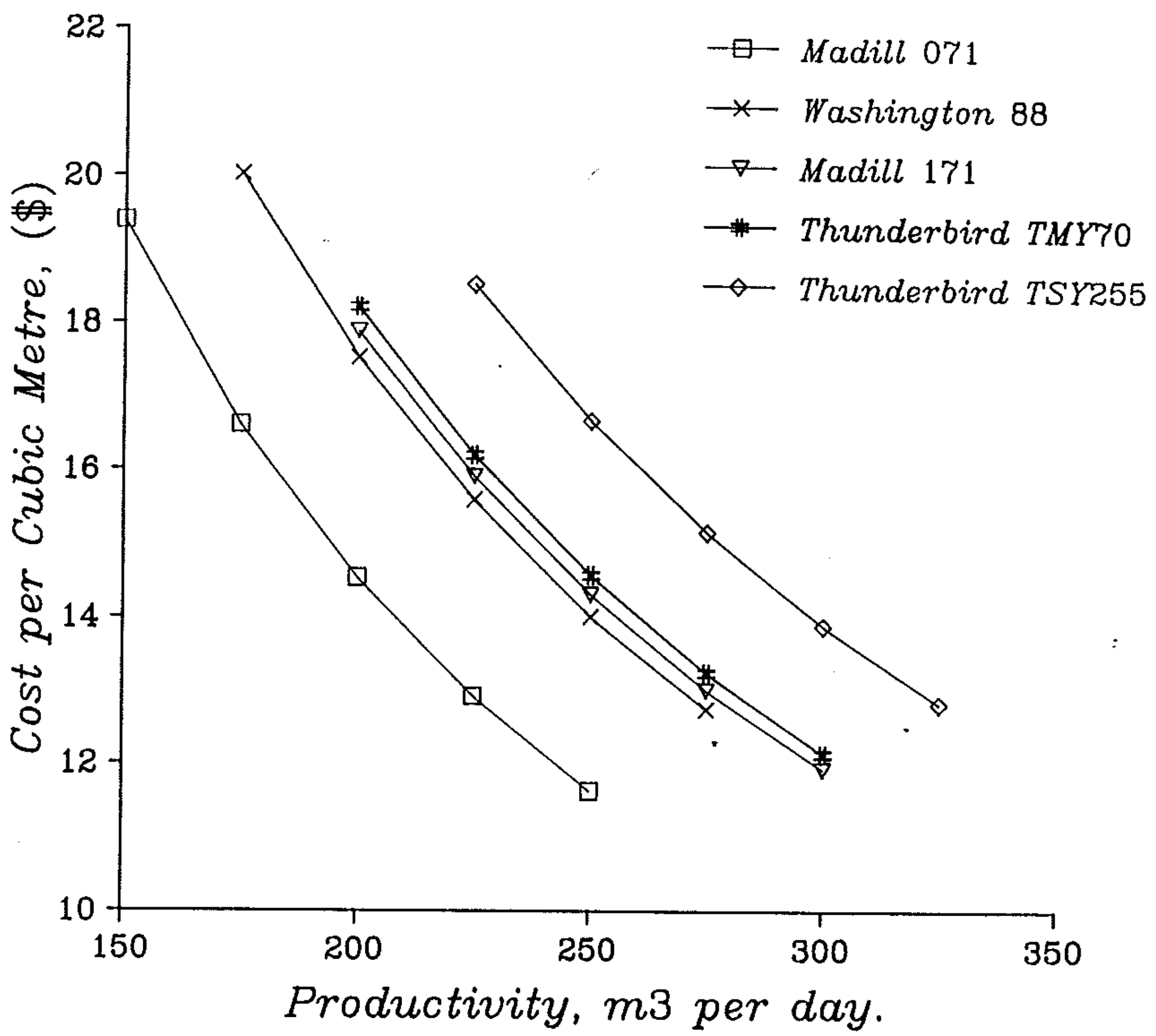


Figure 3 : Unit Costs according to Productivity

$960,000 for a TSY255 Thunderbird should not rest on the machine's productive capability alone, but on its reliability and the availability of parts and servicing facilities. History tells us that these features of the 88 have not been as impressive as its performance.

Costs

As with the productivity figures it is not advisable to directly compare costs. What can be illustrated however is the effect that volume per day can have on unit cost.

Using the LIRA costing format (Duggan, 1989) a daily cost for each operation can be estimated. For simplification a standard 8 hour day is used and a Linkbelt 4300 loader costed in to each operation. Falling costs equivalent to three extra men plus saws have been added to the U.S. operations. Details of these costs are shown in Appendix 2.

Estimated productivity from each of these operations can then be plotted against daily cost to establish a unit cost (see Figure 3). If the new 21m tower haulers can produce between $250m^3$ or more per day, they will be cost competitive with the Madill 071 at around $200m^3$ per day. Similarly if the TSY 255 can produce $50m^3$/day more than the Washington 88 it will be competitive. Given the results of the time study data in Tables 5, 6 and 7, there is no reason to believe that those levels of productivity would not be sustainable in New Zealand operations.

CONCLUSIONS

Five-drum self-propelled skyline haulers with integral 20m towers will be necessary if we are going to efficiently log our up and coming new crop areas. Computerised payload analysis based on wire rope capacities shows that these new haulers could haul more than double the payload of existing machines over critical profiles in these areas.

There are a limited number of skyline haulers available that will meet the recommended specifications, but the cost is high. Prices range from half to three-quarters of a million dollars.

Suitable swing yarders are even more expensive with prices from $750,000 to over $1,200,000 NZ and that is just the hauling machine alone. Appropriate loaders with the capacity to handle the volumes expected, start at $300,000.

Studies have shown that machine related elements can generally be done faster with the new machines. "Outhaul" and "Inhaul" speeds of the 171 Madill for example were 76 - 126% (respectively) faster than the 071 under similar operating conditions. Man related elements in the New Zealand operations are consistently slower than in the U.S. Consider the live skyline systems, the "Hook on" and "Unhook" elements were nearly twice as long in the N.Z. operation.

Swing yarders will have a place in new crop areas where long, even terrace type slopes have natural mid-slope road locations. These machines will allow the logger to use minimal road and landing construction provided the rest of the system is capable of handling the production. Current technology swing yarders such as the Washington 88 have considerable potential but inefficient operation and high R & M costs have tempered their reputation.

The new skyline haulers and swing yarders will be economically viable provided high volumes of wood are pulled with them. I personally believe that if Forest Owners are really serious about logging this radiata new crop resource efficiently, they will have to provide enough incentive for loggers to invest in new equipment and then - most importantly - let them make some money out of their investment.

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APPENDIX 1

LOGGERPC PAYLOAD ANALYSIS FOR 071 AND 171 MADILLS

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------------------( LIVE SKYLINE LOAD ANALYSIS )------------------

STATIC ANALYSIS

PROFILE: A:ECOJUN30.PRO                 YARDER: MAD_071 .YRD

HEADSPAR HT              = 15           TAILSPAR HT  =  6
LANDING CUT(-)/FILL(+)   =  0           YARDING TOWARDS YARDER
CARRIAGE CLEARANCE       =  2           LOG DRAG COMPUTED
LOG LENGTH               = 25           CHOKER LENGTH =  5

RIGGING LENGTH REQUIREMENTS       REQUIRED      AVAILABLE
        SKYLINE                      533           589
        MAINLINE                     498           563
        HAULBACK                    1012          1342
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TERRAIN POINT	PAYLOAD	LIMITING LINE	REQUIRED LINE	CARRIAGE CLEARANCE	LOG CLEARANCE	TYPE SUSPENSION
2	9345	MAINLINE	MAINLINE	2.0	0.0	PARTIAL
3	4269	SKYLINE	MAINLINE	2.0	0.0	PARTIAL
4	3024	SKYLINE	MAINLINE	2.0	0.0	PARTIAL
5	4756	SKYLINE	MAINLINE	2.0	0.1	PARTIAL
6	9918	MAINLINE	MAINLINE	2.0	0.0	PARTIAL
7	4834	SKYLINE	MAINLINE	2.0	0.0	PARTIAL
8	3843	SKYLINE	MAINLINE	4.9	1.4	PARTIAL
9	2529	SKYLINE	MAINLINE	5.3	1.5	PARTIAL
10	2564	SKYLINE	MAINLINE	2.0	0.0	PARTIAL
11	492	SKYLINE	MAINLINE	2.0	0.0	PARTIAL
12	411	SKYLINE	MAINLINE	2.0	0.0	PARTIAL
13	970	SKYLINE	MAINLINE	2.0	0.0	PARTIAL
14	2291	SKYLINE	MAINLINE	4.1	0.5	PARTIAL
15	5141	SKYLINE	MAINLINE	2.0	0.0	PARTIAL
16	458	SKYLINE	MAINLINE	2.0	0.0	PARTIAL
17	387	SKYLINE	MAINLINE	2.0	0.0	PARTIAL
18	11222	SKYLINE	MAINLINE	4.9	0.6	PARTIAL

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---------------------------( * = Critical pt )---------------------------
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------------------( LIVE SKYLINE LOAD ANALYSIS )------------------

STATIC ANALYSIS

PROFILE: A:ECOJUN30.PRO                 YARDER: MAD_171 .YRD

HEADSPAR HT              = 21           TAILSPAR HT  =  6
LANDING CUT(-)/FILL(+)   =  0           YARDING TOWARDS YARDER
CARRIAGE CLEARANCE       =  2           LOG DRAG COMPUTED
LOG LENGTH               = 25           CHOKER LENGTH =  5

RIGGING LENGTH REQUIREMENTS       REQUIRED      AVAILABLE
        SKYLINE                      545           610
        MAINLINE                     510           610
        HAULBACK                    1024          1220
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TERRAIN POINT	PAYLOAD	LIMITING LINE	REQUIRED LINE	CARRIAGE CLEARANCE	LOG CLEARANCE	TYPE SUSPENSION
2	12121	MAINLINE	MAINLINE	2.0	0.0	PARTIAL
3	12020	MAINLINE	MAINLINE	2.0	0.0	PARTIAL
4	8550	SKYLINE	MAINLINE	2.0	0.0	PARTIAL
5	12114	MAINLINE	MAINLINE	2.0	0.0	PARTIAL
6	13287	MAINLINE	MAINLINE	2.0	0.0	PARTIAL
7	8719	SKYLINE	MAINLINE	2.0	0.0	PARTIAL
8	6313	SKYLINE	MAINLINE	4.9	1.4	PARTIAL
9	4622	SKYLINE	MAINLINE	5.3	1.5	PARTIAL
10	7255	SKYLINE	MAINLINE	2.0	0.0	PARTIAL
11	2409	SKYLINE	MAINLINE	2.0	0.0	PARTIAL
12	1595	SKYLINE	MAINLINE	2.0	0.0	PARTIAL
13	2159	SKYLINE	MAINLINE	2.0	0.0	PARTIAL
14	4958	SKYLINE	MAINLINE	3.3	0.0	PARTIAL
15	8577	SKYLINE	MAINLINE	2.0	0.0	PARTIAL
16	1623	SKYLINE	MAINLINE	2.0	0.0	PARTIAL
17	1586	SKYLINE	MAINLINE	2.0	0.0	PARTIAL
18	14534	SKYLINE	MAINLINE	4.7	0.4	PARTIAL

```
---------------------------( * = Critical pt )---------------------------
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APPENDIX 2

DAILY COSTS FOR SKYLINE HAULERS AND SWING YARDERS

Machine	MSP Skyline Systems		Live Skyline Systems		Running Skyline Systems	
	071	171	071	TMY70	88	TSY255
Hauler	616.00	1060.00	611.00	1118.00	1148.00	1434.00
Loader	523.00	523.00	523.00	523.00	523.00	523.00
Labour	1223.00	1376.00	1223.00	1376.00	1223.00	1529.00
Operating Supplies	231.00	231.00	231.00	231.00	231.00	231.00
Overheads	52.00	64.00	52.00	65.00	63.00	74.00
Profit (10%)	265.00	325.00	264.00	331.00	319.00	379.00
TOTAL	2910.00	3579.00	2904.00	3644.00	3507.00	4170.00