FERIC *FOREST ENGINEERING RESEARCH INSTITUTE OF CANADA*
INSTITUT CANADIEN DE RECHERCHES EN GÉNIE FORESTIER

Butt-Damage Levels of Non-Shear Felling Heads in British Columbia

D.Y. GUIMIER

Special Report No. SR-19A
Supplement to Special Report No. SR-19
For The Use of FERIC Members Only
June 1983

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LETTER OF TRANSMITTAL

June, 1983

TO: FERIC Members

Dear Sirs:

This report is a supplement to the Special Report SR-19, "Survey of Non-Shear Feller Buncher Heads in British Columbia", by Bruce McMorland published in November 1982. The report of the survey was restricted to FERIC members because it contained opinions of people outside FERIC without the necessary study and research to qualify these opinions.

This report, "Butt-Damage Levels of Non-Shear Felling Heads in British Columbia", by D.Y. Guimier provides butt-damage information collected during studies during the winter of 1982-1983. It covers most of the machines included in the survey and does not repeat the machine description and other information included in the survey report. In order to cover many machines in a short operating season, the samples were small and the observations limited. The results provide only an indication of the machine's performance.

This report has been sent to FERIC members and the distributors and manufacturers included in the survey. It is not to be used for advertising or promotion.

Yours sincerely,

FOREST ENGINEERING RESEARCH INSTITUTE OF CANADA

G. V. Wellburn
Manager, Western Division

GVW/ms

Encl.

PREFACE

This report is a supplement to FERIC Special Report No. SR-19 "Survey of Non-Shear Feller-Buncher Heads in British Columbia". The intent of the report is only to comment on machine design features related to butt damage; *by no means does this report constitute a complete engineering evaluation of the various machine styles.*

FERIC gratefully acknowledges the co-operation of all the contractors' and companies' staff members who were involved in this study.

The author also wishes to thank FERIC staff members for their assistance, particularly Bruce McMorland who organized the field work and actively participated in the data analysis and report writing, and Pat Forrester who did most of the field work.

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SUMMARY

All styles of non-shear felling machines significantly decrease butt damage and lumber loss as compared to shears. A reduction in the percent lumber loss by a factor of 4 to 10 can usually be expected. The percent lumber loss for non-shear machines winter-tested, ranges from .12% to 1.86%, with 85% of these machines producing less than 1% loss. The two shears studied averaged 4% loss. The lumber loss at the mill depends on the size of lumber sawn; above results assume the mill cuts 2 X 6's. Results on a specific machine will also depend on stand conditions and on the operator. Among the stand conditions, tree size was found to have the greatest effect on butt-damage results; small trees usually result in a larger proportional lumber loss. Species, frost depth, tree lean and other stand characteristics also affect damage levels.

The operator is important and can affect the amount of damage caused by a machine. However, we believe that a machine can be designed so that it produces minimum losses without an attentive, highly skilled operator.

Several excellent and several poor design features were identified among the machines investigated. For minimum butt damage:

- do not use shears;
- leave the tree free during the cutting process;
- design the cutting device so it is insensitive to binding;
- design machine so that the stump will tend to split (not the log) when bending is applied to open the kerf;
- eliminate any opportunity for the operator to apply uncontrolled stress to the tree during cutting.

Damage levels are already fairly low for most non-shears presently working in B.C. but the potential for further improvements exists by applying any of the above recommendations.

SOMMAIRE

Comparativement aux engins munis de cisaille, tous les types d'engins d'abattage sans cisaille permettent de diminuer considérablement la perte de bois resultant des dommages causés à la bille de pied. On peut généralement s'attendre à réduire par un facteur de 4 à 10 le pourcentage de perte en bois. Ce pourcentage pour les engins d'abattage sans cisaille, mis à l'essai en hiver, varie de .12% à 1.86% (85% de ces engins produisant une perte inférieure à 1%). Les deux cisailles étudiées donnaient en moyenne 4% de perte.

La perte de bois à l'usine dépend des dimensions du bois scié; les résultats ci-dessus supposent que l'usine produit des 2 X 6. Pour une machine donnée, les résultats dépendront également des conditions du peuplement et de l'opérateur. Parmi les conditions du peuplement, on a trouvé que le diamètre de l'arbre est celle qui exerce le plus d'influence sur les dommages causés à la bille de pied, les petits arbres donnant généralement une perte de bois proportionnellement plus forte. L'essence, la profondeur du gel, l'inclinaison de l'arbre ainsi que d'autres caractéristiques du peuplement affectent également le niveau des dommages.

L'opérateur est important et peut avoir un effet sur la gravité des dommages causés par une machine. Nous croyons toutefois possible de concevoir une machine qui produirait des pertes minimales, même sans un opérateur très attentif, ni hautement expérimenté.

Parmi les machines étudiées, nous avons observé plusieurs caractéristiques de conception excellentes et plusieurs autres médiocres. Pour obtenir le minimum de perte en bois, nous recommandons:

- de ne pas se servir de cisailles;
- de laisser l'arbre libre au cours du processus d'abattage;
- de concevoir le dispositif de coupe de façon à ce qu'il soit insensible au coincement;
- de concevoir la machine de façon à ce que la souche ait tendance à fendre (et non la bille) lorsqu'on applique un effort de flexion pour ouvrir le trait de scie;
- d'éliminer le risque que l'opérateur applique sur l'arbre une contrainte non contrôlée au cours de l'abattage.

La plupart des têtes d'abattage sans cisaille que l'on rencontre actuellement en Colombie-britannique ne causent que peu de dommages à la bille de pied, mais l'application de l'une ou l'autre des recommandations ci-dessus permettra d'autres améliorations.

INTRODUCTION

Non-shear felling is increasing in importance in British Columbia as more sawmill companies refuse sheared wood because of unacceptable lumber losses.

In October 1982, FERIC published a "Survey of Non-Shear Feller-Buncher Heads in British Columba" (B. McMorland, SR-19). This special report gave a general view of the state-of-the-art in non-shear felling and identified fourteen different styles of heads at various levels of development in the summer of 1982.

As a follow-up on this survey, we have performed a quantitative evaluation of the butt damage created by non-shear heads as compared to a hand faller and a shear during the winter of 1982-83. The objectives of this study were:

1. To determine quantitatively the wood loss resulting from butt damage caused by a shear, a hand faller and the various styles of non-shears;

2. To investigate the different felling methods and determine the causes for butt damage;

3. To make recommendations so that future designs or modifications of non-shear heads result in minimum damage.

This study has concentrated on one major aspect of non-shear felling: butt damage and resulting wood loss. Obviously, other aspects of non-shear felling, such as production, availability and stump height are also important and might be the subject of future FERIC studies.

DATA COLLECTION AND BUTT-DAMAGE RESULTS

In January - February 1983, butt-damage data was collected on 15 different felling methods. Similar data was collected on a Kockums chainsaw in January 1982. Table 1 gives a description of the systems studied. For simplicity, the names given in the last column of Table 1 will be used in the rest of this report when referring to a particular machine. The butt-damage data collection and analysis followed a procedure defined by FERIC in 1981. The procedure, nicknamed the "Bicycle Wheel Method", allows one to calculate wood losses attributable to felling damage from measurements taken on logs at the felling site. The losses thus calculated approximate actual lumber losses in the mill. FERIC Technical Note TN-52 fully describes the method.

An average of 54 trees were sampled for each of the 15 felling systems; damage was checked and measured. A summary of the results is given in Table 2. The felling methods have been ranked in order of increasing percent lumber loss. The percent lumber loss is defined as: the volume of lumber loss expressed as a percentage of the total volume of lumber produced.

The average lumber size is assumed to be 2 X 6. The percent lumber loss is a function of the average size of the lumber cut by the mill. Figure A illustrates the fact that the larger the lumber cut, the greater the loss from a partly split log. As an example, Figure B shows how the percent lumber loss for Kockums 2 increases as the size of the lumber increases.

In addition to the collection of butt-damage data on log samples, FERIC also carried out an engineering investigation of most of the different heads to determine the causes of butt damage and how it can be avoided. The result of this investigation and further discussion of the results of Table 2 are then presented.

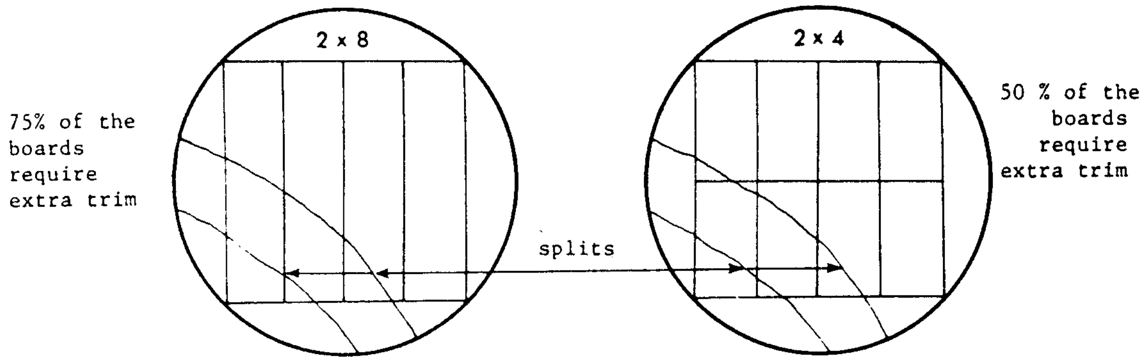


Figure A. The larger the lumber size the greater the percentage of boards with damage.

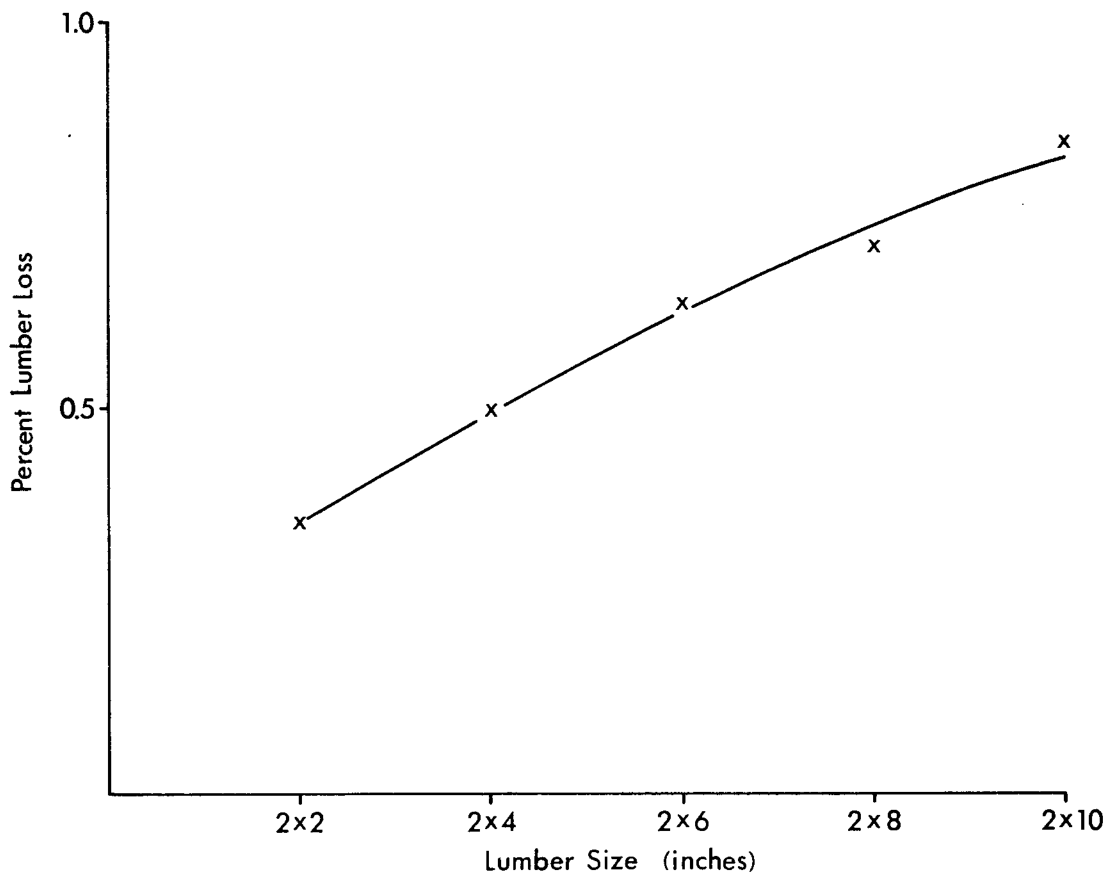


Figure B. Percent lumber loss increases as lumber size increases (example - Kockums 2).

TABLE 1. DESCRIPTION AND LOCATION OF THE FELLING SYSTEMS STUDIED FOR BUTT DAMAGE

MACHINE	MAX. STUMP DIAMETER cm (in)	CARRIER	LOCATION	ABBREVIATED NAME
Anda Feller Buncher	61 (24)	Drott 50	Ft. St. James	Anda
Drott Auger Feller Buncher	61 (24)	Drott 50	Prince George	Auger
Dag Chainsaw Director	51 (20)	Komatsu D65	Ft. St. James	Dag
Denis Feller Buncher	51 (20)	Drott 40	Fraser Lake	Denis
Dika Feller Buncher	71 (28)	Cat 235	Prince George	Dika
Hand Faller	N/A	N/A	Prince George	Hand Faller
Harricana Feller Buncher	56 (22)	Cat 225-235	Ft. St. James	Harricana 1
Harricana Feller Buncher	51 (20)	Drott 40	Kamloops	Harricana 2
Hultdins Felling Saw	61 (24)	TJ520 Clambunk	Telkwa	Hultdins
Kockums Feller Buncher	55 (22)	Drott 40	Princeton	Kockums 1
Kockums Feller Buncher	55 (22)	J.D. 693-B	Princeton	Kockums 2
Northwood/FERIC Feller Director	91 (36)	FMC	Prince George	NW/FERIC FD
Osa 670 Feller Buncher	56 (22)	Osa	Houston	Osa
Spencer Feller Buncher	48 (19)	Drott 40	Princeton	Spencer
QM Shear (Snipper)	71 (28)	Cat D7G	Prince George	QM Shear 1
QM Shear (Snipper)	71 (28)	International 175	Prince George	QM Shear 2

TABLE 2. BUTT-DAMAGE SUMMARY

RANK	FELLING SYSTEM	PERCENT LUMBER LOSS (2X6 BASIS)	PERCENT OF TREES WITH DAMAGE	AVERAGE BUTT DIAMETER (cm)
1	Hand Faller	0.05	4	35.3
2	Spencer	0.12	16	36.1
3	Harricana 2	0.17	13	28.0
4	Harricana 1	0.20	16	31.5
5	Dag	0.41	34	30.4
6	Dika	0.45	41	34.6
7	Osa	0.49	29	27.1
8	Kockums 2	0.63	66	31.7
9	Hultdins	0.67	57	37.1
10	Auger	0.73	29	25.5
11	Anda	0.88	59	34.5
12	Kockums 1	0.92	42	31.0
13	Denis	1.28	40	25.8
14	NW/FERIC FD	1.86	77	40.7
15	QM Shear 1	3.36	100	41.1
16	QM Shear 2	4.54	98	30.3

Detailed results by diameter classes, species and different lumber classes are available on request from FERIC.

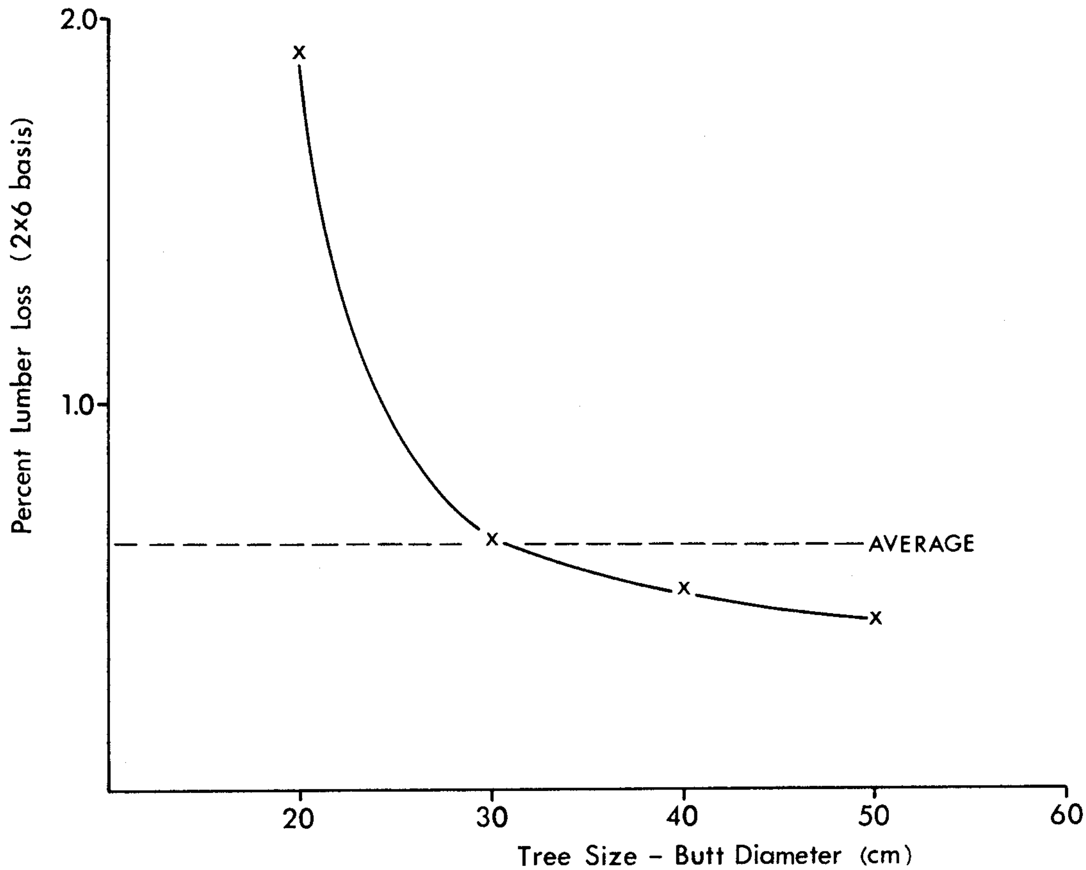


Figure C. Percent lumber loss decreases as tree size increases (example - Kockums 2).

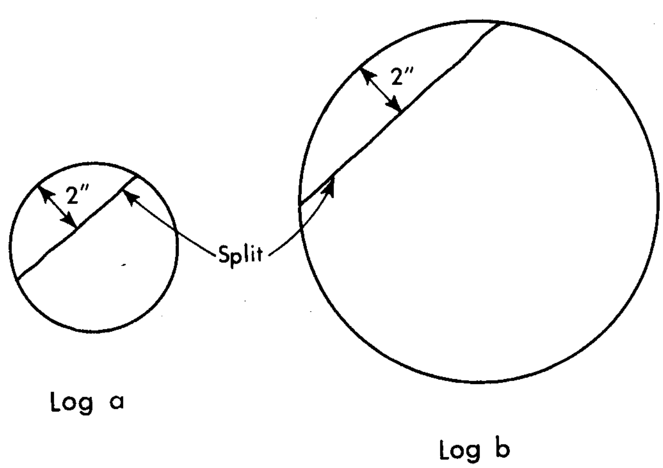


Figure D. Similar splits result in greater lumber loss in small logs.

FACTORS INFLUENCING BUTT DAMAGE

The results presented in Table 2 should be interpreted carefully. They represent damage observed for a machine with a given operator in a very specific set of stand, terrain, weather and other conditions, and should not be taken as an absolute characterization of the machine's performance in all conditions. Three major factors affect the damage results:

- the stand characteristics;
- the operator;
- the machine.

Each one will have an effect on the amount of butt damage. After discussing each of these factors, we will elaborate on the details of the machine's design since this represents the only real potential for systematic butt-damage reduction.

STAND CHARACTERISTICS

Tree size is a major factor affecting wood loss from shatter. Small trees generally result in larger percent lumber loss than large trees. As an example, Figure C shows how wood loss decreases as the tree size increases for a typical machine. Our study showed that for all machines (except the Denis feller buncher), loss on small trees (smaller than 25 cm butt diameter) was larger than average. In the case of the Denis head, technical difficulties with the machine resulted in greater losses on large trees (see section on machine design features).

Table 2 shows that the machines we studied worked in a fairly wide range of tree sizes (from 25.5 cm average butt diameter for the Auger to 41.1 cm for the QM Shear 1). We recomputed the results for the Auger eliminating from the sample all trees smaller than 25 cm; as a result, the average tree size increased to 31.2 cm and the percent wood loss dropped to 0.67%. We also recomputed the results for QM Shear 1, eliminating all trees larger than 42.5 cm; the average tree size decreased to 30.5 cm and the percent wood loss increased to 4.09%.

Because they worked in large wood, the QM Shear 1, the NW/FERIC FD, the Hultdins, the Dika and the Spencer are favoured in the ranking. On the other hand, the Osa and Auger are penalized because of the small wood they cut.

Several reasons can be found to explain why damage is greater in small trees. They are bent more easily by the feller bunchers and higher stresses are applied to the uncut wood, resulting in more splitting. Also, percent wood loss is a function of the percentage of the cross section that is damaged by cracks. As shown in Figure D, the same crack, two inches from the edge of the log, affects a larger percentage of the area of a small log (a) than of a large log (b). Assuming the two splits run the same length up the log, log (a) will have a greater percent wood loss.

Trees too large for a machine usually cause felling difficulties and end up being damaged. Oversized trees were excluded from our samples.

Tree species - Four species were found in our investigations: Lodgepole Pine, Balsam, Engelmann Spruce and Douglas Fir.

Douglas Fir definitely showed less loss than the other three species. Pine and Spruce showed comparable damage. Balsam appeared to show slightly more damage than Pine and Spruce. This ranking by species is exactly what can be expected when comparing their strength:

TABLE 3. STRENGTH CHARACTERISTICS OF THE FOUR SPECIES FOUND DURING THE TESTS

SPECIES	MODULUS OF RUPTURE (PSI) (STATIC BENDING)
Douglas Fir	7500
Lodgepole Pine	5700
Engelmann Spruce	5700
Balsam	5300

Frost depth - The winter of 1982-83 was mild. The average frost depth in the trees we sampled was 3.5 cm. This was much less than in other winters when it was common to find 30 cm diameter trees frozen through. Frozen wood is more brittle than unfrozen wood and butt shatter increases with frost depth. The damage results of this study are lower than would be expected with normal winter weather conditions.

In Table 2, the results shown for Kockums 1 were obtained during the previous winter, which was quite severe. This machine showed significantly more damage than a similar machine (Kockums 2) evaluated in February 1983 in the same area. Differences in the amount of frozen wood help to explain the variation in percent wood loss from one year to the next.

Tree lean and other stand characteristics - Leaning trees, odd shaped stumps, large and low branches, trees growing side by side, rough and steep terrain, deep snow and any other stand characteristics that increase felling difficulties will contribute to damage.

Stand characteristics varied between machines in our study. However, none of the machines worked in extreme stand conditions that would significantly affect butt-damage results.

Varying stand characteristics are part of the real world for the machine. It is unfortunate that trees are not perfectly circular and vertical wooden columns. It is up to the designer and user of the felling machine to deal with the singularities of nature and adapt the machine to the stand conditions.

MACHINE OPERATOR

Operators' techniques affect the butt damage from a felling machine. Most of the operators running the machines studied appeared to be trained, with the exception of the NW/FERIC Feller Director which was run by an operator without lengthy felling experience.

We noted techniques used by some operators that increased damage; however, most of these techniques were developed to overcome a machine problem. For example, many machines required the operator to bend the tree in order to keep the kerf open and prevent the cutter from binding.

Production versus quality will require compromise but the designer must strive to build a machine which will both minimize damage and maximize production.

MACHINE

As shown by the ranking in Table 2, there was a fairly large spread in the results rising from the hand faller through the non-shears and peaking with the traditional tractor-mounted snipper. The type and arrangement of the felling head components will determine how much damage is created. The machine design is the most important factor to investigate when studying butt damage because it is the factor that can be more easily controlled and improved.

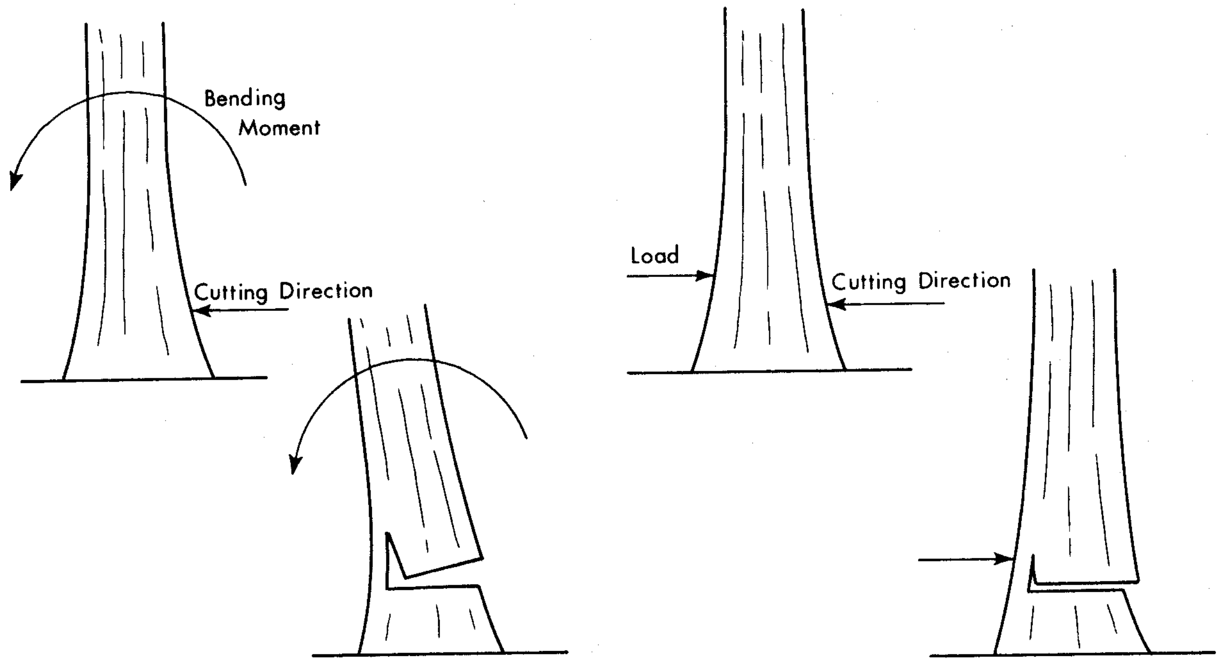


Figure E. Bending moment and/or loads perpendicular to the tree during the cutting phase result in butt damage.

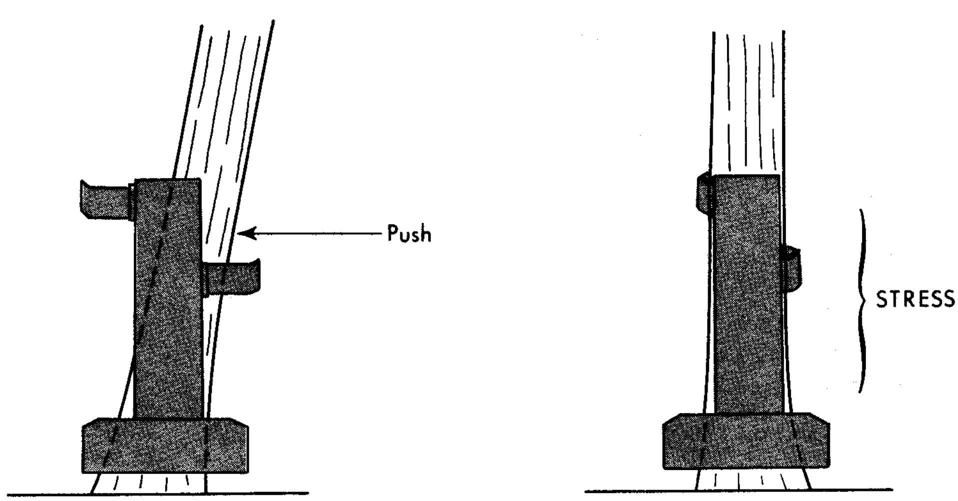


Figure F. Misalignment of the head results in bending stresses in the tree as the grab arms are closed.

IMPACT OF MACHINE DESIGN FEATURES ON BUTT DAMAGE

In order to organize our analysis of the felling machines' design features, we have divided the felling cycle into the following five work elements. Each element can contribute to butt damage:

1. Positioning head on tree;
2. Cutting;
3. Kerf opening;
4. Supporting the tree weight after it is cut;
5. Holding tree after (or while) it is severed (feller buncher) or pushing (directing) the tree (feller director).

In some cases two or more of the above elements are performed by the same mechanism (i.e. the grab arms on the Anda hold the tree and also support the tree weight).

All these elements can cause butt damage if not properly executed. If any element causes the tree to be stressed or pre-loaded in bending or shear (as shown in Figure E) during the cutting phase, damage is unavoidable.

POSITIONING THE HEAD ON THE TREE

To avoid damage, positioning should not bend or deflect the tree. For all the feller-director type machines, such as the Dag chainsaw, the NW/FERIC feller director and the QM tractor-mounted shears, positioning the head only involves placing the machine around the tree stump. This operation cannot stress the tree in any way and does not contribute to damage.

For the feller bunchers, such as the Kockums, Drott, Anda, Dika and Denis, it is critical that the head be aligned to the tree. If the head positioning is not perfect, bending and shear pre-stresses, resulting in damage, will be applied to the tree when the grab arms are closed. However, to maintain acceptable production levels, very exact alignment of the head and tree is not achievable and operators have to compromise between quality and production. Fore and aft head alignment is available on all buncher heads using the "bucket" cylinder on the boom. Sidetilt is used to align the other direction. The Denis, Drott and Dika that we studied did not have sidetilt on the felling head. However, the Drott and Denis mounted on Drott carriers could be aligned sideways using the cab leveller. Operators felt they could not afford the time to be careful with every tree and side leaning trees often were bent and stressed by the grab arms (Figure F). In addition, in the case

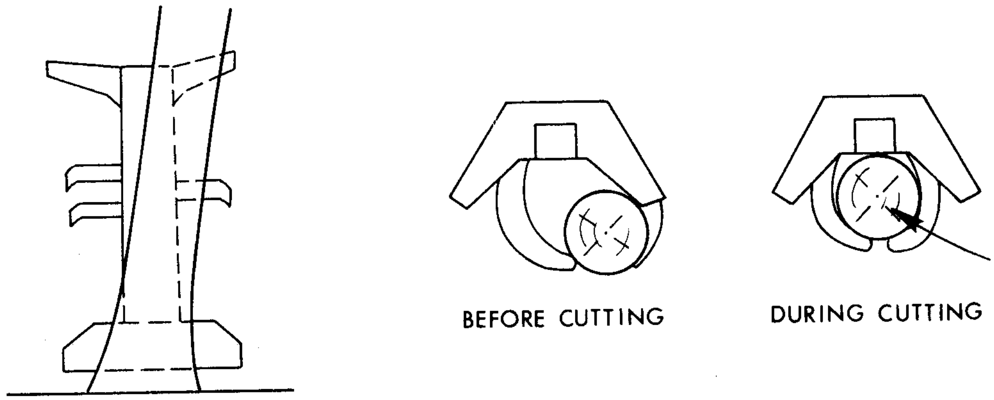


Figure G. Denis head. Fixed horns at the top of the mast and lack of sidetilt create cutting problems resulting in butt damage.

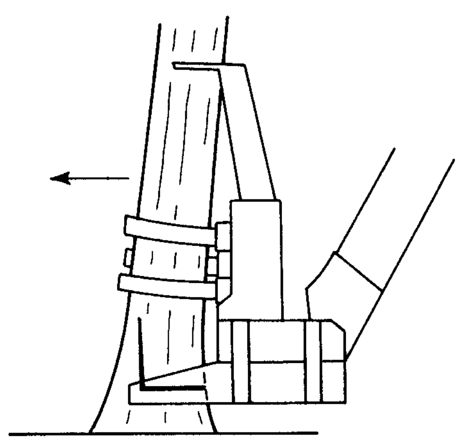


Figure H. Harricana head. Tree leaning toward machine can be pushed and damaged as saw is fed into the tree (grab arms are open).

of the Denis, fixed "horns" at the top of the mast prevent the operator from tucking side leaning trees against the mast (Figure G). As the tree is cut, it is pulled inside the horns, pinching the saws and causing butt damage. The sidetilt option now available on the Denis head would eliminate most of the problem.

Positioning is less critical for the Spencer and Harricana because no attempt is made to grab the tree before cutting starts. As shown in Figure H, stress can be applied to the tree during cutting by the Harricana if the tree is leaning heavily towards the machine.

CUTTING

Four types of devices are commonly used to sever the tree:

Chainsaws:	Hand Faller, Spencer, Dag, Dika (wide kerf), Osa, Kockums, Hultdins, Anda, NW/FERIC Feller Director
Circular Saws:	Harricana, Denis, Koehring (not studied)
Auger:	Drott
Shear:	QM Tractor-Mounted Snipper

Most of the damage created by the QM tractor-mounted snipper can be attributed to the cutting device (the knife). Three types of damage are created by shears:

1. Damage at the fiber level. The force exerted by the knife breaks the growth rings in tension and bending.

2. Damage created by crushing the tree between the knife and anvil.

3. Barberchair-type damage due to the wedging action of the knife being pushed into the tree.

Many attempts were made at improving shears to reduce damage. Ribbed, thin and pretensioned, curved, double or oblique shears did not significantly reduce damage. The solution to the butt-damage problem seems to reside in the use of non-shears.

For cutting action alone, the non-shear cutting devices seem to cause less damage than shears; none of them, however, appears to be superior to the others. The narrow-pitch chains and the Auger always produce a clean cut. The coarse chain on the Dika occasionally tends to rip chunks of wood out of small trees. If the circular saw is dull, the appearance of the cut can be fuzzy but the damage is only superficial.

The way the cutting device is fed into the tree determines the shape and location of the holding wood and therefore the direction most sensitive to splitting. The major types of feed are illustrated in Figure I. Type A machines will induce barberchairing by applying stresses at right angles to the boom (sidetilt); type B and C will induce barberchairing splits by applying stresses in the direction of the boom (as an example with the "bucket" cylinder). Type D, the Denis, creates a triangular-shaped holding wood as the two saws are pushed into the tree; splitting can occur from stresses in almost any direction.

Recognizing that some directions are more sensitive to damage, forces applied to the tree in that particular direction should be avoided.

KERF OPENING

A major element of the felling cycle that will result in most of the damage is keeping the kerf open to prevent the cutter from binding.

It should be noted first that some cutting devices are more susceptible to binding than others. The following list ranks, by increasing order of susceptibility to binding, the different styles we looked at:

- Auger;
- Harricana Circular Saw;
- Wide Kerf Chain (Dika);
- Narrow Kerf Chain;
- Denis Twin Circular Saw.

The Auger has the ability to cut itself free when the kerf closes (Figure J). The follow-up plate also prevents the kerf from closing. As shown in Figure K, the Harricana circular saw will not bind even if the kerf closes slightly. Again, the kerf is kept open by the butt support plate. The twin saws on the Denis do not have the same advantage (Figure L); the back of the blades can easily be pinched when the kerf closes. If support plates were added in the areas shown in Figure L, it might reduce that problem.

Saw chains bind and the return side of the bar is especially vulnerable when the kerf closes. Stronger chains have a better chance to cut themselves free when binding starts.

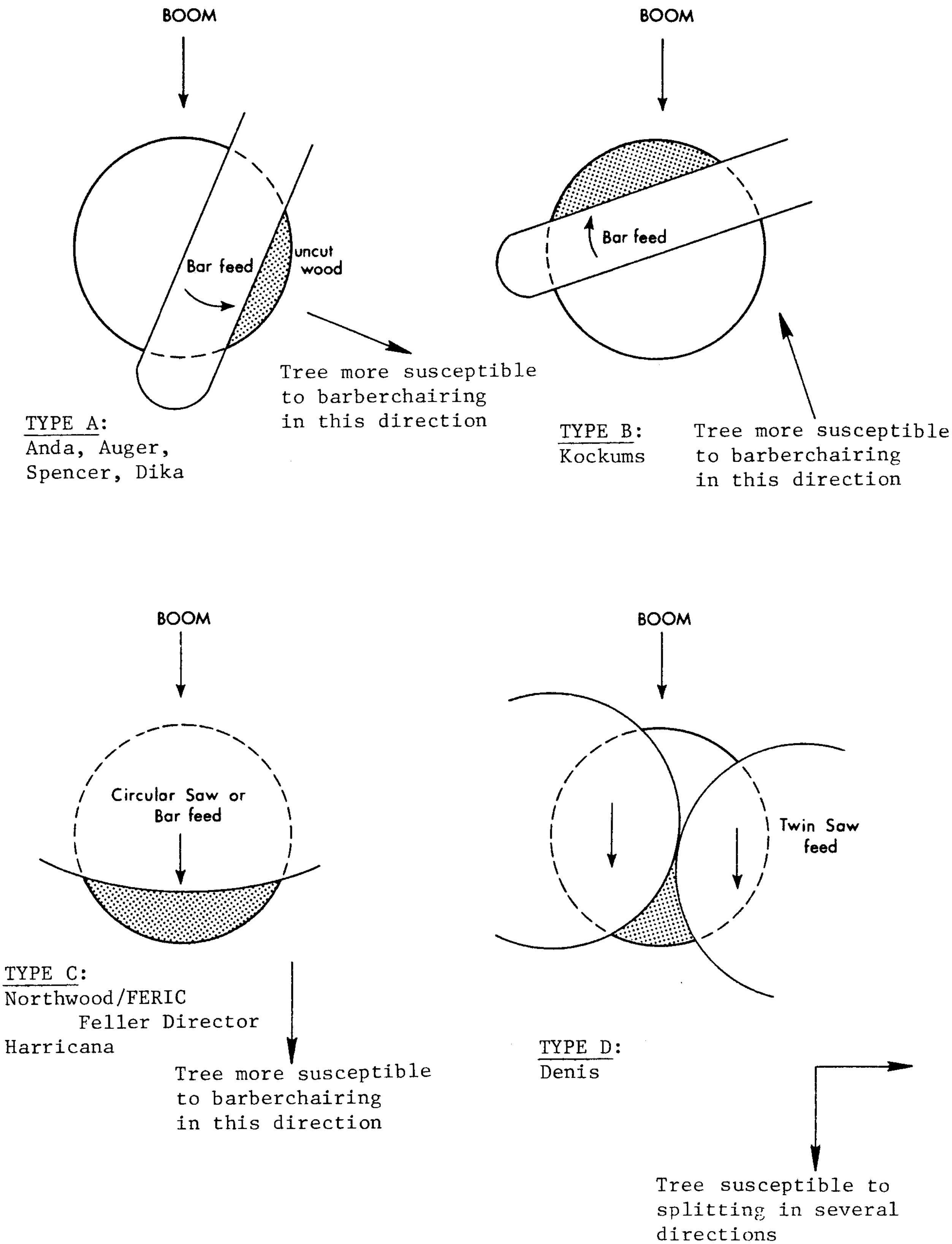


Figure I. Four major types of holding wood patterns can be identified for the different styles of non-shears.

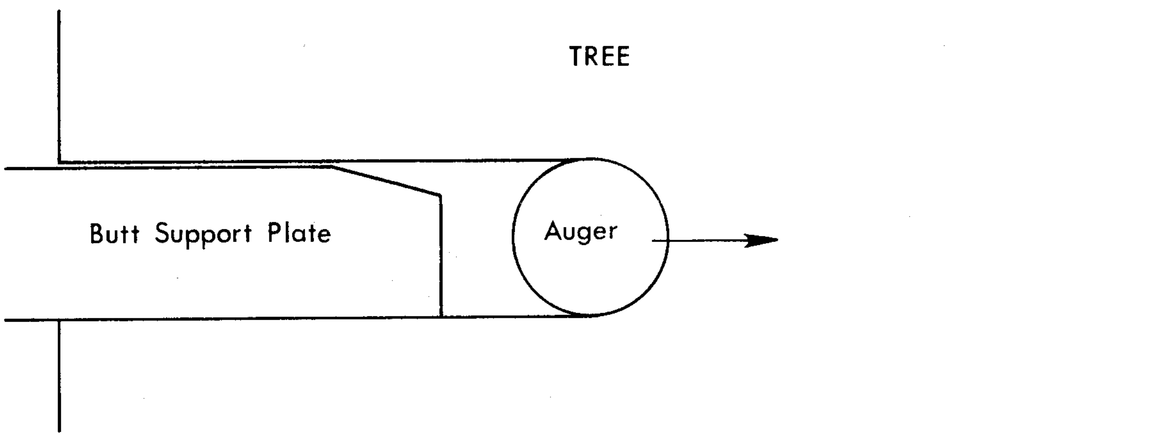
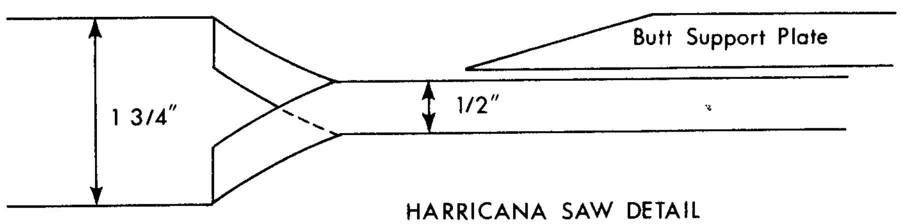


Figure J. Auger in cut. Auger is less sensitive to binding than most other cutters.



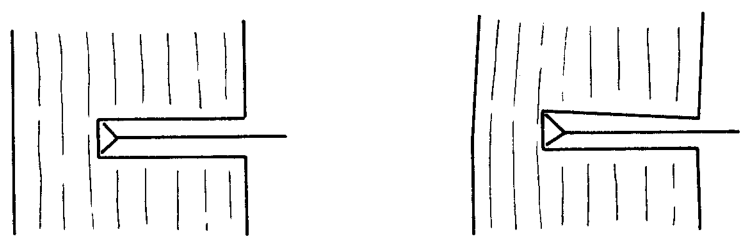


Figure K. Harricana circular saw does not bind even if kerf closes slightly.

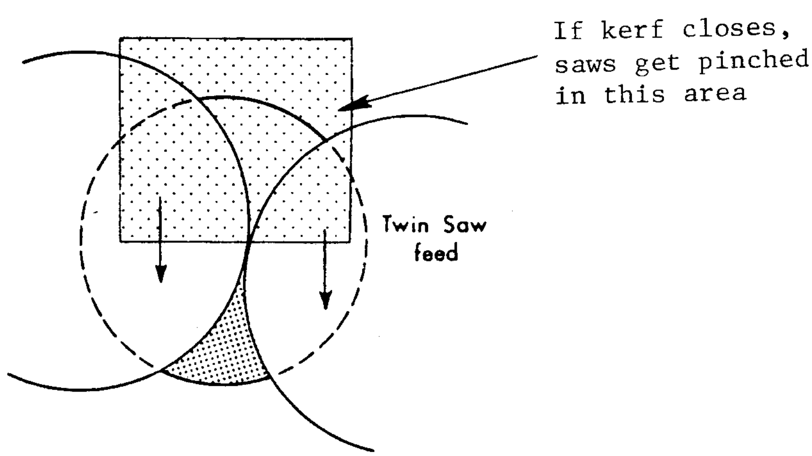


Figure L. Back of Denis saws get pinched if kerf closes.

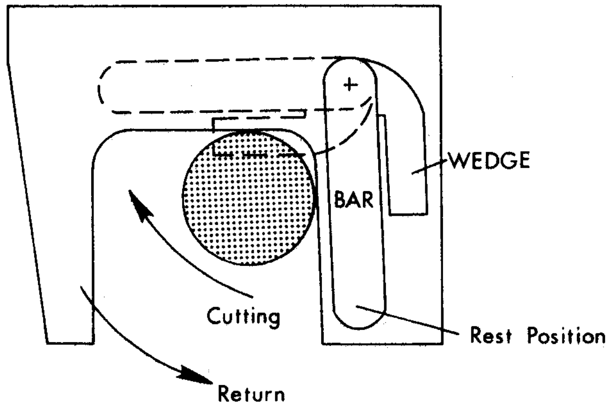


Figure M. Cutting cycle on Kockums showing follow-up wedge.

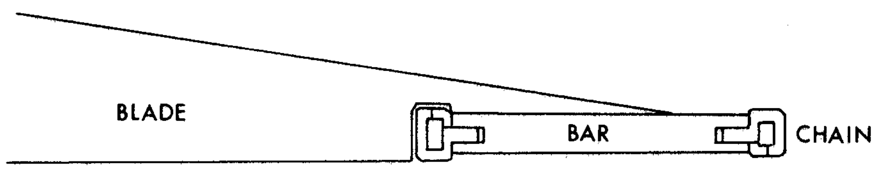


Figure N. Bar-wedge combination on the Dag keeps the kerf open independently of operator's input.

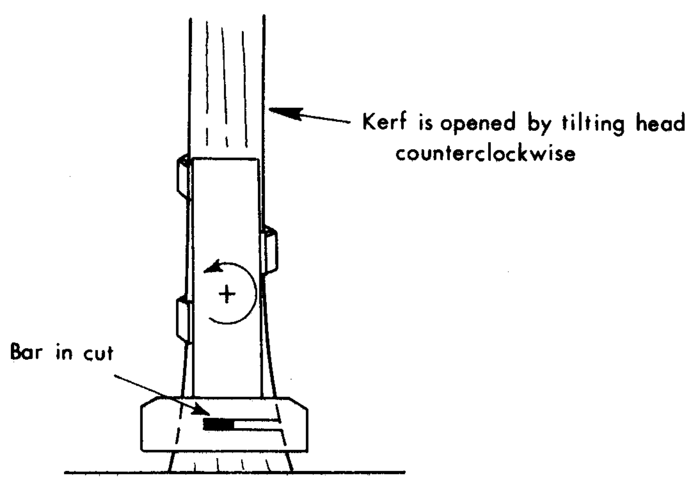


Figure O. Opening the kerf. Type A machine.

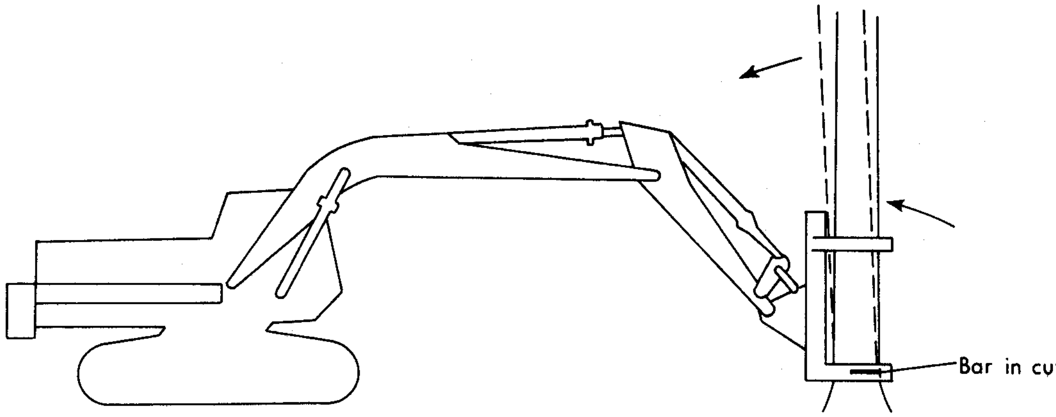


Figure P. Opening the kerf. Type B machine.

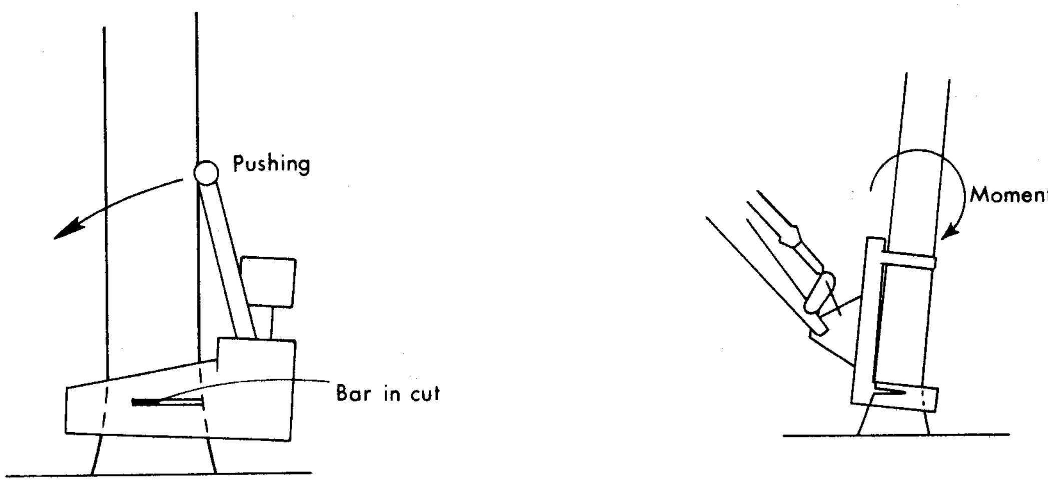


Figure Q. Opening the kerf. Types C and D machine.

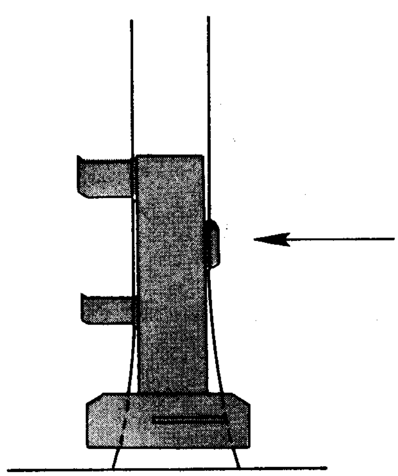


Figure R. Spencer uses middle grab arm to open kerf. Other grab arms stay open during cut.

Several machines, like the Kockums and the Spencer, use a follow-up wedge to prevent the kerf from closing (Figure M). The wedge in itself is not strong enough and does not have enough push behind it to force the kerf open. It also gets pinched if the kerf is not opened by other means. A very interesting solution is that used by the Dag (Figure N). It combines the wedge and the bar; the kerf is automatically opened, provided enough push is applied to the bar-wedge assembly. The back of the chain is also protected and cannot get pinched. With this configuration, the amount of force applied to open the kerf is determined by the angle of the wedge and is independent of the operator's judgement. Our test on the Dag has shown that an angle of about 3.5 degrees does not produce excessive damage.

Most of the other machines require operator input and judgement to open the kerf. Depending on the type of cutting pattern defined in Figure I, different actions are necessary to open the kerf. With machines of type A, the head has to be tilted sidways to free the chain (Figure O); with the Kockums (type B) the tree must be pulled towards the machine, as shown in Figure P; with the NW/FERIC FD (type C) the operator has to push the tree away from the machine to free the bar (Figure Q); the same is true of the Denis (type D).

It appears to be easier for the operator to gauge how much he deflects the tree with type A machines, since the movement of the tree is perpendicular to his line of sight. This is accomplished on the Spencer head by using the middle grab arm as a finely controlled pusher (Figure R), the other grab arm remaining open during the cutting cycle.

Keeping the kerf open usually requires applying loads to the tree in the direction that is most sensitive to splitting. Most machines leave that action up to the machine operator who has difficulties in judging how much push is required and usually ends up over-pushing the tree. This is a major cause of damage.

Several solutions to this problem are possible:

1. Use of cutters that are very insensitive to binding, such as the Harricana circular saw or the Auger.

2. Use a combination cutter and wedge (such as for the Dag) that eliminates the need for operator's input.

3. Encircle the butt of the log and apply enough clamping force to prevent the butt from splitting. (FERIC is presently experimenting with this idea on small log samples.)

4. Apply the moment necessary to open the kerf in such a way that

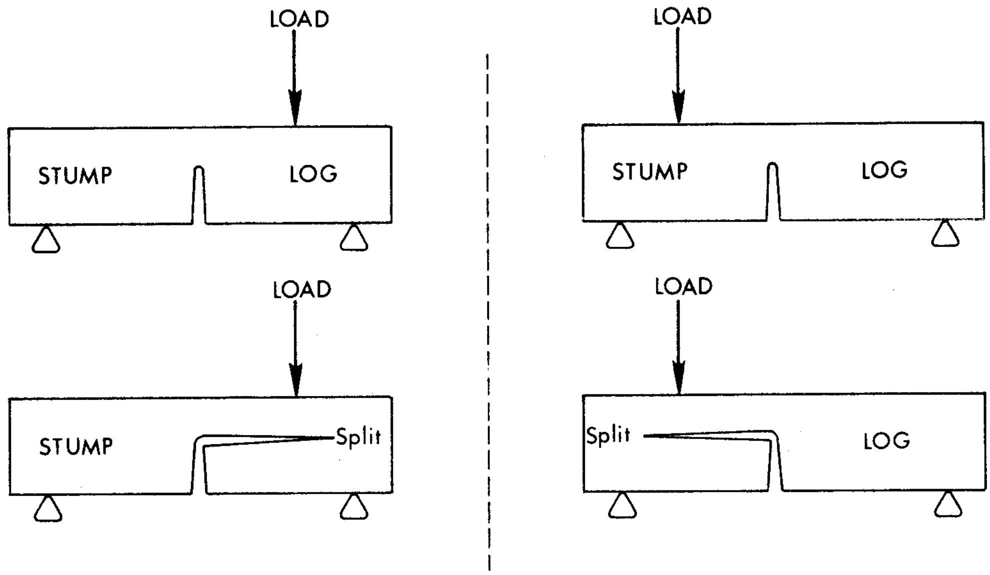


Figure S. The direction of splitting depends on how the load is applied to open the kerf.

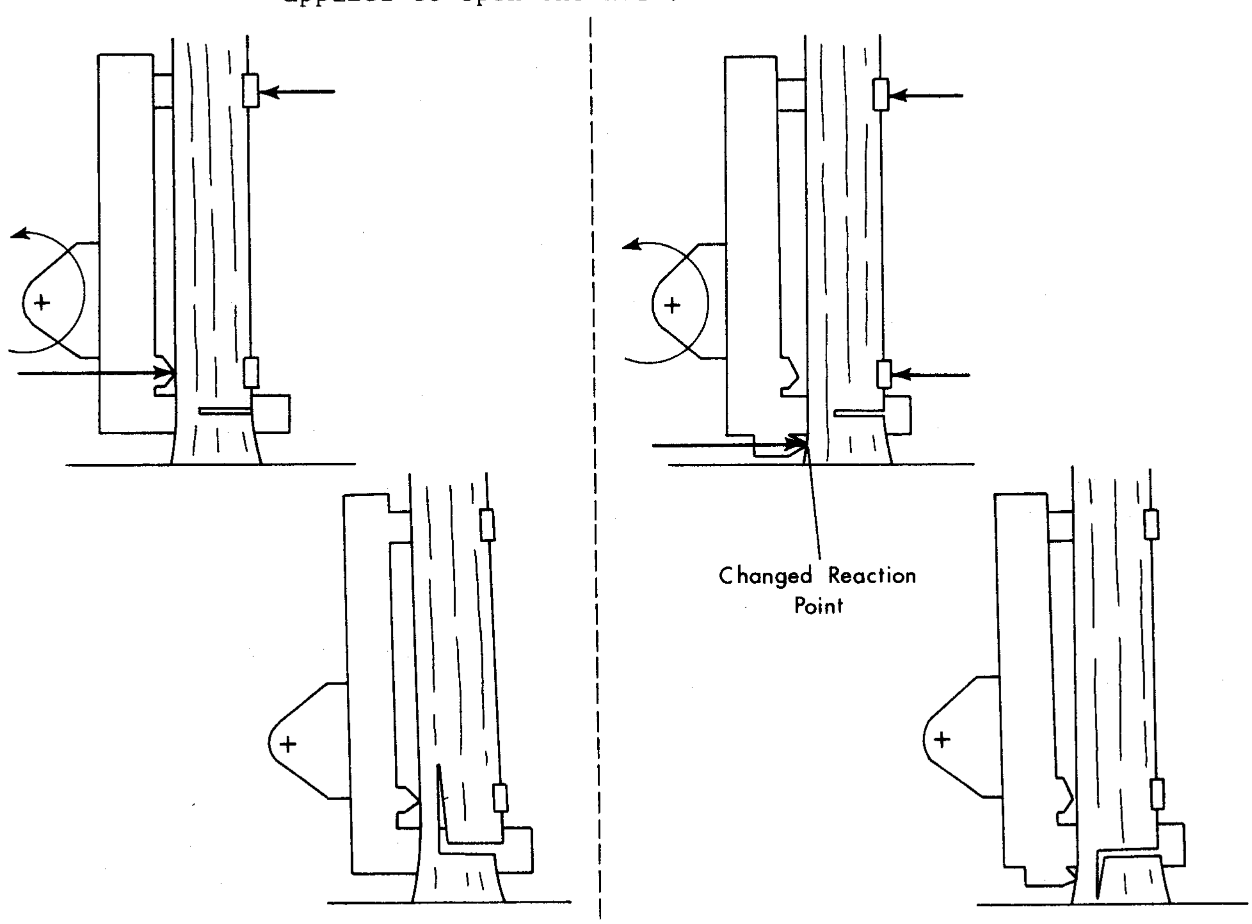


Figure T. Moment applied by the Kockums to open the kerf tends to split the log. Proposed modification would tend to split the stump.

the barberchairing takes place in the stump rather than in the butt log. Figure S shows a simple example of how a barberchair-type of split can be created to the left or the right of a notched beam. The same general idea can be used to barberchair the stump rather than the butt log. Most feller bunchers tend to split the butt log rather than the stump when a bending moment is applied to open the kerf. As an example, the Kockums is shown in Figure T. By changing the position of reaction points on the Kockums, the same moment applied to open the kerf would tend to split the stump. This idea will be tried in the field in the near future.

SUPPORTING THE TREE WEIGHT

The weight of the tree is supported by the holding wood until the tree is completely cut. It then tends to crush the cutter between the butt log and the stump.

The Drott, Dika, Harricana, Dag and QM Shear have support plates or bars strong enough to support the weight of the tree.

On the Kockums and the Spencer, the follow-up wedge is useful to protect the chain from being crushed but cannot support the weight of large trees (Figure M). The other machines have to rely entirely on the grab arms and the head structure to support the tree weight. Very often spikes are added to the grab arms and tower to prevent the tree from sliding down. This need to grab the tree results in stresses and therefore damage.

HOLDING THE TREE

Grabbing the tree (or pushing in the case of a feller director) can be done before or after the tree is cut. The machines in Table 2 that do not grab the tree before cutting is completed produce by far the least damage. They are: the Spencer, the two Harricanas and the Dag.

All the other non-shear machines hold the tree firmly with the grab arms before cutting starts (the NW/FERIC FD pushes the tree during the cut to keep the kerf open). As a result, most trees end up being bent and pre-stressed by the grab arms and splitting occurs during cutting. Damage level can be reduced greatly by postponing grab arm closure until after the tree is cut, or holding the tree in such a way that the tree is not stressed. This is more easily said than done because for most machines the grab arms are required to either keep the kerf open or to prevent the weight of the tree from crushing the cutting device. Future feller bunchers should avoid holding the tree before cutting starts.

CONCLUSION

The five basic work elements of the felling cycle are performed in many different ways by the various machine styles, some resulting in minimum damage, others in greater damage. Efforts to improve existing felling machines and to develop new ones will undoubtedly continue. Reduced butt damage will be one of the targets. The machine designer can learn from this multiplicity of solutions and integrate the best features from each style in a new design or in improvement of an existing machine.

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