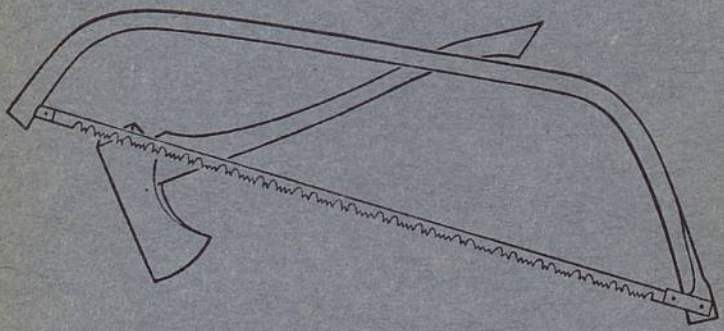
FORESTRY COMMISSION

BOOKLET No. 9

Felling and Converting Thinnings by Hand

By R. E. CROWTHER AND I. TOULMIN-ROTHE



EDINBURGH

HER MAJESTY'S STATIONERY OFFICE

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FELLING AND CONVERTING THINNINGS BY HAND

I. INTRODUCTION

The Work Study Section of the Forestry Commission has now (1963) been working on production operations for six years and this is a record of sound working methods observed during this period. The credit for developing these methods is due to Forest Workers and Foresters in various parts of the country and the authors have selected for description those methods that give maximum output with minimum effort and are basically safe.

It is hoped that it will serve as a handbook for the Forester or Head Woodman who is about to commence first thinnings in a young forest and is faced with the problem of introducing sound methods to a labour force inexperienced in this work; figures showing the output that can be achieved by the average man are included.

Mechanisation in forestry is far less highly developed than in other industries and because of the wide variations in conditions and extended nature of the work, many operations are difficult to mechanise efficiently. It is most important to have a basis of good hand work against which mechanised developments can be compared, quite apart from the fact that small-scale work is unlikely ever to be completely mechanised. No excuse is therefore necessary for writing about hand work in this mechanised age.

The power saw is rapidly coming into use in British forests following the pattern of Scandinavia and America, where nearly all men engaged on felling and crosscutting now use these machines. On larger trees and where one saw can serve a team of men, the power saw can achieve worthwhile savings over hand work, but at present-day costs it is very doubtful whether power saws are an economic proposition for one-man felling of small first thinnings.

The responsibility for ensuring that good working methods are used is fundamentally that of management. If forest workers do not know or practise good methods, then training will be necessary, but provided the forest worker is skilled and accustomed to his work the responsibility for using his repertoire of good methods

should be devolved upon him. This is usually done by applying an incentive scheme, and in forestry in this country piecework systems based on output are widely used.

1. The Principle of One-man Working

One of the main foundations of a good working method is for one man to carry out all the operations on one tree (1). This one-man work is emphasised because:

(a) It gives room for each worker, without other team members getting in his way.

(b) It enables each man to assess his own performance.

(c) It avoids delays caused by waiting for other workers to complete parts of the operation.

(d) It avoids multiplication of unproductive elements such as walking between trees.

(e) It is easier for one man to develop a logical pattern and rhythm to his work, than it is for a team to fit in with each other.

The ideal of one-man working has to be modified in practice for several reasons:

(a) Parts of some operations may be physically impossible for one man to accomplish on his own.

(b) Safety dictates that it is undesirable for one man to work completely isolated from his workmates.

(c) For management reasons (e.g. supervision, transport to work, control of output and reduction of work in progress) it will be undesirable to have the labour force working completely as individuals.

None of these points really detract from the general principle that each portion of a task should be performed by one man. He may be a member of a team producing a finished product on roadside but the various tasks should, whenever possible, be carried out by one man.

For example small trees should be sawn by one man using a suitable one-man saw. If a two-man saw is used for this purpose time is lost, because two men have to walk to each tree and often one waits whilst the other clears the brash round the tree. Similarly two men should never sned the same fallen tree, because time will be lost by each man having to "break his own way" into the crown, and one man will inevitably finish before the other and have to

wait to turn the tree. Quite apart from lost time and wasted effort it is dangerous for two men using axes to work close together.

2. Safety

Where appropriate, attention is drawn to safety in the main body of the text, but it is convenient to look at it in more general terms here.

Logging (i.e. felling, extraction and conversion) is recognised in other countries as being the most dangerous part of forest work and this is confirmed from Forestry Commission figures which show 40% of the accidents in 1957 were associated with these operations, although these same jobs accounted for only 25% of the total wages bill. All accidents do not result in the same loss of time or other serious effects. Cuts from edge tools are the most frequent in logging, but a high proportion of accidents happen when actually handling trees and logs. As these handling accidents commonly cause strains or sprains, they usually lead to longer periods of lost time.

Safety in the use of hand tools can be improved by the following:
(a) **Tools of right design for the job.** Forestry Commission figures show that the billhook is the tool most frequently associated with accidents. The replacement of billhooks for snedding by light axes, with shafts of the correct length, is one illustration of the way in which selection of the right tool for the job can make the job safer.
(b) **Correct Maintenance.** A blunt-edged tool can be more dangerous than a sharp one, because it is more likely to bounce from a cut. Correct shafting is essential.
(c) **Training.** Training in the use of edge tools, so that safe practices become a habit, is important. Correct positioning of the body when lifting is another aspect.
(d) **Methods.** Good methods are safe methods. The worker must have the right tools for the job and know how to use them. Awkward or large trees are encountered in every crop, and a man should have someone else working nearby so that he can give assistance in such cases. This is also a reasonable precaution to take in case an accident does occur.

Though responsibility for safety is a joint one between management and man, the major portion rests with management who can do much to promote safety on the lines indicated above. Management must also be responsible for facilities in case of accident, ranging from provision of first-aid kits at the site (which is obligatory by law) to provision of transport in case of emergency and facilities for workers and staff to attend first aid classes.

II. FACTORS AFFECTING METHODS

A. CROP AND SITE FACTORS

It is convenient when discussing felling methods to look at the broader questions of the felling direction, both of individual trees and the general direction of working, and the factors that control them, before looking at the detailed methods associated with the way various parts of the job are performed.

In work so varied as thinning there can be no universal *best* methods but only *good* methods. Sound principles can however be recognised that are modified and adapted to suit varying conditions. The three major factors that affect methods are size of pole, the crown density and the steepness of slope, and these can be classified as follows:

Size of Pole — (a) First Thinnings.
(b) Second Thinnings and subsequent ones.

Crown Density — (a) Free.
(b) Tight.

Slope — (a) Gentle.
(b) Steep.

"Size of pole" and "slope" are self-explanatory.

Crown density is dependent on species and the relationship between height and stocking; thus it affects the ease with which trees can be brought to the ground. Sitka spruce is the most difficult and the larches the easiest, with Norway spruce, Douglas fir and other conifers lying between these two extremes. A delayed thinning, even in larch, may give trouble, whilst delayed first thinnings in Sitka spruce present great difficulties that can only be overcome by use of special techniques (e.g. rope and hook).

It is possible to arrange the above six categories into eight permutations as follows:

First thinning, free crown, gentle slope.
First thinning, free crown, steep slope.
First thinning, tight crown, gentle slope,
and so on.

But for purposes of description of methods this can be reduced to four, by considering first the effect of pole size.

Size of pole governs the team size, and broadly speaking thinnings, in which the average volume does not normally exceed two hoppus feet, can and should be worked by one man alone. The exception to this rule is first thinnings that are so tight in the crown (usually because thinning has been delayed) that one man cannot bring the trees to the ground, so this becomes a job for a two-man team.

Second and subsequent thinnings include an increasing proportion of trees that are too large for the one-man bow saw, so a two-man crosscut saw is necessary.

The four remaining combinations of crown density and slope and their effect on felling methods are discussed below.

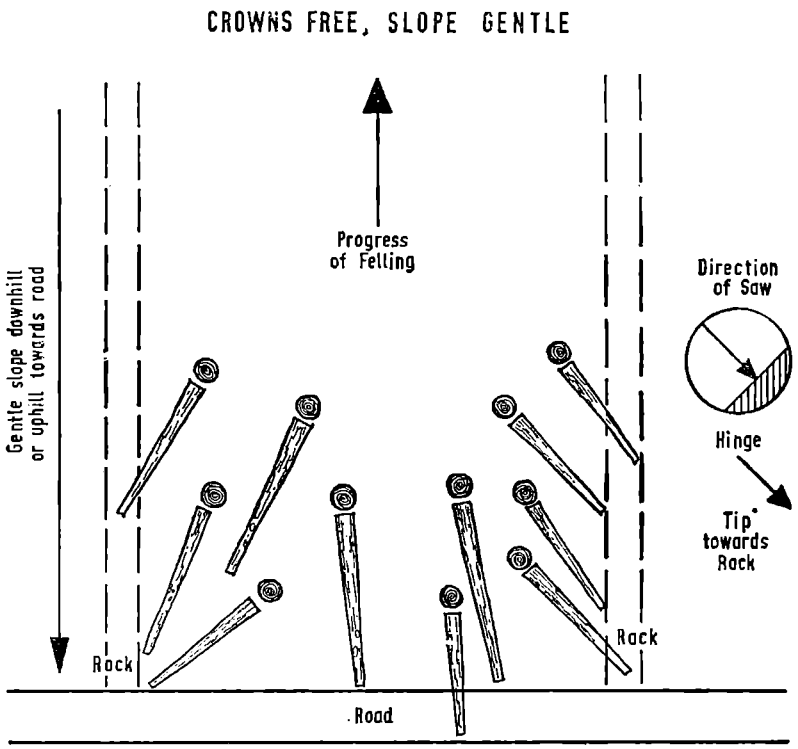

FIG. 1. Felling method where crowns are free and slope gentle. Extraction will be through the thinned crop, but brash and tops will be little encumbrance in these conditions.

1. **Crowns Free, Slope Gentle.** See Figure 1.

Here neither crown density nor slope has a strong influence on felling direction, so extraction direction must be allowed to take priority and trees should be felled towards the extraction track. If hand extraction follows after conversion at stump, then trees felled with their *tips* in the direction of extraction have already been moved one step in the right direction. Normally felling will commence at the road and progress inwards from there.

If hand or horse extraction of poles is to take place *butt*-first, then felling direction will be as in Figure 2.

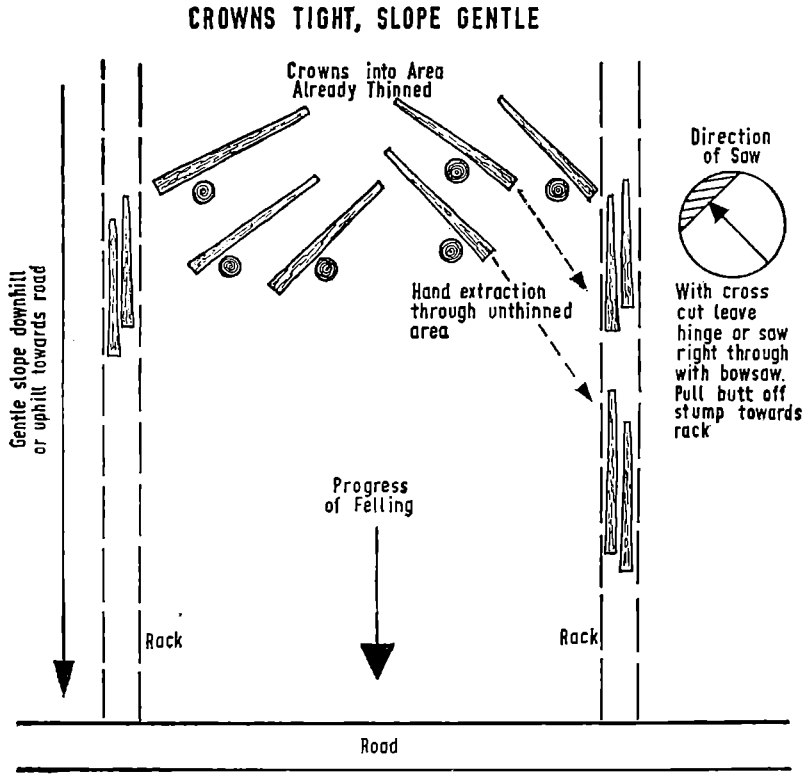

FIG. 2. Felling method when crowns are tight and slope is gentle. Simultaneous hand extraction will be through the unthinned, but brash-free, part of the stand.

2. **Crowns Tight, Slope Gentle.** See Figure 2.

Here felling should be into the area already thinned, where the canopy has been broken, thus easing the problem of bringing the tree to the ground, and felling should progress towards the road. If hand extraction follows, it is also made easier by the butt being pulled in the direction of extraction whilst bringing the tree to the ground, and through the absence of lop-and-top in the unthinned area. In this case horse dragging has to be butt-first.

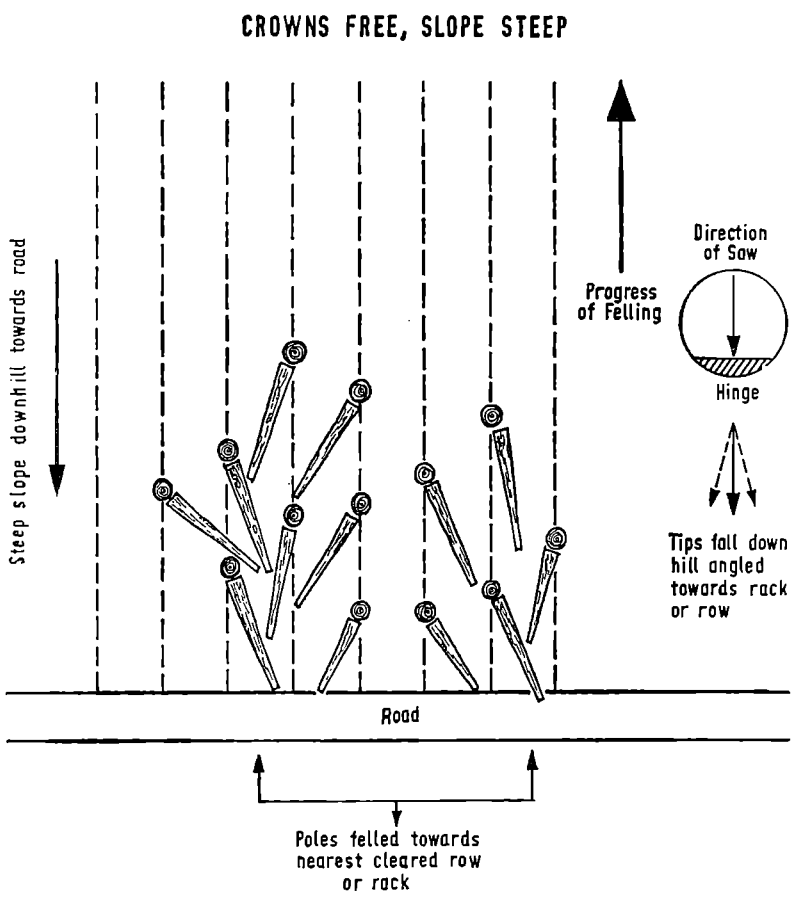

FIG. 3. Felling method when crowns are free and slope steep.

3. **Crowns Free, Slope Steep.** See Figure 3.

On steep slopes (say over 20 degrees) trees tend to have their heaviest branches on the downhill side and to lean that way; in addition pushing a tree from the downhill side is difficult and dangerous. These two points, coupled with the fact that trees felled uphill are very fatiguing to sned, because each axe stroke has to be directed uphill, dictate the normal practice of felling tips downhill on steep slopes. Work should commence at the bottom of the hill and progress upwards; trees then fall easily into the area already thinned. From the safety point of view this method is sound, because the man is on the uphill side of the tree when it falls and he is out

of danger should it "break away" down the hill. (There may be some risk of broken stems in large timber in clear falls and late thinnings).

Extraction by hand or horse, across the slope, is not feasible, so the felling direction is tip downhill, with a slight variation to bring trees into racks (or selected cleared rows if the original planting rows are straight up and down the slope).

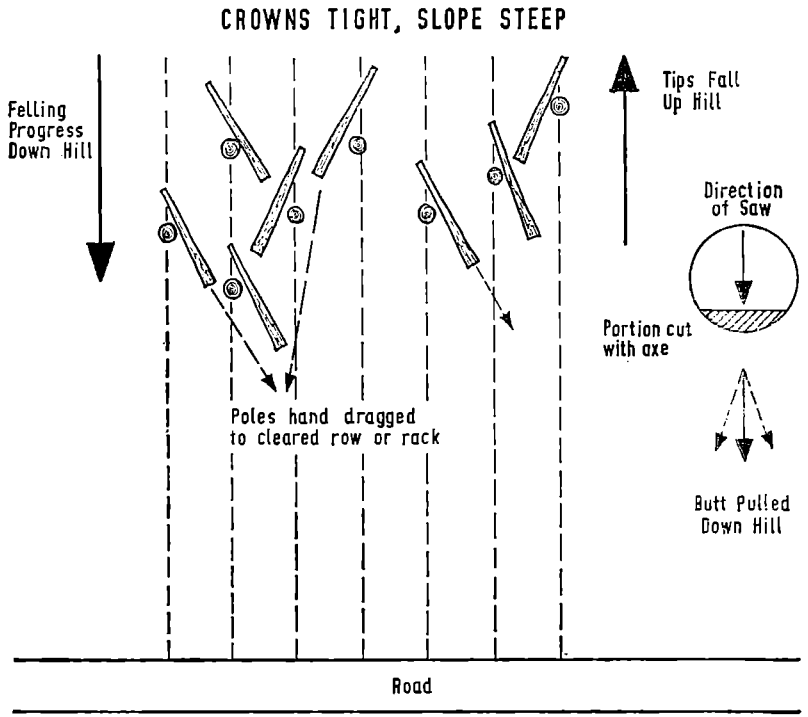

FIG. 4. Felling method when crowns are tight and slope is steep.

4. **Crowns Tight, Slope Steep.** See Figure 4.

In this case the difficulty of bringing the tree to the ground has to override the disadvantage of snedding uphill; it is extremely difficult to pull the butt of a tree uphill on a steep slope, and it therefore has to be taken downhill. Felling should commence at the top of the hill, and should work downwards to take advantage of the broken canopy.

B. EFFECT OF OTHER WORK

1. Peeling and Crosscutting

In the broad sense in which we are discussing methods, the addition of peeling and crosscutting to the feller's task does not require a radical alteration in methods; so their introduction can be covered by the general principle that all operations on one tree should be completed before commencing the next. Peeling and crosscutting should however be avoided on very steep slopes, because peeled poles tend to run away and extraction of short lengths is difficult. Longer poles, whose length makes extraction awkward, should be crosscut to remove a timber length.

2. Stump Creosoting

Where creosoting of stumps is necessary as a protective measure against the fungus *Fomes annosus* (3), this must take place immediately after felling, as any delays allow spores to be drawn into the wood and sealed in by resin so that the creosote cannot reach them. This means that in any felling method, which leaves trees standing whilst a batch is sawn, the trees must be pulled off the stump and the stump must be creosoted as soon as it has been sawn.

Creosoting is today an essential part of the work of thinning in many areas, but as an addition to traditional methods it is unpopular because its smell clings to clothes and contact with the skin can cause smarting particularly in warm weather. Work is in progress to try to find an alternative to creosote.

III. METHODS

A. ONE-MAN WORKING.

If there is more than one man in the gang, each man should work separately, but close enough (for example six rows apart) to render assistance if required.

1. Tools:

Bowsaw 36-inch tapered back.
,, blade, raker tooth.
Trimming axe, $3\frac{1}{4}$ lb.
Creosote can, 1 gallon with spout.
,, brush, short handled.
Felling tongs, long-handled—if required.

2. **Conditions:**

For small poles with butt diameter generally under 8 inch (5 inch breast-height quarter-girth).

3. **Method Summary:**

(1) Walk to tree—clear brash.
(2) Saw.
(3) Pull off stump.
(4) Creosote.
(5) Take down.
(6) Sned (including turning).

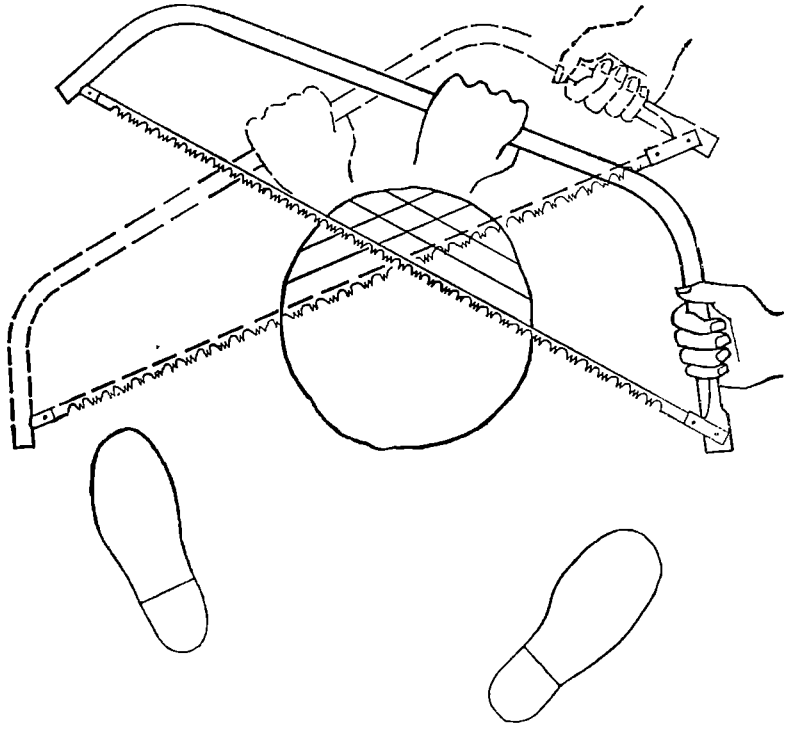

FIG. 5. Rocking motion of the saw leads to more rapid cutting.

4. **Method Description.** See Figure 6.

(a) The feller carries the tools to the first tree and places them within easy reach; he removes branches with the axe, clears brash that is in the way of the saw, and does any necessary axe work on the butt.

(b) He stands on the low side of the tree, sawing towards himself and keeping the cut low and square to the pole; he saws right through the tree by speeding up the last two or three strokes. See Figure 5.

(c) The tree is pulled off the stump over the saw blade, and the saw is removed and thrown to the next tree.

(d) The stump is creosoted and the can and brush placed to one side.

(e) The tree is taken down by sliding the butt, or pulling down by stem or branches, according to circumstances; the axe is carefully thrown to the point where snedding will commence.

(f) Snedding starts at the butt of the tree, and when the tip has been cut off at the desired top diameter the pole can usually be turned from the top; completion of the snedding then proceeds from tip to butt. When trimming is completed, the pole is hand-extracted and the axe and creosote equipment are then carried to the next tree.

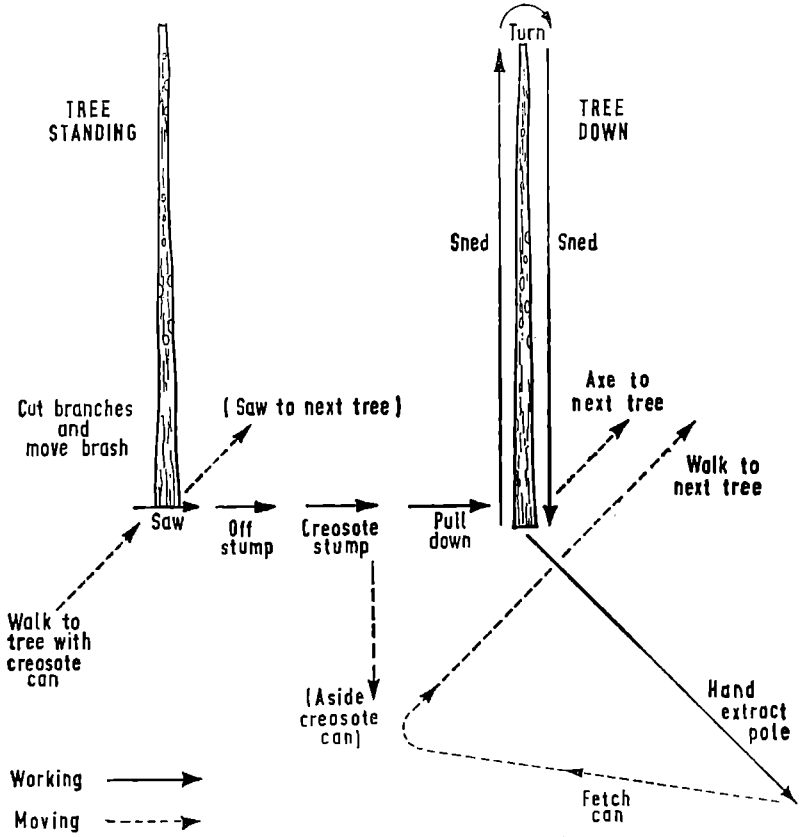

FIG. 6. One-man felling method.

5. Modifications to Method

(a) **On very steep slopes**, a sloping cut may be made to give a low stump, as the hillside prevents the bow saw from working horizontally (see Figure 7); this method is better than sawing from the low side of the tree, which gives a very awkward working position. The resulting pointed butt will have to be squared if pitwood is being produced.

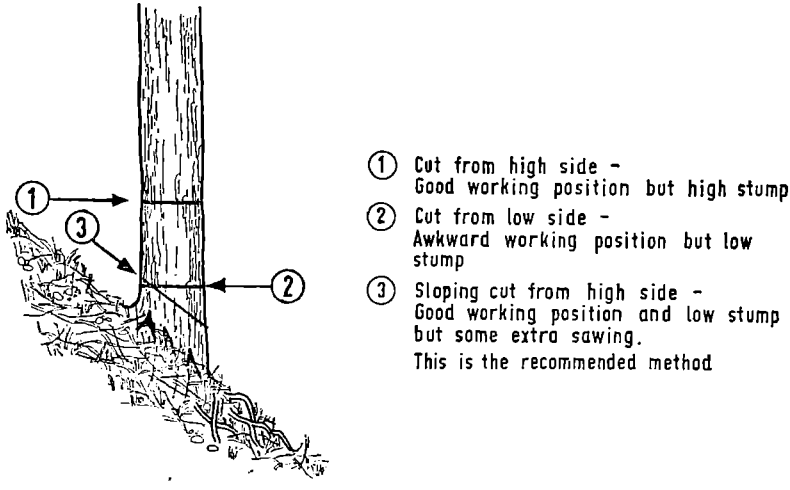

FIG. 7. Possible ways of cutting a tree with a bow saw on a steep slope.

(b) **Close Control of Felling Direction.** Usually in first thinnings the crowns are tight, and the trees are small enough to make the complete sawing-through quite satisfactory; but occasionally larger trees will be encountered, or the crop becomes more open, making control of felling direction difficult by this method. In such cases only about 4/5ths of the diameter should be cut, leaving enough to keep the tree upright; this unsawn portion is cut with the axe before pushing it in the fall line.

(c) **Aid to Turning Larger Trees.** During snedding, two convenient branches should be cut, six inches to nine inches from the stem on the underside, to form handles for turning.

(d) **Butt-first Extraction.** Fellers will usually prefer to fell so that the tip falls straight or diagonally downhill, as this facilitates trimming. In this case, work will proceed from the bottom of the hill upwards. But felling "tip-up-the-hill" may be specified for butt-first extraction (e.g. by sledge), or because of the difficulty of taking down. In this case work will proceed from the top of the hill downwards.

PLATE I

The easiest position. The stroke is made from an upright stance with feet apart on a line parallel to the tree. Axe shaft continues line of arms.

PLATE II

Knees are bent and right hand lowered so that axe shaft becomes nearly parallel to the ground; the axe head may be even higher than the hands for some branches. The axe shaft will make an angle with line of arms.

PLATE III

Here the man leans over the tree so that his shoulders are above the cut. Elbows are bent and the shaft held nearer the head. It is difficult to develop a powerful stroke in this position and care is needed because the tree trunk affords no protection. See also Plate VI following.

PLATE IV Felling with the one-man bowsaw.

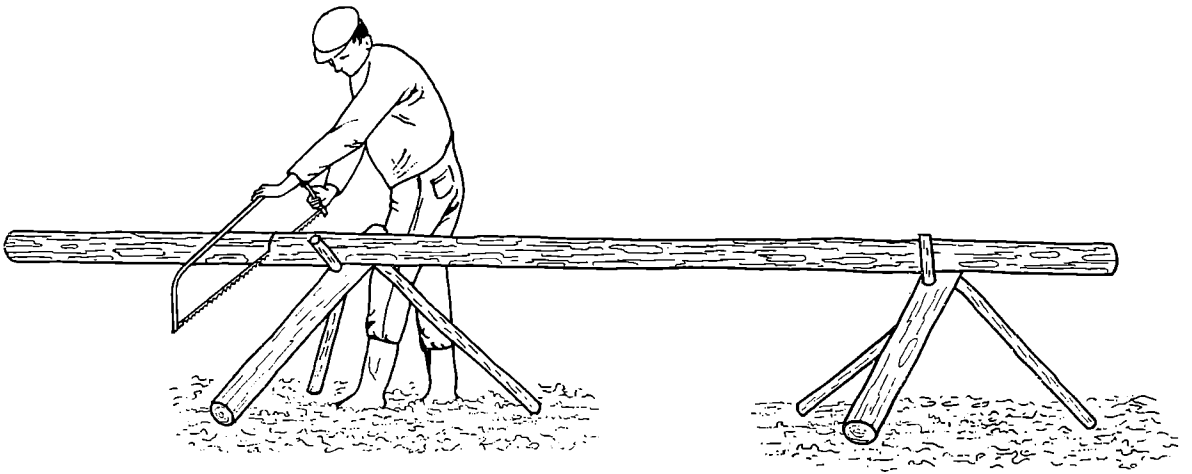

PLATE V Crosscutting a pole supported on saw-horses.

PLATE VI

When branches on the feller's side of the tree have been cut it is then possible to lean over and remove those on the opposite side. The axe is supported in a near-vertical position by the right hand and the elbow is bent; movement is imparted by the left hand.

6. Aiding Extraction

With poles of this size, hand extraction into suitable sized stacks is desirable at time of felling. The feller should plan his work so that after completing four or five trees they may be drawn together with little trouble into a 'tush' of about 10 hoppus feet. Small poles should be drawn towards the larger ones, all lying in the extraction line. With butt-first extraction, poles should be laid on a "stringer" (tip of pole), with their butts neatly together, extending beyond the stringer by about two feet.

Defined extraction routes must be kept clear of brash; this should also be considered by the feller as he decides the direction of fall of each tree.

B. TWO-MAN WORKING

1. Tools

Raker tooth crosscut saw, length 4 ft. 6 in. to 5 ft. 6 in. as suitable.
Trimming axes, 3½ lb.
Felling wedge.
Creosote can and brush.
Canthook.
or Felling tongs (for suitable-sized poles).

2. Conditions

Crops of larger trees not suitable for one-man felling, because of the difficulties of single-handed sawing or take-down.

3. Method Summary

Team Work

Man A.	*Man B.*
(1) Walk to next tree	(1) Creosote last stump
(2) Prepare next tree	(2) Walk
(3) Saw together	
(4) Axe off	(4) Push
(5) Pull off stump together or Take down together	

This sequence (1-5) is repeated for a number of times.

Individual work

Take down (if not completed).
Sned, including turning, peeling and hand extraction.

4. Method description

Felling large trees requires a greater degree of judgment than in smaller crops, so a regular pattern of working cannot be so closely adhered to. With two-man working it is most important that unnecessary work should be avoided (e.g. laying-in with the axe when the tree will not fall freely), and that no work that could be left for one-man alone is done by the pair together.

One man carries the crosscut saw and an axe, his mate carries a canthook and the creosote equipment. Brash is cleared as necessary from the base of the tree, and the tree is sawn, both men standing on the low side. When about four-fifths has been sawn, one man pushes the tree whilst the saw is withdrawn. While the tree is still upright, the butt is axed off, and the tree pushed or pulled into the fall-line. The butt is then pulled or levered off the stump, and whilst this stump is creosoted, the other man moves off to prepare the next tree. This process is repeated for a suitable sized batch (say one quarter of a day's work), and the men then separate to take down and sned individually.

Time may sometimes be saved by leaving the trees hanging up after sawing, provided that they may be easily taken down by the snedder and the wind is not too strong. If the trees of a batch were all brought to the ground at once their crowns would meet and snedding be greatly hindered. Left hanging they are brought down one at a time, thus falling on top of the brash cut from earlier ones. In windy weather trees will have to be brought to the ground as they are sawn, otherwise there is a danger of their falling in the wrong direction or splitting. This means that either a small batch has to be worked, or else a wide front has to be taken if a congested working space is to be avoided.

5. Modifications to Method

(a) **Large trees.** If the crop consists of large trees which require laying-in as well as undercutting, the axe-work is best performed in a separate operation, each man preparing half the batch to be sawn. With the "tip uphill" felling method, only used when trees are exceptionally difficult to take down, the sawing position and direction are as described above, and the saw is withdrawn leaving enough wood uncut to hold the tree upright. This remaining portion does not act as a hinge in this case, and it is cut with the axe before both men pull and lever the butt downhill (see Figure 4).

This method is obviously not practicable with very large trees, which must be sawn uphill in the fall-line in the more conventional

manner, but such trees do not occur often in a crop in which tip-down felling is impracticable. The canthook is the best tool for taking down these larger sized trees, whatever the direction of fall may be.

(b) **Trees Free-falling.** When trees are free-falling, precautions must be taken against splitting of the stem. With small trees, this may often be achieved by sawing quickly as the tree falls, only the bark strip being split. But with larger trees an undercut is required. The saw can be used for the sole of the notch, but the axe is more efficient for the other cuts. A reasonable size of batch for sawing is still possible in free-falling crops, by working on a broad front as for a clear-fall. This is more efficient than working on a narrow front, where either the trees are felled on top of one another, or very small batches have to be taken.

IV. TOOLS, MAINTENANCE AND TECHNIQUES

A. FELLING

1. The Axe

(a) **Specification.** Before considering the type of axe required we need to look at the work it has to do. The axe is the feller's most important tool because he uses it up to 80% of his working time; it is therefore most important that it should be of the right type for the job, well maintained and correctly used. In coniferous thinnings the main work with the axe is snedding (trimming). Laying-in is rarely necessary and even then takes only a fraction of the time, while cutting off the top is usually a matter of only one or two strokes. The main function of the axe is therefore to cut large numbers of small branches from the stem. Frequent, light, accurate strokes are essential and each branch should be cut flush with the stem with one stroke. Sufficient momentum can be achieved to make the cut either by a heavy axe moving relatively slowly or by a light axe moving fast. From a mechanical point of view the amount of work is the same in both cases. With the heavy axe more work is required on the return stroke in lifting it and, once lifted, gravity helps to impart sufficient momentum. The light axe is easier to lift but momentum has to be imparted by applying a greater force on the downward stroke. The big disadvantage of the heavy axe is the weight that has to be carried. Although in the mechanical sense no work is done by a man supporting a weight, in fact sustaining a static load is extremely fatiguing because the

muscles have no opportunity to relax; this is especially true of the hand muscles. The heavy axe has been evolved in Britain over centuries for felling larger timber especially in hardwoods, where laying-in is important and large branches are encountered; here a maximum momentum to achieve a depth of cut at each stroke is valuable. When cutting small branches this maximum momentum is never required and hence the feller is carrying extra axe weight all day that he never needs to use. This briefly is the reason why light axes ($1\frac{1}{2}$-$2\frac{1}{2}$ lb.) are used in Scandinavia and why the 3 lb. axe is becoming popular in this country.

Shaft length too is dependent on the type of work (and the size of man using it); while a 36″ shaft is desirable for laying-in where the vertical cut is important, this length is an encumbrance when snedding. Many fellers have for years shortened the traditional shaft length by cutting off 6 inches from the end, but this is not a satisfactory solution because a shaft without a fawn foot will slip out of the hands in wet weather.

For snedding then the best axe is a light one (say 3 lbs. or even less) with a shaft of 26 to 28 inches to suit the physique of the man using it. There are two main shapes of axe readily available, the 'wedge' and the 'English'. The latter gives a longer edge for the same weight whilst the wedge axe has a thicker shoulder. Choice of shape depends on personal preference.

(b) **Maintenance.** To be safe and fully effective the axe must be sharp and properly shafted. Warped or cracked shafts are dangerous and should be replaced; this is a job that can only be done efficiently in a workshop where a bench, vice and axe drift, spare shafts and baked hardwood wedges, are available. In the forest a loose axe head can often be tightened by leaving it in water overnight.

The axe should be sharpened twice a day with the whetstone, or combination axe stone, and periodically it will be necessary to reduce the shoulder by grindstone or file; care must be taken when this is done and axes properly finished with whetstone before use.

The edge must be sharp and unbroken and the thickness of the shoulder not reduced below the maker's specification. For difficult cutting (e.g. Sitka spruce) where the edge may turn and chip it should be strengthened in the following way:

Use the coarse side of the combination stone to eliminate any flaws and bring to an edge, then use the fine side, giving a good polish and even taper. This is as for conventional sharpening. Finally working only on the extreme edge, alter the angle of the stone and make a few strokes with the fine side, cutting diagonally in towards the edge on both sides. This will give a slight chisel effect, which should be visible only by a slight change in the "light"

surface, and though the effect on the edge is apparently very small it is greatly strengthened and should work equally efficiently without fear of damage.

Axes should be protected from hard frost; in very cold weather always warm the axe head before use; sharpening will protect the edge.

The face of the shaft at the head should be protected from wear, a tin shield lightly tacked on is the most effective. Axe-guards should be used when axes are carried any distance away from the work site and particularly on vehicles.

(c) **Technique.** Good axemanship has to be learnt by experience and practice which alone can develop accuracy. The following are a number of useful points to bear in mind.

From the safety point of view there are four rules (2):

1. Always make sure there is a clear path for the axe; even a small twig can deflect the axe and cause injury.
2. Never stand astride a tree and use an axe.
3. Always stand so that the impact is made beyond the legs so if the axe bounces from the cut it will not cause injury.
4. Never stand behind another man using an axe.

The learner, until he has developed accuracy, should always place the stem between himself and the cut; this means frequent crossing from one side of the pole to the other. But with experience a man learns always to make the point of impact beyond his legs, and he can then safely work from one side of the tree.

The correct grip for a stroke originating over the left shoulder is for the right hand to hold the shaft end, with the left just above it nearer the axe head. The return stroke is made by moving the left hand nearer the head to help lift it. Hand positions are reversed for a stroke originating over the right shoulder.

For much snedding work, a full swing as described above will not be necessary; the grip however remains the same but is lower down the shaft, and there is then no need to move the lower hand for the return stroke.

Where branches are small and numerous, light axes can be used single-handed, the other hand being used to hold branches aside whilst they are cut.

For each stroke:

(i) Decide point of cut
(ii) Adjust feet position } whilst lifting axe.
(iii) Keeping eye on point of cut, swing axe and make cut.

The axeman should learn a repertoire of strokes that will enable him to cut all branches except those immediately underneath the

tree. He should teach himself to swing with equal accuracy both left-handed and right-handed.

A right-handed man will find it easiest to stand on the right-hand side of the tree (looking towards the crown). The axe strokes vary with the position of the branches on the circumference of the trunk and the main strokes are illustrated in Plates I, II, III, and VI of the central inset.

2. The Saw

(a) **Specification.** The standard tool for felling smaller thinnings should be the one-man bowsaw seen in use in Plate IV. This has a tapered back which eases control by one man. The blade for felling should be a raker-tooth type, because the grain in a root buttress runs at a shallow angle across the cut; a raker-tooth clears this effectively while a peg-tooth cannot. The hardpoint blades which retain their edge for several weeks' work are cheaper than conventional blades, because of reduced maintenance. On thinnings which are too large for the one-man bowsaw, there are the following alternatives:

(i) **The One-man Crosscut Saw,** which is the traditional tool for felling in Scandinavia, has not been adopted in this country, probably because the necessity for one-man working on large trees has not been dictated by other factors such as difficulty in finding a partner near isolated small-holdings. The one-man crosscut is a difficult tool to use effectively, and with the advent of the chain saw it is not likely to be generally adopted. It is very useful however in windblows too large for bowsaws, where the second man on a crosscut may have difficulty in finding room to work.

(ii) **Large Bowsaw.** This tool can be used effectively by two men for felling, but has the disadvantage that the size of tree that can be tackled is limited by the bow, and there is a tendency for the saw to "run," i.e. to make a curved cut. This is a useful tool for crops of a size which it can tackle, but often the feller will have to have a crosscut available for occasional large trees or variations in the crop. It takes a standard hardpoint blade so maintenance is simple.

(iii) **The Two-man Crosscut.** This is the traditional tool for larger trees. There are no limits, virtually, to the size of tree it can tackle and its speed of cutting is fast provided it is properly maintained. Its main disadvantage is that it requires careful sharpening and setting, and periodically this job must be done under workshop conditions with the correct adjusting tools and gauges.

(iv) **Chain Saws.** These are rapidly replacing the two-man crosscut on larger trees where they can save effort, time and money; their economic justification on small trees as an alternative to the bowsaws is less certain.

(b) **Maintenance.** Frames should have tension released when not in use. They should be wiped with oily rag as frequently as possible, and moving parts must be well oiled. Where possible they should be hung up at night under cover.

Blades should also be oiled frequently. Hardpoint blades can be touched up when they become dull by running the whetstone once lightly on each side, the stone being held flat against the blade.

If a blade shows a tendency to "run," the blade should first be reversed in the frame; if this is ineffective, the set on the "gaining" side should be adjusted with the whetstone, as for sharpening. Setting of the blades may sometimes be necessary; for this the special setting pliers should be used, the best set being the smallest possible one that gives clearance for the saw blade in the cut.

Sharpenable blades must be sharpened regularly. Raker-toothed types must have rakers adjusted at every sharpening, but setting may be required less frequently. Buckling of the blades should be avoided if possible, as such blades cannot be of further use. When bowsaws are transported, blades should be covered with guards or else removed from the frame and wrapped.

Crosscut saws require regular sharpening every one to three weeks, according to use. "Touching-up" is not recommended; this improves a bad saw, does nothing for a good one. Complete stripping, sharpening, and re-setting should be done each time (2 hours work), tools and saw-vice being essential. One or two saw manufacturers provide excellent leaflets on crosscut saw maintenance.

Saws should be kept well oiled and handles should be easily removable. Liberal use may be made of oiling mixture (a mixture of 7 parts paraffin, 2 parts turpentine or turpentine substitute, and 1 part lubricating oil), when trouble with resin is encountered. Saw-guards, giving adequate tooth protection, are required for transportation; wooden guards with spring clips are available for bowsaws and an effective guard for crosscuts can be made from old firehose.

(c) **Technique.** Felling with bowsaws is tiring work if a good technique is not used. A comfortable position for the body is the most important requirement. To this end, when sawing on slopes, the feet should be on the low side of the tree, the blade cutting towards the body regardless of the desired line of fall. The stance should be either with the torso leaning over the saw and one leg propped against the tree, as in Plate IV, or with the body positioned

at the side, arms in line with the cut. Sawing strokes must be easy and relaxed, using the full length of the blade, which is used in a slight rocking motion, always "cutting on a corner" (see Figure 5). The saw is pushed and pulled with one hand on the end of the frame, the other hand resting lightly on the back of the frame, keeping it in line with the blade and feeding the cut, so that equal cutting is achieved with both "push" and "pull" strokes.

In many cases the blade may be made to pass right through the tree, the butt being then pulled off the stump over the blade and the saw removed and thrown to the next tree. Where this is not feasible, particularly in "tip-down" felling, the saw is removed before the cut is completed.

3. Aids to Taking Down

Further details of various aids to taking down are given in *Aids to Handling Conifer Thinnings* (4) so they are only briefly mentioned here.

Long-handled tongs are well worthwhile in tight spruce crops of medium size (say 2 to 4 hoppus feet). Trees over this size are too heavy to allow for one man lifting at the butt end, and the canthook becomes the more useful tool. The best results are obtained by twisting the tree with the canthook, after it has been properly axed off, but whilst it is still on the stump. When trees are sawn and creosoted in batches, the worker, when snedding, has only to carry an axe, so that a canthook is no great encumbrance and is useful both in take-down and for turning during snedding. In both cases, the tree or pole should be twisted to the "easy" side.

With exceptionally difficult trees (e.g. under-thinned Sitka spruce), to fix a rope with a hook at one end twelve to fifteen feet up the tree, is a good method of pulling down.

B. PEELING

Time study shows that peeling by machine of the knife type at roadside is basically cheaper for sizes under eight inches diameter than is hand peeling. But to be efficient machine peeling must have a large enough programme to keep the machine reasonably fully employed throughout the year. There are many places where this quantity is not available, or where the only available machine cannot cope with the whole programme.

Peeling "at stump" may also be required where poles cannot be removed from the forest soon enough to prevent beetles breeding below their bark. In these circumstances hand peeling may be the better economic proposition.

Hand peeling is most efficiently carried out at stump by the feller. If it is left until extraction has taken place, the bark dries out, making the peeling more difficult. Extra work is caused by having to take poles out of stacks in order to peel them, and then by re-stacking. Hand peeling after conversion is even more inefficient because of further drying out and the additional handling of individual pieces. Its only justification might be as a job to keep men occupied under cover in wet weather.

There is a marked difference in ease of peeling between summer conditions when the cambial layer is active, and bark is easily separated, and in winter when it is not. Hard frost will freeze water in the bark making peeling even more difficult. Hand peeling is therefore cheapest in the summer and should be suspended entirely in hard frost.

1. Tools

The best tool for peeling is one of the Swedish peelers with detachable four-inch blade and a forty-inch shaft. The blade has two bevels, and is used with the large bevel upwards; the small back bevel is set to suit the man's own preference and its function is to stop the blade digging into the wood. The blade is sharpened and adjusted by using a hand carborundum stone on this small back bevel.

Peeling by the feller should form one of the sequence of operations carried out on one tree at a time.

2. Technique

The correct way to use this peeler is to stand with feet apart with toes pointing towards the tree, holding the peeler in both hands with knuckles on top. Peeling strokes should be long and sweeping, making full use of the body by turning and bending the knees; a good follow-through is essential. Small knots and irregularities will be cut through, but the feller will quickly learn to trim larger branches cleanly with the axe to facilitate peeling.

By commencing peeling about six feet from the butt, a section three-quarters of the circumference is peeled first, the peeler running off the end of the pole with each stroke. The feller then turns round and peels up the stem in the same way or, if he is not ambidextrous steps over the pole first. On reaching the tip, the pole is turned and the remaining strip of bark taken off by working back towards the butt.

A pole with a kink or curve in it should be made to lie in its

unstable position first. When three-quarters of the circumference has been peeled, a twist from the tip rolls the pole over, exposing the remaining quarter circumference for peeling. If the pole is first peeled in its natural position it becomes extremely difficult to make it stay in its unstable position once the bark has been removed.

Some strain on the back whilst peeling may be avoided by placing the pole on a simple wooden stand or horse, but this advantage of a good working height has to be weighed against the disadvantages of carrying the stand and having to lift poles. Some fellers use their axe driven into a stump as an improvised stand.

C. CROSSCUTTING

If extraction methods permit, crosscutting can be carried out by the feller at stump, immediately after he has finished snedding or peeling. If the poles are small enough for hand extraction, then it will be easier to extract the pole length to rack and convert there, rather than carry several small pieces from stump. With larger poles, crosscutting at stump will facilitate hand extraction. This pre-supposes that extraction of small pieces from the lane is feasible, e.g. by wheeled tractors; if it is not, then crosscutting will have to be postponed until the poles are extracted to roadside. Where large poles are being dealt with, the feller makes a single saw cut to remove the butt length.

Crosscutting, at ride or roadside, by circular saw or chain saw is usual, but there may be occasions (e.g. small quantities or the need to provide fellers with rideside work when trees are wet) when hand conversion is desirable.

1. Tools

The best tool for hand crosscutting is the bowsaw; this can be the same tapered-back pattern as is used for felling, but the ordinary symmetrical-back bowsaw can easily be controlled in the vertical position, and it has the advantage of a greater cutting depth.

The correct blade is the peg-tooth; it is faster than the raker-tooth for crosscutting, where the grain runs consistently at right angles across the cut; the raker-tooth saw is also difficult to start smoothly, especially on small poles. Forest maintenance for these saws is the same as when used for felling.

2. Technique

The following is a good method for cutting pitwood or pulpwood. Two saw-horses are placed strategically for each pole about seven

feet apart. The pole is then lifted from the stack, by the point, to rest on the first saw-horse at about mid-length. The heavier butt half is then levered up by bearing down on the point, the butt being then swung round on to the second saw-horse. The pole is marked in appropriate lengths using the scribe on the measuring rod and a diameter gauge where accuracy is required.

Cuts with the bowsaw are then taken from the tail end, the rod having been thrown back to the butt. The operator moves to the butt end before the pole overbalances and cuts the heavy butt length. All cuts should be made with the pole supported on *both* saw-horses, giving a firm two-handed cutting position. No more than one cut need be taken between the saw-horses, necessitating some manual support. See Plate V.

Products are usually stacked on completion of the cutting of each pole, the cycle being repeated until all poles are sawn. Poles which are too heavy to manhandle onto the saw-horses should first have butt lengths cut off, by using a log-jack, so that the pole is a convenient size for lifting on to the stands. This method is extremely simple, though some experience is required in judgment for best utilisation of the poles, and the placing of the saw-horses and cut stacks.

Crosscutting with bowsaws is considerably easier than felling. The main requirement is that the pole should be held firmly at a convenient height for cutting, as on a saw-horse, and poles should always be positioned for two-handed cutting if possible and in such a way that cuts may be completed in one operation without splitting or jamming. The body is positioned with the feet apart, both pointing in the line of the cut. One hand holds the frame near the end of the blade, the other rests on the back holding the frame upright. Saw strokes are made with a more pronounced rocking motion than that used for felling, movement coming from a swaying of the body as well as from the arms. Speed of the sawing action should be relatively slow, greater cutting speed being achieved by increased pressure on the saw than by faster strokes. Cutting is easy on the "push" stroke, pressure and "angle" are needed for effective cutting on the reverse or "pull" stroke.

This rocking method of cutting is faster because there is less opportunity for sawdust to accumulate in the gullets, than when a straight cut across the log is made.

A low working position has to be used for conversion at stump or on a log-jack; a half-kneeling position is best in these circumstances, and more pressure will have to be applied to compensate for inability to "rock" the saw.

Wedging and undercutting should be unnecessary with bowsaws,

having a narrow, tapered blade; proper positioning of the pole is the most effective way of ensuring an easy cut without splitting.

D. HAND EXTRACTION

It is something of a paradox that the more extraction is mechanised, the more essential becomes hand extraction from stump into stacks, tushes, heaps, or bings. To carry out this initial extraction by mechanical means is slow amongst standing trees, and damage to the crop is difficult to avoid; while equipment, which is designed for large loads over several hundred yards, is expensive when moving individual poles short distances.

From the man's point of view hand extraction is heavy work and it needs therefore to be reduced and made as easy as possible. The usual practice in Scandinavia, whereby trees are cut into small pieces at stump (1, 2 or 3 metres in length; that is, roughly 3, 6 or 9 feet) involves excessive handling, while the alternative practice of hand extraction of poles in their full length often involves weights that are too large for safety. A compromise between the two is required, in which poles are reduced to reasonable proportions (10 to 15 ft. in length or not more than 2 hoppus feet=130 lbs. in volume), and large timber lengths are left lying where felled, for extraction later by horse or tractor.

Hand extraction can be reduced by cutting racks at close intervals (say 20 to 30 yards apart) and by careful control of felling direction by the feller.

1. Tools

There are several effective tools that make hand extraction easier and safer, because they provide a hold on the wood and enable a good position to be adopted. These are described in greater detail in Forestry Commission Booklet 8, *Aids to Working Conifer Thinnings* (4).

They include:

(a) *Rope.* A fourteen-foot length of rope noosed over the butt of the tree.
(b) *Hand Tongs.* Either the spring-loaded pattern or the scissor type.
(c) *Long-handled Tongs.* Used for both pulling the tree down and for hand extraction.
(d) *Skid Pan.*
(e) *Pulp Hook.* For short lengths.
(f) *Sappie.* For poles and small timber lengths.

2. Technique

Much effort can be saved by forethought in deciding on the felling direction of individual trees. Trees that fall freely are in fact moved for part of the right way on their own, provided their crowns are directed towards the rack. The same applies to trees that are hard to bring down, if their butts are pulled towards the rack during the taking-down process. If tushes are being made up, adjustments in felling direction so that small trees can be moved towards large ones, also reduce the amount of work.

In general it is easier and safer to drag a pole along the ground, or to lift one end and drag it, using tongs or a similar aid, than it is to pick it up and carry it.

V. OUTPUT

Some information on the expected output on the main hand operations is included in Tables 1 to 3 below:

TABLE 1

FELLING THINNINGS:
EXPECTED OUTPUT PER MAN-DAY
including creosoting stumps, making up into tushes and cutting butt logs where necessary

Tree size Hoppus feet	Sitka Spruce		Norway Spruce and Douglas Fir		Pines and Larches	
	Trees	H. ft.	Trees	H. ft.	Trees	H. ft.
1	65	65	80	80	90	90
2	45	90	55	110	60	120
3	35	105	40	120	50	135
4	30	120	35	140	45	160
5	30	150	30	150	40	175
6	25	150	30	180	35	210
7	25	175	25	175	35	245

TABLE 2

HAND PEELING IN LENGTH AT STUMP: EXPECTED OUTPUT PER MAN-DAY

Spruces only

Tree size Hoppus ft.	Summer Output/Man-day		Winter Output/Man-day	
	Trees	Hoppus ft.	Trees	Hoppus ft.
1	90	90	80	80
2	70	140	60	120
3	60	180	50	150
4	50	200	45	180

TABLE 3

CROSSCUTTING INTO FOUR-FOOT LENGTHS: EXPECTED OUTPUT PER MAN-DAY

Tree size Hoppus ft.	Output	
	Trees	Hoppus ft.
1	100	100
2	70	140
3	50	150
4	40	160
5	35	175

A man's physical ability and skill have a very wide influence on output, but the average man, skilled and accustomed to the work and with an effective incentive, should achieve the output indicated. The figures are derived from time studies in North Wales and West Scotland.

1. **Felling**

Time study shows that the main factors influencing output are:

(i) Species.
(ii) Tree size.
(iii) Tariff Number (5).

In the tables an average Tariff number for the various sizes has been used, but crops may well vary from these averages; for instance

lower Tariff numbers may be encountered on high and exposed localities. In general, for a tree of the same volume, a tree with a low Tariff will take more work to fell than a tree with a high one, because it is slower grown, has more branches and its butt diameter is larger.

2. **Peeling**

The amount of work depends on tree size, and volume is a satisfactory expression of this. Peeling in summer conditions, when sap is flowing, is easier than in winter, and quality of snedding has considerable effect.

3. **Hand Crosscutting**

The main factor is diameter of cut, which for pieces of constant length is easily related to tree volume. With pitwood, the amount of work can be directly related to the number of pieces of the different top diameters.

TABLE 4

EXAMPLE OF PIECEWORK RATES

	Output per man-day		Piece rate based on 50/- per man-day*	
	2·0 hoppus-foot Sitka Spruce	4·0 hoppus-foot Norway Spruce	2·0 hoppus-foot Sitka Spruce	4·0 hoppus-foot Norway Spruce
	No. of trees	No. of trees	Price per tree	Price per tree
Fell . .	45	35	13·3d.	17·2d.
Peel . .	70	50	8·6d.	12·0d.
Crosscut .	70	40	8·6d.	15·0d.
Fell, Peel and Crosscut .	20 trees	14 trees	30·5d. per tree	44·2d. per tree
Do.	40 hoppus feet	55 hoppus feet	15·2d. per hoppus foot	11·0d. per hoppus foot

*Note**—This figure of 50/- per man-day is given mainly as an illustration. It is based, however, on potential earnings of an efficient man in 1960. Such a worker would earn *less than* £12. 10s. 0d. in an average five-day week, owing to time lost through bad weather.

4. Piecework Rates

These figures of output can be used as a basis for piecework rates, but this procedure is not very satisfactory because the figures are averages not taking into account detailed variations (e.g. Tariff number and species). To set piecework rates accurately requires either long experience or time study, but a rough guide can be obtained by dividing the average expected piecework earnings per day by the number of trees per man-day for the particular operation, size and species, as derived from Tables 1 to 3.

As an example, the calculation of piecework rates for thinning, peeling (in summer) and crosscutting into 4 ft. lengths of 2·0 hoppus-foot Sitka spruce and 4·0 hoppus-foot Norway spruce is shown in Table 4.

ACKNOWLEDGMENTS

Thanks are due to Mr. M. van Hattem (1) for ideas on the principles of one-man working; and to Mr. Ragnar Broch (2) for safety points of axemanship. Mr. Marc Sale prepared the drawings, from sketches by the authors, and photos by Mr. K. H. C. Taylor, of the Commission staff; Mr. Taylor also took the plates.

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