

WORK STUDIES ON SELECTED HARVESTING OPERATIONS

by

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NOT FOR LOAN

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ABSTRACT

The text discusses work study aspects with special reference to harvesting in pine thinnings using chainsaw based systems. A large portion of the text is a review of literature on previous work studies relevant to harvesting. The first two chapters discuss which factors one should consider when planning to do work studies. The third chapter discusses some work studies on cutting thinnings in pines and factors that can affect worker productivity. The fourth chapter describes the procedures and findings of a work study done on an Ecologiser (mobile sawmill) working in the A.C.T. forests. The fifth chapter gives the summary and conclusions of this text.

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CHAPTER 1

GENERAL

1.1 PRODUCTIVITY : BASIC CONCEPT.

We are all motivated to maximise our material wealth. Most countries' economies are planned to achieve development. In order to have development, technological change and capital investment are essential. However, many enterprises are at present faced with declining profits due to rapid increases in equipment costs, early obsolescence of equipment and wage rises out of step with improvements in productivity.

Productivity can be defined in broad economic terms as the ratio of outputs (goods and services) over inputs (resources) (I L O 1977). In his studies on productivity in felling and preparing logs, Whiteley (1971) measured output as the merchantable volume of logs and pulp wood, and input as productive time.

Productivity should not be considered as synonymous with production; the latter only considers outputs, not inputs. Productivity can be analysed as either total or partial productivity. Where there is a single end product or where input factors can easily be broken down to components such as labour, capital and material inputs then the result may be considered as total productivity. If the calculations for analysis are based on one input factor, the result gives only a partial productivity. These relationships can be expressed as follows:

$$\text{Total productivity} = Q / L + C + N$$

$$\text{Labour productivity} = Q / L$$

Capital productivity = Q / C

Productivity of the site = Q / N

where Q = output, L = labour, C = capital input and N = site input
(or land input) (Haarlaa 1981).

These equations are simple. However, complexity arises when one comes to quantifying the factors involved in these equations. One of the best techniques which can be applied to get the necessary information is a forest work study; the main theme of this text.

There is generally a conscious effort by forestry officers to improve productivity by continuously raising outputs for a given input or by maintaining output for a lower input. This increase in productivity can be done in one or more of four major ways:

- 1) Development of new plant and equipment,
- 2) improvement to existing processes, plant and equipment,
- 3) improvements in the methods of operating plant and equipment,
- 4) better use of manpower .

The first two are feasible where there is a high proportion of manual work (e.g logging operations) although the scope for improvement may sometimes be very limited because of the often very heavy physical work associated with some forestry operations, for example, hand loading of logs on to a truck.

Depending on individual enterprise, an increase in the productivity of one factor can reduce the requirements per unit of output for another factor of input (e.g, increased labour efficiency aimed at machine or equipment saving). Increases in productivity can

be stimulated or induced by a number of factors including wage rises, cost increases, resource scarcity, competition and work study. Work study stands out as one of the inducements as it is endogenous and can be planned by the enterprise. The overall aim of work study from a manager's point of view is to lower the unit cost of production. Work study can also be said to aim at a technological change which either moves the production possibility curve to a higher position using the same amount of resources or maintains the production possibility curve in the same position with less resources.

1.2 TOTAL JOB TIME.

Most of the factors tending to reduce productivity can be controlled within industry. Productivity as mentioned earlier is an output/input ratio; is often stated for a given period of time, and is then measured in terms of man hours or machine hours. Time can therefore be one of the possible bases for measuring the work content in forest harvesting operations.

Work content can be divided into the following major categories, as classified by I.L.O. (1977)

- (1) Basic work content: This can be defined as the time a product would take to manufacture or the time a production operation would take to perform if the design, layout and specifications were perfect, the process or method perfectly carried out and there was no loss of working time from any cause whatsoever during the operation. It is, therefore, the irreducible theoretical minimum time required to produce one unit of output.

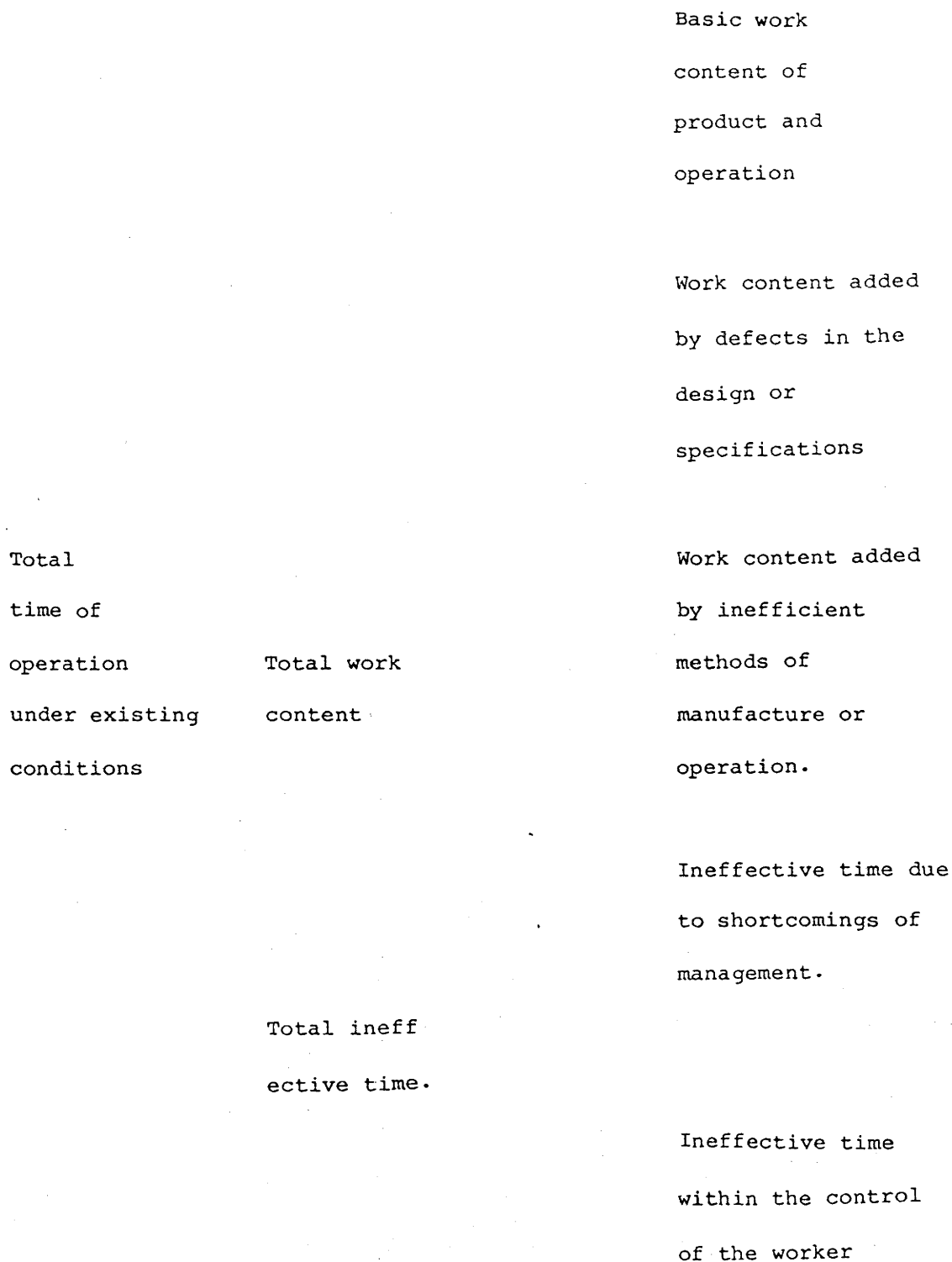
In practice, especially in forest operations, this does not occur and actual operation times are often greater due to excess work content.

- (2) Excess work content: This is additional work content due to the following reasons (also see Fig 1.1):
 - (A) Work content added by defects in the design or specification of a product:
 - (1) The product and components may be so designed as to make it impossible to use the most economical process or methods of manufacture e.g silviculturists may grow forests without reference to the conditions necessary for harvesting efficiency.
 - (2) Excessive variety of products or lack of standardisation of components will affect the speed of operation e.g the supposed need to segregate into many log lengths or timber sizes.
 - (3) Increased quality standards may increase work content, e.g segregation into numerous quality standards which may not be necessary.
 - (4) Components of a product may be so designed that an excessive amount of material has to be removed before reaching the final stage e.g poor delimbing or poor felling resulting in splitting and checks.

It is, therefore, important to eliminate as far as possible all features in product design, specification and manufacture likely to cause excess work content, as a first step towards raising productivity.

Figure 1.1

Total job time.



Source: ILO 1977.

- (B) Work content added by inefficient methods of production or operation.

This can be defined as that time taken over and above the basic work content and "A" above due to inefficiencies inherent in the process or method of operation, for example:

- (1) Wrong type of machine used; one which has a lower output than the correct one e.g the use of a tractor when a rubber tyred skidder would be more appropriate.
- (2) Process not operating properly; e.g. improper sawmilling plan which causes bottlenecks instead of a smooth flow.
- (3) Wrong tools used e.g the use of an axe for felling when a saw would be more appropriate.
- (4) Layout of the workplace causing wasted movement e.g poor planning and layout of landings in integrated logging operations.
- (5) Working methods causing wasted movement, time or effort e.g trimming with a chain saw without adequate training for the operator.

- (C) Ineffective time due to shortcomings on the part of management.

This can be defined as that time during which men and / or machines are idle because the management has failed to plan, direct, coordinate or control effectively, for example:

- (1) Marketing or operational policies which require repeated changeovers. The workers do not have opportunity to aquire

skill and speed in any one operation; hence short runs and idle time e.g the use of a bulldozer to do a variety of work in hardwood logging operations. This may be the most rational solution if volumes are low. However, where the volume of output justifies it, specialisation of machine functions may give greater efficiency.

- (2) Failure to standardise products or operations; hence short runs and idle time; e.g. sawing multiple log-sizes which could dictate frequent change of sawblades or machine parts in sawmilling.
- (3) Frequent operational or product design changes which cause stoppages; e.g. milling a variety of sizes to be produced in a given period such that machine stoppage is inevitable.
- (4) Bad planning of work flow and orders resulting in discontinuous employment of labour and machines; e.g. using an efficient highly productive independent loader where there are only a few log trucks in the fleet.
- (5) Failure to ensure supply of raw materials, tools and other equipment necessary to do the work, resulting in labour and plant being idle; e.g. lack of spare sawblades in sawmilling; fuel, chains and minor tools in motor manual felling operations.
- (6) Failure to maintain plant and equipment properly leading to stoppages because of machine breakdown; e.g. chainsaw failures due to improper daily cleaning and maintenance.
- (7) Allowing plant and machinery to be operated in bad conditions so that work is scrapped or returned or has to be

redone; e.g. employing an unskilled operator to control the sawing process.

- (8) Failing to provide working conditions in which work can be done steadily; e.g. failure to design a proper blower system to remove all sawdust from the sawbench in a wind exposed site.
- (9) Failing to take proper precautions for the safety and health of workers; hence loss of time due to accidents or illness; e.g. failure to use safety gear and/or wear safety clothes.

Commonly, most ineffective time is because of management shortcomings.

(D) Ineffective time within the control of the worker;

This can be defined as that time during which men (or machines) are idle for reasons within the control of the worker himself, for example:

- (1) Worker taking time off without good cause; lateness; failing to start work after clocking in, idling at work or deliberately working slowly.
- (2) Careless workmanship causing scrap or making it necessary for work to be done again; e.g. poor limbing by an experienced faller.
- (3) Failing to observe safety regulations, thus ensuring accidents through carelessness; e.g. felling trees without safety gloves, helmets etc.

If all the factors enumerated above can be eliminated, the minimum time for an operation or production process and hence maximum productivity is achieved.

There are various management techniques for minimising excess work content. Those considered as direct means are summarised in Fig.1.2 and the role of work study elaborated. Other means are briefly outlined in appendix B.

1.3 WORK STUDY

Knowledge of productivity grows through obtaining answers to basic questions about inputs. To obtain these answers we often need basic measurements through work study. Work study is one of management's main weapons of attack when trying to increase productivity.

Figure 1.2

DIRECT MEANS OF RAISING PRODUCTIVITY.

Approach	Type of Improvement	Role of work study
Capital Invest- ment	(a) Development of a new basic process	Method Study to improve ease of operation and maintenance at design stage
	(b) Installation of more modern or higher- capacity plant or equipment	Method Study to improve ease of operation when modernising
Better Manage- ment	(c) Reduce work content of the product	Method Study to improve design for ease of production.
	(d) Reduce work content of the process	Method Study to reduce wasted effort and time in operating the process by eliminating unnecessary movement.
	(e) Reduce ineffective time	Work measurement to investigate existing practice, locate ineffective time and set standards of performance.

Source: ILO 1979.

1.3.1 Definitions (I.L.O 1977)

Work study:

Work study is a generic term for those techniques particularly "method study" and "work measurement" which are used in the examination of human work in all its contexts, and which lead systematically to investigation of all the factors which affect the efficiency and economy of the situation being reviewed in order to effect improvement.

Method study:

Method study is basically the systematic recording and critical examination of existing and proposed ways of doing work, as a means of developing and applying easier and more effective methods and reducing costs.

Work measurement:

Work measurement is the application of techniques designed to establish the time for a "qualified worker" to carry out a specified job at a defined level of performance.

Qualified worker:

A qualified worker is one who is accepted as having the necessary physical attributes, who possesses the required intelligence and education, and has acquired the necessary skill and knowledge to carry out the work in hand to satisfactory standards of safety, quantity and quality.

Method study and work measurement are therefore related; method study is concerned with the reduction of the work content of a job while work measurement is mostly concerned with the investigation and reduction of any ineffective time associated with it. Work study as a whole can, therefore, be said to be concerned with increasing productivity with minimum further investments, ensuring that appropriate investments are made in any given socio-economic context, and finally ensuring that workers receive adequate payment and benefits from what they are asked to do.

1.3.2 Common steps in carrying out work study

- (a) Select the job, process or activity to be studied. This is perhaps the most important stage once the decision to carry out work study has been made. The most important job must be studied first; that which will most obviously raise productivity once improved. When a spoon is required a spade should not be used (I.L.O 1977).
- (b) Record from direct observation everything that happens using the most suitable of the recording techniques, convenient, easy to analyse and understand. A work study officer should not rely on data recorded by a foreman or information reported unless there is no alternative. It is important to have an easily understandable recording system so that any other person can benefit from what's been done.
- (c) Examine the recorded facts critically and challenge each; considering the purpose of the study, activity location, sequence, technique applied and any other relevant aspects.

- (d) Develop the most economic method taking into consideration all the circumstances which may be not only economic but, for example, cultural and environmental as well.
- (e) Measure the quantity of work involved in the method selected and calculate the standard time for doing it.
- (f) Define the new method and the related time so that it can always be identified. This must be done succinctly in a simple understandable language in order to eliminate any loopholes during implementation.
- (g) Install the new method as agreed standard practice with the time allowed. It is important that every person involved in the job understands exactly what is to be done in order to achieve agreed standards and times.
- (h) Maintain the new standard practice by proper control procedures. Work study would be of no use if the recommendations are implemented for a short period only. Proper follow up of the new practices is important to make the study worthwhile.

1.3.3 Aspects and usefulness of work study

- (a) By the application of the results of systematic study quite ordinary men can achieve results as good as or better than the less systematic genius was able to achieve in the past.
- (b) Work study exposes all the facts and hence ensures that any alterations in procedures which are made are based on accurate information and therefore more likely to be effective.

(c) It is a means of raising the productive efficiency of an operating unit by the reorganisation of work, a method which normally involves little or no capital expenditure on plant and equipment.

(d) It is systematic: this ensures that no factor affecting the efficiency of an operation is overlooked, either in analysing the original practices or in developing the new.

It is the most accurate means yet evolved of setting standards of performance, on which the effective planning and control of production depends.

(f) The savings resulting from properly applied work study start at once and continue as long as the operation continues in the improved form.

(g) It is a universal tool which can be used with success wherever manual work is done or plant is operated; not only in manufacturing but also in offices, stores, farms and service industries if people accept the objectives of work study and are willing to co-operate in its implementation.

(h) It is one of the most penetrating tools of investigation available to management. It is therefore an excellent weapon for starting an attack on inefficiency in any organisation since an investigation of a given set of problems will tend to expose inefficiencies in other related functions.

In forest work study, its uses may differ depending on individual aims. Common aims as defined by Haarlaa (1981) are as follows:

- (a) Economic development aims such as using resources more efficiently eg. improved productivity and /or improved profitability.
- (b) Technological aims such as those of improved work methods; development of machines and tools; development of work organisation and supervision; and development of technical work conditions.
- (c) Human development aims such as better salaries, easier work, better working conditions, improved organisation and supervision.
- (d) General development aims such as environmental control and changes in attitudes to work.

More detailed uses will be elaborated in following chapters.

1.3.4 Problems of work study in the context of harvesting operations

Work study is a good management tool but is not without its problems in many spheres of work, including forestry and harvesting. For example:

(a) Time Allocation:

Most of the personnel carrying out time studies have other responsibilities such as administrative, technical or managerial so that only a portion of their time is on work study. To get reasonable results, one has to devote one's

time fully to work study instead of relying on data collected by foremen or other personnel (I.L.O. 1977).

(b) Variability between and within a forest:

- (i) Site and trees: In forests, work elements , although repeated, are more variable because of variation in the independent variables eg. size and form of trees. No two trees are exactly alike in shape or size, similarly conditions of the work place such as soil, surface roughness, slope, undergrowth and climatic conditions vary greatly (Whiteley 1971).
- (ii) Resources: These differ from place to place eg. manpower, its skill, experience and amount; machinery type, efficiency, availability etc. (Conway 1976)

(c) Interrelation of operations:

Harvesting operations are interrelated, eg. directional felling will affect some aspects of skidding, condition of the remaining stock, safety and efficiency. One or more of these aspects can determine the others and can control overall efficiency.

(d) Physical demands:

Many harvesting operations, especially in thinnings make high physical demands on workers and cannot be continued for long periods. The human body is not very powerful "at best it can produce 0.2 HP in sustained (aerobic) work and 3-4 HP during short bursts of effort" (McWhirter 1965). To assess

what qualified workers should achieve, "the speed of motion of the limbs of a man of average physique walking without a load in a straight line on level ground at a speed of 6.4 km/hr (for Europeans and North Americans working in temperate conditions) or the rate of movement in dealing a pack of 52 cards in 0.375 minutes" are the suggested standards, by I.L.O. "Forestry work, especially stump operations, is different in that a host of variables such as light, rainfall, temperature and ground conditions preclude stable working conditions. "(Shaw 1982). Reliability of data collected for time studies at the end of an exhausting day is questionable (Miyata et al 1981).

(e) Danger and risks:

Logging is one of the most dangerous operations. During the operation, handling moving logs involves lots of variation in levels of risk, hence difficulty in assessing them.

(f) Payment systems:

Cost and productivity differs for different payment and incentive systems. These differ for different operations as well as management systems. (Cowan 1965).

(g) Rating:

Rating, as defined by I.L.O., means assessing the effective working speed of the particular operator being studied,

relative to the observer's concept of a standard working speed or performance level. This can be ambiguous in forest work study; judgement faculties on performance do differ, depending on individuals, not only in varied conditions but even in standard ones (Shaw 1981). Performance rating based on subjective estimates is, therefore, difficult to carry out in the forest and is not regarded as a scientifically acceptable method. The International Union of Forest Research Organisations (IUFRO) in 1965 and later the the Nordic Forest Work Study Council (NSR) in 1968 agreed not to use performance rating for time studies and performance measurements in forestry. Performance rating has since then been used for special cases, when seen necessary (Haarlaa 1981).

1.3.5 History

Work study is not new. It has previously been known by several names such as "Time and motion study", "method study", "methods engineering", "work design" "industrial engineering", just to mention the main alternatives.

The names of some people also stand out. Matthew Robinson, Boulton and James Watt Jr. used method study whilst working as metal engineers in Birmingham. Charles Babbage (Professor of Mathematics in Cambridge England) had many ideas which were used in America. Frederick W. Taylor first described time study, while Frank B. and Lilian M. Gillresh started motion study.

The two functions (time study and motion study) developed simultaneously, advancing along two parallel lines which did not meet until just before World War 2. They were bitterly opposed during the 1920's and early 1930's. It was during World War 2 and afterwards that the discipline became consolidated as work study.

The developing discipline acquired a bad name in the early 1920's to late 1930's because it was used to cut rates and reduce employment. Since the war it has been expanding in most industrialised countries, mostly in manufacturing industries. It moved slowly from these industries until, after the war, it was introduced in such diverse fields as dentistry, agriculture, forestry, clerical work and garage work.

The history of work study in forestry is not long. Simple method study has been used for several hundred years in forestry operations but detailed work measurement was only started seriously in the 1930's in Scandinavia and Germany. It was mostly focused on method study, until 1948, when Sweden started work on the timing of thinnings to rationalise piece work rates (Cowan 1965).

Most European countries including Holland, Germany, Britain, Norway and Denmark have since followed similar approaches to Sweden, primarily being concerned with collecting realistic data for setting piecework rates. To date it is being used in most developed and developing countries (Shaw 1982, Whiteley 1973, Wittering 1973).

Summary

Work study is among several managers' tools for improving productivity. It is necessary to investigate thoroughly the

feasibility of work study and the reason why it should be applied. There are many obstacles to increasing productivity, and work study is not the only solution but can be one of them. There could be some cases where simple reorganisation of work can improve productivity at a greater pace and shorter time than going over work study procedures. Work study should therefore, be applied only where it is found feasible.

CHAPTER 2

HUMAN FACTORS IN THE APPLICATION OF WORK STUDY

2.1 HUMAN FACTORS IN AN ENTERPRISE

There has been growing awareness of the importance of people in the forest industries in the 1970's. This has brought to the fore such matters as ergonomics, enhanced job security, the working environment and wider influences afforded to employees at the work place (Anderson 1979).

In his paper on "Reading in human relations" Professor McGregor (1959) comments that "the social scientist does not deny that human behavior in industrial organisation is approximately what management perceives it to be. This behavior is not a consequence of man's inherent nature but a consequence rather of the nature of industrial organisation, of management philosophy, policy and practice". Though the human side of the logging industry is beyond the scope of this paper it is worth mentioning a few points which management should appreciate before looking into its relationship to work study.

McGregor (1959) summarised, in one of his sets of propositions, conventional concepts of management's task in harnessing human energy, in three broad terms. Firstly, that management is responsible for any productive enterprise, and the money, materials, equipment and people used in the enterprise. Secondly, that with respect to people this is a process of directing their efforts, motivating them, controlling their actions, modifying

their behaviour to fit the needs of the organisation. Finally he stresses that, without this active intervention by management, people would be passive, even resistant to organisational needs. They must, therefore, be persuaded, rewarded, punished, and controlled and their activities must be directed. Management consists of getting things done through other people. Making people want to do what management wants can be considered the major task of management (I.L.O.1977). In addition McGregor suggests, that the average man is, by nature, indolent and works as little as possible. He lacks ambition, dislikes responsibility and prefers to be led. He is inherently self centred, indifferent to organisational needs and resistant to change. He is also gullible, not very bright and the ready dupe of the charlatan and the demagogue. He then suggests the essential task of management to be that of arranging conditions and methods of operation so that people can achieve their own goals best by directing their own efforts towards organisational objectives.

With the above guidance, management can conceive a range of possibilities. It should be borne in mind that work as a human activity has two dimensions, namely mental and physical effort. To sustain productivity in a job there is a need to develop both of these faculties (McWhirter 1968). Therefore, a good forest manager ought to concern himself with the engineering of the human mind as well as understanding what the human frame can accomplish. In mechanised logging in Canada, 80% of machine downtime was found to be caused by human frailty and error as compared with normal mechanical tear and wear (Schabas 1979). In addition to this drawback, the turnover rate, even of trained loggers, is very high. Canadian

logging industry sources suggest only 43% remain in the industry after a year while the Canadian manpower ministry suggest 29% only remain in the industry after 3-4 months. Both figures are discouraging and it is not surprising if similar trends occur elsewhere. This situation obviously, dictates programmes focused on reducing turnover rates (Feric 5/77). In Swedish forestry it has been shown that mechanisation "per se " does not solve productivity problems. This has been due to changing social attitudes and new laws (Anderson 1979). It is, therefore, important to look into human factors in an enterprise before attempting work study aimed at raising the productivity of the logging enterprise. However, this information was relevant when unemployment was only a little cloud in the sky. Now that it is serious, turnover rates are not so troublesome

2.2 GOOD RELATIONS

An I.L.O. productivity and development mission, wherever it went, found that work study alone could not make bad relations with workers good. However, if wisely applied, it might often improve them. Further, it should not be applied as a substitute for good management. It should be considered as one among a number of possible alternative tools for managers (I.L.O.1977).

It should always be understood that, for example, a feller in the forest is not a machine but a human being, subject to all sorts of feelings some of which might not be openly exposed. In forest operations it happens that most work studies are done on lower rank workers, operating machines or working manually. If such work

study is to contribute to productivity, good relations between management and those in the forest must be established. If not, those being studied could be suspicious as to why there should be a work study man "on their backs". More on this will be discussed in the following sections.

The importance of having the man in the bush understand why work study is done is even more significant where illiteracy or unemployment is experienced. In all respects, work study should be aimed at both increasing productivity and benefiting the workers being studied.

2.3 MANAGEMENT

A well conducted work study analysis is ruthlessly systematic. The places where effort and time are being wasted are laid bare one by one (I.L.O.1972). This is why work study is considered as the most penetrating tool of management. Exposure of inefficiency which could be due to lack of planning, bad organisation, insufficient control or lack of proper training could imply failure of the logging management in their duties. Improvement of productivity, which is the thrust of work study, will further confirm this. On the other hand, a feller who has been using a traditional technique can be made to feel a novice when a new technique proves the former is not efficient but wasteful, and that a young, recently trained, feller can surpass him.

Nobody likes to be made to feel that he has failed, as feelings of job security are then threatened. It should therefore be understood that work study investigation has far reaching effects

and, therefore, must be handled with tact and great care . If not, the work study man may find all workers at all levels combine to obstruct him and possibly make his study unsuccessful.

It is common for people in the lower ranks to take their attitudes from their foremen or bosses. Work study should have both the understanding and backing of the management at all levels.

2.4 THE SUPERVISOR (FOREMAN)

It is important the foreman in the field understands exactly what is being done and why. If he does not, he can be difficult for many reasons. For example:

- 1) His work might be challenged due to the improvements brought about by work study and, therefore, his prestige before his juniors and superiors lessened. He is, therefore, deeply affected.
- 11) If any disputes arise the foreman is the first person to be called upon to settle them. If he does not understand the problem and/or its source it would be difficult for him to do so fairly (I.L.O.1977).

Foremen are more concerned with the practical side than the administrative and the most difficult problem of a work studyman may often be the attitudes of foremen.

The work studyman must show from the very beginning that he is not trying to usurp the foreman's place and should be friendly whilst at the same time showing respect. The following is a summary of practical rules which should be observed as outlined by I.L.O.(1977).

- (a) The work studyman must give instructions or orders to a worker only through the foreman.
- (b) Problems calling for decisions outside the technical field of work study should always be referred to the foreman.
- (c) The work studyman should never allow himself to express opinions to a worker which may later be interpreted as critical of the foreman. Trouble is likely to erupt if the worker later quotes to the foreman " but Mr X said ".
- (d) The work studyman should not allow the workers to play him off against the foreman or use him to get some decisions altered which they, the workmen, consider harsh.
- (e) The selection of jobs to be studied should be seen to take into account the foreman's advice .
- (f) At the start of an investigation a work studyman should be introduced by the foreman and should never start on his own.

The above are simply common sense and good manners and, if not followed, could plant seeds of discord.

2.5 THE WORKER (FELLER)

Any sound technique can be made to work if the workers have confidence in the sincerity and integrity of the management. If there was any tension between the management and the workers not only work study but anything else can increase the tension. When work study is properly applied it tends to improve industrial relations due to the following reasons.

- (a) The worker's interest is aroused because a member of the management (ie the work studyman) takes the trouble to discuss the worker's job and its problems.
- (b) The work studyman will be regarded by the workers as an educated man in the bush, full of wisdom, who never shouts, is always polite and if he seems to be working with them represents a new enlightened management.
- (c) A feeling of confidence develops when all study sheets are readily available for inspection and workers' representatives are fully informed of all that is happening.
- (d) The flow of work and material supply should be improved by work study. Workers will, therefore, be happy if there are less interruptions or unnecessary stops especially if they are on piece work (I.L.O.1977).

The workers will then feel an increased confidence in the need for work study. On the other hand, the opposite could happen and resistance to work study could increase, however genuine the management and the work studyman may be. The following are some factors which could cause resistance.

- (a) Workers who have been working for many years in a particular job would usually believe themselves to have mastered that job. Resistance could arise simply because it is human nature to resist changes which could shake their confidence in their ability and possibly lower their prestige. In such a situation, the work studyman should clarify the basic effect of work study as eliminating unnecessary movements and wasted energy and not affecting the craft or skilled part of the job. In some cases it might be necessary to train new, young workers instead of creating problems with conservative, old ones, but this should only be done if there is no other alternative (ILO 1977, McCormack et al. 1979).
- (b) Some workers might resent being timed. This is likely to be pronounced in forestry since the work is often very hard. Having someone standing nearby with a stopwatch while one is sweating could worry or even upset some workers.. It is important the studyman tries to ensure the workers are accustomed to his presence before attempting to record times. "Nothing breeds suspicion like attempts to hide what is being done; nothing dispels it like frankness,

whether in answering questions or in showing information obtained from studies. Work study honestly applied has nothing to hide" (ILO 1977).

- (c) There could be a fear of creating redundancy by increasing productivity due to work study. Sometimes less men may be needed but productivity improvements could be due to better plant utilization and operation, making more effective use of space or energy and securing greater economy of materials without affecting the labour force. In fact where machinery or plant is used (eg. in a mobile sawmill as will be shown later) it might be worthwhile to increase the number of people serving it if, by so doing, the machine availability, utilisation and productivity can be increased and the additional labour costs are more than offset by additional production.

It should be appreciated there would be little use studying, for example, a felling operation or any other, if the management is not efficient. There would be little use halving the time a worker takes to do a certain job by work study if he is constantly being held up, for example, by lack of materials, tools and machine breakdown due to bad planning by the logging management.

Where there are many workers being studied it is best if a workers' nominee can spend more time with the study team, and have access to all data being gathered. He must be acceptable to all the workers concerned, experienced in the work and educated enough to

understand work study procedures. The importance of having a liaison nominee is more pronounced in countries where most workers are illiterate and/or unemployment is a problem.

2.6 THE WORK STUDYMAN

A work studyman should have status in the community he is dealing with. As elaborated in previous sections, if he doesn't carry out any study with tact, he is likely to bring it to a standstill. The following are qualities and qualifications essential for success, as recommended by ILO (1977).

(a) Education

A good secondary education or the equivalent of school leaving examination is usually essential, for one to be able to carry out a work study. However, there could be some exceptions for those who have special aptitudes for this discipline.

(b) Practical experience:

It is usually essential to have had practical experience in the work being studied since not only does the work studyman have a better understanding of the job from the worker's point of view but this would help him to command respect from foremen and workers and enable a better exchange of ideas.

(c) Personal qualities:

An inventive turn of mind, sharp, capable of devising simple time and effort saving techniques, and able to gain the cooperation of foreman and workers in the field is necessary. The following would be essential qualities:

- (i) To gain the confidence and respect of the workers and foreman the work studyman must have sincerity and honesty.
- (ii) Interest and sympathy with people is essential in order to get along with them at all levels. Further, he should appreciate ideas offered by them.
- (iii) He must be keen on his job, the importance of his work and be able to transmit his enthusiasm to the people around him.
- (iv) People are neither machines nor trees. Tact in dealing with them is brought about by understanding. Though apparently justified, harsh or ruthless words will never help. Work study will never end with success if the work studyman has no tact.
- (v) The work studyman must look tidy. This does not mean he should dress in a three piece suit and tie while timing a feller in the bush, but he should wear field dress which is neat and practical. He should also be efficient in all that he does. He will then gain the confidence of the people he is studying.
- (vi) A work studyman must always know what he is doing to arrive at recommendations which have a good foundation. It would be embarrassing if the work studyman appeared not to know what to do next in front of other workers. He should be able to defend his findings, at all levels of management, with concrete arguments which are not offensive, but which gain him respect. The confidence to do this can be achieved with good training and experience in work study.

It is not easy to find a man with all the above qualities. One who has will probably go up the ladder and become one of the senior management staff. However with appropriate selection of workers, followed by training it is possible to approach the ideal.

Summary

The human element in the application of work study is one of the most important factors which should be considered before applying work study. Most work studies (especially in labour intensive operations) involve many people who could jeopardize the implementation of a study and hence its results if they feel they are not justified as to why there should be work study.

CHAPTER 3

LITERATURE REVIEW3.1 CHAINSAW SYSTEMS

There is an increasing diversity of harvesting practices throughout the world (Fig. 3.1). The mechanisation of thinning operations has proved to be more difficult, consequently the level of mechanisation is considerably lower compared to that of clearfelling (Fig. 3.2, Anderson, 1979). Though Fig. 3.2 extrapolates, the real situation is still biased towards motor manual techniques and these will retain their popularity in cutting thinnings for a number of years to come (Kerruish, 1976; Henderson et al, 1981). There are a number of difficulties which should be considered before mechanising cutting operations, especially in thinnings. The Forest Research Institute New Zealand (F.R.I.) (1977) sounds the following cautions to those who go for mechanised systems.

Difficulty could arise due to:

- (a) Lack of suitably trained supervisors and servicing staff.
- (b) Lack of experienced operators.
- (c) The need for mechanical modifications and the incidence of breakdowns.
- (d) Shortage of spare parts and the lack of a sound repair and maintenance strategy.
- (e) Difficulty in meeting standards for log preparation required by the processing plant.

- (f) Sub-optimum compartment planning in the form of poor landing location will inhibit production rates through excessive haul distances, frequent unproductive 'move' times, landing congestion, and machine interference.
- (g) Labour turnover will add to costs because of the lower than normal rates of production from an inexperienced machine operator. Constant and rapid turnover will inevitably lead to chronic low production rates.
- (h) Imbalance between the machines making up the system.
- (i) Need for the adoption of new work methods.

Kerruish et al (1981) lists the following disadvantages experienced in mechanised thinning in Australia.

- (a) High capital investment and high unit costs when working with small trees.
- (b) More damage to residual stands and soils than chainsaw - based systems if conditions are other than favourable.
- (c) Standards of delimbing which are not acceptable to some sawmills.
- (d) The fuel component of costs of wood at mill door 26% greater than those of chainsaw-based systems.

In order to decide in favour of a mechanised system for logging, F.R.I. (1977) recommends the following pre-conditions:

- (a) A large volume of trees of suitable size and characteristics;
- (b) A large area of suitable terrain;

Figure 3.1

Increasing Diversity of Harvesting Practices.

Source: Logger 1980.

Figure 3.2

Achieved and forecast development in the degree of
mechanisation in final felling and thinning
1970-84 in Swedish forestry.

Degree of mechanization

Source: Anderson 1979.

- (c) A large demand;
- (d) The opportunity to double shift the system to help defray the fixed costs;
- (e) Adequate service and an efficient supplier of spare parts;
- (f) Competent management and proficient and stable machine operators;
- (g) An adequate records system and sound financial advice.

Capital costs involved in motor manual techniques are far lower than those of mechanised systems. In New Zealand, a highly mechanised system would dictate an investment ranging from \$350,000 to as high as \$600,000 for one system (FRI 1977) while an average chainsaw would cost only about \$600. In Sweden a chainsaw would cost only SKr 5000 *(Aus \$770) in contrast to a harvester which would cost SKr 1,500,000 *(Aus \$230,770) (Anderson, 1979). Table 3.1 gives various further comparisons.

* March 1983 exchange rates.

Table 3.1

Comparisons between operations based on power saws
and those based on harvesters in Sweden

	Alternatives				Relationship of
	Power Saw		Harvesters		Harvester to
	SKr	Aus\$	SKr	Aus\$	power saw
Investment	5,000.0		1,500,000		3.00
Machine cost/eff.h*	8.0		380		48.0
Manual cost/eff. h	66.0		95		1.4
Effective hours/day (shift)	6.5		4.5		0.7
Performance m ³ /eff h.	2.0		18.5		9.3
Performance m ³ /day shift	13.0		83.0		6.4
Cost/m ³	37.0		26.0		0.7
Manpower requirement eff.h/m ³	0.5		0.05		0.1
Machine power requirement kwh/m ³	1.3		6.5		5.0
Mandays/m ³	0.076		0.012		0.1

* Effective hour = one hour gross effective time, including
delay times shorter than 15 minutes.

Source: Anderson 1979.

Table 3.1 shows, however, that given a sufficient quantity
of the right size of tree a harvester can produce at a lower unit
cost than a chainsaw.

Chainsaw based systems are notable for their flexibility; they can be applied to:-

- (a) A wide variety of thinning treatments, ranging from 2nd to 3rd row non-selective thinnings to the removal of every 10th row and the selective thinning of the rows between (Kerruish 1976).
- (b) Felling and converting trees of poor form. In both very high and very low site quality stands of radiata pine the number of deformed trees may be high, at times exceeding 50% of all trees removed (Johnston 1968, Kerruish 1976).
- (c) A wide range of terrain: extraction, not felling techniques, being the limiting factor (Kerruish 1976).
- (d) Recovery of a wide range of assortments including special products such as round timber. (Ronan 1974, Kerruish 1976).

3.2 LABOUR AND PHYSIOLOGICAL INPUTS

3.2.1 Labour requirement

Chainsaw based techniques consume more man days per unit volume harvested compared to mechanised systems. This is true for both thinning and clearfelling Fig. 3.3, (Anderson 1979).

Figure 3.3

Man day consumption in felling and thinning
in Swedish forests.

Final felling Thinning

Source: Anderson 1979

The labour input in shortwood harvesting of first thinnings is higher than in second and subsequent thinnings. This is true for both chainsaw and mechanised harvesting. In South Australia, the

productivity in first thinning was found to be about 20% of that obtained when handling larger timber. It was also found to be sensitive to an increase in diameter at breast height (Table 3.2) (Bills 1972).

Figure 3.4

Labour input for cutting and piling in first
thinnings (motor-manual system).

Labour input

man hr/m²



Source: Kerruish et al, 1981.

Figure 3.4 gives a comparison of labour input for cutting and piling in first thinnings in Australia using three chainsaw based systems and one mechanised system, the mechanised system being the length, the others as indicated.

The dotted lines indicate ranges of inputs that occur in production operations.

Studies on traditional harvesting of thinnings in Australian pine plantations in 1972 indicate labour costs account for about 70% of the total cost of pulpwood at milldoor. This stimulated intensive research on the methods used (Kerruish et al, 1981).

Table 3.2

Work content per m³ including loading
(first thinning)

Mean diameter b.h.u.b. of removals c.m.	Work content mins/m ³
15.2	10.9
17.8	8.5
20.3	6.9

Source: Bills, 1972

3.2.2 Physiological requirements

The human body is not very powerful. At best, it can produce 0.2 HP in sustained (aerobic) work and 3.4 HP during short bursts of effort (McWhirter, 1968). Forestry work, especially in stump operations in thinnings, requires a lot of effort. A worker can expend only a certain amount of energy on his work. Extensive studies in temperate countries imply that the average daily expenditure of energy on work should not exceed about 8.38 MJ per day (about 16.8KJ/min) for an average man weighing 65 kg and 6.70MJ per day (about 13.4 KJ/min) for an average woman of 55 kg. Other studies show similar results for different races inhabiting tropical countries (ILO 1979).

A worker spontaneously lowers his work tempo if the energy output exceeds 29 KJ/minute nett for any length of time. Alternatively, he reduces his productive work time if he can. These effects would be more pronounced, the more pronounced the difference between energy demand and work capacity. In the long term, health deterioration in various forms could be expected (Henderson et al, 1981). Chainsaw work is extremely arduous and the energy costs can be considered high to very high (ILO 1979; Henderson et al, 1981; Kerruish et al, 1981).

In work studies, this is an important factor which, unfortunately, is difficult to account for. In most forest work studies reported on, in fact, this has not been done. Miyata et al

(1981) questions the accuracy and reliability of data collected at the end of a long exhausting day and suggests this as one of the drawbacks of time studies of logging operations.

ILO recommends a maximum load to be carried by a man of about 32 kg. This assumes factory conditions and lifting with a straight back and extended arms so that power can be exerted from strong thigh muscles. All harvesting is done in conditions which vary from day to day and even from hour to hour such as temperature, slope, soil, ground vegetation, frequency of remaining trees, which makes such work more difficult than in a factory (ILO, 1979; Bills, 1972).

In a study carried out on Australian fellers in first thinnings, stacking was identified as the most energy demanding element, being 34.14 kJ nett using the 'bench' technique (Henderson et al, 1981). In later thinnings, green 1.2 m pulpwood billets can weigh over 46 kg; this wood may have to be stacked and loaded manually on to a truck (Bills, 1972).

A partial study on the physiological workload imposed on Australian fellers provided evidence that despite the improvements in felling technology, motor manual techniques are heavy to very heavy work from the physiological point of view for both traditional and bench techniques (see figure 3.5, appendix D and E). Though there are efforts to reduce this e.g. using a felling bench (see table 3.4) it has been shown that even technically good solutions are not

sufficient significantly to reduce this physiological overload (Henderson et al, 1981). However, excessive strain can be avoided if the following precautions are adopted:

- (a) Adopt an upright working stance to permit easier breathing and less strain on the back.
- (b) Limit working height to a range of 50-70 cm.
- (c) Space feet wide apart to provide a firmer stance and better control and precision in sawing.
- (d) Bend the knees and hold the chainsaw as close to the body as possible.
- (e) Follow a systematic felling pattern.
- (f) Ensure proper training on modern tools and techniques.
- (g) Use of an appropriate size of chainsaw.

These, in addition to reducing excessive strain can contribute significantly to increases in productivity (Conway, 1965; Banks, 1981; Henderson et al, 1981).

Table 3.4

Heart rate/min. using traditional technique and
bench technique in radiata pine thinnings.

Element	Traditional		Bench	
	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Walking to trees	123.7	4.6	-	-
Walking to trees and moving bench	-	-	135.7	4.8
- Preparing to fell	130	6.3	128.5	4.1
- Falling	131.0	6.3	132.3	3.5
* Trimming	133.9	5.1	128.2	4.1
* Stacking	152.1	10.0	142.5	8.0
$\bar{x}$	135.4	9.8	132.9	6.6

- No significant difference between the two techniques at $p < 0.011$

* Significant difference in favour of bench technique at $p < 0.011$

Source: Henderson et al 1981.

3.3 Time study in harvesting operations

Work study has already been defined in section 1.3.1. However, time study specifically in harvesting can be defined as a work measurement technique for recording the times and rates of working for the elements of a specified harvesting task eg. felling carried out under specified conditions, eg. of slope, and other stand

parameters and for analysing the data so as to obtain as accurately as possible the time necessary for carrying out the job at a defined level of performance.

Time study is a basic technique of work measurement and it has been used for most forest work studies to date.

3.3.1 Time study techniques

In harvesting there are two basic approaches to time study. Firstly, 'detailed time study' in which each operation is subdivided into a number of component elements, which are then studied individually. This has been used by, amongst others, Samset et al (1969), Whiteley (1973) and Shaw (1982). The other alternative is 'gross data study' in which each operation is studied as a whole or subdivided into as few elements as possible. This technique has been used in several forest work studies where gross data eg. log extraction or road hauling may be regarded as sufficiently precise. Because detailed time studies involve studying more components of any given operation than gross data study, the latter should cost less. However, detailed time studies might give more precise results if an operation is composed of several separate sub-operations. Cheaper techniques yield less precise results but may be adequate depending on the purpose of the studies.

The two techniques are not necessarily mutually exclusive but can be used concurrently. Whiteley (1973) used both techniques in his work: detailed time study to construct a simulation model of

tree length cutting and later both detailed time and gross data study techniques to study the effects of differences between radiata pine stands on sawlog cutting productivity. He concluded the two techniques generally gave the same precision of estimate. These results supported other time study results on extraction operations by Cottrell and Winer in 1969 which implied no differences of practical importance between the two methods. However, they recommended gross data studies as sufficient for providing management information by established logging operations, though detailed time study could provide extra information needed for critical or comparative studies of logging methods (Whiteley, 1973).

Shaw (1982) also applied both work study techniques. His study was aimed at providing accurate and current data on productivity for cutters' work. He used detailed time study to determine the major factors influencing cutter productivity. These data were then augmented with gross data which were collected concurrently. The gross data, together with records of daily production and estimates of working time per day, provided a method of monitoring productivity and identifying the differences on days of detailed time study.

3.2.2 Designing Time Studies

Work study is expensive; its feasibility and likelihood of success must be considered. The following would be some factors of importance in the design of forest work study.

(a) Manpower: This includes all levels of manpower; eg. a qualified work study man, trained supporting technical staff, and committed cutters. The importance of manpower requirements has been dealt with in Chapter 2.

(b) Finance: This is important in order to cover for example such costs as incentive payments, payment for equipment owned by workers, and overheads particularly those associated with labour and machinery (Wittering, 1973(2)).

(c) Equipment: This includes, for example, stop watches, calculators, computers and automatic recorders.

Appendix F summarises the use of manpower in some work studies referred to in this text (Samset et al, 1969; Whiteley, 1973; and Shaw, 1982). In most other work studies not only the manpower involved but also the overall costs after completion of the study are not disclosed. Whiteley, in his 1973 study, estimated the field work for either gross data or detailed time study to involve about 433 hours for a professional forester and 4 hours for initial preparation and assessment of each mensuration plot. He estimated 3 months of office work would be required before carrying out detailed time study and one month for gross data study. Preparatory office work was done by one forester; in the field the forester was helped by a technician who would also assist in the subsequent preparation from detailed time studies. Samset et al (1969) as shown in Appendix F involve far more technicians than Whiteley (1973). Whiteley's 1973 cost estimates are given in Table 3.5.

3.3.3 Calendar time.

Calendar time is total elapsed time and can be broken down to its components as shown in Figure 3.5. The details of the categories are as shown in Appendix G.

Table 3.5

Cost of Time Study (after Whiteley 1973)

Item	Cost of detailed time study in \$ Aust.	Cost for gross data study in \$ Aust.
Field work		
Wages and travel allowances for a graduate forester	2393	2393
Wages and travel allowances for a technical assistant	1948	-
Office work		
Wages for a graduate forester	1229	819
Wages for a technical assistant	905	-
Card punching	307	43
Computer use	58	2
Total cost	6840	3257

Source: Whiteley 1973.

Figure 3.6

Components of time in a work study

Calendar time

Total working time

Unused time

Moving time

Changeover time

Main time

Productive

By time

Work place time

Non-productive

Avoidable

Abnormal R & M*

Unavoidable

Total repair time

Normal R & M*

Interruption time

Travelling time

Mealtime

* R & M = Repair and maintenance

Source: Groves, 1981

The components of the calendar time differ depending on individual harvesting systems and the purpose and precision of the study. In the study reported on in this thesis more emphasis will be on workplace time at the stump.

Workplace time can be divided into two major categories; productive and non-productive time. The productive time can be grouped as that time spent working on each tree; while non productive time, including delay, is that time spent either preparing for 'productive time' or any other activity. Studies of cutter productivity¹ usually take into account the relation between productive time per tree and factors affecting this time such as tree and stand characteristics. Other, non-productive times may or may not be related to such characteristics. However, it could be costly to carry out a study which separates the effects of stand types or differences and all other factors that can affect productivity, and it would be difficult to develop relations between individual stand characteristics and, for example, non-productive delays (Shaw, 1982).

In detailed time study, components or 'elements' are segregated and then finally aggregated to construct a predictive model of the whole operation. It is assumed the elements are independent of each other. Whiteley (1973) quotes an experiment by Nanda (1968) which suggests the validity of this assumption for

¹ Productivity here regarded as production per unit of time (Whiteley, 1973; Haarlaa, 1981; Shaw, 1982).

various light industrial operations but this validity may not hold for forest work. There is some doubt as to whether or not elements are independent of each other in heavy sequential work such as chain-saw cutting. Bennet et al (1965) in their study on the measurement of environmental factors and their effect on productivity of tree length logging, concluded with the following:

"If these sub-processes (elements) are essentially independent of each other, then their combined error variances in a 'gross' model may obscure or obliterate real effects of condition factors (eg. stand, terrain and climatic variables) on one or more sub-processes. However this is not the only possibility... The sub-processes may not be truly independent of one another, and the sum of the sub-process estimates may therefore prove to be no better than an overall estimate from a gross model."

3.3.4 Job Breakdown

This is a listing of the content of a job by elements. An element is defined as a distinct part of a specified job selected for convenience of observation, measurement and analysis. Different types of elements are listed in the glossary of terms. A detailed breakdown of a job into its elements is necessary. ILO 1977 lists the following reasons for job breakdown:

- (a) To ensure that productive work (or effective time) is separated from unproductive activity (or ineffective time).

- (b) To permit the rate of working to be assessed more accurately than would be possible if the assessment were made over a complete cycle. The operative may not work at the same pace throughout the cycle and may tend to perform some elements faster than others.
- (c) To enable different types of elements to be identified and distinguished, so that each may be accorded the treatment appropriate to its type.
- (d) To enable elements involving high fatigue to be isolated and to make the allocation of fatigue allowances more accurate.
- (e) To facilitate checking the method so that subsequent omission or insertion of elements may be detected quickly. This is necessary if, for example, at a future date, the time standard for the job is queried.
- (f) To enable a detailed work specification to be produced.
- (g) To enable time values for frequently recurring elements, such as the operation of machine controls or loading and unloading workpieces from fixtures, to be extracted and used in the compilation of synthetic data if necessary.

There are some general rules concerning the way in which a job should be broken down into elements. These are listed in appendix H. It is important that elements are clearly defined and their break points identified. Industrial Engineering Manual (IEM) (1961) classifies all actions required to perform an operation in the following ten classes of basic motions.

REACH
MOVE
TURN
APPLY PRESSURE
GRASP
POSITION
RELEASE
DISENGAGE
EYE TIME
BODY MOTIONS.

The elements to be isolated depend on the technique used, the equipment used and the purpose and precision of the study. Appendix I lists some examples of work study elements in thinning by Whiteley (1972), Whiteley (1973) and Shaw (1982). Whiteley (1973) studied a less advanced chainsaw system where an axe was used for limbing. Shaw (1982) used a more advanced chainsaw cutting system, where the cutter works systematically using a chainsaw only, for all cutting work, a system which is now in general use in much of the industrialised world where labour costs are high. The following define the elements and their end points¹, which are common for fellers in pine plantation thinnings in Australia (Shaw, 1981; Shaw, 1982).

¹ Where not specified the end of the element coincides with the start of the succeeding element

Productive elements:

- (a) Prepare and Inspect. This is the time taken to walk to a tree, inspect, remove unpruned low branches and ground vegetation or other obstacles around the tree to create a convenient working space.
- (b) Fell. This starts when the chainsaw removes the first chip of the first cut and finishes when the tree hits the ground or alternatively lodges in another tree and stops falling.
- (c) Trim. This starts with the chain-saw held by both hands ready to trim, starting from the butt end, and ends when the hand is lifted from the saw. It includes all necessary walking.
- (d) Measure. This is done with a tape which is carried on the feller's belt and may include the following activities.
 - . hooking end of tape into log
 - . turning to read the log length
 - . waiting for the tape to recoil,and, therefore, starts with the cutter reaching for the tape, turning to read the length and pulling the tape free. It ends when the cutter starts another element or the tape is fully recoiled.
- (e) Clear slash. This starts when the cutter finishes any other element and starts to move trimmed branches away from the work site.
- (f) Crosscut. This starts as the saw is placed ready to crosscut and finishes when the saw is through the log.

- (g) Stack. This starts when the cutter finishes another element to place logs into stacks and includes time necessary for walking to and from stacks.
- (h) Clear slash from stack. This is time required to move already trimmed branches and remnant crowns from an area selected for stacking or clearing branches on or around a stack.
- (i) Return trim. This can start in three ways, i.e.
 - (a) the cutter moves to pick up the chain saw to remove branches not trimmed in the first cycle, or
 - (b) rolls the log to expose the branches underneath, or
 - (c) the cutter tries to remove branches using other methods such as pulling, breaking etc.

Delays: The following are some of the common delays as segregated by Shaw (1982). They start and end appropriately. Appendix J defines them.

	Categories ¹		
	A	B	C
Sharpen chain		x	
Refuel		x	
Move hardwood		x	
Cutting hardwood		x	
Excessive wind velocity		x	
Rain, hail, snow		x	
Saw jam-felling	x		
Saw jam-crosscutting	x		
Hangup	x		
Walk to and from the vehicle		x	
Drink			x
Meal			x
Injury	x		
Smoke	x		
Personal	x or	x	
Talk to studyman	x		
Talk to workmates	x or	x	
Talk to supervisor		x	
Move gear		x	
Start saw		x	

1

- A. Unanticipated delays and those not necessary for productive work.
 B. Delays associated with and necessary to undertake productive or environmentally unavoidable work.
 C. Meals and drink.

These subdivisions demonstrate how cutters spend unproductive time and may be used to determine which delays occur most often and how these may be reduced or eliminated. Whiteley (1973) added any unavoidable delays associated with a particular element to that element; those remaining were classified as caused by supervisory activities and grouped together as organisational delays. He disregarded avoidable delays in his analysis since they consisted of time spent on operations other than cutting.

Shaw (1982) incorporated delay times in his analysis in order to determine absolute productivity levels. He regarded avoidable delays as caused by lack of skill or expertise. Hangups were insignificant and were ignored in his analysis. Figure 3.6 shows the proportion of productive and delay times for five of the cutters he studied.

Figure 3.6

Histogram for a sample of cutters

(subjectively chosen to represent the range)

illustrating proportion of

- (i) productive time
- (ii) unavoidable delays
- (iii) avoidable delays
- (iv) meals

Hours per day

Study day

Source: Shaw 1982

3.3.5 Problems arising in recording productive elements.

Data collection is not simply pressing a stopwatch and recording times on a work study sheet. Whilst timing, the work studyman has to analyse the cutter's method continually, at the appropriate time press the stopwatch button, read the time for the element and record it, at the same time continuing to monitor the cutter's activity. All these need mental coordination and understanding of the process. Different felling techniques have differing problems in recording.

The following is a short description on what was experienced and should be expected in timing the productive elements of a chainsaw based felling operation, and some of the problems associated with it as reported by Shaw (1982).

(a) 'Prepare and inspect'

The assessment of completion of one tree and starting the next is not so difficult although, on occasions, a cutter might stop to assess the surrounding conditions, have a rest, use a handkerchief or any number of things. The timing person has to assess if a 'delay' element had been started or if 'prepare and inspect' was continuing. Finishing the element is usually easy to define as the saw is positioned ready to commence 'fell'. It is usual to have one element under prepare and inspect and seldom two.

(b) 'Fell.'

The start and end of this element is not difficult unless a hangup or fuel delay was encountered; only one record will comprise the felling element.

(c) 'Trim and Clear Slash'.

After felling a tree the cutter processes it. The sequence of elements would vary depending on the tree's branching characteristics and form, its position relative to the surface of the ground and the work method and skill of the individual cutter. Determining these elements might not be easy. For example, if in moving from one whorl of branches to the next, the cutter should actually move a branch from within his path, then in this case two questions must be asked:

(i) Can the movement be accurately timed if it was less than, say, .05 minutes?

(ii) If the time to move from one whorl to the next would have been the same with or without moving the branch, has the element actually changed?

The general problems mentioned at the beginning of this subsection (3.2.5) were more pronounced in this element. The relationship between trim and clear slash, usually one following the other, and the 'flyback timing' which Shaw used could result in reaction delays, or in misjudgement of or overcompensation for, reaction delays so that 'error time' for one element may be subtracted from or added to the succeeding element. One observer may repeat the same kind of error indefinitely so that some of the

apparent additional variability in element times compared to total times may be accounted for by the cumulative errors of additional observations.

The decision on whether an element changes or not is also dependent on definition. For example, if the cutter picks up a branch to move it then 'clear slash' is entered and timed until the cutter actually returns to 'trim' by placing both hands on the saw again. In some cases moving a branch may not really be necessary for the cutter to continue trimming, but the branch might be moved nonetheless. In other cases, with the same cutter, similar branches might not be moved. The total times of these considered elements for a particular tree size can be similar, but the individual elements might differ between trees. This depends on the whim of the cutter or his ability to make correct decisions as to whether or not a branch needs to be moved. Shaw (1982) concluded that the combined variance of the two elements could, in fact, be greater than the variance of a total element consisting of both, but the additional variance is, to some extent, imagined rather than real as the total time required for the total task has not changed.

(d) 'Measure'

Attaching the tape to a log butt can easily be identified and timed with corresponding precision. By the use of coloured adhesive tape on the recoil tape the cutter could identify log length with a quick glance; this in most cases could provide the only reference to measure whilst processing the tree, but such a glance is impossible to time.

Problems could arise if, after glancing at the tape, the cutter was undecided what to do next. The timing person has to anticipate what is likely to occur, and either press the stopwatch button to record the last element and start recording measure, or continue timing the last element. Confusion could arise in two ways:

- (i) With commencement of "measure" the cutter would almost immediately return to another element; the timing person has to reach quickly to record the change correctly, and another short observation and inherent error would then be incorporated;
- (ii) Whilst timing of the last element continues, the cutter would have to deliberate the next action, for example, whether to 'crosscut', reassess the length, continue timing, or assess conditions such as the distance from the ground to branches yet to be trimmed. All these are unrelated to measure. During this period of uncertainty the timing person may have had difficulty defining which element was actually being timed, and errors in recording could occur.

(e) 'Crosscut'

As the element crosscut commences with the saw actually starting the crosscut and finishes with its completion, few problems, usually not difficult ones, occur. The timing person has to maintain a clear line of vision to the saw (and yet stand sufficiently clear not to interrupt or influence the cutter's work) such that a decision as to whether or not the cutter is trimming or

crosscutting can be made. This is not a common problem but Shaw (1982) experienced it in his study and should therefore be reflected in the data.

Furthermore, when the cutter is working in the upper crown of the tree and log diameter is as little as 7 cm, it is difficult to decide when 'trim' finishes and 'crosscut' starts. With little perceptible change in movement a cutter can change from 'trim' to 'crosscut' and complete the action before the timing person has time to react. The actual times involved can be small and can, for practical purposes, be ignored on some trees. On other similar trees, however, the timing person may react quickly and take an observation, small though this could be. The proportion attributable to error can therefore be relatively large, and hence a combination of inclusion and its error, and non-inclusion can give a false impression of the variance.

(f) 'Stack' and 'Return trim'

The cutter reaches for tongs or hooks, rolls the log by foot or hand, or places the saw on the ground on starting to 'stack'. These movements are easy to identify and time. Whilst stacking, however, the cutter may have to move a branch during the return for the next log, a situation similar to that which can be encountered in 'trim'. The time studyman cannot be sure whether the cutter will continue to 'clear slash' or 'stack'. During this period of uncertainty timing errors may have occurred. Likewise, the cutter whilst stacking a log might have removed a small branch or stub. Whilst time spent in removing such a branch by hitting or kicking it

may have been insignificant, a stubborn branch could require more effort or even require the chainsaw to finish the 'return trim' job. The timing person can therefore have difficulty in maintaining precise observations; an accurate prediction of future events is hence required to do so.

(g) 'Clear slash from stack'

Problems with this element can arise in a number of ways. When a tree is felled across a stack of logs the cutter may have had to 'clear slash' whilst trimming on the stack, or may have spent additional time clearing slash which might not be required to facilitate further trimming. The timing person has to decide which element had been timed and when the two are to be differentiated.

The cutter may not clear slash as each tree is processed, but only after he fells a number of trees, when accumulated slash on the stack has reached a certain level. In this case not every tree would fall with its crown on a stack and it will therefore be virtually impossible to allocate even an average time for a group of trees, let alone a precise time for each tree.

3.3.6 Factors affecting cutters' productivity

When carrying out work study in forestry there are many factors which can affect productivity, including a number of complex and inter-related variables which are not easy to isolate. This is why one has difficulties in making direct comparisons between operations. Banks (1981) lists the following as some of these variables:

Tree size and merchantable stem volume.

Tree form and branch or crown characteristics.

Forest conditions and constraints e.g. soil, slope and aspect.

Weather

Products required from the forest for which a market exists

Skill experience and training of the faller

Physical strength and stamina

Mechanical aids available

Faller relations at home and at work

Motivation of the individual

In addition to Banks' list the presence of a work studyman can also affect cutter productivity. It is virtually impossible to carry out a single work study which will test the effect of all the factors mentioned since this would need impracticable replication and high manpower and financial costs. The following discussion gives some light on how some of the above factors would affect cutter productivity with supporting evidence, where possible

(a) Tree size and merchantable stem volume

(i) Tree size

Tree size is proportional to the diameter at breast height (d.b.h.), the most popular dimension used for most work studies in cutting. The productivity of cutters has always been found to bear some relationship to the d.b.h. (Samset et al 1969, Haarlaa 1981, Shaw 1981).

In his comprehensive study, Shaw (1982) found the following:

- positive linear relationship between total time per tree and dbh^2 for increases in dbh^2 between 100-600 cm^2 (figure 3.7).
- a more complex non-linear relationship between productive time in minutes per m^3 and dbh implying less time per m^3 as dbh^2 increased for dbh^2 between 100-600 cm^2 (figure 3.10).

Table 3.6

Element regressions : time verses dbh²

Element	Regression Slopes Significance to "t" test		Regression Constants		Remarks on Tree site influence
	95%	99%	95%	R ²	
Prepare & inspect	not sign		sign	1-49%	minor
Fell		sign	sign	5-70%	related
Trim		sign	sign*	22-75%	related
Clear Slash	sign		sign*	0-64%	not related
Measure	sign		sign*	4-81%	related
Crosscut	sign		not sign	10-86%	related
Stack	sign		sign*	0-44%	not related
Return trim	sign		not sign	0-59%	related
Clear slash from stack	sign		not sign	0-55%	not related
Total time/tree	sign		sign	15-84%	related

Key Sign = significant

* for most cases

Source: Shaw 1982.

(b) Tree form and branching or crown characteristics

The effect of tree form and branching or crown characteristics on productivity is more pronounced on trees grown in the native forest rather than in plantations. However, levels of management for wood production are also important. Pines have common characteristics of having fairly straight stems, few double leaders, and consequently, in well managed plantations, usually have trees of much better form than unmanaged native forest. Nonetheless, branch characteristics in pines can cause significant variations in productivity.

Whiteley (1970) found a significant variation in overall productivity according to "live branch index" (the product of the mean diameter of live branches and the mean live branch frequency or number of live branches per unit length of stem). He also found the position of the lower boundary of the live crown to affect the efficiency of trimming but the magnitude of the variation in total productivity was negligible for large stands with mean dbh of 60cm, increasing to a maximum of 10% for small stands with a mean dbh of 30cm and having a high branch index.

Studies by Whiteley (1973) on trimming showed mean time for trimming to be related to the mean value per tree of the aggregated diameters of knots resulting from trimmed branches. He also concluded the rates of trimming dead and live branches of radiata pine were the same. He quoted previous studies which suggested the branch thickness was more for larger bole diameters and decreased with bole taper.

The diameters equivalent to the mean basal area and mean small end area per removed tree significantly affected the mean trimming time per tree. The height and small end diameter at the merchantable limit provide a measure of taper for a given dbh. Whiteley (1973) found the branch frequency (number per unit length) to increase along the stem from butt to tip, and the greater the taper of the merchantable stems, the more branches to be trimmed, hence the longer the trimming time.

Figure 3.7

The Effect of Tree Size on Productivity,
for the hypothetical 'average' cutter.

Source: Shaw 1982.

Similar results had been found in most of the referred studies mentioned earlier.

(ii) Bole Volume

This is the second most popular unit for measuring tree size. A study of 13 cutters (Shaw 1982) is summarised in figure 3.7 & 3.8 which shows less time per m^3 for larger trees than for smaller in first thinnings of radiata pine. Figure 3.7 suggests that for small volume trees the minutes spent for cutting a unit volume is higher than that when cutting large dimension trees. Figure 3.8 suggests that total productive time increases linearly in proportion to tree volume

Figure 3.8

Regression of 'Total Productive Time per Tree in minutes'
against 'Tree Volume (m^3)' for each cutter and for
all the data pooled to represent a hypothetical
'average' cutter.

Source: Shaw (1981)

(c) Forest Condition

Working conditions in the forest vary. Different places usually have different vegetation, slope and other obstacles. Similarly there are daily as well as seasonal changes of weather and climate. Dirt, dampness, wild animals, snakes and insects may make the forest less attractive as a workplace and could affect workers' productivity. The following are some examples of different forest conditions known to affect workers' productivity.

(i) Vegetation

Understory cover and vegetation in pine plantations can vary from a blanket of needles to a collection of brambles, thorny bushes, lianes and climbers. The denser the ground vegetation, the more difficult it will be for workers to move around, hence the lower their productivity. Whiteley (1973) showed the density of old hardwood debris affected the time taken for some cutting elements though it didn't affect the overall productivity significantly.

(ii) Slope

Harvesting on steep slopes can be both expensive and risky. Whiteley (1971) studied the effect of slope on cutter productivity concluding that productivity decreased with an increase of slope. Work on a 36° slope was only 34 to 74% as productive as on flat ground. He also noted more lodged trees on steeper areas.

Samset et al (1969) found total time per tree for cutting Norway spruce sawlogs increased with an increase in slope. A decrease in cutting productivity of about eight percent was suggested on a 20° slope compared to flat ground.

The loss of productivity while working on steep terrain can be explained by two major reasons, namely:

- movement requires more physical effort and also there is difficulty in balancing while moving across the slope or even when standing on one spot to perform work,
- constant concentration required to maintain safe working conditions.,

(d) Payment system

The payment system conditions a cutter's attitude towards his work. Today, in many countries, job security is being given more weight than in previous years. In Australia for example, some cutters are paid under the terms of industrial awards, some by contract, and others by piecework. Different payment systems have their advantages as well as disadvantages. There are factors which may dictate the payment system to be used. The details on this are beyond the scope of this study but it is worth mentioning a few which are common, for example:

- existing union policies and strength,
- social relations in the industry,
- government policy on employment,
- existing economic situation of the industry,
- type and location of work,
- supply and demand for labour,
- stand variables,
- equipment supplied.

In the early 1970's Swedish forest managers expected workers' productivity to increase towards the late 1970's, but the reverse occurred when piecework was abandoned in 1975 to offset overproduction. A study was carried out in the late 1970's to assess the effect of the change in payment system. The study showed that, on average, men were producing 20% less in all operations. This loss of productivity differed in different age groups. Those under 41 years of age achieved 26% less output compared to that before the change of payment system. Those of age between 41-50 years produced 19% less and those over 50 years of age produced 16% less. This loss was far more than the management forecast of 10%. On the other hand there were some gains from giving up piecework. The number of accidents per million hours fell from 119 to 80, and sick leave resulting from accidents fell from 2.94 to 1.99 per thousand working hours (Anderson 1979, Shaw 1979, Wittering 1980).

Cutter productivity is affected by stand variables. This has implications for piecework determinations (Samset et al 1969, Whiteley 1973), and an employer would have to adjust rates when workers move from one stand to another to stabilize earnings. Whiteley (1973) recommended adjustments to ensure no cutter who worked the required hours should receive less than the minimum weekly award wage. He further comments that a study of cutting productivity can only provide suggestive data for wage negotiations as the other factors mentioned above would also have some importance.

(e) Silvicultural management constraints

Harvesting thinnings has more silvicultural constraints imposed than clearfelling. Most thinnings are carried out to give the remaining stand better growing conditions. Management prescriptions on how the thinning should be done can affect felling efficiency and previous silvicultural operations such as planting, weeding and pruning affect stand conditions. For example, a faller working in a plantation which has not been weeded and pruned will spend more time clearing, preparing to fell and trimming compared with one who works in a weeded and pruned plantation. Previous work in cutting e.g. Samset et al (1960), Whiteley (1971), Whiteley (1973), Shaw (1981), had shown loss of productivity on sites with more ground vegetation, climbers and branches.

Emtage (1981) analysed the effect of managerial changes on pulpwood harvesting in the central tablelands of New South Wales for the past twenty years. Silvicultural management changes had an effect on cutter productivity. Table 3.7 lists these changes and their effects on cutter productivity.

The volume removed per hectare can affect some elements in the felling work cycle. The time taken to walk between trees and clear tracks is dependant on the number of trees removed per hectare.

In his study Whiteley (1973) assumed walking time to be proportional to the distance walked on each occasion and that the shortest path between removed trees was followed. He found the time per tree to be inversely proportional to the square root of the number of trees removed per hectare. His regression model supported this for elements "walk to tree" for felling and "walk to tree" for

trimming. Appendix N shows result for worker productivity for differing volumes removed from Whiteley's (1971) study.

Table 3.7

Plantation Management Changes and their effect
on Productivity.

Year	Management action	Productivity
Mid		Gain + Loss -
1960	Thinning yield must exceed 85 tonnes/hectare on average	+
1968	Outrow spacing brought in from 24m to 19m where hardwood debris is light	+
1972	Residual basal area after 1st thinning reduced from $20.5 \text{ m}^2\text{ha}^{-1}$ to $17\text{m}^2\text{ha}^{-1}$	+
1973	Outrow spacing reduced to 14.5m when extracting with forwarders	+
1975	Mean thinning age reduced from 15 to 14.5 years	-
1979	Started to encounter areas where no low pruning (to 1.8m) had been done	-
1980	Started to thin areas with little or no ground debris.	+

Source: Emtage 1981.

(f) Equipment and Mechanical Aids

(i) Chainsaws

A chainsaw is the main equipment in motor-manual techniques of processing a tree. There is a wide variety of chainsaw models on the market with a range of specifications for different purposes. Fellers would normally prefer a lighter chainsaw consistent with the work they have to do. For example, light saws are adequate for first thinnings in pine plantations but would not be very suitable for crosscutting old hardwood debris in such plantations. In this case a large saw might be used for cutting the debris.

An experiment on the use of lighter chainsaws for limbing was carried out by Nova Scotia Forest Industries using a Husqvarna 240S. The results revealed that a chainsaw weight reduction of 25% can raise cutter productivity by 10-15% in addition to other gains such as those of lower fuel and oil consumption, and lower hourly operating costs. On the other hand, these light weight chainsaws were found to require more operator maintenance and were a little more sensitive to incorrect mixtures of petrol and oil (Kluender 1980). Appendix L a & b shows the Husqvarna recommended alternatives suitable for different situations in stump operations and technical data for the models indicated.

Other factors of chainsaw design which would affect a cutters efficiency include:

- a vibration isolation system which minimises the risk of getting Raynaud's disease. Most modern chainsaws would have several shock isolation points.

- an exhaust system which directs the exhaust gases away from the faller's face.
- noise reduction by fitting more effective exhaust mufflers.
- safety trigger interlock, chainbrake, rear hand guard, anti kick-back T-tip. (Fig. 3.9) are some of the modern modifications of various models to minimise chainsaw accidents.

A cushion which can be inflated by pressure from the saws cylinder can be placed in the backcut and used as a wedge. This is an efficient aid for directional felling in later thinnings and clearfelling where pulling down hangups would require more physical effort (Fig. 3.10).

Scandinavians have designed a frame which is used for supporting the chainsaw when felling thinnings. This is aimed at reducing the back strain to the faller. By using this frame, he can work in an upright position, at the same time felling the trees into windrows easily. However this frame is feasible only for thinning stands which don't have thick undergrowth.

Figure 3.9

A Modern Chainsaw

Chain break and hand guard

Safe T-tip

Source: Logger 1983.

Figure 3.11

How to use a Felling Cushion

Source: Nordefeller

(ii) Auxiliary felling aids

Auxiliary felling aids (Fig. 3.11) can either help to increase productivity or reduce the workload. Serious injuries could occur by not using simple tools; for example a faller who uses an axe to move logs instead of timber tongs can have serious injuries (Fig. 3.12A). Similarly one who uses an axe as an aid for pulling out a cutter bar jammed while crosscutting can end up damaging both the chain and the cutter bar (Fig. 3.12B).

Work studies on the effect of felling aids on cutter productivity are not common because the simple felling aids normally cost far less than the cost of carrying out a workstudy and their importance is evident.

Figure 3.11

Common Auxiliary Felling Aids

- A Felling wedges B Axe C Billhook D Barking
spud
- E Two men saw F Bow Saw G Timber Tongs
- H Hook

Figure 3.12

Dangerous use of an Axe

- A Using an axe instead of timber tongs.
- B Misusing an axe to release a jammed cutter
bar in crosscutting

(g) Training and Safety

There is only limited knowledge of people's attitudes to harvesting work and their motives for entering and/or remaining in the industry. At management level, there should be concern about lack of skills, low level of training (except among some larger employers) and the high cost of logging accidents. Proper training would expose the faller to safe methods and procedures in the forest, and the proper techniques to use in various situations. The importance of training is more pronounced where new equipment is introduced to the industry or an individual.

Mining and forestry maintain an unacceptably high accident rate (ILO 1979). This rate decreased in the 1970s but the level is still high compared to most other industries (see Figure 3.13). A chainsaw is the single most dangerous piece of equipment (FAO 1982) because of its fast cutting chain and its relative weight especially when limbing. Table 3.8 shows the number of accidents occurring whilst chainsaw limbing in Sweden and shows the decreasing trend for the period 1967-1972.

The most susceptible parts are the arms and legs including the hands, feet and ankles since all these members are close to the chain when it is running at high speed. Table 3.9 gives the percentage breakdown of chainsaw accidents involving parts of the body whilst limbing in Sweden.

Figure 3.13

Accident Statistics for the Swedish Forestry Industry

Source: Milling 1981.

Table 3.8

Number of accidents occurring in connection with
chainsaw limbing in Sweden 1967-1972.

Year	Number	Limbing Accidents %
1967	3290	43
1968	2423	38
1969	2328	38
1970	2072	30
1971	2072	33
1972	1332	30

Source: Husqvarna

Studies by FAO in both developed and less developed countries showed accidents in less developed countries to be as much as ten times more numerous than in developed countries. For example, studies carried out in South East Asia and West Africa in natural forest logging indicated a rate of two accidents per worker per year. People were killed in one in five accidents a year. On the other hand, in industrialised countries the accident rate was found to be one per fifty workers a year, mainly due to safety training and mechanisation (FAO 1982).

Another aspect worth mentioning is nutrition. This has several effects on a worker's productivity as well as his safety. A

worker living on a poor diet is likely to become very tired and this could cause a number of avoidable accidents. As regards productivity, FAO carried out an experiment in Jamaica and found that additional food worth two million US dollars would achieve a net saving of eight million in the establishment of 4000 hectare of pine plantations (FAO 1982). Similar benefits should also be expected in harvesting operations.

Table 3.9

Percentage Breakdown of Accidents Involving
Different Parts of the Body (Sweden)

Year	1969	1972
Parts		
Head	4.9	5.4
Eyes	7.4	12.3
Abdomen and Back	2.7	3.2
Hands and Arms	55.3	34.0
Leg, ankle and foot	29.7	45.1

Source: Husqvarna

The logging Industry Training Team (LITT) in Mount Gambier studied motor manual techniques when the accident rate increased in the early seventies. APCEL (Pulp and Paper Company) for example were paying 11% of gross wage in workers compensation insurance premiums in 1972, 38% in 1976 and 17% in 1981 for those areas harvested by the South Australian Woods and Forests Department (Douglas 1981). A study by CSIRO suggested that Workers Compensation for the forest industry in Australia averaged 20.6 to 30% of total wages and also drew attention to injuries resulting in strained backs, hernias and deafness, which are not immediately obvious (Kerruish 1976). Table 3.10 shows the reduction in accident rate from 1974 to 1978 after the study by LITT. The accident rate per faller, fell considerably from 1974 to 1978. After that the figure shows a slight increase. Days lost per faller showed the same trend, but the increase after 1978 is more pronounced. This could be due to reasons explained later.

Despite design improvements, chainsaws continue to be the most dangerous forest tool. Apart from the injuries mentioned above, the operator is at risk from toxic exhaust gases, noise and vibrations which could lead to poisoning; complete or partial deafness; and white fingers (Raynauds disease) respectively. ILO (1977) text on Protection of Workers Against Noise and Vibration in the Working Environment gives details of the limits which, if adhered to, minimise the risk of injury from noise and vibration.

Table 3.10

Table of Accident Rates (South Australia LITT)

Year	1974	1976	1978	1980
Total Accidents	364	208	117	131
Days lost	4570	2628	1755	2464
No. of fallers	493	355	289	314
Accident rate per faller	0.74	0.59	0.40	0.42
Days lost per faller	9.27	7.40	6.07	7.85

Source: After Douglas (1981)

Severe injuries and high accident rates obviously make the harvesting industry unattractive. New untrained workers tend to have more accidents than those with experience or who have been trained. Training yields two major gains; less accidents and higher productivity. After training the worker uses his equipment more efficiently and more safely. Several work studies have been carried out to find the effect of systematic training. Amongst these Bills (1972) and Banks (1981) both indicate increases of productivity as shown in Table 3.11 and Figure 3.14.

Figure 3.14

Effect of Training on Cutter Productivity

Individual faller Productivity cubic metres per 2 monthly period and impact of training period.

(a) Faller K

(b) Faller Z

Source: Banks 1981.

Table 3.11

Effect of training on manual unloading productivity.

Average % time per element

Trainee	1	2	2	4	5	6
Age	30	36	50	47	44	35
Experience (years)	6	1	9	0.5	6	6
Previous Training (weeks)	2	-	5	3	4	3
Unloading Time						
centimin/m ³ before:	51	68	52	46	45	51
After	45	42	46	33	42	33
Improvement (percent)	12	38	12	28	.7	35

Source: Henderson 1974.

Though most studies carried out in the seventies indicate a decrease in accident rates, the introduction of new technology and existing unemployment in Australia could increase industrial accidents. The federal President of the National Safety Council of Australia Mr C.W. Peterson (in Logger 1983) gave the following reasons for this.

- (i) Greater stress and strain would be imposed on some employees as production problems increase.
- (ii) Newly employed workers competing to hold fewer available positions, could be tempted to take greater risk in trying to demonstrate superior ability.
- (iii) Boredom and depression resulting from inactivity in a production downturn could make employees inattentive and careless.
- (iv) Tension and anxiety among older employees would increase as their skills were replaced by new technology or they felt threatened in the job security.
- (v) Reduced supervision for reasons of economy.

There are several methods of training which may be used to develop and upgrade the skills required by the workforce. Which method applies in a given situation depends upon several factors, for example the complexity and responsibility of the job, the ability and background of the trainee, the industry structure, existing training framework and the costs involved. The effect of training on machine use, productivity and operator safety could be analysed on a gross basis but would be more difficult to isolate to individual components.

(h) Products required from the forest.

The products required from the forest dictate how the tree processing should be done. These requirements would include, for example, log lengths and mill acceptance standards.

Bills (1972) and Whiteley (1972) studied cutter productivity in radiata pine cutting random lengths and 1.2 m billets. Bills' costings indicate that 1.2 m billets cost 5.25% more than random lengths per m³ produced. Whiteley showed that productivity was higher for random length cutting, than when cutting 1.2 m billets. He studied two cutters; their respective productivity on random lengths was 161% and 171% of that for 1.2 m billets. The lengths of logs harvested therefore affected the productivity greatly.

Mill acceptance standards could demand more time spent on processing a tree, which can reduce cutter production. LIRA (1978/1) lists the following as some of the sources of sawmill damage and downtime:

- nodal swellings,
- bumps,
- bends,
- splits,
- partial breaks,
- fluting and taper.

Other factors influencing the size of logs as processed in the forest would be skidding and loading equipment and methods, transport vehicles used, and road safety standards.

(i) Presence of a Work Studyman.

Most workers in the forest work independently. Normally there is no person who stands and watches them. The fact that some one is watching and monitoring, can, of itself, trigger the cutter either to work harder or work less. This can occur in two ways:

(i) It can increase the effort put into work as the worker tries to look as efficient as possible.

(ii) If the worker is not happy that a work studyman is standing by and watching him, he may deliberately work more slowly or create obstacles simply to confuse the studyman (ILO 1977).

In his study, Shaw (1982) concluded that 3 of the cutters studied had performed at an increased rate in the presence of the time study team. This implied using a study method whereby abnormal work performance could be identified and that results from studies without such precautions (e.g. where only one cutter of a few are studied) should be treated with caution. It should be expected that productivity of the cutters would be higher during a period of workstudy if the cutters are casually employed and unemployment is a problem in that particular area.

CHAPTER 4

WORK STUDY ON ECOLOGISER

INTRODUCTION

A work study was carried out on an Ecologiser mobile sawmill in the Australian Capital Territory (A.C.T.). This was done since it was most convenient for a number of reasons such as:

- (i) The mill foreman and his workers were interested in a study of their work.
- (ii) The writer could not call on the extra men needed for a study of stump operations in harvesting nor were there any funds available (e.g. see Appendix F).
- (iii) Cutting in A.C.T. forests is done by individual contractors. In order to minimise variations and produce valid results, extended studies of even one crew working in one area would have to be done. There simply was not enough time to do this. This was not so with the Ecologiser and the environment would be much the same; variations in stump operations arising from differences in slope, ground vegetation, tree spacing, equipment used, aspect and other conditions did not occur with the Ecologiser which was set up in a cleared open area on flat ground for a long time.
- (iv) In Tanzania, where the author works, utilisation of pine thinnings has been very low. There are very few mobile sawmills at present in plantations but there are plans to have more to ensure better utilisation of thinnings (Joint Mission 1981).

4.1 OBJECTIVES

The main objectives of the Ecologiser work study were as follows:

- (i) To gain experience in organising and implementing work study.
- (ii) To gain experience in the detailed techniques of work study and the problems that arise.
- (iii) To isolate factors tending to reduce productivity and tentatively to suggest possible ways of overcoming them.
- (iv) To obtain production and productivity data.

4.2 ECOLOGISER DESCRIPTION

The Garret-Weldco Ecologiser is a portable sawmill, driven by a 213 HP diesel engine, and designed to saw small dimension logs, up to a maximum diameter of 30 cm. in one pass. The Ecologiser is about 2.5 x 3.0 x 1.5 metres mounted on wheels, with a detachable bench (see photos 4 and 5). The sawmilling is done in a cleared site in the forest where the Ecologiser and other equipment, logs and sawntimber can easily be accommodated.

The Ecologiser studied was bought from the USA some 3 years ago as a second hand unit. Its actual age and previous utilisation is not known.

4.3 ORGANISATION OF WORK

4.3.1 Manpower

Normally the Ecologiser was manned by four people i.e. one foreman, two operators (infeed and outfeed) and one forklift

driver. At times there would be two others, one helping on the infeed section and the other on the outfeed. These two people would also help in sorting logs.

The Ecologiser owner also has a wood processing mill at Bomaderry on the South coast of New South Wales, which takes the sawntimber from the Ecologiser and converts it to other products such as pallets, boxes and containers, cable drums, and cores for cable drums. Table 4.1 shows the processing specifications: log sizes, timber to be produced, end products at the main mill at Bomaderry and potential markets. The number of people employed to operate the Ecologiser depended on the market for the end products. In an extreme case the Ecologiser could, in fact, be operated by 2 people only.

4.3.2 Work Duration

The Ecologiser works on one site as long as logs are within reasonable hauling distance before moving to another site. This is monitored by the A.C.T. forestry office in Canberra. The operation goes on throughout the year except when the condition in the forest (e.g. heavy rain) or for other reasons such as shortage of logs and machinery breakdown makes it impossible to run the Ecologiser. The crew then goes to work at a sawmill in Fyshwick (in Canberra), owned by the same company.

Table 4.1
Milling Options

Option 1

Minimum top end diameter: 11.0 cm

Maximum top end diameter: 14.0 cm

Possible timber production

Cross sections:-

8.7 x 8.7 cm 1 pc.

10.0 x 5.6 cm 1 pc.

Further processing:

8.7 x 8.7 cm plugs

or pallet legs

End products

Plugs, end plugs and

pallet legs

Common market

Bomaderry Paper Mills

Option 2

Minimum top end diameter: 14.0 cm

Maximum top end diameter: 16.0 cm

Possible timber production

Cross sections:

10.0 x 2.2 3 pc.

10.0 x 5.6 1 pc.

10.0 x 2.2 1 pc.

10.0 x 3.8 2 pc.

Further processing:

Cores

End products:

Pallets & reel ends, boxes and
containers, cable drums, cores
for cable drums.

Market:

Bomaderry Paper Mills, Grace
Brothers Co., Steel Works
Kembla, Cable manufacturing
factory, Sydney

Option 3

Minimum top end diameter: 16.0 cm

Maximum top end diameter: 18.0 cm

Possible timber production

Cross sections:

12.5 x 2.2 3 pc.

Further processing:

Cores or reel ends

End products:

Reel ends or cable drums.

Market:

As option 2.

Option 4

Minimum top end diameter: 18.0 cm

Maximum top end diameter: 20.0 cm

Possible timber production:

Cross sections:

13.7 x 13.7 1 pc.

Further processing:

Cores

End products:

Plugs 13.7 x 13.7 for large
Paper rolls.

Common Market:

As option 2.

Working hours are from 7.30am to 4.00pm Monday to Friday. There is a 20 minute tea break at 10.30 a.m. and 45 minute break for lunch at 12.30. The Ecologiser stops working at 3.30pm. From 3.30 to 4.00p.m., it and the front end loader are serviced and refuelled and any other minor work necessary to ensure an immediate start the next day is carried out. Normally the Ecologiser works for about 6 hours each day. There are about 80 hours lost every year due to unexpected machine downtime.

4.3.3 Supply of material and equipment

The supply of sawlogs is organised by the A.C.T. forestry office. All logs supplied are from commercial thinnings or clearfellings from pine plantations. Usually the logs are supplied from the forest in which the Ecologiser is located, but at times they might be supplied from other forests. Since the Ecologiser was brought to Australia about 3 years ago, it has been working in Stromlo, Kowen and Uriarra forests in the A.C.T.

There are limiting factors on the size of logs to be supplied:

- (i) The diameters to be handled are between 12 and 30 cm. Anything less than 12 cm cannot be sawn safely, anything more than 30cm will not go through the infeed gate conveniently.
- (ii) Log lengths which can be safely handled by the infeed operator should be between 2.4 m and 3m.

(a) Stump operations:

Tree felling and stump processing is done by individual contractors, all of them using chainsaw based systems.

(b) Log transport:

Log transport is also done by contractors. The loading is done by self loading or independent loading equipment owned or hired by the contractors. The logs are then transported to the Ecologiser site. Unloading is normally done in three ways:

- (i) Unloading using a truck mounted device.
- (ii) Unloading using a rubber tyred front end loader.
- (iii) Unloading by gravity, i.e. by releasing the chains and stanchions containing the logs on the truck.

The unloading technique depends on the truck or trailer design.

(c) Sawn-timber transport:

Sawn timber is transported to the mill on the south coast by trucks hired by the mill owner.

(d) Equipment:

There are two major machines on site namely the Ecologiser (which processes the logs) and the front end loader. The front end loader has several jobs to perform including:

- Unloading logs from the truck,
- Piling logs in the log yard,
- Loading logs on to the Ecologiser infeed bench,
- Moving logs from the infeed reject pile,

Moving timber from the outfeed to a sawn timber stack,

Loading sawn timber onto a truck.

Other equipment on site includes:

Sawdoctor's bench with a motor for grindstones and an air compressor

Chainsaw for cutting block stacked and strapped sawntimber to a uniform edge and length

Fuel tank and fire extinguishers.

(e) Moving the Ecologiser

Moving to a new site can be done in a short time within the same forest.

The Ecologiser unit is towed by the front end loader, the Ecologiser bench by a 4-wheel drive car and the fuel tank by the front end loader or 4-wheel drive vehicle depending on how much oil is in the fuel tank.

Packing up usually takes about 20-30 minutes. Unpacking and setting up usually takes 15-20 minutes.

Travel time depends on the distance between sites, road standard and terrain.

4.3.4 Flow Process

Figure 4.1

Flow Process at the Mill Site

		Photo
A	LOGS ARRIVE ON SITE (AND ARE MEASURED ON THE TRUCK)	4.1
B	UNLOADING LOGS	4.2
C	PILING LOGS IN THE LOG YARD	4.3
D	SORTING LOGS	
E	LOADING LOGS ON TO ECOLOGISER INFEED BENCH	4.4
F	FEEDING LOGS TO THE ECOLOGISER	4.5
G	CHIPPING AND SAWING	4.6 & 4.7
H	OUTFEED: SORTING AND STACKING SAWN TIMBER	4.9
I	BINDING	
J	MOVING SAWN TIMBER STACKS	
K	CROSSCUTTING THE STACKED TIMBER	
L	LOADING TIMBER ON THE TRUCK	

- A. The logs are brought to the sawmilling site and the stacked volume on truck measured with a tape. The volume is, therefore, approximate only. Measuring takes about 2 minutes as the forestry staff doing it are experienced (photo 4.1).
- B. Unloading logs is done as explained previously and takes 5 to 10 minutes depending on unloading technique. The logs are unloaded on to a clear area which can accommodate a continuous supply of logs (photo 4.2).
- C. Piling logs is done using the front end loader. The logs are piled as shown in photo 4.3.
- D. Sorting of logs is done when there is enough manpower and it is convenient. Logs that are crooked, defective, large, too small or having any other undesirable defects are discarded. The rest are piled according to desired diameter classes.
- E. Loading the Ecologiser bench is done using the front end loader as shown in photo 4.4. Usually, a single supply can take about 10 minutes before another load is required. A normal load will be 15-20 logs depending on diameters.
- F. Feeding logs into the Ecologiser is done by an hydraulically operated roller system on the infeed bench. Manoeuvring

logs on the bench, especially crooked ones, is a difficult job. In some cases, the infeed operator has to retrim logs because of large branch stubs. If the log does not qualify for processing, the operator will discard it by pushing a lever before the log goes into the Ecologiser. The discarded log falls off the other side of the bench. Photo 4.5 shows these discarded logs in the lower left hand corner.

- G. The processing takes place in three stages. Firstly there are two vertical rotating sets of chipper knives, one set on each side of the log, which form two vertical parallel sides on the log. Secondly there are two horizontal sets of chipper knives which form two horizontal parallel sides on the log, thus producing a square or rectangular flitch. Lastly there is a set of circular sawblades, the number of which varies between 1 and 4, depending on the desired thickness of timber to be produced. Sometimes the sawblades are not installed, the end product being a flitch. The sawn timber is ejected on to a conveyor system. The sets of knives and sawblades and their relative position are shown in photo 4.6. Photo 4.7 shows the three stages of conversion in a reversed half processed log.

- H. Sorting and stacking is done by segregating three groups depending on the finish. The finish can be on all four sides, three sides, or two sides only in the case of small dimension logs.

- I. Strapping is done by the outfeed operator, when the size of the stack is about 1m^3 in cross-section, using steel wire and a strapping machine.
- J. Moving strapped sawn timber is done with the front end loader. The timber is moved to a cleared site and stacked ready for loading onto the truck for transportation to the mill at Bomaderry.
- K. Crosscutting the stacked timber is done using a chainsaw in order to get a uniform desired length.
- L. Loading timber onto a truck is done using the front end loader and takes about 30 to 45 minutes even when supplying logs to the Ecologiser at the same time.

4.4 WORK STUDY

Work study was carried out in two stages: firstly a general study of the Ecologiser activities on a daily basis, trying to isolate any areas which could cause reduced efficiency, secondly, time studies carried out on selected components of the whole operation.

4.4.1 General Work Study

This had three objectives:

- (i) Getting used to the workers and vice versa to promote mutual confidence and acceptance of the study.

- (ii) Identifying any drawbacks which could be rectified without necessarily carrying out time study.
- (iii) Identifying the key process, hence deciding which components of the process should be time studied.

The results were as follows:

(i) Worker relations:

The workers were hardworking and had an excellent relationship with the foreman. The best co-operation was achieved from the workers by discussing their problems frankly.

(ii) Identifying drawbacks:

It was not difficult to see the drawbacks. The Ecologiser was meant to be operating continuously, but frequently did not, for various reasons.

(a) Machine Breakdowns

The Ecologiser unit is not new, and was subject to breakdowns common to all old machines. This caused a lot of time to be lost and all other equipment and manpower might have to stop work for some time. The commonest breakdowns occurred in the hydraulic system. Most of the movements (e.g. infeed mechanism, and roller systems) are hydraulically operated. There could be unexpected leaks from valves or joints which had to be repaired to keep the machine operating. A major breakdown occurred due to a leak in an oil hose of the clutch assembly. A minor leak in the oil hose lead to clutch failure. The whole motor had to be lifted out to get at

the clutch for repair, and this took 3 full working days. Other minor breakdowns occurred because of poor engine tuning, blunt knives or sawblades and such like problems which normally took less than one hour to fix.

These breakdowns cannot be avoided completely. Minor spares such as blades, knives, valves and hoses were usually on site, and the foreman and workers were able to effect repairs.

(b) Shortage of Manpower

The number of people employed on the Ecologiser depends on the market for final products. However, shortage of manpower caused delays, generally connected with poor sorting of logs. Sorting of logs is of the utmost importance. When there were four or less people working on site the sorting of logs was not efficient enough to cope with the Ecologiser's needs. Poor sorting caused delays for a number of reasons including:

- the number of reject logs delivered to the infeed increased, the infeed operator had to push a manual lever to eject them and then push an hydraulic lever to load another log which might also be a reject. The flow of material through the Ecologiser thus became discontinuous.
- Poor delimbing in the forest required the infeed operator to delimb a log properly before feeding it into the unit.
- Spiral grain or big knots, which could have been identified at the sorting stage, might go in and while being sawn the logs might jam, slow-down the sawing rate or in some cases

require the log to be reversed out as a reject after being partially sawn (photo 4.7).

- The infeed operator had to concentrate constantly on whether each log was of sufficient quality or not. He, therefore, used much more energy to judge this and also to operate the reject lever manually. To reduce this work load on the infeed operator and also reduce delays it is worthwhile having the sorting regularly done.
- Without proper sorting being done, the logs fed in are of varying sizes and the pre-set cutting pattern might be unsuitable for some of them causing excessive wastage.
- Sawdust blockage can occur. This occurs because the sawdust exhaust system is fed by spiral blades as shown in photo 4.8. At times the sawdust accumulated such that the fan blades jammed, and the sawdust had to be removed using a spade. If there was only one person on the outfeed, the machine might have to idle for some time whilst the sawdust was being cleared. A second person would minimise this delay and would also speed up the sorting of timber at the outfeed.
- Delivery of logs to the infeed was not common but it occurred when the front end loader operator was doing other things such as moving sawn timber, loading a truck and piling up logs. The infeed operator might run out of logs, especially if he had too many rejects, or the front end loader operator might have underestimated the average of 10 minutes between deliveries of logs to the infeed. This

delay could be avoided by fixing a horn on the Ecologiser to advise the front end loader driver another delivery was needed.

(c) Other delays were not common and were usually unimportant. Delays in log supply from the forest were beyond the control of the Ecologiser foreman, so that nothing much could be done about it except wait and use the time for repairs, maintenance refuelling, clean ups and any other minor tasks. The only thing the foreman could do was to caution the forestry office when there were not enough logs on site to last the next day or two..

(iii) Identifying key process

After several days of operation, the key process in terms of maintaining output, was identified as the actual sawing and ensuring its continuity. This affected all the other operations, the main objective being to feed the unit with the appropriate log size of required quality continuously. Time study was therefore carried on at the infeed of the Ecologiser as a base for the whole operation.

4.4.2 Time Studies

Objective

The main objective of the time study was to determine the daily maximum possible output of the sawmill and the components of the delay times.

Equipment

This was:

- (a) Stop watch. A digital display Cronus 3-T single event timing watch was used. This measured to an accuracy of 1/100 of a second for each elapsed element. The digital display made the watch very easy to read.
- (b) Booking board.
- (c) Recording sheet (Appendix P).

Method

The time was measured by the intervals between log deliveries to the infeed conveyor. The intervals between logs landing on the infeed conveyor bench were timed easily as the impact of landing was easily determined by the sound. Rejects that affected the continuous flow of log processing were recorded as reject delays. Those delays that were caused by slow processing due to defects, sawdust blockages or other mechanical problems while the motor was on were grouped as slow delays in final analysis.

Results

On two different days, two different sizes of logs being sawn were timed.

- (a) 11-14 cm small end diameter logs x 2.4 m long.

The average sawing speed for this size was 17.10 seconds i.e. 8.4 m min^{-1} . A total of 149 logs were sawn at normal speed. The number of rejects which affected the flow continuity were 62. These took an average of 5.67 seconds to land, assess and throw away. Other delays, mainly sawdust blockage, only occurred 4 times

and took an average of 25.48 seconds or 3.4% of total time when the Ecologiser was running.

On this particular day of the study, the sawblades were blunt and replacement took more than 3 hours. This was because it was difficult pulling out the hot blades which had expanded and stuck onto the shaft. The productivity for the day was, therefore, far below normal.

Normal sawing was 85.1% of the total sampled time; rejects 11.5% and other delays 3.4%. The percentage of rejects was high as the logs had not been sorted prior to sawing.

In a normal 6 hour day, the number of logs to be sawn, 11-14cm s.e.d. is supposed to be 1260 per day, or a total of 3030 lineal metres of 2.4m logs. On the first day of the time study, the number of machine hours sampled was 4 (i.e. up to lunch time). Production, assuming no delays or rejects, would have been 2020 lineal metres. The achieved production was only 358 lineal or about 18% of potential achievement.

(b) 16-18 cm small end diameter logs x 2.4 m long.

The average sawing speed for this size was 22.21 seconds. A total of 392 logs were sawn at a normal speed. The number of rejects which affected the flow was only 8 with an average reject time of 12.08 seconds. There were 30 other delays with a mean delay of 145 seconds. There were not many rejects on this particular day because of the sorting done beforehand. Other delays arose during sawing because the logs were bigger and had large hard knots.

In this case, normal sawing took 66.1% of the total sampled time, rejects 0.7% and slow delays 33.2%. The potential daily production for this size would be 972 logs processed i.e. 2334 lineal metres. Five machine hours were sampled. The total production for the day was 1012.8 lineal metres or 52% of the potential production target. Table 4.2 summarises the results for this study.

Table 4.2

Time Study Results

Size cm top	Particulars	No. of Logs	Total Time in sec.	Mean Time in 1/100 sec.	Std. Dev.	% of Total Time
11-14	infeed	149	2548	1710	450	85.1
	rejects	62	345	557	338	11.5
	slow (delays)	4	102	2548	760	3.4
	Total		2995			
			= 50 min.			
16-18	infeed	392	8706	2221	640	66.1
	rejects	8	97	1208	25977	0.7
	slow (delays)	30	4377	14589	404	33.2
	Total		13180			
			= 220 min.			

Unfortunately, because sorting was not done during most of the study it was impossible to obtain actual volumes of logs fed through the Ecologiser. Similarly, because of this, it was not possible to relate sawn timber output to log volume input and obtain a percentage recovery factor.

4.4.3 Conclusion

The major problems with the Ecologiser from the very limited observations of this study were:

(i) Machine breakdowns: These, unfortunately cannot be avoided completely, as the machine is fairly old. Breakdowns might be minimised by more servicing and better 'on-site' availability of the more commonly needed spares.

(ii) Manpower: There should always be sufficient manpower to ensure that all logs can be sorted into size classes and defective logs rejected before reaching the infeed to the Ecologiser. The latter is especially important for large dimension sawlogs. However the company had marketing problems so that more efficient production might simply end up in over production. The ideal manpower in a normal situation should have the following:

- 1 Foreman
- 2 Infeed operators
- 2 Outfeed operators
- 1 Front end loader
- 2 Sorters

In total the crew would have 8 workers on site. This would ensure smooth running of the sawmill.

(iii) Safety gear should be supplied to the crew. Most of the workers had no hard hats, gloves, ear muffs or protective goggles, despite the environment they work in which is both dusty and noisy. (see Appendix M). Furthermore, the handling of logs and sawn timber with bare hands is not very safe; gloves at least should be worn and some of the felling aids mentioned in Chapter 3, Page could be used when man handling of logs is necessary.

With minor reorganisation and adjustments, the Ecologiser could produce far more than it does at present.

CHAPTER 5

SUMMARY AND CONCLUSIONS

Chapter 1 deals with work study as one means of raising productivity of men, machines and other resources; defines what is meant by work study and how it is carried out; defines total job time and its components and also inefficiencies that can add to it, discusses its history in general terms and those factors common to all industrial operations which are most important in reducing productivity in practice and which can be overcome, at least to some extent, by the application of systematic work study techniques.

The problems of work study in the context of harvesting are introduced, pointing out for example, that standard industrial practices of work study must be modified, often very considerably, in harvesting and showing how practices such as performance rating are not relevant to the extremely variable working conditions encountered in harvesting. It cautions that work study is only one of a manager's tools for increasing productivity.

Since work study deals with people and their problems in the workplace, Chapter 2 discusses the human factors in its application. It highlights the importance of all levels of the firm being studied to accept and understand why work study should be carried out, before anything is done. The danger of having any level of management or the workforce not being clear on the need for work study is discussed and examples on what can be expected in such a situation are given. It also discusses how a work studyman should

conduct himself during his studies and the qualities he should have. It also cautions that work study cannot necessarily be used to make bad workplace relationships good. However, if systematically and tactically planned and implemented, it might. Management should therefore plan the work study not only to achieve increased productivity but also workers' objectives as well.

Though there is an increased diversity in modern harvesting techniques, chainsaw will still be widely used in developing as well as developed countries, at least for the next decade. Chapter 3 reviews the literature on productivity work studies of chainsaw operations mainly in Australian pine thinnings. Although chainsaw based operations are more labour demanding and make higher, physical demands on workers compared to those of more mechanised systems, they are recommended especially for those countries or firms where forest resources, technical know how and foreign reserves for equipment purchases are not favourable.

In most literature reviewed, time concepts have been used as a common measure of inputs into forest harvesting, for example, machine hours or man hours or both. Time study is therefore recommended as a technique for basic work study aimed at increased productivity in forest harvesting. Problems arising while carrying out time studies are also discussed in Chapter 3. For example it is impossible to design a work study which can isolate all factors affecting a cutter's productivity in the forest as this would need enormous replication and funds, which would not be justified by the returns. This makes it necessary to design a work study carefully and minimise all factors that could contribute to variations before

recommendations are made. Elemental details (e.g. Appendix Q) will depend on the technique used and precision required.

A work study on an Ecologiser milling small timber in the A.C.T. was carried out. This was more convenient than a work study on a cutting operation because of full time course work commitments during the academic year, and for the following additional reasons:

- (i) The mill foreman and other workers were interested in a study of their work.
- (ii) There were no funds available and no extra manpower was available for a study. Both would have been required for cutting studies.
- (iii) Cutting in A.C.T. forests is done by individual contractors. There are many factors that would affect cutter productivity and very extended study would be necessary to minimise variations and obtain representative data. Most of these variations (e.g. slope, ground vegetation, tree spacing, equipment used, aspect and others) do not apply in the Ecologiser study. The Ecologiser is set up in a cleared open area on flat ground for a long time.
- (iv) In Tanzania, where the author works, mobile sawmills are being introduced in order to ensure better utilisation of pine and cypress thinnings and therefore the Ecologiser study would be relevant in connection with harvesting.

The study had the following main objectives:

Gaining experience in organising and implementing work

study; gaining experience in the detailed techniques of work study and possible problems that might arise; hence isolating factors tending to reduce productivity and suggesting possible ways of overcoming them; and obtaining production and productivity data.

The study was organised in two stages. Firstly a general work study was carried out, aimed at promoting mutual interest and gaining workers' confidence and acceptance; identifying drawbacks which could be rectified without doing a detailed time study; identifying the key processes and defining the components to be time studied. The workers were cooperative and had confidence in the study; the main drawbacks were identified as machine breakdowns and periodic shortages of manpower which caused stoppages in the production flow in one way or the other. The key process in terms of maintaining continuous output was identified as the actual sawing.

The second stage of the study was a time study on the key process, which had as its main objective the determination of the daily maximum possible output of the sawmill and the components of the delay times. Two log input sizes were studied and maximum possible daily output determined. 11-14 cm s.e.d. could produce 3030 lineal metres from 2.4 m logs and 16-18 cm (s.e.d.) could produce 2334 lineal metres from 2.4 m logs. It was not possible to obtain actual log input volumes. This was mainly because sorting to size classes was done only when it was convenient. Furthermore, measurement was always done by eye and, during most of the study it was not possible to relate volume of log input to sawntimber output

and hence recovery. Most delays were related to machine breakdown and unsorted timber brought to the Ecologiser for sawing. Others were related to insufficient manpower to keep the process working constantly. The study recommended the following.

- (i) More servicing of the Ecologiser and better "on site" availability of commonly needed spares.
- (ii) Supplying sufficient manpower to make full use of machines, equipment and raw material supplied; and reducing the physical effort demanded from individual workers.
- (iii) Supplying personal safety gear to the workers.

From this study it was evident that it was possible to discover areas which cause reduced productivity without carrying out an expensive work study and that with minor reorganisation and adjustments, the Ecologiser could produce far more than it does at present.

References

- Anderson, S. (1979). Operational efficiency in Swedish forestry. Paper Presented at the 60th Annual Meeting of the Woodland Section, Canadian Pulp and Paper Association Held in Montreal, March. 6pp.
- Anon. Feric Bulletin, May 1977, Canada.
- Banks, T.G.H. (1981). Motor Manual Techniques - Productivity and Costs with Special Reference to the Felling Bench. Paper Presented to IUFRO Conference on Economics and Techniques of Thinning Plantations in Australia and New Zealand. Commonwealth Scientific Industrial Research Organisation (CSIRO), Canberra. pp. 30-35.
- Bennet, W.D., Winer, H.I. and Bartholomew, A. (1965). Measurement of Environmental Factors and Their Effect on the Productivity of Tree Length Logging With Rubber Tyred Skidders. Pulp & Pap. Res. Inst. Can. Tech. Rep. 416.
- Bills, D. (1972). First Thinning in P.radiata stands - A Comparison of Fixed and Random Length Techniques. Mt Gambier -S.A. Logging Research Report No. 7214, Forestry and Timber Bureau, Department of Primary Industry. 23 pp.
- Craker, D.L. (1965). The Application of Work Study to Logging. Logging Research Section CSIRO, Canberra. 5pp.
- Crowe, M.P., Douglas, D.G., and Tyers, G.N. (1978). Work Technique in Pine Thinning. Training Manual, Division of Forest Research, Harvesting Research Group. CSIRO, Canberra. 103 pp.
- Conway, S. (1976). Logging Practices. Principles of Timber Harvesting Systems. Miller Freeman Publications inc. 416 pp.
- Cowan, R.M. (1965). Application of Work Study to Forest Operations with Special Reference to the Problems of Fixing Piecework Felling Rates in Coniferous Plantations. Dissertation for Requirement of Diploma in Forestry, University of Oxford. 161 pp.
- Davis, G. (1978). Noise and Vibration Hazards in Chainsaw Operations.: A Review. Aust. For. Vol. 41 No. 3, pp. 153-159.
- Douglas, D.G. (1981). Motor Manual Techniques: Effects of Systematic Training. IUFRO Regional Meeting, Canberra, CSIRO, pp. 25-29.
- Eager, G.D. (1981). Skidder Thinning - An Update on Productivity and Costs. IUFRO Regional Meeting, Canberra, CSIRO. pp. 52-55.

- Entage, S.J. (1981). Harvesting of Shortwood Pulp - Oberon, N.S.W. IUFRO Regional Meeting, Canberra, CSIRO, pp. 36-39.
- FAO (1980). Chainsaws in Tropical Forests. Training Series 2. Rome, 96 pp.
- FAO, (CRES); (1982). Review on Agriculture and Development, No. 82 (vol 15, No. 3) May-June, 50 p.
- FRI (Forest Research Institute) (1977). FRI Looks at Mechanisation. 40. Sept. Rotorua, pp. 34-35.
- Gaskin, J.E. (1981). Tarawera Pilot Scheme. 'Introduction of a new Felling and Delimbing Technique' in LIRA report, Vol. 6, No. 5, 4 pp.
- Gibson, D.F. and Rodenberg, J.H. (1975). Time Study Techniques for Logging System Analysis. USDA Forest Service, General Technical Report INT-25. 32 pp.
- Groves, K.W. (1965). Safety in Logging in Australia. in Proceedings of Plantation Logging Seminar held in Canberra. Forestry and Timber Bureau, pp. 25-33.
- Groves, K.W. and Lyons, R.G. (1968). Occupational Hazards for Chainsaw Operators. Aust. For. Vol. 32, No. 4. pp. 205-210.
- Groves, K.W. (1982). Lecture Notes and Handout for MSc by Coursework. Forestry Department, Australian National University, Canberra.
- Harlaa, R. (1981). Productivity Measurement in Logging Operations. Recommendations based on international practices. CSIRO Division of Forest Research. Canberra. 29 pp.
- Harstela, P. (1982). Organising Logging Work. Seloste: Puunkorjuntyon Organisointi in Metsantutkimuslartoken Julkaisuja. Communicationes Instituti Forestalis Fenniae 96 Helsinki, pp. 1-21.
- Henderson, E.L. (1974). The Training Requirements of the Logging Industry. CSIRO Project Report 73/3. Canberra. 19pp.
- Henderson, M., and Fibiger, W. (1981). Physiological Inputs in Motor Manual Techniques of Thinning. in IUFRO Regional Meeting, Canberra, CSIRO. pp. 19-24.
- Husqvarna, (Undated). - Work Technique For Limbing. 10 13 371-26. Sweden, pp. 12.
- Information from Husqvarna AB 10 13 370-26.

- ILO (1976). Man at Work. Studies on the Application of Physiology to Working Conditions in a Subtropical Country. (by Christensen E.H.). Geneva. Second impression. 40pp.
- ILO (1977). Introduction to Work Study. Revised edition, 5th Impression, Geneva, 436 pp.
- ILO (1977/2). Protection of Workers Against Noise and Vibration in the Working Environment. Geneva, 74 pp.
- ILO (1979). Guide to Safety and Health in Forestry Work. 4th Impression. Geneva, 223 pp.
- Industrial Engineering Manual (IEM) (1961). Standard Procedures, Department of Supply, Australia.
- Johnson, A.J., Hillstrom, W.A., Miyata, S.E., and Shetron, S.G. (1980). Strip Selection Method of Mechanised Thinning in Northern Hardwood Pole Size Stands. in Northern Logger and Timber Processor. May, pp. 26-27.
- Johnston, P.C. (1968). Logging Damage and the Resulting Defect in Pinus radiata D. Don. in the Australian Capital Territory. Honours thesis, Australian National University, Canberra, 81 pp.
- Joint Tanzania-Nordic REview Mission and Seminar (1981). Report In the Forestry Sector of Tanzania. Dar-es-Salaam.
- Jonsered and Norfor. (Undated). A New Device for Safer and Lighter Felling Work. in Nordfeller, Jonsered AB, Chainsaw Division, Sweden.
- Kerruish, C.M. (1976). Thinning Techniques Applicable to Pinus Radiata Plantations. New Zealand Journal of Forestry Science, Vol. 6, No. 2, p. 200-213.
- Kerruish, C.M., McCormack, R.J., Henderson, M.E. and G.A. Moore, (1981). Thinning Systems for Radiata Pine - A Review of Research. in Biennial Report, CSIRO Division of Forest Research, 1979-81, pp. 9-13.
- Kluender, D. (1979). Lightweight Power Saws for Delimbing. American Pulpwood Association. 80-P-13. Technical Papers.
- LIRA Report, (1978)/1. Delimbing: Mill Acceptance Standards. Vol. 3, No. 2, 4 pp.
- LIRA Report, (1978)/2. Reducing Delimbing Costs. Vol. 3, No. 3, 4 pp.
- LIRA Report, (1979). Logging's Labour Force: Pilot Study. Vol. 4, No. 6, 4 pp.

- Logger (1980). Logging into the '80s. Australian Forest Industries Journal, Logging Engineering and Research News (5) Edited by Harvesting Research Group, CSIRO, January p. 35-37.
- Logger (1983). Potential for Increase in Industrial Accidents. February/March. pp. 18.
- McCormack, R.J., Brett, D., and Melmoth, A. (1979). Productivity Measurement Workshop 28-29 November. Record of Proceedings, CSIRO, Canberra. 65 pp.
- McGregor, D. (1959). The Human Side of Enterprise, in 'Readings in Human Relations', McGraw-Hill, pp. 49-59.
- McWhirter, J.H. (1968). The Relationship Between Forestry and The Labour Resource in Economic Development. Special Subject, Final Honours, School of Forestry, Oxford. (Microfilm).
- Milling, S. (1981). Training and Development Needs of Forest Workers in the '80s. Pulp and Paper, Canada. Vol. 82, No. 4, April. pp. 73-76.
- Miyata, E.S., Helmuth, M.S., and Winsauer, S.A. (1981). Using Work Sampling to Analyse Logging Operations. U.S. Department of Agriculture, Research paper NC-213, 8 pp.
- Mobbs, I.D. (1973). Statistical Analysis. in 'Work Study in Forestry'. Forestry Commission Bulletin No. 47, 40-48 (Ed. Wittering, W.O.).
- Ronan, N.M. (1974). Veneer Recovery From Radiata Pine in the ACT. BSc Thesis. Australian National University, Canberra, 180 pp.
- Samset, I., Stromnes, R. and Vic, T. (1969). Cutting Studies in Norwegian Spruce and Pine Forests. Norwegian For. Res. Inst., Vollebekk, Norway, 607 pp.
- Schabas, W. (1979). Is Man the Weak Link' in Mechanisation of the Woods? Woodlands, paper Vol. 80, No. 5, Canada, pp. 35.
- Scott, A.H. (1973). Work Measurement: Observed Time to Standard Time in Work Study in Forestry. Forest Commission Bulletin No. 47, London. pp. 26-39.
- Shaw, S.N. (1981). Production and Productivity of Cutters in First Thinnings of Pinus radiata D. Don at Tumut, N.S.W. IUFRO Regional Meeting, Canberra, CSIRO, pp. 40-51.
- Shaw, S.N. (1982). Work Studies of Cutting in Scheduled First Thinning in Pinus radiata Plantations at Tumut, N.S.W. Masters Thesis, Australian National University, 92 pp.

- Taylor, R.W. (1978). Harvesting Productivity in Coniferous First Thinning. South African Forestry Journal, No. 105., pp. 33-34.
- Vari, S. (1981). The Relative Productivity and Costs of Thinning and Clearfelling. IUFRO Regional Meeting, Canberra, CSIRO, pp. 56-60.
- Warren, J.B. (1980). Viewpoints of the Woods Worker: A Shortage of Manpower or Motivation? in American Logger, Nov., pp. 12-15.
- Whiteley, D. (1968). Measurement of Productivity in Logging Operations. Proceedings of the Logging Research Conference. July. Forestry & Timber Bureau, Canberra, pp. 47-55.
- Whiteley, D. (1970). Tables of Average Worker Productivity for Felling and Preparing Logs. Pinus radiata in New South Wales and the ACT. Forestry and Timber Bureau, Softwood Logging Report, No. 70/1, 62 pp.
- Whiteley, D. (1971). Tables of Average Worker Productivity for Felling and Preparing Sawlogs and Pulpwood of Pinus radiata in South Australia. Forestry and Timber Bureau, Softwood Logging Report, 71/1, 10 pp.
- Whiteley, D. (1971). A Study of the Effect of Terrain Slope on the Productivity of Two Workers Felling and Preparing Tree Length Logs During Delayed First Thinning Operation in Pinus radiata Plantations. Forestry and Timber Bureau, Softwood Logging Report 71/2, 19 pp.
- Whiteley, D. (1972). A Comparison of the Productivity of Felling, Preparing and Stacking Four-Foot and Random-Length Pulpwood Billets During First Thinning Operations. Forestry and Timber Bureau, Logging Research Report, No. 72/2, 6 pp.
- Whiteley, D. (1973). Work Studies of Cutting in Radiata Pine. Masters Thesis, Australian National University, Canberra, 141 pp.
- Wittering, O.W. (1980). Piecework Abandoned. Forestry and British Timber, April, pp. 33-34.
- Wittering, O.W. (1973). Method Study: Researching and Examining the Facts in Work Study in Forestry. Forest Commission Bulletin, No. 47, London (edited by Wittering, O.), pp. 12-25.
- Wittering, O.W. (1973)(2). Costing and Other Money Matters in Work Study in Forestry. Forest Commission Bulletin No. 47. London (edited Wittering O.W.), pp. 55-58.

APPENDIX A

WORK STUDY AND TECHNICAL TERMS

Basic Time	The instant at which one element in a work cycle ends and another begins.
Break Point	The instant at which one element in a work cycle ends and another begins.
Check Time	The time intervals between the start of a time study and the start of the first element observed, and between the finish of the last element observed and the finish of the study.
Cycle Time	The total time taken to complete the elements constituting the work cycle.
Elapsed Time	The total time from the start to the finish of a time study.
Element	A distinct part of a specified job selected for convenience of observation, measurement and analysis.

Constant Element.

An element for which the basic time remains constant whenever it is performed.

Foreign Element.

An element observed during a study which, after analysis, is not found to be a necessary part of the job.

Governing Element.

An element occupying a longer time than that of any other element which is being performed concurrently.

Machine Element.

An element automatically performed by a power-driven machine (or process).

Manual Element.

An element performed by a worker.

Occasional Element.

An element which does not occur in every work cycle of the job, but which may occur at regular or irregular intervals.

Repetitive Element.

An element which occurs in every work cycle of the job.

Variable Element.

An element for which the basic time varies in relation to some characteristics of the product, equipment or process, e.g. dimensions, weight, quality.

Fatigue Allowance A subdivision of the relaxation allowance intended to cater for the physiological and psychological effects of carrying out specified work under specified conditions.

Flow Process Chart A process chart setting out the sequence of the flow of a product or a procedure by recording all events under review using the appropriate process chart symbols.

Equipment Type Flow Process Chart.

A flow process chart which records how the equipment is used.

Man Type Flow Process Chart.

A flow process chart which records what the worker does.

Material Type Flow Process Chart.

A flow process chart which records what happens to material.

Idle Time That part of attendance time when the worker has work available but does not do it.

Ineffective Time That portion of the elapsed time, excluding the check time, spent on any activity which is not a specified part of a job.

Inside Work Elements which can be performed by a worker within the machine- (or process-) controlled time.

Interference Allowance An allowance of time for production unavoidably lost through synchronisation of stoppages on two or more machines. (or processes) attended by one worker. Similar circumstances arise in team work.

Interference Time The time when the machine (or process) is idle awaiting attention, while the worker attends to another machine (or process). Similar circumstances arise in team work.

Job Breakdown A listing of the content of a job by elements.

Machine Ancillary Time The time when a machine is temporarily out of productive use owing to change-overs, setting, cleaning etc.

Machine Available Time	The time which a machine could work based on attendance time - i.e. working day or week plus overtime.
Machine Capacity	The volume of output of a machine, usually expressed in physical units capable of being produced in any convenient unit of time, e.g. tons per week, pieces per hour, etc.
Machine Effective Utilisation Index	The ratio of: Machine Running Time at Standard Performance to: Machine Available Time.
Machine Efficiency Index	The ratio of: Machine Running Time at Standard Performance to: Machine Running Time.
Machine Idle Time	The time during which a machine is available for production or ancillary work but is not used owing to shortage of work, materials or workers, including the time that the plant is out of balance.
Machine Interference	The queueing of machines (or processes) for attention - e.g. when one worker is responsible for attending to more than one machine. Similar circumstances arise in team work when random delays at any point may affect the output of the team.
Machine Running Time	The time during which a machine is actually operating, i.e. the Machine Available Time less any Machine Down Time, Machine Idle Time, or Machine Ancillary Time.
Machine-Controlled Time	The time taken to complete that part of the work cycle which is determined only by technical factors peculiar to the machine.
Machine-Hour	The running of a machine or piece of plant for one hour.
Man-Hour	The labour of one man for one hour.
Method Study	The systematic recording and critical examination of existing and proposed ways of doing work, as a means of developing and applying easier and more effective methods and reducing costs.

Observed Time	The time taken to perform an element or combination of elements obtained by means of direct measurement.
Outside Work	Elements which must necessarily be performed by a worker outside the machine- (or process-) controlled time.
Personal Needs Allowance	A subdivision of the relaxation allowance intended to cater for attention to personal needs.
Plant Layout	The production of a floor plan for arranging the machinery and equipment of a plant, established or contemplated, in a way which will permit the easiest flow of materials, at the lowest cost and with the minimum of handling, in processing the product from the receipt of raw material to the dispatch of the finished products.
Productivity	The ratio of output to input.
Qualified Worker	One who is accepted as having the necessary physical attributes, who possesses the required intelligence and education, and has acquired the necessary skill and knowledge to carry out the work in hand to satisfactory standards of safety, quantity and quality.
Rating	(i) The assessment of the worker's rate of working relative to the observer's concept of the rate corresponding to standard pace. (ii) The numerical value or symbol used to denote the rate of working. (a) Loose rating: an inaccurate rating which is too high (b) Tight rating: an inaccurate rating which is too low. (c) Inconsistent ratings: a mixture of loose, tight and accurate ratings. (d) Flat ratings: a set of ratings in which the observer has underestimated the variations in the worker's rate of working. (e) Steep ratings: a set of ratings in which the observer has overestimated the variations in the worker's rate of working.

Relaxation Allowance	An addition to the basic time intended to provide the worker with the opportunity to recover from the physiological and psychological effects of carrying out specified work under specified conditions and to allow attention to personal needs. The amount of the allowance will depend on the nature of the job.
Standard Performance	The rate of output which qualified workers will naturally achieve without over-exertion as an average over the working day or shift provided they know and adhere to the specified method and provided they are motivated to apply themselves to their work. This performance is denoted as 100 on the standard rating and performance scales.
Standard Time	The total time in which a job should be completed at standard performance, i.e. work content, contingency allowance for delay, unoccupied time and interference allowance, where applicable.
Synthetic Data	Tables and formulae derived from the analysis of accumulated work measurement data, arranged in a form suitable for building up standard times, machine process times, etc., by synthesis.
Time Study	A work measurement technique for recording the times and rates of working for the elements of a specified job carried out under specified conditions, and for analysing the data so as to obtain the time necessary for carrying out the job at a defined level of performance.
Timing	The practice of observing and recording, by the use of a watch or other device, the time taken to complete each element. Three alternative methods of timing with a stopwatch are:

Cumulative Timing

A method in which the hands of the stopwatch are allowed to continue to move without returning them to zero at the end of each element, the time for each element being obtained subsequently by subtraction.

Differential Timing

A method for obtaining the time of one or more small elements. Elements are timed in groups, first including

and then excluding each small element, the time for each element being obtained subsequently by subtraction.

Flyback Timing

A method in which the hands of the stopwatch are returned to zero at the end of each element and are allowed to restart immediately, the time for the element being obtained directly.

Work Content	Basic time + relaxation allowance + any other allowance for additional work - e.g. that part of contingency allowance which represents work.
Work Cycle	The sequence of elements which are required to perform a job or yield a unit of production. The sequence may sometimes include occasional elements.
Work Measurement	The application of techniques designed to establish the time for a qualified worker to carry out a specified job at a defined level of performance.
Work Study	A generic term for those techniques, particularly Method Study and Work Measurement, which are used in the examination of human work in all its contexts, and which lead systematically to the investigation of all the factors which affect the efficiency and economy of the situation being reviewed, in order to effect improvement.
Workplace Layout	A convenient term used to describe the space and the arrangement of facilities and conditions provided for a worker in the performance of a specified job.

APPENDIX B

FACTORS TENDING TO INCREASE WORK CONTENT AND INEFFECTIVE TIME HENCE REDUCING PRODUCTIVITY. (In brackets are some possible Management techniques to reduce work content and ineffective time).

- A. Work added by defects in design or specification of the product
 - 1. Bad design of product prevents use of most economic processes.
(Product development and value analysis)
 - 2. Lack of standardisation prevents use of high production processes.
(Specialisation and standardisation)
 - 3. Incorrect quality standards cause unnecessary work.
(Market, consumer and product research)
 - 4. Design demands removal of excessive material.
(Product development and value analysis)

- B. Work added by inefficient methods of manufacture or operation.
 - 1. Wrong machine used.
(Process or activity planning)
 - 2. Process not operated correctly or in bad conditions.
(Process planning and research)
 - 3. Wrong tools used.
(Process planning and method study)
 - 4. Workplace layout causing wasted movement.
(Method study)
 - 5. Operator's bad working methods.
(Method study and operator training.)

- C. Ineffective time due to shortcomings of management
 - 1. Excessive product variety adds idle time due to short runs.
(Marketing and specialisation)
 - 2. Lack of standardisation adds idle time due to short runs.
(Standardisation)
 - 3. Design changes add ineffective time due to stoppages and rework.
(Product development)
 - 4. Bad planning of work and orders increases idle time for men and machines.
(Production control based on work-measurement)
 - 5. Lack of raw materials due to bad planning increases idle time for men and machines.
(Material control)
 - 6. Plant breakdowns increase idle time for men and machines.
(Maintenance)
 - 7. Plant in bad condition increases ineffective time due to scrap and rework.
(Maintenance)

8. Bad working conditions add ineffective time through forcing workers to rest.
(Improved working conditions)
 9. Accidents add ineffective time through stoppages and absence.
(Safety measures)
- D. Ineffective time within the control of the worker
1. Absence, lateness and idleness add ineffective time.
(Sound personnel policy and incentives)
 2. Careless workmanship adds ineffective time due to scrap and rework.
(Personnel policy and training)
 3. Accidents add ineffective time through stoppages and absence.
(Safety training)

Source: ILO 1977

APPENDIX C

Examples of energy requirements in different forest operations.

Physical difficulty of work.	Operation
Very high	. climbing trees . carrying loads uphill . pulling winch cable . spraying with portable power-operated machines
High	. tree-felling and cross-cutting with hand-powered saws . axe work . breaking up loam soil with spade . scything of weeds
Moderate	. tractor driving . crane operation . manual planting of trees
Low	. manual weeding in nurseries . maintenance of tools and equipment

Source: ILO 1979

APPENDIX D
CHARACTERISTICS OF THE SUBJECTS

Variable	Unit	ACT study			Comparison of two techniques		
		N = 6 (traditional)		Range	N = 3 (bench)		Range
		x	SD		x	SD	
Age	Years	32.5	4.6	27-41	36.7	10.6	27-48
Weight	kg	78.1	7.4	68-90.5	89.7	12.4	74-99
Height	cm	178.5	6.3	171-187	182.7	4.2	178-186
Months of Experience as faller	month	23.3	24.3	4-60	141.3	149.1	4-300
Physiological parameters at rest							
Heart rate	beats/min	60	5.5	54-68	70.7	9.2	60-76
Minute volume	litres	8.9	2.3	5.4-10.6	7.9	1.2	6.8-9.2
Oxygen intake	ml	312	79	200-400	240	20	220-260
Energy output	kJ/min	6.34	1.61	4.06-8.12	4.87	0.41	4.41-5.28
Maximal aerobic capacity	litres	3	0.83	2.81-4.96	3.43	0.55	2.80-3.80
VO ₂ max							
Jenkins Activity Survey							
Number of Type A	-	1	-	-	1	-	-
Number of Type B	-	5	-	-	2	-	-

Source: Henderson et al 1981.

APPENDIX E

THE PHYSICAL EFFORT STANDARDS

Lehmann (kJ nett) Level of effort	Energy Output per 8 hrs work	British Medical Soc. (kJ nett) Level of Effort	/hour
Light	Up to 2093	Very light	0 - 293
Moderate	> 2093 - 4187	Light	> 293 - 419
Moderately heavy	> 4187 - 6280	Moderate	> 419 - 837
Heavy	> 6280 - 8374	Heavy	> 837 - 1256
Very heavy	> 8374 - 10647	Very heavy	> 1256
Extremely heavy	>10467		

Source: Henderson et al. 1981.

APPENDIX F

Some hints on manpower and organisation intensity for work study (previous experiences).

(a) Samset et al (1969) hired 13 forest technicians who were trained to carry out detailed time studies for one winter and one summer. 24 cutters were hired, 16 of whom were selected by cooperating agencies, two of whom were selected as 'standard' cutters, the latter based on experience of this previous work.

(b) Whiteley

1967	3 cutters were hired
1970	41 cutters
1971	2 non-professional cutters

Source: Shaw 1982

(c) Shaw (1982)

Mandays	Thinning No.	Trees Studied	Cutters	Place
6	3rd	377	3	Oberon
20	1st	1129	11	Oberon
10	2nd	655	6	Oberon
55	1st	3978	13	Tumut
40	1st delayed	2100	12	Tumut
131*		8239	33	

Source: Shaw 1982

* Total would exceed 131 mandays as 2 cutters could be timed in a day.

APPENDIX G

Calendar Time Breakdown

1. Calendar time: All available time in a specified period eg.
 1 week = 7 x 24 hrs
 = 168 hrs.
2. Total working time: Time required directly or indirectly to complete a certain job.
3. Unused time: 1 - 2 above.
4. Moving time: Time to move machines equipment and/or workers from one work place to another.
5. Changeover time: Time taken to repair machines and equipment or the condition of the workplace before or after a specified job.
6. Work place time: Time spent directly in doing a job at a work place. A job usually consists of several work elements.
7. Total repair time: Repair and maintenance which is not a normal routine procedure or the workplace. This may be sub-divided into times within normal working time and the outside normal working time.
8. Interruption time: Time during total working time when no work is actually carried out because of climate conditions, industrial disputes, accidents etc.
9. Travelling time: Routine daily travel of man and machine to and from the work place.
10. Meal times: These are self explanatory.
11. Productive time (effective time):
 - (a) Main time: This is that time spent on each tree or log which directly changes the position or condition of the log or tree.
 - (b) By time: This is that time which changes the position or condition of the workplace eg. working from top end to the butt end of a felled trimmed and crosscut tree.
12. Non-productive time (delay time): These are those interruptions to work place time or previously accounted for. These could be:

(a) Unavoidable delays:

These are those interruptions due to the nature of the work which might reasonably be expected. eg. lodged trees (hangups) during felling. These could be personal or operational; personal being those caused by individuals while operational could be such as those arising from organisation, lost delay times, repair and maintenance within work place time.

(b) Avoidable delays:

These are unnecessary delays during the work. Most of these would be attributed to lack of proper training or operators' negligence.

APPENDIX H

Deciding the Elements.

General rules as listed in ILO 1977.

(a) Elements should be easily identifiable with definite beginnings and endings so that once established they can be repeatedly recognised. These beginnings and endings can often be recognised by a sound or a change of direction of hand or arm. They are known as the 'breakpoints' and should be clearly described on the study sheet. A break point is thus the instant at which one element in a work cycle ends and another begins.

(b) Elements should be as short as can be conveniently timed by a trained observer. Opinion differs on the smallest practical unit that can be timed with a digital stopwatch, but it is generally considered to be about 0.04 min (2.4 sec). For less highly trained observers it may be 0.07 to 0.10 mins. Very short elements should, if possible, be next to longer elements for accurate timing and recording. Long manual elements should be rated about every 0.33 min (20 sec).

(c) As far as possible, elements - particularly manual ones - should be chosen so that they represent naturally unified and recognisably distinct segments of the operation.

(d) Manual elements should be separated from machine elements. Machine times with automatic feeds or fixed speeds can be calculated and used as a check on the stopwatch data. Hand time is normally completely within the control of the operator. This separation is specially important if standard times are being compiled.

(e) Constant elements should be separated from variable elements.

(f) Elements which do not occur in every cycle eg. occasional and foreign elements should be timed separately from those that do.

APPENDIX I

Some job breakdowns in some referred studies
in cutting radiata pine.

(a) Whiteley D. 1972(2)

Operation	Elements
Fell	Collect tools Walk to tree Inspect Saw Trim butt
Trim	Collect tools Walk to tree Trim Throw slash
Measure	Collect tools Walk to tree Measure billets
Dock	Collect tools Walk to billet Dock billet
Stack	Walk to billet Carry billet Trim billet
Clear track	
Unavoidable delays	Saw jams while felling Pull down hangers Saw jams while docking Others Maintain tools

Rest

Total productive time.

(b) Whiteley 1973

Sub-operation	Element
Felling	Collect tools Walk to tree

	Clear debris from base of tree
	Inspect and prepare to fell
	Saw
	Remove splinters from butt of felled tree
	Delays
Trimming	Collect tools
	Walk to tree
	Trim branches
	Delays
Measuring	Collect tools
	Walk to tree
	Measure billet lengths
	Delays
Docking	Collect tools
	Walk to log
	Crosscut
	Delays
Stacking	Collect tools
	Walk to billets
	Pick up billet, carry to stack and put down
	Trim branch stubs left on billet
	Delays
Miscellaneous	Clear slash from outrow
	Cut and clear hardwood debris on outrow
	Chainsaw maintenance
	Rest and meal breaks.

(c) Shaw 1982

i. Productive time

Element	Prepare and inspect
	Fell
	Trim (delimb)
	Measure
	Clear slash
	Stack
	Return trim
	Clear slash from stack

ii Non-productive time

Sharpen chain
 Saw maintenance
 Refuel
 Move hardwood
 Talk to supervisor
 Rain, hail, snow
 Sawjam felling

Sawjam crosscutting
Hangup
Walk to and from vehicle
Drink
Meal
Injury
Smoke
Personal
Talk to studyman
Talk to workmates
Move gear and stuff.

APPENDIX J

Delay times

Sharpen chain. Self explanatory (s.e.)

Saw maintenance (s.e.)

Refuel: (s.e.)

Move hardwood: Includes all time spent to move any hardwood hindering any other element.

Cutting hardwood: This is cutting hardwood ready to be moved, or for extraction convenience.

Excessive wind velocity: Time spent waiting for dangerously high winds to ease.

Rain, hail, snow: Time spent in a shelter during rain, hail or snow interruptions.

Saw jam-felling: Time spent removing saw from jam.

Saw jam-crosscutting: Time spent removing saw from jam.

Hangup: Time spent trying to pull down a tree which has been hang up.

Walk to and from vehicle (s.e.)

Drink: (s.e.)

Meal: (s.e.) and may include rest.

Injury: May include time to remove saw dust from eye, first aid to cuts and removal of splinters.

Smoke: May include rest.

Personal: (s.e.)

Talk to studyman: May include rest.

Talk to workmates: May include short time spent helping workmates with hangups, saw maintenance etc.

Move gear: Time spent moving equipment, stuff and belongings which are on the fellers way for safety.

Start saw: Time spent beyond the time when the chainsaw engine starts or would be expected to start easily.

APPENDIX K

Some common chainsaw models used in Australia.

Year	Make-Model	Wt (kg)	cc.	loaded chain speed (m.per min.)
1963	Canadian 270	12.5	95	
1967	Homelite XL2	7.3	58	800
	Partner R-14	7.9	76	930
	Stihl 040	7.0	61	840
1974	Jonsereds 621	6.9	56	1190
	McCulloch SP60	7.3	62	800
	Partner R17	6.8	55	1200
	Stihl 031	6.6	48	1080
	041	7.5	61	960
1981	Jonsereds 70	7.9	69	1200
	Husqvarna 162SE		6.9	61.5
	444SE		5.8	44
	Stihl 938	7.6	61	1170
*1983	Stihl 024	5.6	42	

Source: Emtage 1981.

* To be released in market, a sample sent to A.N.U. Forestry Department (January 1983).

APPENDIX L (a)
Choice of Husqvarna Saws for Stump Operations
Recommendation

Element	Saw Model					
	65	77	140	163-263	280-380	1100
Felling:						
Stump Diameters cm.						
Less than 30	B	C	A	B	C	D
30-70	A	A	C	A	A	B
70-120	C	A	D	B	A	A
120-170	D	D	D	D	D	A
Cross-cutting						
Diameters cm						
Less than 30	B	B	A	B	B	D
30-60	A	A	C	A	A	B
60-110	C	A	D	B	A	A
110-135	D	D	D	D	D	A
Limbing						
Small trees	A	B	A	A	B	D
Large trees	A	A	A	A	A	A

Source: Husqvarna

A = Very suitable
B = Suitable
C = Fairly suitable
D = Not suitable

APPENDIX L (b)

Technical data and capacity.

Model	65	77	140 S	163 S	263 CD	280 S	380 CD	1100 CD	165 R
Displacement, cc	65	77	40	53	63	77	77	99	65
cu.in	4.0	4.7	2.5	3.8	3.8	4.7	4.7	6.0	4.0
Engine speed at max. power	7.500	8.000	9.000	8.500	8.500	8.000	8.500	8.000	8.000
Weight, empty with standard guide bar and chain	7.1 kg 15.6 lbs	7.2 kg 15.8 lbs	5.8 kg 11.8 lbs	7.6 kg 16.7 lbs	7.8 kg 17.1 lbs	8.5 kg 18.7 lbs	8.5 kg 18.7 lbs	9.9 kg 21.8 lbs	10.6 kg 23.4 lbs
Guide bar length ¹⁾ standard	15" S	18" S	13" S	15" S	15" S	18" S	18" S	21" S	
Guide bar length, max.	20" RT	24" RT	15" RT	20" RT	20" RT	24" RT	24" RT	34" RT	
Guide bar length, min.	13"	13"	13"	13"	13"	13"	13"	18" H	
Max. tree diameter, felling	127 cm 50"	152 cm 60"	84 cm 33"	127 cm 50"	127 cm 50"	152 cm 60"	152 cm 60"	216 cm 85"	
Max. tree diameter, cross-cutting	102 cm 40"	122 cm 48"	66 cm 26"	102 cm 40"	102 cm 40"	122 cm 48"	122 cm 48"	173 cm 68"	
Chain pitch, minimum	3/8"	3/8"	3/8"	3/8"	3/8"	3/8"	3/8"	404"	
Chain pitch, maximum	404"	404"	325"	404"	404"	404"	404"	404"	
Fuel tank capacity	0.7 Pint US 1.5	0.7 Pint US 1.5	0.5 Pint US 1.05	0.85 Pint US 1.8	0.85 Pint US 1.8	0.85 Pint US 1.8	0.85 Pint US 1.8	1.0 Pint US 2.1	1.0 Pint US 2.1
Oil tank capacity	0.4 Pint US 0.84	0.4 Pint US 0.84	0.25 Pint US 0.53	0.5 Pint US 1.05	0.5 Pint US 1.05	0.5 Pint US 1.05	0.5 Pint US 1.05	0.7 Pint US 1.5	
Oil pump capacity cm ³ /min	8	9	5		adjustable 9 or 18 cm ³ /min				15-27

¹⁾ S = solid nose RT = sprocket nose

APPENDIX M

THE USER AND HIS EQUIPMENT

A chain saw is a demanding tool and should not be used by children and young people.

Anyone using a chain saw should be fully aware of the hazards involved, partly with the saw itself and partly with the work that is done with it. Furthermore, they should know how to avoid these hazards.

Personal equipment should provide satisfactory protection. For this reason a chain saw user should wear:

- 1/ A SAFETY HELMET FOR ALL TYPES OF FELLING
- 2/ EAR PROTECTORS
- 3/ EYE PROTECTION — GOGGLES OR VISOR



- 4/ TROUSERS WITH INTEGRAL OR REMOVABLE LEG GUARDS

SUITABLE GLOVES AND BOOTS OR SHOES SHOULD ALSO BE WORN.

Source: Husqvana/6

APPENDIX N

WORKER PRODUCTIVITY IN FELLING AND PREPARING
SECOND AND LATER THINNINGS OR CLEAR
FELLINGS (CU FT PER HOUR)

Mean dbh in	Volume Removed per Acre cu ft.					
	1000	1500	2000	2500	10000	100000
8	34	34	34	35		
9	42	42	42	43		
10	51	51	52	52	53	53
11	62	63	64	64	65	65
12	76	78	79	80	82	82
13	96	99	100	101	105	105
14	124	129	132	134	139	140

Source: Whiteley 1971.

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S34
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APPENDIX Q

(i) Recording Sheet - Time Study

F.S. 9

TIME STUDY - T OPERATION

[illegible]