Draft Only

Session 3
Paper (c)

PRODUCTIVITY IN HARVESTING SINCE THE 1970s

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ABSTRACT

Statistical information on the harvesting industry is confused. Production rates and productivity for harvesting operations dominated by large piece size old crop radiata are mainly of historical interest. Production rates and productivity will drop with piece size in the transition and young crop radiata stands and work content will increase in the bush and on the landing. Thinning productivity has increased with piece size but the lack of standards and definitions makes meaningful comparisons difficult. Increased research effort with full industry participation and cooperation is required to clarify the state of the productivity factors.

KEYWORDS : Productivity, radiata pine, harvesting.

WHAT IS PRODUCTIVITY?

DEFINITION

Productivity is the ratio between output and input. This definition applies in an enterprise, and industry or an economy as a whole. In simpler terms productivity is nothing more than the arithmetical ratio between the amount produced and the amount of any resources used in the course of production. In forestry we are concerned with the productivity of the land, of materials, machines and of men. This paper is mainly focussed on the men and machines.

It was reckoned in the 1950s that higher productivity provided opportunities for raising the general standard of living, including the opportunities for:

(a) larger supplies both of consumer goods and of capital goods at lower costs and lower prices;
(b) higher real earnings'
(c) improvements in working and living conditions,. including shorter hours of work; and
(d) in general, a strengthening of the economic foundations of human well being.

How are we doing?

THE NZ LOGGER AND PRODUCTIVITY

STATISTICS

Reliable up-to-date information on the labour force working in the NZ logging industry is currently not available. A recent survey by Walker (unpublished) showed considerable differences between different sources of statistics. The following is taken directly from his note:

Movement in workers employed

"Of all the elements of this analysis, the identification of the numbers employed proved to be the most frustrating. The original Quarterly Employment Survey (QES) of the Labour Department ceased circa 1986/87. Subsequent efforts by the Statistics Department produced such marked discrepancies that the Labour Department had to undertake a re-run. The major difficulty in reconciliation appears to be due to the dispersion of labour at the time of the demise of the Forest Service, coupled with private sector changes in preceding years. Comment to this effect is to be found in chapter 13, p. 155 "The Economy in transition", published by the NZ Planning Council. Unfortunately the discrepancies shown are not analysed for a split between Forestry and Log Harvesting. In a new Statistics Department publication called "NZ Business Patterns: (NZBP) the 1987 level for logging personnel was quoted in this publication at 2328. The QES level appears to be, from Labour Department data, 2305, hence at the 1987 date there is some agreement between the two sources.

By 1988 however, considerable divergence appeared. The QES is quoted at 1658, while the NZBP shows 2504. One clue to the variation lies in the number of units surveyed; the QES data derives its personnel level from 196 units while the NZBP quotes the active units as being 560. Even this is in question, for other informed sources have indicated that this latter figure is exceeded within the Bay of Plenty region alone. There is some indication that the dispersion of labour has led to a fragmentation of what used to be a cohesive logging operation that embraced felling, log hauling and skid work, as well as truck loading in many instances. This cohesion no longer appears to exist. In its place there seems to have arisen a series of sub-units, dealing with the various phases of the overall operation, being viewed as separate entities".

Therefore the fallback position for the balance of this paper will be to establish some apparent national trends, strengthened wherever possible by more specific information supplied by industry ; The specific data will wherever possible, mainly relate to the production in radiata pine harvesting operations, and to ground extraction systems, within the Bay of Plenty.

TABLE I - Manpower changes over time

Type of gang	Manpower per gang			
	1957 KLC	1980 KLC	1980 WAIPA	1980 NZFS
Double tractor	14	15	14	14*
Skyline	13	12	10	-
Highlead SJ7	8	9	-	-
Highlead Madill 009	-	10	-	-
Single tractor	10	11	10	8
Single skidder (rubber-tyred)	-	11	-	8

* contract operation

PIECE SIZE AND PRODUCTIVITY : THE PAST

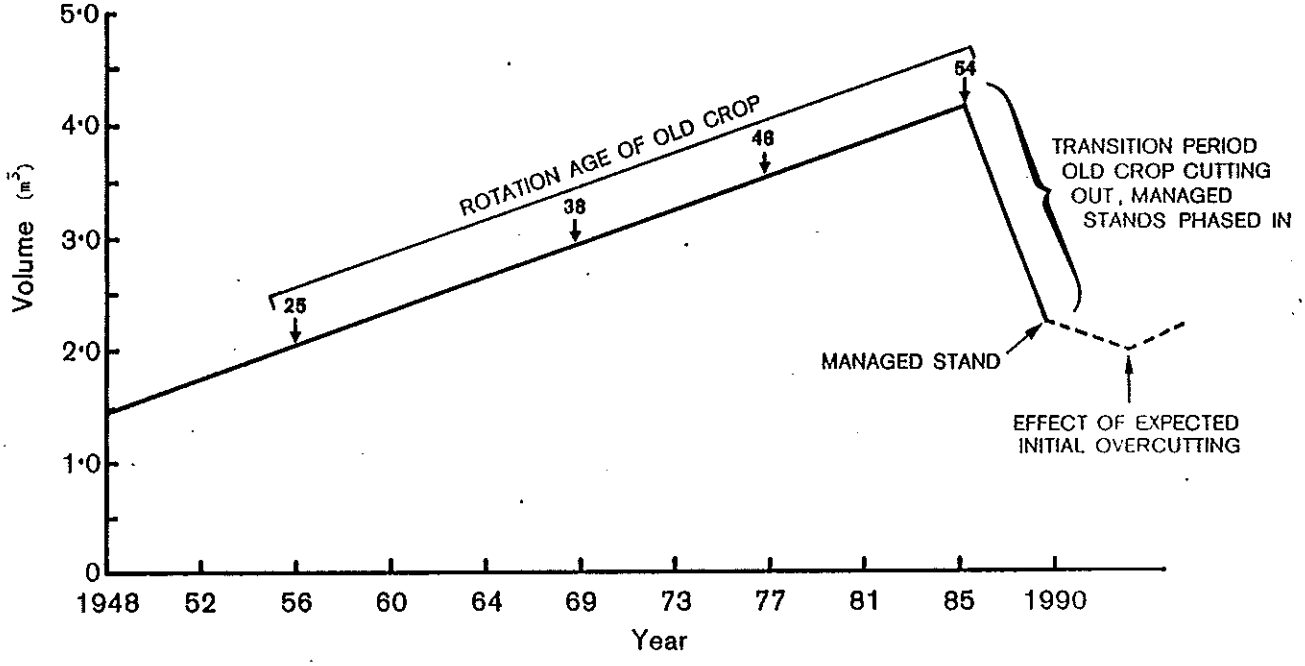
From a review carried out by J. Fry in 1982 (unpublished) on productivity gains in clearfell operations in Kaingaroa it was found that crew numbers varied considerably between the organisations at the time. Refer Table I.

Graph I again taken from Fry shows the predicted effect of the phasing out of the large old crop radiata and arrival of the smaller transition crop. Hindsight shows that the finish of the old crop stands has been delayed - nevertheless the predicted reduction in piece size has occurred.

GRAPH 1

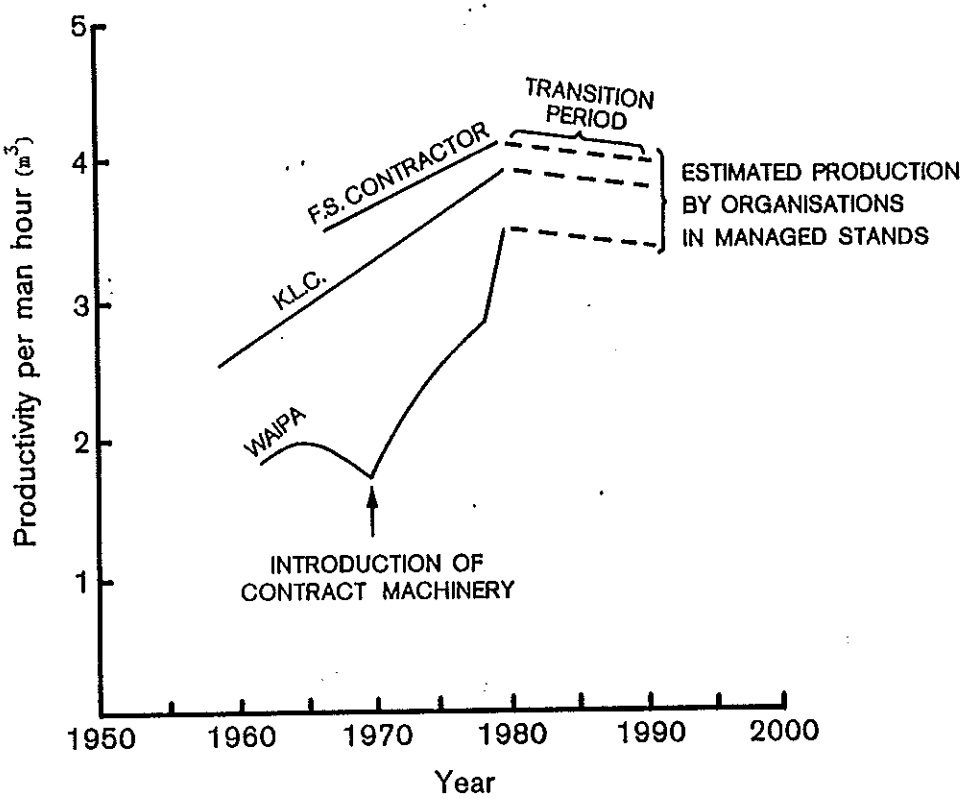
PIECE SIZE TREND IN RADIATA PINE

A comparison between the ageing old crop stands and the highly managed stands expected to come on stream in the late 1980's
Kaingaroa forest



GRAPH II

INCREASE IN PRODUCTIVITY SINCE MAJOR LOGGING OPERATIONS COMMENCED IN KAINGAROA FOREST



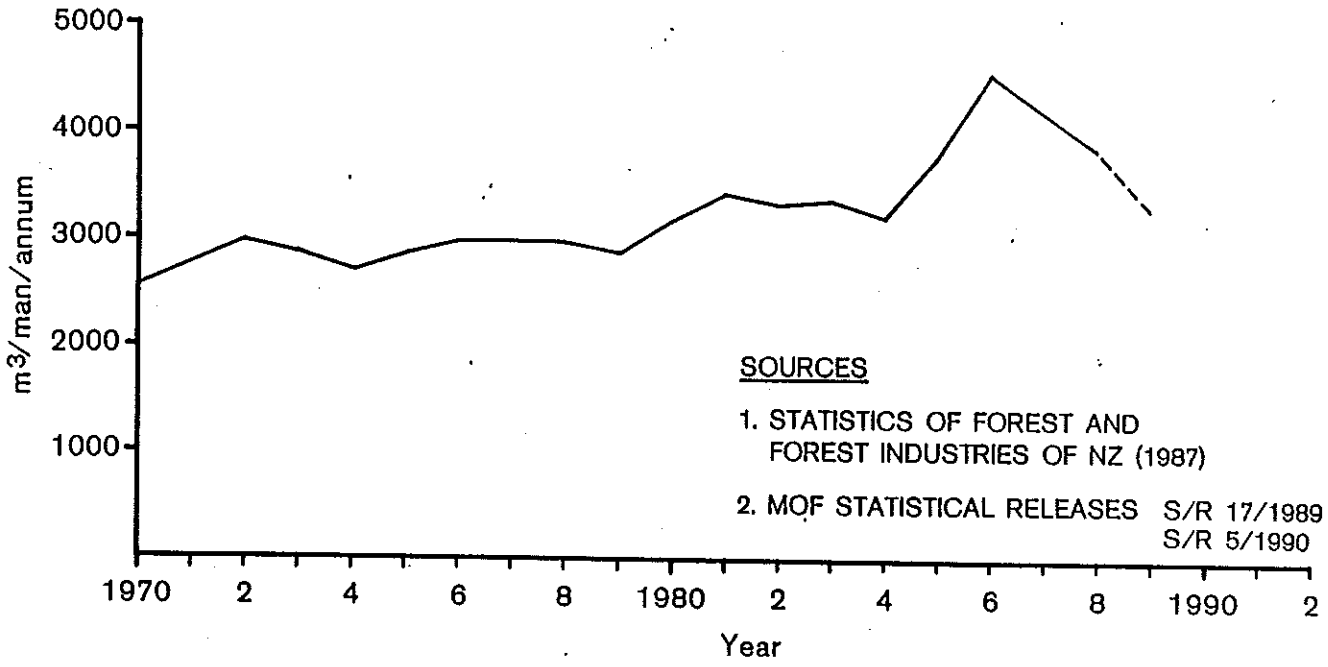
NATIONAL STATISTICS

Graph II attempts to show the increase in productivity from 1957 by various organisations, the effect of using contractors on production rates and the predicted impact of reducing piece size on productivity in the 1980s. It is most probable that much of the productivity gains were from increased piece size, the move to contractors and a reduction in crew strength.

Data taken from Statistics of Forest and Forest Industries of New Zealand (1987) and from the MOF Statistical Releases SR17/1989, SR5/1990 are shown in Graph III. Man year production steadily increased from 1970 to 1984, accelerated in 1985 and 1986 and declined over the years 1987, 1988 and 1989. Manday productivity in this latter period is however much greater than that recorded in the 1970s by ca. 28%.

GRAPH III

NATIONAL MAN YEAR PRODUCTION TRENDS
1970-1990



The information in the graph is an amalgam of various logging systems, thinning and clearfelling old crop and minor species etc. Production in some years has been dramatically influenced by natural disasters, earthquakes, Cyclones Bernie (1982), Bola (1988), economic downturn at home and abroad and major industrial disputes.

During the period 1970 to 1989 other significant happenings have occurred; piece size has steadily increased in most species being harvested, company and bonus crews have largely been replaced by independent contractors with reduced manpower in the logging crews. (Wilson *et al.* 1988).

PRODUCTION STUDIES CLEARFELLING GROUND EXTRACTION

The balance of this paper will concentrate on harvesting of radiata pine using ground-based systems within the Bay of Plenty. This decision was made because some of the trends showing up in the national statistics could be checked through consultation with industry representatives at minimal cost. Developments in the harvesting outside the Bay of Plenty region warrant further study but this will require extra research effort and widespread industry cooperation

Production rates for tree sizes in the range of 0.9 m^3- 4.0 m^3 were presented by Terlesk (1980). The results of three studies were standardised at 8 hours/day and an average

TABLE II - Clearfelling *P. radiata*: Piece Size/Productivity*

Age	Tree size (m^3)	Daily production (m^3)	Crew man hours/ day	Man/hour production (m^3)
17	0.9	157	48	3.27
29 Transition	1.9	249	56	4.45
48 Old crop	4.0	330	64	5.16

* circa 1980

haul distance of 100 m. (Table 2). Annual production figures were not available.

The three contract crews under study were considered to be above average. Production rates were therefore considered high at the time but achievable.

From information supplied by industry personnel annual crew production rates of over 100,000 m3 are regularly achieved by competent contractors working in the better stands of old crop radiata pine in Kaingaroa Forest. Quotas are not in place and hours of work are flexible and often market driven. Annual production levels this high appear to represent a man hour production level in excess of 8.0 m^3; substantially greater than the rate of 5.16 m^3 shown in Table II.

The reasons for this are considered to be increased piece size, a further reduction in manpower and most likely longer on-the-job hours.

Industry sources report a fall off in piece size as the remnants of good quality old crop are harvested and crews move to the smaller transition crop and the poorer old crop "Matea type" stands.

Work content is significantly increased in the radiata pine transition stand where the faller spends in excess of 60% of his time delimbing. Work on the landing is also increased through closer stem scrutiny and grade log cutting.

Industry information also indicates that in the transition operation annual production rates will be in the vicinity of 50-55,000 m^3/annum. Based on a 7 man crew and 235 work days/year a man/hour production range of 3.80-4.20 m^3 is derived. This compares with the figure (Table II) of 4.45 m^3 for the 29-year-old transition stand. (The range for 10 crews in the Bay of Plenty is from 42,000-75,000 m^3/annum). At the 75 000 m^3 production rate the man/hour production figure climbs to 5.70 m^3 - a very significant increase. Piece size is variable between 2-3.0 m^3.

The annual difference in tractor crew production between "good" quality old crop radiata and transition crop appears to be in

TABLE III - Production Thinning : Daily production versus piece size
Galbraith & Vaughan 1989
No fleeting machine

Piece size (m^3)	Man power	Man hours*	Daily* production (m^3)	Man hour productivity (m^3)	Man day production (m^3)
0.15	4	32	31	0.97	7.75
0.22	4	32	39	1.22	9.95
0.30	4	32	49	1.53	12.25

*The assumptions in this reconstructed table is that a standard 8 hour/day was worked and that up to a piece size of 0.30 m3 a fleeting machine was not used.. Tonnes converted to m^3 by a factor of 0.9.

the range of 25-35,000 m^3. Crew numbers in both instances range from 6-8 men.

PRODUCTION THINNING

P. RADIATA - GROUND EXTRACTION

A recent paper by Galbraith and Vaughan (1989) show production rates (in graph form) for a range of piece sizes. Haul distance is said to be around 150 m. The data has been gleaned from a variety of industry sources and amalgamated where appropriate to produce a composite overview.

Table III shows the piece size/production rates extracted from the graph.

Again from Galbraith and Vaughan (1989) information has been extracted showing the production rates for the larger piece sizes. A fleeting machine operator has been included in the 5 man crew complement. See Table IV.

However a closer examination of recently collected survey data (LIRA) indicate the lower daily production rates shown in brackets.

A recent (1989) (in press) production study of a production thinning operation carried out by the FRI Harvest Planning Group results in a daily production rate of 57.5 m^3/day at 150 m average haul distance, and a piece size of 0.33 m^3 and a standard 480 minute day. A Bell Infield logger sorted and stacked on the landing. The breakout in the bush was assisted by the faller and the drop at the landing by the skidworker.

The production rate of 57.5 m^3/day is 14.5 m^3/day below a similar piece size rate on the production rate shown in Table IV.

A second crew studied in the same locality with a similar haul distance and piece size produced 64.3 m^3/day, 12% above the first crew but still 7.7 m^3 below the piece size production rate shown in Table IV.

TABLE IV - Production thinning : Daily production versus piece size
Galbraith and Vaughan 1989
Fleeting machine

Piece size (m^3)	Man power	Man hours*	Daily production (m^3)*	Man hour productivity (m^3)	Man day production (m^3)
0.35	5	40	72	1.80	14.4
0.45	5	40	81 (66)	2.03	16.2
0.65	5	40	99 (94)	2.48	19.8

*Converted tonnes to m^3 by a factor 0.9. The authors agree that the collective nature of their data could lead to a less than clear picture of the production rates.

The increased production of the second crew under review comes from a larger haul size (1.93 m^3 versus 1.65 m^3) and quicker breakout times/piece. This latter factor is probably due to the higher stocking levels per hectare; 633 versus 508. The piece size is 0.33 m^3 in both instances. The combined production rates averaged 59.30 m^3/day.

This is still short of the production rate shown in Table IV for a similar piece size of 0.35 m^3.

The comparison base is weak, for in one instance the production rate quoted is for a standard day while in Table IV it is of a generalised nature. Agreed definitions and some form of standards are necessary before confident comparisons can be made between the many data sets available.

However it appears from the analyses that once the production thinning operations are standardised (as far as it is possible) similar levels of production emerge. This is almost inevitable if the comparisons are based on sound work measurement data, similar piece sizes and similar harvesting systems. It also seems probable that the increased production often confused with increased productivity comes from increased hours on the job. This is supported by data (Evanson in press) that in 6 contract hauler crews the average 1988 on job hours were 8.7 and in 1989 8.9. Gaskin *et al.* reported 8.1 hours on the job from an industry survey conducted in 1986.

The harvesting systems under review in 1989 are mostly identical to those cited in the 1970s. However technology will have improved reliability, fuel consumption and weight to horsepower ratios.

Probably the most dramatic increase in productivity in radiata pine production thinning arose from the introduction of the Bell Infield Logger as an in woods prebunching machine.

TABLE V- Comparison of Bell bunching productivity (from Ashby and Vaughan 1988)

Characteristic	Earlier studies 1	2	3	4	5	6	7	Recent studies 8	9	10*
Av. piece size (m^3)	0.16	0.19	0.17	0.15	0.15	0.29	0.26	0.35	0.31	0.24
Stocking - Initial	950	550	590	630	535	600	550	645	613	726
(sph) - Final	425	200	235	305	345	375	250	250	256	284
Cycle time	15.46	7.93	8.15	7.89	9.58	4.74	9.34	3.56	4.00	3.71
Bunch size (pieces/bunch)	20.3	12.2	12.3	11.9	12.0	6.3	8.9	7.8	7.0	8.6
Bunch size (m^3)	3.34	2.76	2.13	1.75	1.84	1.83	2.30	2.35	2.17	2.05
Productivity (pieces/PMH)	79	92	91	90	75	79	57	131	105	136
Productivity (m^3/PMH)	13	17.1	15.7	13.3	11.5	23.2	14.8	39.6	32.6	33.2

* Mechanised processing with Lako

PREBUNCHING

Prebunching in the bush with a Bell Logger for a larger extraction machine held out the opportunity for increasing production in small piece size material. An analysis of this approach is shown in Table V taken from Galbraith and Vaughan (1989).

Galbraith and Vaughan state "Early studies focussed on the Bell's role as a bunching machine. Trials in selection thinning operations in Tarawera forest (0.16 m^3) recorded bunching productivity of 14 m^3/PMH, an increase in cable skidder production from 36 to 85 m^3 per day and cost reductions of 14%" (Gleason and Stulen 1984). However Galbraith and Vaughan (1989) conclude that despite the productivity gains the number of Bell loggers involved in bunching has reduced in recent times.

High levels of productivity using a Bell Infield logger have also been reported by Terlesk *et al.* (1989) when operating in FRI stand reorganisations trials in Woodhill and Hautu forests. The systematic layout of the trials in various configurations of groups and rows allowed high levels of production to be maintained in relatively small piece size material (0.16 m^3). A further trial reported by McConchie (unpublished) also show high production rates and competitive costs. However as reported earlier the Bells have largely moved from the bush to the landing.

THE FUTURE

PRODUCTION THINNING

Recent studies of current operations in radiata pine reveal little change in the harvesting systems used in the 1970s especially on the easy terrain in the Bay of Plenty. More complete mechanisation is being attempted by a contractor supplying Northern Pulp's triboard plant at Kaitaia. The system is made up of Waratah DFB harvesters. Waratah processors and forwarders producing 2.6 m shortwood. No substantial long term production data is generally available.

The operation has faced considerable difficulties in establishing itself but is probably the only fully mechanised harvesting system in NZ at present. Further mechanisation, if the growing habits of radiata pine will allow it, and this includes heavy branching, nodal swelling and other malformation, is the only option that holds out the possibility for a quantum production leap in the harvesting of small piece size material. As is the case in other parts of the world the silviculturist will have to give ground to the logger in order to capture the full benefits from mechanisation.

CLEARFELLING

The most significant event in the 1990s will be the disappearance of the old crop radiata with its very large piece size and minimal delimbing content. An increasing number of log sorts will inevitably lead to some interference on the landing and a reduction in production, or a major change in method. An increase of 1 minute per tractor cycle will reduce production by 10% and increase the cost per m^3 by 60-70 cents. These data are based on the recent study of a young crop radiata pine stand in Rotoehu. Any further attempts to carry out detailed assessment for log cutting on a landing of 60 x 40 m must add to the probability of increased interference to both the primary extraction and stacking/sorting machines.

CONCLUSIONS

HOW ARE WE DOING? - HARD TO SAY

Real increases in productivity in production thinning are difficult to isolate if the earlier definition of the term is accepted. The current equipment on the easy terrain is similar to that used in the 1970s and in some cases it is the same equipment. The results from increased training are not easily discernible although they are undoubtedly present. However the ongoing benefits to the industry arising from the earlier Woodsmen Training Scheme and the trainee logging gangs that were present in all the major Forestry concerns should not be completely discounted. Much of the recorded increases in productivity in production thinning appear closely related to an increase in piece size.

Clearfelling productivity must drop over the next 5 year period as the small piece

size, higher work content transition and "young crop" stands come on stream if current logging options are adhered to.

The desire to maximise the value from each stem through more deliberate examination of each stem and the cutting of a much greater number of short logs must also have an effect on throughput and thus the productivity of operation in the managed stands. These losses may be balanced through the added value concept.

It also seems clear that in order to increase production in the young crop stands ways must be found to introduce new machinery similar to the Hahn processor to overcome the delimbing content which absorbs 60-65% of the bushworker's time. However accurate measurement of length and diameter and operator ability to recognise quality changes will be essential to meet log grade requirements.

Further mechanisation and the attendant injection of large amounts of capital will require changes in measurement emphasis from man hour production rates to consideration for the efficiency use of and return to capital.

As an added incentive to increased innovation is the predicted increase of the national annual cut to 17 million m^3 by the year 2000. To achieve this target with current technology, performance and operations mix would require an additional 2000 persons in the labour force. In addition, by extrapolation from Liley (1985) and using average equipment type costs for medium power range of ground and cable logging systems an additional $ 220 million (1989 dollars) is required to produce the additional tonnage. These are speculative figures but likely to be in the right ball park.

Finally the most significant factor emerging from this review is that sound statistical information regarding the performance of the work force is not readily available or in some cases believable. The industry requires a better base than is currently available for planning the harvest expansion over the next two decades and this will require considerable research effort and industry cooperation to achieve. This would be an ideal opportunity for a joint FRI/LIRA project supported by industry. The assembled information would serve as a strong industry planning base through the expansion period of the 90s and beyond.

REFERENCES

ORR, Adrian 1989: Productivity Trends and Cycles in New Zealand : Sectorial and Cyclical Analysis 1961-1987. Monograph No. 48. New Zealand Institute of Economic Research, March.

MINISTRY OF FORESTRY 1990: New Zealand Forestry Briefing for Minister and Associate Minister of Forestry (Published version). February.

NZ LABOUR & EMPLOYMENT GAZETTE: Supplementary Tables : Quarterly Employment Survey 1979-1988. Department of Labour.

NZ BUSINESS PATTERNS; Tables 1 and 4 1988-1989. Department of Statistics.

RESERVE BANK: Bulletins 1979 to 1989 (Exchange Rates Tables G3 1979 to 1986; Tables C3 1987-1988).

MINISTRY OF FORESTRY: Statistics of the Forests and Forest Industries of New Zealand to 1987.

MINISTRY OF FORESTRY: Statistical Release S/R /17/1989.

MINISTRY OF FORESTRY: Statistical Release S/R/5/1990.

TERLESK, C.J. 1980: Harvesting : Radiata Pine Production and Cost Trends. NZ Journal of Forestry 25(2): 172-83.

GALBRAITH, J.E. VAUGHAN, L.W. 1989: IUFRO Proceedings. IUFRO PO4.02.02 Conference "New Approaches to Spacing and Thinning in Plantation Forestry.

WILSON, Peter, GASKIN, John, SMITH, Barry 1988: Production & Capital Equipment in Logging. NZ Logging Industry Research Association. Report No. 15, Vol. 13.

GLEASON, A., STULEN, J. 1984: Prebunching in Thinnings. LIRA Report 9(3).

GASKIN, John., SMITH, Barry., WILSON, Peter 1987: 1986/7.

TERLESK, C.J. and McCONCHIE, M. 1988: Stand Reorganisation : Results from the Trials at Hautu Forest, New Zealand. NZ J. For. Sci. 18(3): 329-44.

LILEY, W.B. 1985: A Survey of the Logging Industry - 1985. LIRA Report No. 12, Vol. 10.