LOGGING INDUSTRY RESEARCH ORGANISATION

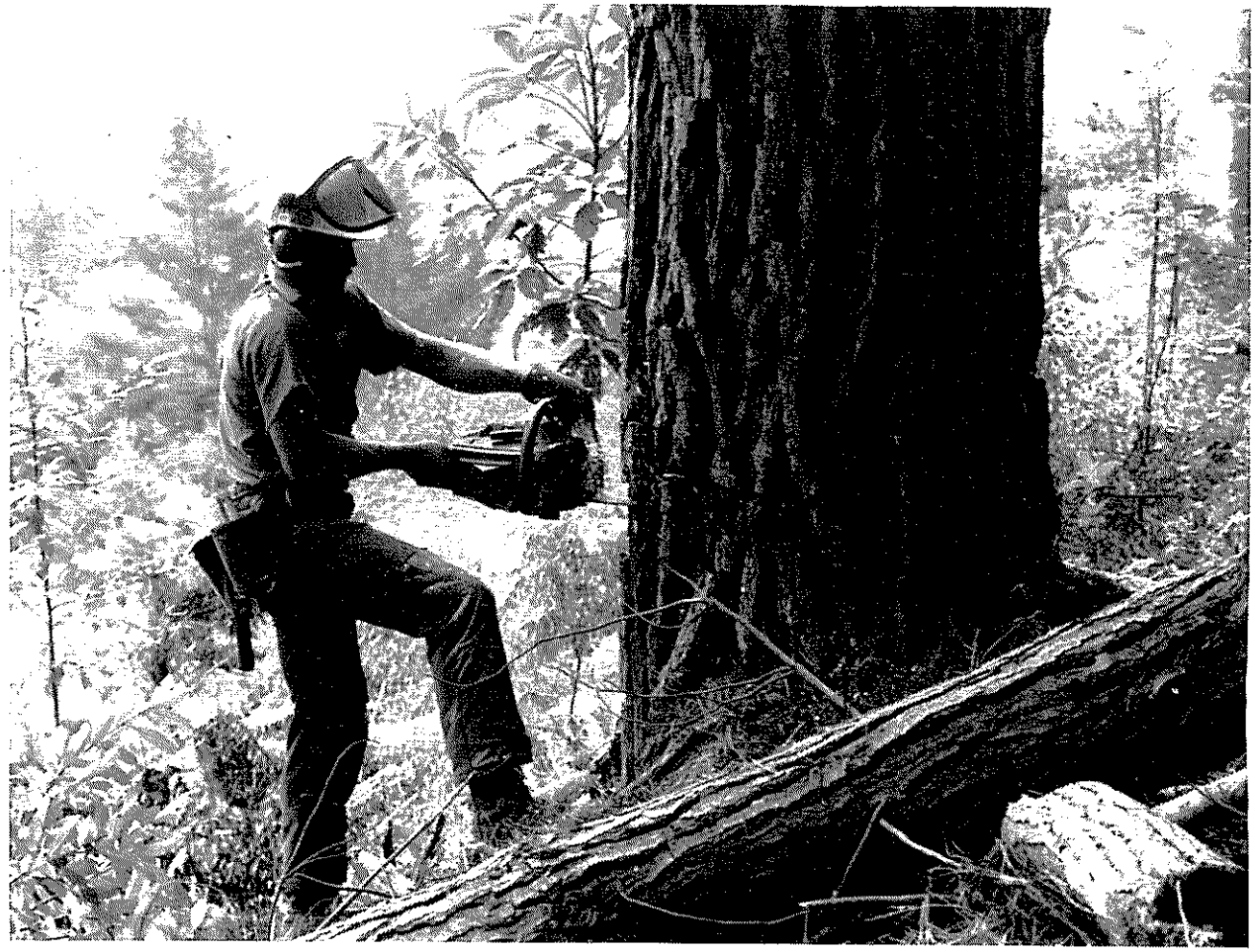
NEW ZEALAND

PROJECT REPORT

1992 STIHL RESEARCH GRANT

An Investigation of Techniques to Reduce Chainsaw Injuries to the Hand

PATRICK KIRK



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P.R. 52

New Zealand Logging Industry
Research Organisation
Box 147
Rotorua
NEW ZEALAND

1992 STIHL RESEARCH GRANT

An Investigation of Techniques to Reduce Chainsaw Injuries to the Hand

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ACKNOWLEDGEMENTS

I wish to express my thanks and gratitude to Andreas Stihl Limited for awarding me the 1992 inaugural Stihl research grant which helped finance this study tour.

I would also like to thank LIRO's Board and Director for their support and assistance.

This study tour was not only of great benefit personally, but will be of invaluable assistance in the future development of LIRO's Human Factors research field.

SUMMARY OF FINDINGS AND RECOMMENDATIONS

Key Findings

* In Europe, Scandinavia and North America, the climatic conditions have resulted in vibration white finger (VWF) being the predominant concern regarding chainsaw related hand injury.

* The high degree of mechanisation currently employed in these countries significantly reduces the chances of finding forms of overseas developed hand protection that is applicable for New Zealand.

* The leather chainsaw mitt commonly used by many operators in New Zealand does have tangible benefits in terms of durability, lack of heat retention and increased level of saw control. The key features should drive any future developments concerning chainsaw operator hand protection in New Zealand.

* A major factor influencing the frequency and severity of chainsaw operator hand injuries is in fact the actual work method often employed by New Zealand fallers and skid workers, namely delimbing while standing on top of the stem.

Recommendations

* A combination of chainbrake **and** leather mitt should be compulsory for New Zealand chainsaw operators and not simply two of the three current choices.

* The minimum requirement for a chainsaw should be a chainbrake. They should be **compulsory** on all chainsaws used by operators within the forest industry, and not simply an option, as is currently the situation.

* Any future developments regarding chainsaw operator hand protection must consider information gained from local loggers, contractors and companies.

* Any such development should be based along the same design principles as the leather mitt, these being durable, cost effective and offering low heat retaining properties.

* The New Zealand forest industry should make every effort to isolate the chainsaw operator from the chainsaw. One of the most effective methods for achieving this goal is through the advancement of mechanised harvesting systems, as has occurred in most of the countries visited.

OBJECTIVES OF TOUR

The primary objective was to examine forms of chainsaw operator hand protection used in different countries and ascertain their applicability for the New Zealand forest industry.

An additional objective was to obtain relevant information beneficial to LIRO's Human Factors research field.

The tour concentrated on contacting appropriate research, manufacturing, training and legislative organisations.

INTRODUCTION

As a result of receiving the 1992 Stihl Research Grant a six week study tour was undertaken in Scotland, Germany, Sweden, Finland, USA and Canada.

A diverse assortment of contacts were made as a result of this study tour. These ranged from contractors through to research organisations, manufacturers and product developers.

Several overriding differences became apparent from the outset of the tour. These consisted primarily of New Zealand's warm temperate climate, large diameter fast growing plantation trees and the dependence of the forest industry labour force on motor-manual methods. These features combine to make New Zealand's forest industry a relatively unique one in terms of the type of harvesting systems utilised, and consequently, injuries received by the workforce.

This report is presented to the Board of Andreas Stihl Ltd to fulfil the acceptance requirements of the grant.

The Benchmark: New Zealand.

The Forest Resource:

New Zealand's total land area is 27.0 million hectares, of which plantation forestry accounts for 1.3 million hectares, or 5%. The North Island contains 72% of the plantation forestry with 35% of this being located in the central North Island alone. The main tree species within the plantation forest structure is Radiata Pine, accounting for 89.4% of the plantation area. The average growth rate for the plantation forests is 20.3 m^3/ha/yr. Total production for 1991 is estimated at 14.15 million cubic metres of which 65.3% was exported, primarily to Australia, Japan, Korea and Taiwan (NZFOA, 1992).

Harvesting Operations:

Motor-manual harvesting systems account for 95% of the total volume of timber harvested in New Zealand. A further 3% is harvested by manual/mechanical combinations, and fully mechanised systems account for the remaining 2% (Raymond & Lyon, 1993). A typical New Zealand clearfell ground based harvesting operation would comprise two or three manual fallers, one log maker, two skid workers, one extraction machine and one log loader.

The Faller:

The fallers would typically operate chainsaws in the 88 to 92 cc range weighing approximately 7.3 to 7.7 kg with bar lengths of 46 to 50 cm. They would be expected to fall and delimb on average a minimum of 60 trees per day.

Figure 1 - New Zealand faller wearing full safety equipment

The standard method of delimbing is carried out by the faller walking along on top of the log then leaning forward to cut off the branches. While not being advocated as an ergonomically sound delimbing method due to the high spinal loadings (Gaskin, 1990) this method is prevalent throughout the forest industry. One main reason given is that the dense undergrowth associated with New Zealand plantation forests makes delimbing while standing next to the stem physically more difficult and less productive.

Figure 2 - Common New Zealand logger delimbing posture

Each faller must by law wear chainsaw protective legwear, steel capped boots, a safety helmet and ear protectors. The saw must be equipped with either a chainbrake or a rigid-type hand guard or a safety mitt.

The Logmaker and Skid Workers:

Once the logs have been extracted from the cutover to the landing, they are then processed at the landing into several different quality grades depending on stem defects and current market requirements. The logmaker's task is to fulfil as many market requirements as possible from each stem without compromising the overall value recovered from the stem. The end result is that products required to satisfy several different markets can be obtained from one stem.

The role of the skid workers is to remove any branches that the fallers may have been unable to remove, as well as cut the stem into logs at the points marked by the logmaker. Skid workers tend to use chainsaws in the 94 to 122 cc range weighing between 7.7 and 8.8 kg with bars ranging in length from 50 to 55 cm. They are required to wear the same protective equipment as fallers. This also applies to logmakers if they use a chainsaw as part of their normal working procedure.

Primary Extraction Machine:

For a ground based system the extraction machine would be a rubber tyred skidder of the 100 - 130 kW range or a tracked skidder of the 75 - 90 kW range. For cable skidders the driver of the machine usually attaches the logs to the cables, locally called "breaking-out".

Figure 3 - Caterpillar 528 Rubber Tyred Skidder

Figure 4 - Caterpillar D4H Tracked Custom Skidder

Log Loader:

Log loaders perform the dual task of sorting and fleeting processed timber on the landings, in addition to loading logging trucks. They are usually a rubber tyred front end loader of approximately 125kW capacity or a hydraulic knuckle boom loader, with or without a live heel.

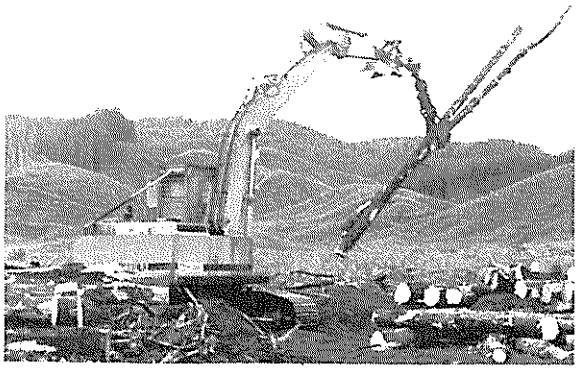

Figure 5 - Caterpillar PC300 Hydraulic Knuckleboom Loader

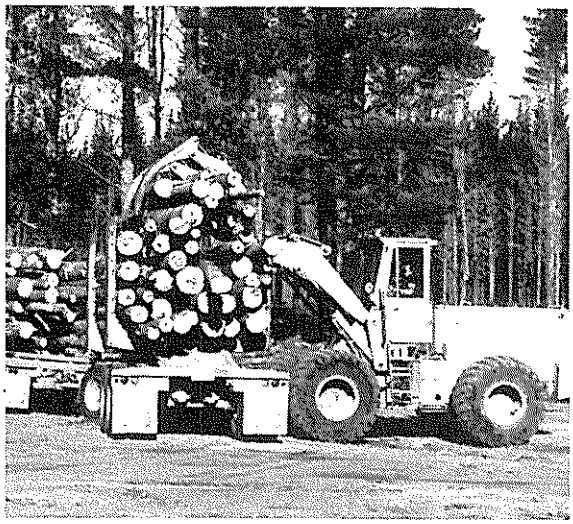

Figure 6 - Caterpillar 520B Rubber Tyred Loader.

A relatively more recent change to work methods has been the inclusion of a machine solely dedicated to the fleeting process, such as a Bell Ultra Logger. This machine sorts and stacks the timber on the landings and a separate contract loader then loads out the timber once the crew has moved to an alternative landing.

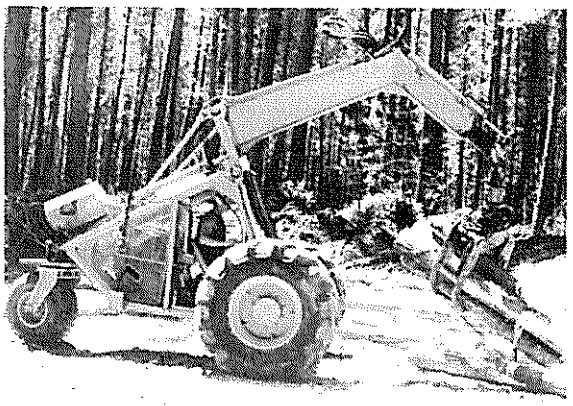

Figure 7 - Bell Logger

Contract Structure:

The prime contractor usually owns the extraction and sorting machines and employs the men. The chainsaws used on the job are usually supplied by the men who are paid a daily allowance for the running, maintenance and eventual replacement of the chainsaws. Most chainsaws are traded in after 10 to 12 months depending on the level of servicing and maintenance undertaken.

Loader operators are more commonly independent contractors that sub-contract to the primary contractor or be a cold deck loader servicing multiple crews. One loader contractor could, for example, sub-contract his services to three primary contractors and load out their timber alternatively.

Principal Differences:

New Zealand logging differs in many ways to the situations experienced by the central

Europeans, Scandinavians and North Americans.

Climate:

New Zealand's climate is temperate in nature, compared to those countries visited. New Zealand's summers are warm (26 + °C) and humid (80 - 90 % relative humidity) with the winters being moist and cool (0 °C to +12 °C). In comparison, the countries visited tended to experience moderately hot, dry summers and cold, dry winters where snowfalls are common and temperatures can reach -30 °C in some cases. The exception to this being the southeastern region of the USA.

Forest Resource:

The Pinus radiata plantation forestry system currently operating within New Zealand's forestry sector produces a final crop tree in approximately 30 years with an average diameter of 60 cm and a volume of 1.5 to 3 cubic metres. Such trees also tend to have sparse but heavy branching characteristics. This feature, when combined with the flexible nature of the Pinus radiata branches, makes high quality mechanised harvesting and processing difficult.

In contrast, the countries visited experienced a much longer timber rotation period, ranging from 70 to 150 years. Final crop trees achieved diameters of around 30 to 40 cm and volumes ranging from 0.4 to 1.5 cubic metres. Branching characteristics tended to be smaller in diameter and of a more brittle nature. Such tree characteristics therefore encourage the use of mechanised harvesting systems. The notable exceptions to this being the Pacific North West region of the U.S.A and British Columbia, Canada. These two regions tend to have larger tree sizes and more difficult terrain and accordingly have a higher percentage of motor-manual harvesting systems.

Wages and Insurance:

The high accident compensation and insurance rates experienced within the forestry sectors of the visited countries further encouraged the development of mechanisation. Combined with this was the requirement to have to pay steadily increasing wage levels in order to attract and retain skilled workers within the forestry sector. The primary reasons given for this were that forestry work entails hard physical work, often in isolated and somewhat hostile locations, and a relatively high incidence of injury.

To date this is not the case in New Zealand, although the changes which have recently been made to the *Accident Rehabilitation and Compensation Insurance Act* dramatically change the accident insurance structure currently operating within New Zealand.

Predominant Injuries:

Accident rates within New Zealand's forest industry are relatively high when compared to other industries. This point is stressed in that the fatality rate among New Zealand loggers is 28 times higher than that of the average New Zealand worker.

For the period 1988 to 1991 the New Zealand forest industry employed on average 2456 people in the timber harvesting sector. For this same period, the average number of accidents (fatal, lost time and minor) was 274/year resulting in an average of 2818 lost days/year. On average, 70% of these accidents occur in clearfell harvesting operations.

Due to the predominance of the motor-manual harvesting system within the New Zealand forest industry, chainsaw related injuries account for a relatively high proportion of the total injuries sustained by the workforce. Accident statistics for the 1991 year reveal that chainsaw related injuries accounted for 27% of lower leg, 68% of hand, 62% feet and 58% of the upper leg injuries.

Hand Injuries:

A fundamental difference between New Zealand and the countries visited was that the most common type of chainsaw related hand injury was not lacerations, but rather vibration induced white finger (VWF). Vibration white finger is a form of Raynaud's phenomenon which is commonly associated with the operation of vibrating tools. Cold climates exacerbate the symptom as the body conserves heat by reducing blood flow to the extremities, especially the hands and feet. Prolonged exposure to chainsaw vibration, combined with cold temperatures, may aggravate VWF causing a loss of manual dexterity and reduction in tactile sensitivity. This may get to the point where there is limited ability to control hand-held objects (e.g. chainsaw) and perform manual work.

This posed a perplexing problem as it meant that the countries visited on the tour were by and large investigating ways of developing forms of hand protection whose primary aim was heat retention. Due to New Zealand's climatic conditions, the exact reverse, that is heat dispersion, is required for any form of hand protection to be utilised here in New Zealand. All of these situations made achieving the initial goal of the tour very difficult. There were few situations, if any, that were comparable to those encountered by most New Zealand chainsaw operating forest workers.

SCOTLAND

Organisations Visited:

Forestry Authority Headquarters
Safety Division,
Edinburgh

Local Contractors

Forest Resource & Harvesting System:

The primary harvesting system in use in the United Kingdom is mechanical, which accounts for approximately 90% of the total volume harvested. Processing has also been fully mechanised and a strong Scandinavian influence can be seen in both the machinery and operational systems used.

Predominant tree species is currently Sitka Spruce with a rotation of approximately 50 - 60 years with clearfell tree volumes of 0.5 - 1.0 m^3

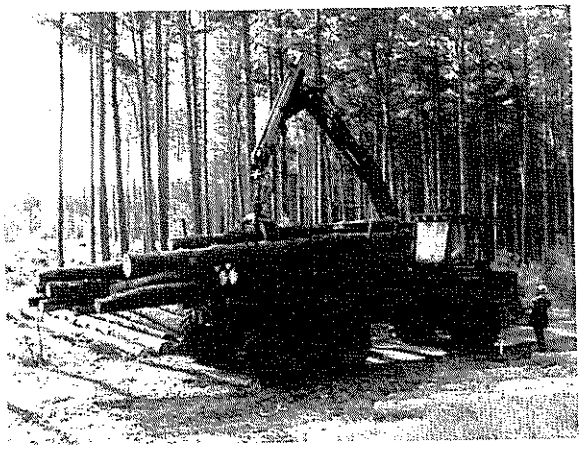

Figure 8 - Scottish forwarder extraction system, Edinburgh.

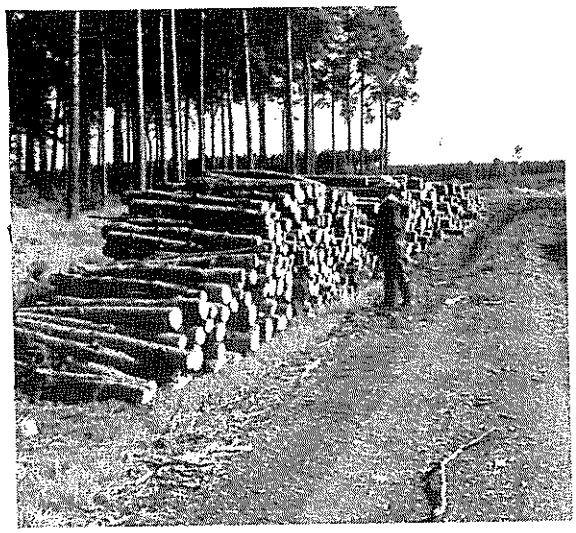

Figure 9 - Scottish shortwood roadside log storage, Edinburgh.

Findings:

The main concern for chainsaw operators regarding hand injuries was vibration white finger (VWF) due to the cold climatic conditions experienced during winter. In an attempt to diminish the incidence of VWF, the Forest Authority has made the wearing of gloves compulsory for its own forestry crews.

There appeared to be two main types of protective glove being worn by the forestry workers visited. These were an adaptation of the Swedish "Husqvarna" style, and a thick leather style developed by the Forestry Commission.

The adapted Swedish style was constructed from a durable nylon type material with a leather palm covering for added traction. The back of the left hand had a protective insert of ballistic nylon as a protection measure against kickback injuries.

The thick leather style was basically constructed from a heavy grade leather, along the same lines as construction worker's gloves. They contained no cut protection insert on the back of the left

hand.

Comments from the chainsaw operators who wore them were by and large not too complimentary, especially those regarding the leather style gloves.

The main areas of criticism were:

(1) A loss of dexterity due to the ill fitting nature of the gloves as a consequence of there being only a limited size range to choose from.

(2) Reduced feeling of control over the chainsaw as hand sensitivity was severely reduced by wearing the gloves.

(3) Heat retention in warm weather leading to heavy sweating of the hands and consequently, the development of associated skin irritation problems such as dermatitis.

(4) The gloves had little or no water repellent ability in the rain so rapidly became waterlogged. Working in cold conditions with wet gloves made the VWF scenario more likely as the gloves actually cooled down the hands further.

When asked if the workers would wear the gloves if they did not have to, a large proportion of them said no. This in itself demonstrated that further development of the glove's design was required. The points raised by the workers answered many of the concerns regarding the applicability of such forms of hand protection for New Zealand production forestry chainsaw operators.

Recommendation:

Neither style of hand protection seen could be effectively applied to New Zealand's situation.

GERMANY

Organisation Visited:

Andreas Stihl Limited
Research & Development Section
Waiblingen

Apart from being the benefactors of the study grant, Andreas Stihl Ltd are one of the worlds leading chainsaw manufacturers and developers. The purpose of this visit was to examine the research and development aspect of the safety division within the parent company.

It was noticeable that considerable research is going into all aspects of chainsaw design and development so as to increase operator safety and comfort. With particular regard to chainsaw hand protection, Andreas Stihl Limited are not only targeting the area of garment design but also attempting to improve matters at the source of the injury itself, that is, the chainsaw.

Due to commercial sensitivity, a large proportion of events witnessed cannot be revealed in this report. Needless to say though, the area of chainsaw operator safety is not being overlooked in the slightest way by the manufacturers.

SWEDEN

Organisations Visited:

**Husqvarna Forest & Garden Ltd,
Huskvarna.**

**Engtex Ltd,
Mullsjo.**

**Nordic Forestry Equipment Ltd,
Falun.**

**Swedish University of Agricultural Sciences,
College of Forestry,
Garpenberg.**

**Swedish National Board of Occupational Safety & Health,
Solna.**

**The Forestry Research Institute of Sweden (Skog Forsk),
Kista.**

**Local mechanised / motor manual contractors
Garpenberg.**

Forest Resource & Harvesting Systems:

Sweden's forest industry has a major impact on the Swedish infrastructure since 57% of the 41 million hectare land area is covered in forest. Accordingly, forestry is of major importance to the Swedish economy and accounts for 19% of the total value of exports. Approximately 50% of Sweden's forest production is exported as sawn timber, pulp, paper and paperboard.

The two predominant tree species are Norway Spruce (46%) and Scots Pine (37%) , with assorted hardwoods making up the remainder. The national average annual increment for the forest is 4.2 m^3/ha/yr with an annual total production of 70 million cubic metres. Stand rotation on average varies between 70 and 140 years and trees at final crop stage have diameters of 20 - 40 cm with volumes of approximately 1 - 1.5 m^3.

The principal logging system used in Sweden is the shortwood system, accounting for 94% of the total harvest. Mechanisation plays a major role in this form of harvesting system. Motor-manual systems have steadily decreased since 1982 to the point where by 1992 only 10% of total final felling is undertaken by the motor-manual system.

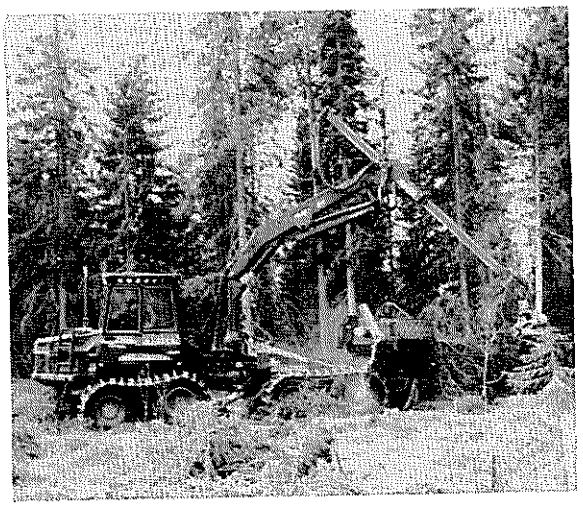

Figure 10 - OSA 707/280 Two grip harvester

Chainsaw Operators

The standard chainsaw being used by the few remaining motor-manual operators is in the 40cc range with a 33 cm bar. Safety gloves, helmet, ear and eye protection and chainsaw leg protection are all worn.

Figure 11 - Swedish Faller in full protective equipment felling residual seed trees near Garpenburg

Findings:

Due to the significant reduction in motor-manual harvesting and processing systems, the requirement for further development of chainsaw operator hand protection has been reduced. Health problems associated with mechanised systems such as whole body vibration now spearhead the Human Factors research within the Swedish forestry sector.

In Sweden, as with Scotland, vibration white finger (VWF) was the main health concern regarding chainsaw operators, particularly during the winter season. As a consequence, hand protection development has concentrated on the fully enclosed glove/mitt style which gives both heat retention and the option of cut protection.

The gloves that provide cut protection only do so for the rear of the left hand, as past experience has shown that it is this area that receives the majority of injuries during kickback situations. The gloves are made from soft leather with a water resistant nylon upper and come in a variety of sizes so the operators are able to get reasonably good fitting garments. Operators estimate that on average the gloves have an effective lifespan of around one month and cost approximately NZ$15.00.

Figure 12 - Swedish Chainsaw Operator Protective Gloves.

The customary use during the colder winter months of chainsaws fitted with heated handles removes many of the problems associated with the gloves getting wet. Operators stated that once the gloves became wet the heated handles of the chainsaws provided enough warmth during use to partially dry the gloves. Other operators tended to use two or three pairs of gloves and rotated them during the day as they became wet.

In warm weather, operators stated that the gloves did retain a large amount of heat and this caused the hands to sweat heavily. This however appeared not to be of great concern as in most cases the motor-manual chainsaw operators tended to work in the smaller family or community owned forests. Such forests are usually harvested during winter when farm work is not able to be carried out.

Chainsaw manufacturers such as Husqvarna Forest & Garden are, like their

German counterparts Andreas Stihl Limited, focusing a great deal of time and effort on improving the safety of the chainsaw. Particular importance is placed on the areas of reducing vibration and the incidence of kickback.

A good example of this was seen with the evolution of an additional chainbrake located on the rear handle of the chainsaw. Commonly known as the " V Guard ", it is activated manually by the rear hand when the saw climbs up a vertical object during the situation known as gradual "kickback". In such situations the upward velocity of the chainsaw may be too slow to initiate the inertia chainbrake that is standard issue on most modern chainsaws today.

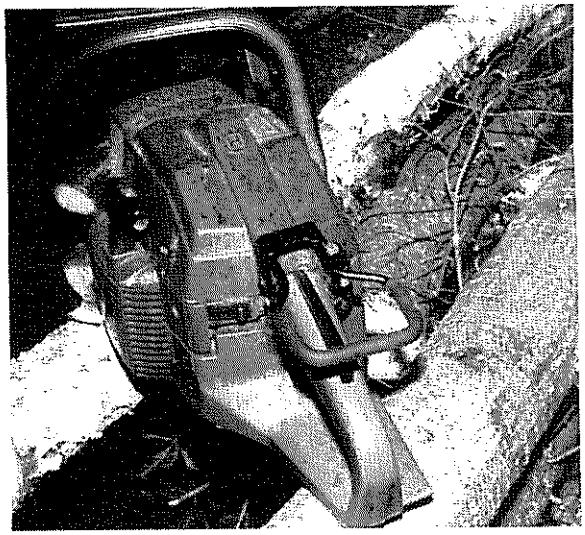

Figure 13 - Rear Handle Hand Activated Chainbrake.

The acceptance by Swedish chainsaw operators of the "V Guard" device appears to be favourable, once an initial familiarisation period has elapsed.

Recommendations:

The Swedish design of the chainsaw operator hand protection glove in its present form is not applicable to the general New Zealand chainsaw operator. The heat retaining aspects of the glove in warm climatic conditions would result in a low level of acceptance by the workers, and possibly cause additional health problems associated with skin irritations.

In situations here in New Zealand where operators are working in cold climatic conditions that require the use of insulating gloves, then this style of glove which incorporates the cut protection would be appropriate.

Most importantly, current and future chainbrake advancements should be fully utilised by New Zealand's chainsaw operators.

FINLAND

Organisations Visited:

The Finnish Forest Research Institute, Helsinki.

Kuopio Regional Institute of Occupational Health, Agriculture and Forestry Office, Kuopio.

Local Contractors Helsinki

Forest Resource & Harvesting Systems:

Of Finland's total 30.4 million ha land area, 20.1 million ha (66%) is covered in

forest containing primarily three species; Scots Pine (45%), Norway Spruce (37%) and Birch (15%). Private citizens own 63% of the forest area and produce three quarters of the timber. Over 50% of these owners combine forestry with farming and average woodlot size is 35 ha.

Annual production is approximately 44 million m^3, of which 80% is utilised by the forest industries, 10% used as fuel /farm wood or exported and a further 10% being left as logging residue. Crop rotation ranges between 70 to 120 years depending on location, with the Northern regions experiencing the slower growth rates. Final crop tree size is between 0.2 and 0.7 m^3 with recoverable timber having butt diameters as small as 10cm.

Mechanisation within the Finnish forestry sector has substantially increased within the last two years to the point where it is now the predominant form of timber harvesting in Finland. In 1990, motor-manual systems accounted for 50% of final harvesting volumes. Today this has been reduced to around 5 - 10%. The main reasons given for this rapid decrease was the increasing cost of labour, both in terms of wages and insurances, and the ability to substantially increase production using machinery. By operating a double shift system of two 10 hour shifts (including maintenance and service breaks), production could be increased from $40m^3$/hour to $70m^3$/hour. The main configuration currently in use is a two machine system employing a harvester/processor and a forwarder.

Motor-manual chainsaw operators are by law required to wear a helmet, hearing protection and steel toed work boots. Most however, do wear some form of leg and hand protection. Like their Swedish counterparts, the chainsaws used by the operators are in the 40cc range with a 33 cm bar.

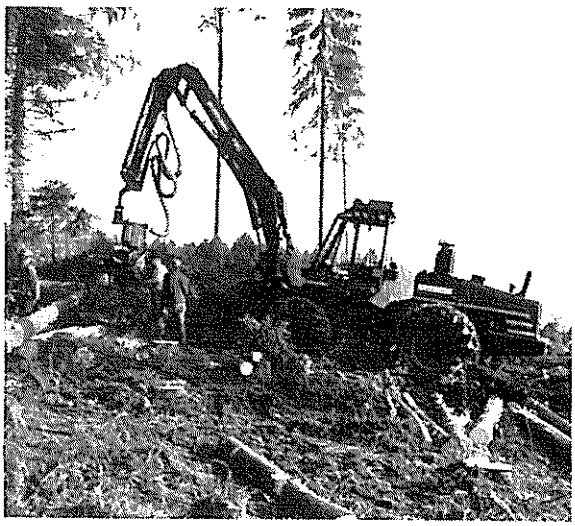

Figure 14 - Finnish FMG single grip harvester, Helsinki.

Figure 15 - Finnish FMG Forwarder extraction to roadside, Helsinki .

The type of hand protection seen tended to be along the same lines as the Swedish design. The primary function was heat retention due to the cold climatic conditions that some operators have to work in. As with the Swedish situation, a large proportion of the forest owners are also farmers. Therefore forestry work tends to be carried out during the winter months when the ground freezes. This situation makes farming impossible but timber harvesting and extraction

favourable.

Noticeable features of the type of glove/mitt hand protection seen was the lack of cut protection to the back of the left hand, and the cumbersome nature of the mitt.

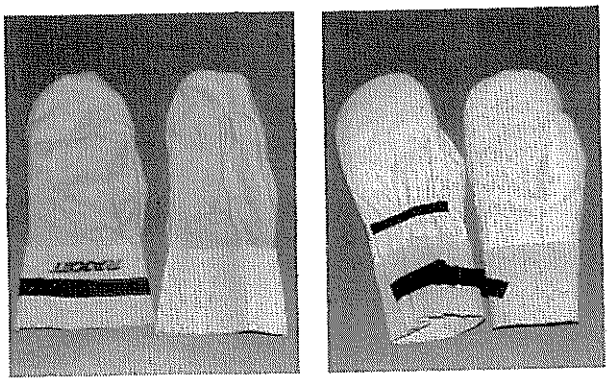

Figure 16 - Two examples of Finnish Chainsaw Operator Hand Protection

Discussions with local contractors who used these forms of hand protection stated that the gloves/mitts:

1) caused their hands to sweat heavily, even in cold climatic conditions.

2) frequently became wet and were difficult to dry, so several pairs were required during the day.

3) caused a noticeable loss of dexterity due to the thickness of the glove/mitt.

4) had only a short effective lifespan of between two to four weeks.

Findings:

Most manual saw operators could see room for improvement with the glove/mitt design. However, with the rapid phasing out of the motor-manual harvesting system, I feel that such development work may be preceded by further mechanised based Human Factors research.

Recommendation:

The current style of Finnish chainsaw operator hand protection could not be effectively applied to the New Zealand production forestry situation.

CANADA

Organisations visited:

Workers Compensation Board (WCB) of British Columbia.
Occupational Safety & Health Division,
Vancouver,
B.C.

Forest Engineering Research Institute of Canada (FERIC).
Eastern and Western Divisions.

Forest Products Accident Prevention Association (FPAPA),
North Bay,
Ontario.

Henry Fiset & Sons Ltd,
Elk Lake,
Ontario.

Homelite-Terry Textron Canada Ltd,
Montreal,
Quebec.

Institut de recherche en sante et en securite du travail du Quebec (IRSST), Montreal, Quebec.

Grant Lumber Company, Elk Lake, Ontario.

Harvesting Methods:

Due to Canada's size and the limited time available, only a relatively small facet of the country's forestry operations in Quebec, Ontario and British Columbia were visited during the tour.

The logging operations consisted of fully mechanised and manual-mechanised harvesting systems. The manual component of the latter system was chainsaw felling for skidder extraction and mechanical processing, either stroke delimbing or in-field chipping.

The typical tree size seen was relatively small (30 cm) and slow growing (approx 70 - 100 years). As a consequence, most manual felling was carried out with 40 to 54 cc chainsaws using 36 to 44 cm bars. Due to the mechanical processing, no delimbing was carried out by the fallers.

The type of hand protection worn varied considerably between workers and tended to be targeted at the prevention of VWF rather than cut protection. In several cases, no hand protection was worn at all as its use is not mandatory.

The type most commonly worn appeared to be of similar design to the Husqvarna style. This incorporated a nylon back on a padded glove with a leather palm. In most cases there was no cut protection inserted into the back of the left hand.

Figure 17 - Manual Faller Wearing Glove Protection, Elk Lake Ontario.

The operators that wore the gloves felt that as there was no requirement for delimbing, the reduced sensitivity caused by wearing the gloves had no major impact on their work method or level of control over the chainsaw. The operators felt that the protection offered by the chainsaw chainbrake was adequate for their requirements as long as they were well maintained.

This aspect was also reinforced when visiting a local chainsaw manufacturer Homelite-Terry Textron. This manufacturer has developed an in-field chainbrake testing device.

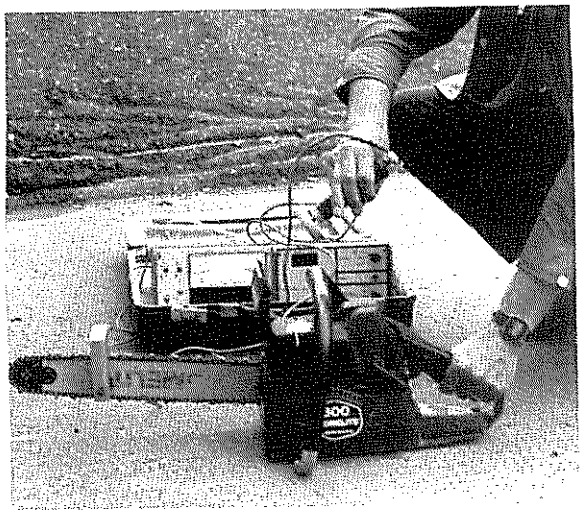

Figure 18 - HOMELITE-TERRY Portable Chainbrake Testing Device.

The aim of this development was to have a method of reliably testing operator's chainbrakes in the field quickly and effectively.

However, due to the relatively small tree size, the predominant harvesting method for the eastern Canada region was the fully mechanised system.

The mechanised systems usually incorporated a harvester which felled trees for whole tree skidder extraction to the roadside where they were processed either by a stroke delimber or whole-tree chipped.

The harvesting systems used in western Canada appeared to be very similar to those adopted by the Pacific North West region of the United States. This is due to their similarities of steeper terrain and large tree sizes. Chainsaws of 70 - 90 cc with 91 cm bars tend to be used and motor-manual systems are employed for the felling, delimbing and logmaking phases.

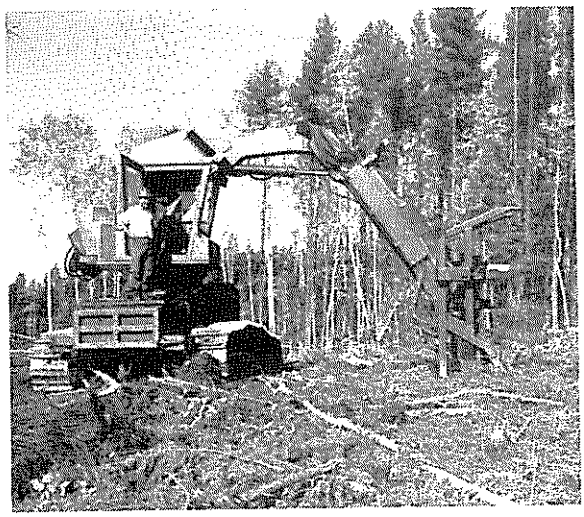

Figure 19 - Timbco 2520 Harvester, Elk Lake, Ontario.

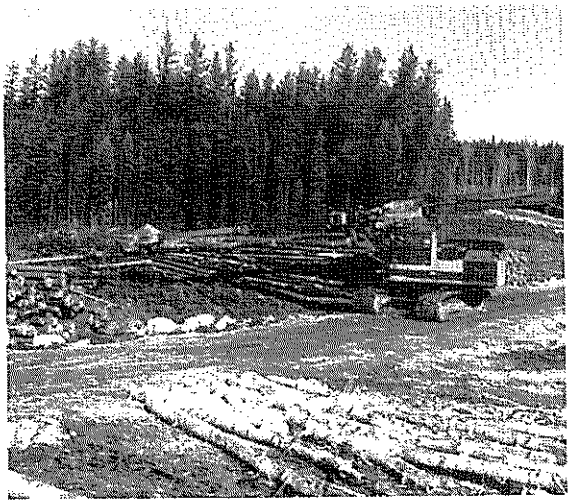

Figure 20 - Denis Stroke Delimber , Elk Lake, Ontario.

Hand protection also varied between operators from the type previously seen in Eastern Canada to a thin cotton type glove with a flexible rubber coating on the palm. This glove offers no cut protection at all due to its slim design and construction. The idea is to give a good grip and general overall protection against cuts and scratches received from the undergrowth and/or the rigging gear of the extraction machines.

Findings:

Discussions with FERIC, FPAPA, WCB and the IRRST revealed that the large-scale and fragmented nature of the Canadian forest industry made the development and implementation of protective equipment difficult. In eastern Canada, the high degree of mechanised harvesting and the crop characteristics meant that hand protection received minimal investigation compared to other safety features such as leg protection, whole body vibration and the like.

Similarly with western Canada, the situation there prescribed the adoption of the Pacific North West (PNW) harvesting methods.

Recommendation

Neither form of hand protection would be of use or benefit to the New Zealand chainsaw operator. The Eastern Canadian design would be of little protective value, nor would the PNW design, since neither contain cut resistant materials. The heat retention aspect of the Eastern Canadian style glove would also discourage its use in New Zealand.

UNITED STATES OF AMERICA

Organisations Visited:

United States Department of Agriculture,
Forest Service,
Southern Forest Experiment Station,
Auburn, Alabama.

Auburn University,
Auburn,
Alabama.
- **School of Forestry.**
- **Agricultural Engineering Department.**
- **Industrial Engineering Department.**

Oregon State University, College of Forestry, Corvallis, Oregon.

Oregon Occupational Safety & Health Agency,
Salem,
Oregon.
- **Insurance & Finance Department**
- **Information Management Division.**

Local Contractors.

Forest Resource & Harvesting Methods:

Forests in the U.S.A cover an area of nearly 300,000,000 ha, over 8 regions. Private ownership accounts for 78% of this forested area. Annual production is approximately 464 million m^3 with annual sales of more than US$195 billion. The forest industry employs approximately 1.3 million people and ranks among the top ten employers in 45 of the total 50 states.

Due to time constraints two regions were visited, the Southeast and the PNW. These two regions account for 45% of America's total annual harvest volume.

Findings:

The Southeastern region appeared to be heavily mechanised with the usual operation consisting of a harvester or feller buncher, skidder and delimber.

Figure 21 - 511E Hydro-Ax harvester with a 50cm rotary saw felling head operating near Auburn, Alabama.

The occasional combination manual / mechanised operation is used for felling and/or delimbing trees prior to skidder extraction.

Depending on the contract boss, the level of protective equipment used by the crews visited varied from none at all, to the bare minimum of protective legwear and safety helmets. No form of hand protection was seen at all in any of the operations. The very high humidity and temperature would make the wearing of such devices difficult to implement and/or enforce without strong legislative backing.

The Pacific North West (PNW) region on the other hand contained significantly more motor-manual crews, due primarily to the relatively large tree size and difficult terrain. Two noticeable features of the loggers in this region became apparent from the onset. These were the fact that they all wore spiked (caulked) boots and operated 70 -90 cc chainsaws with 91 cm bars. Of all the regions visited during this study tour, the PNW region loggers were the only ones who delimbed while standing on the log, as do their New Zealand (NZ) counterparts.

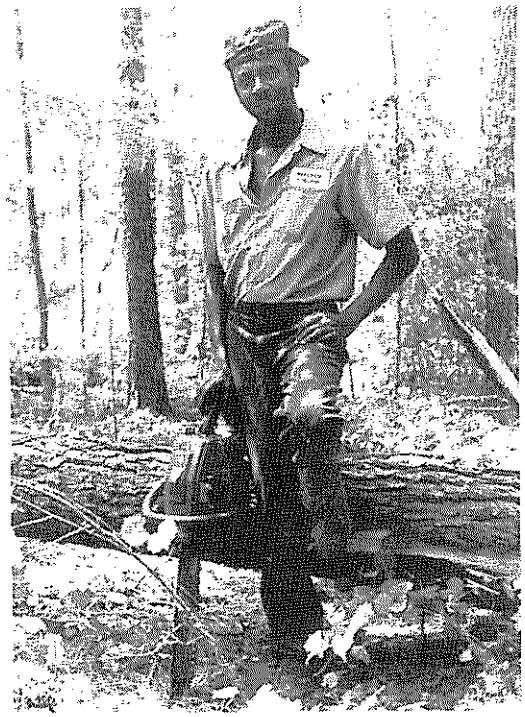

Figure 22 - Southeastern manual faller Auburn, Alabama.

The most noticeable difference between the PNW and NZ techniques, however, was the fact that the PNW loggers did not have to bend over as far as the NZ loggers due to their significantly longer bars. When asked about the significance of using such long chainsaw bars the loggers stated "that the use of long bars meant that they could remove all the branches from the stem without unnecessarily bending their backs or placing themselves off balance while delimbing ".

However, it should be noted that the significant increase in weight being carried (90 cm bar vs 60 cm bar), has a detrimental impact on the body's spinal loadings (O'Leary, 1988).

The alleged increased safety of this upright stance was then further enhanced by the

wearing of spiked boots which increase traction and stability.

The form of hand protection observed consisted of cotton gloves, with some designs incorporating a rubber latex material on the palm region. The function of the glove was to assist hand grip and protect against small cuts and scratches from the surrounding undergrowth etc.

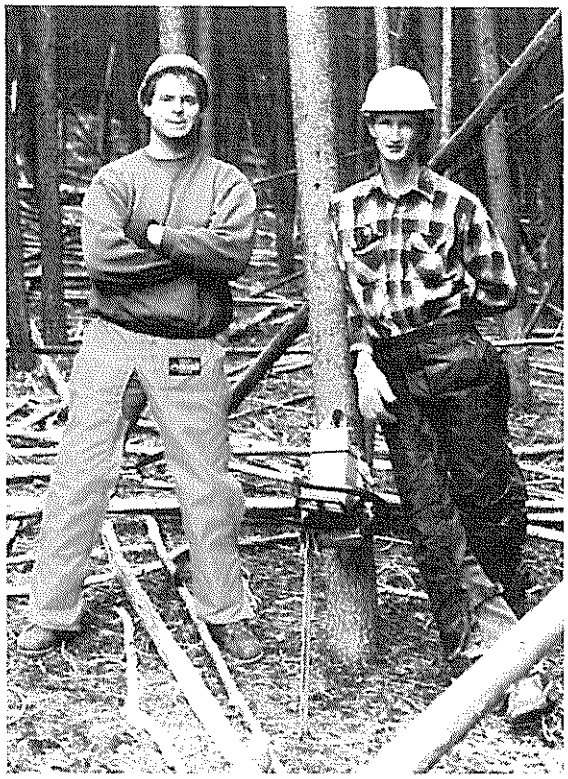

Figure 23 - American manual fallers wearing rubber coated gloves.

The gloves contain no form of cut protection and are made from light-weight breathable cotton. They appear to provide no problems with heat retention during summer, while at the same time providing adequate warmth during the cooler winter period. Though only having a relatively short lifespan of 3 to 4 weeks, the cheap unit price ($US 3 - 4), means that this feature presents no major problems for the loggers.

Recommendation:

While apparently satisfying the requirements of the local loggers, I feel that since the glove contains no cut protection material, this glove would be of little practical use to loggers here in New Zealand.

SUMMARY OF FINDINGS

In Europe, Scandinavia and North America, the climatic conditions have resulted in vibration white finger (VWF) being the predominant concern regarding chainsaw related hand injury. As a consequence, the development of hand protection devices has centred on gloves and mitts whose primary function is heat retention. Chainsaw lacerations are mitigated to a degree by the inclusion of cut resistant material to the back of the left hand of several of the mitts and gloves.

The high degree of mechanisation currently employed overseas further reduces the chances of finding an applicable form of overseas-developed hand protection for New Zealand. As more and more workers are removed from the chainsaw and placed into a protective cab, the requirement for further development of chainsaw operator hand protection decreases. In situations where manual chainsaw operators account for less than 10% of the total timber harvested, the continued development of chainsaw hand protection devices ranks relatively low.

Therefore, since a relatively large amount of heavy manual work is carried out by New Zealand forestry chainsaw operators using powerful heavy chainsaws in hot humid conditions, the use of many of the overseas garments do not have application within New Zealand's production forestry environment. In colder climate situations in southern New Zealand where VWF may be of concern, then some of the European and Scandinavian mitt and glove designs could be acceptable and are currently available here in New Zealand.

The leather mitt currently used by many operators in New Zealand, does have tangible benefits. By having the operators left hand secured to the top handle of the chainsaw, during a kickback situation the operator still retains some degree of control over the chainsaw. While this degree of control may be small, it can in some cases be enough to deflect the momentum of the saw away from the operator. Additionally, the mitt prevents the left hand from slipping off the top handle and into the rotating/stationary chain during a kickback situation. This is backed up by the fact that the overseas glove and mitt designs only have cut resistant material the back of the left hand. Past experience has shown that it is this area that sustains most injuries during kickback situations.

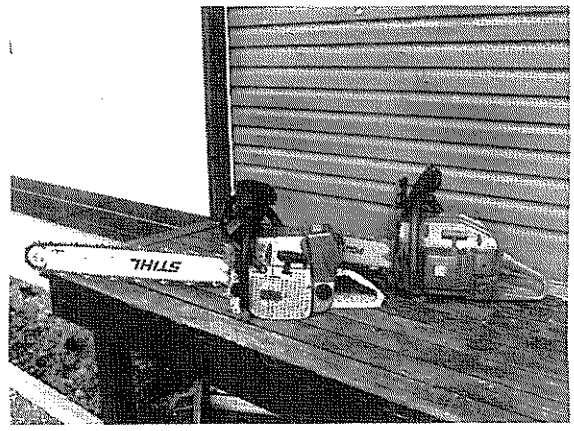

Figure 24 - Typical New Zealand logger's chainsaws with leather mitt attachment. (Stihl 066 & Husqvarna 288 with 55cm bar)

The open design of the leather mitt enables effective heat dissipation which is an essential factor in operator comfort and product acceptance. The relatively high degree of durability, ease of use and low cost of the mitt are also features which make its use attractive to the operators. Any future alternative type of hand protection device that may emerge must also exhibit these features if it is to be successfully introduced into the New Zealand forestry sector.

One major factor that influences the frequency and severity of chainsaw operator hand injuries is in fact the actual work method often employed by New Zealand chainsaw operators, primarily fallers and skid workers. While being clearly recognised as being a poor and unsatisfactory method of delimbing, many New Zealand forestry workers delimb the tree once it is felled by walking along the top of the stem. In doing so the operator increases the chances of slipping, tripping or falling off the stem. If and when such an accident occurs, the injuries sustained are often magnified when the operator either tries to fend off the chainsaw as he is falling, or lands on the chainsaw itself.

Figure 25 - Typical New Zealand Logger's Delimbing Technique.

Data shown in Figure 26, obtained from the LIRO Accident Reporting Scheme, backs up these findings. Since the commencement of the schemes computer based data recording in 1985, slipping related accidents have on average accounted for 28% of all chainsaw related hand injuries.

In contrast to New Zealand, the motor-manual operations observed overseas tended to delimb the stem while walking **beside** the stem. Apart from substantially decreasing the risk of slip type injuries, this method has the added advantage that the weight of the chainsaw is borne mostly by the stem of the tree.

Figure 26 - Scandinavian Logger's Delimbing Technique

Of the countries visited, only the logging crews in the PNW region of USA and in British Columbia, Canada delimbed while walking along the top of the stem. The major difference between these two regions and the New Zealand situation was that the operators wore spiked (caulked) boots and used 91 cm long chainsaw bars on smaller 70 - 90 cc chainsaws.

While the use of longer chainsaw bars is not recommended for New Zealand chainsaw operators due to an unfavourable increase in spinal loadings, the wearing of caulked boots reduces the chance of losing one's balance and coming in contact with the chainsaw. The wearing of spiked boots is still relatively new within the New Zealand production forestry scene. However, research has shown that the used of such devices can significantly

Year	Total chainsaw related hand injuries (1985 - 1991)	Slip related chainsaw hand injuries (1985 - 1991)	Slip injuries as a % of total chainsaw hand injuries (1985 - 1991)
1985	40	10	25
1986	35	4	11
1987	31	8	26
1988	37	15	41
1989	24	11	46
1990	19	5	26
1991	17	4	24
Average	29	8	28

Table 1 - Slipping accidents as a percentage of total chainsaw related hand accidents.

increase the safety of chainsaw operators working in New Zealand (Kirk & Parker 1992a, 1992b, 1993).

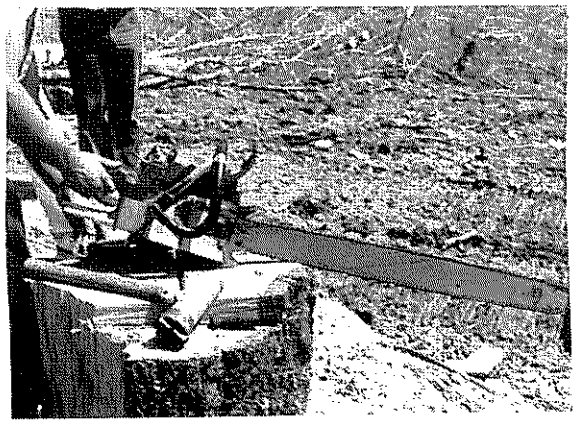

Figure 27 - American Logger's 80 cc Chainsaw Equipped with a 91 cm bar.

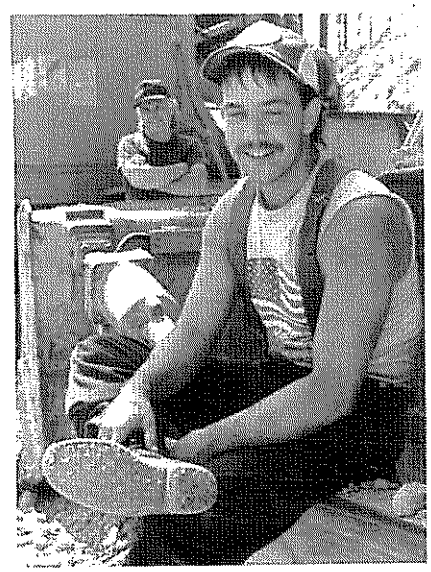

Figure 28 - American loggers Using Caulked (Spiked) Forestry Boots.

SUMMARY OF RECOMMENDATIONS

1) *A combination of chainbrake and leather mitt should be compulsory for New Zealand chainsaw operators and not simply two of the three current choices.*

2) T*he minimum requirement for a chainsaw should be a chainbrake. They should be compulsory on all chainsaws and not simply an option as is currently the situation.*

Manufacturers are continually improving and evolving new and improved chainsaw designs with the operator's safety uppermost in their minds. Advances are continually being made so as to lessen the occurrence and severity of kickback situations, with the chainbrake being an integral part of this development.

3) *Any future developments regarding chainsaw operator hand protection must consider information gained from local loggers, contractors and companies.* There is no point in introducing foreign products into a country with different conditions than that for which they were originally designed.

During this study tour several examples were seen where so called solutions actually created more problems simply because the product did not fit the situation.

4) *Any such development should be based along the same design principles as the leather mitt. These being, easy to apply, durable, low heat retention and inexpensive.* Such development must also consider the unique climatic conditions experienced and work methods used in New Zealand's forest industry.

5) *The New Zealand forest industry should make every effort to isolate the chainsaw operator from the chainsaw.*

One of the most effective methods for achieving this is by the mechanisation of the harvesting and processing operations. In many of the countries visited, this situation has already taken place. The result is a significant reduction in the frequency and severity of chainsaw operator injuries.

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O'Leary C., (1988): "A Bio-Mechanical Analysis of Two Delimbing Techniques". A dissertation presented in partial fulfilment of the requirements for the Degree of Bachelor of Forestry Science. School of Forestry, University of Canterbury, New Zealand.

Raymond K.A & Lyon C., (1993): "A Survey of the Logging Industry - 1991". LIRO Report Vol 18 No1.

Appendix I: Organisations visited and contacts made.

**Forest Enterprise,
Business Enterprise
Division,
Edinburgh,
Scotland.**

* Dr David Chadwick
(Safety Officer)

* Allen Hansford
(Safety Officer)

* Mike Green
(Harvesting Officer)

**Husqvarna Forest &
Garden Ltd,
Huskvarna,
Sweden.**

* Per Hesselgren
(Area Manager Asia
Pacific)

* Bo Stenholm
(Asst Area Manager Asia
Pacific)

* Ulf Näslund
(Manager R&D)

**Engtex Ltd,
Mullsjo,
Sweden.**

* Magnus Gröndahl
(Sales Manager)

**Nordic Forestry
Equipment Ltd,
Falun,
Sweden.**

* Sture Milling
(Managing Director)

**Andreas Stihl Ltd,
Waiblingen,
Germany.**

* Dr Rudolf Krebs
(Division Manager
Research)

* Manfred Bortfeld
(Manager Test
Engineering)

* Walter Gernhard
(Product Certification)

* Angelika Scheidacker
(Export Liaison Officer)

* Arno Schewski
(Overseas Sales
Promotion)

**Forest Engineering
Research Institute of
Canada,
Eastern Division,
Quebec,
Canada.**

* Gordon Franklin
(Researcher)

* Peter Hamilton (Researcher)

* Jean-Marie Golsse (Researcher)

* Michael Folkema (Group Supervisor)

* Jean-Francois Gingras (Group Supervisor)

Forest Engineering Research Institute of Canada, Western Division, Vancouver, Canada.

* Jack MacDonald (Senior Researcher)

* Jim Ewart (Researcher)

* Jake Kraan (Researcher)

* Eric Phillips (Researcher)

Workers Compensation Board of B.C. Occupational Safety & Health Division, Vancouver, B.C. Canada.

* John Hindson (Director Field Service Dept)

* Olaf Knezevic (Engineer)

* Kit Chan (Engineer)

Forest Products Accident Prevention Association, North Bay, Ontario, Canada.

* Cecil Demers (General Manager)

* Thom Foster (Consultant-Trainer)

* David Dehaas (Technical Writer)

Henry Fiset and Sons Ltd Elk Lake, Ontario, Canada.

* Jerome Fiset (Manager)

Homelite-Terry Textron Ltd Textron Canada, Quebec, Canada.

* Ernie Zohorsky (Service Manager Canada)

Institute de recherche en sante et en securite du travail du Quebec (IRSST). Montreal Quebec Canada.

* Jean Arteau (Director Safety Engineering Laboratory)

Swedish University of Agricultural Sciences, College of Forestry, Garpenberg, Sweden.

* Sven-Åke Axelsson (Professor)

* Sture Carlsson (Researcher)

Swedish National Board of Occupational Safety & Health, Solna, Sweden.

* Ulf Andersson (First Section Engineer)

* Ulf Wahlstrom (Forest Engineer)

* Erik Ahlberg (Researcher)

The Forestry Research Institute of Sweden, (Skog Forsk) Kista, Sweden.

* Göran Eriksson (Forest Engineer)

Swedish Institute of Agricultural Engineering, Uppsala, Sweden.

* Mats Bohm (Research Manager)

The Finnish Forest Research Institute, Helsinki, Finland.

* Kaija Kanninen (Researcher Occupational Psychology)

* Erkki Verkasalo (Research Officer)

* Olli Eeronheimo (Research Officer)

Kuopio Regional Institute of Occupational Health, Agriculture and Forestry Office, Kuopio, Finland.

* Tapio Klen (Research Leader)

* Kari Ojanen (Research Engineer)

Oregon State University
College of Forestry,
Corvallis,
Oregon,
USA.

* Dr John Garland
(Extension Timber Harvesting Specialist)

* Dr Eldon Olsen
(Ass Prof Forest Engineering)

* Dr Loren Kellog
(Ass Prof Forest Engineering)

Oregon Occupational Safety & Health Agency,
Department of Finance & Insurance,
Salem,
Oregon,
USA.

* Joe Miller
(Manager Enforcement)

* Mike Maier
(Research Analyst)

Department of Agricultural Engineering,
Auburn University,
Alabama,
USA.

* Steven Taylor
(Assistant Professor)

Department of Industrial Engineering,
Auburn University,
Alabama,
USA.

* Dr Robert Thomas
(Assistant Professor Ergonomics/Human Factors)

* Dr Tony Smith
(Professor Ergonomics/Human Factors)

Department of Consumer Affairs
Auburn University,
Alabama,
USA.

* Teresa Bellingar
(Graduate Research Associate)

School of Forestry,
Auburn University,
Alabama,
USA.

* Bobby Lanford
(Associate Professor)

* Robert Tufts
(Associate Professor)

Appendix II : Section 12 of the Occupational Safety & Health Departments "Safety Code for Forestry Operations" Part - 3 Logging , which relates to chainsaw safety.

12. Chainsaw safety

12.1 All chainsaws held directly by hand shall have at least one of the following securely attached, in place, and in good working order before it is used:

(a) A safety mitt; or
(b) A rigid-type hand guard: or
(c) A chain brake

12.2 The chainsaw shall be inspected before work is begun to ensure it is in safe working condition.

12.3 Except for the fine tuning of the carburettor, no cleaning, oiling or adjustments shall be carried out while the motor is running.

12.4 All operations relevant to tensioning the saw chain and any other maintenance shall be carried out in a safe manner and to the manufacturer's specifications or recommendations.