Harvesting Systems and Equipment in British Columbia

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PART 2: REFERENCE

PROCESSING EQUIPMENT

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The handbook does not attempt to define a single "best" system for any site. Instead, it presumes that readers need to be aware of the key factors that influence the probability of achieving success with any given combination of equipment and site characteristics. Readers will then use their own judgement to evaluate the merits of the various options. The information in the handbook should be considered only as part of an overall process for equipment selection which will vary from company to company.

PROCESSING EQUIPMENT

The term "processing" is used generically to include any action applied to the trees after they are felled and before they are delivered to the mill. Processing typically involves cutting trees into logs that meet the requirements of the secondary transport system and the mills. Common functions include cutting the logs to specific lengths, topping, trimming branches, and removing defects such as rot, spiral grain, and forks. As used here, "processing" also includes debarking, chipping, or slashing at sites other than at mills.

Like falling, the processing phase can be conducted manually or mechanically, and also like falling, the timber characteristics play a large role in the choice between the two methods. For most coastal old-growth stands and some sites in the Interior, the trees are simply too large for typical mechanical processing equipment, therefore manual methods must be used. On the other hand, mechanical processing is standard practice for many Interior sites, and is becoming more common for coastal second-growth sites. Terrain plays only a minor role in the choice between the manual and mechanical processing methods — its influence on falling and extraction methods is more pronounced.

In the choice between manual and mechanical processing methods, the interaction between the phases is more important than terrain. For example, the processing capacity should be matched to the other phases' productivities, the equipment must be suitable to accept the timber as presented by the extraction phase, and it must present the processed logs to the loading phase as efficiently as possible. Mechanical processing equipment has much higher productive capacity than manual processing, but it also carries higher ownership costs. The productivity of the whole system must be high enough to amortize the higher fixed costs at an acceptable rate.

The following sections describe the characteristics for processing equipment, and how these characteristics affect its operational and environmental success.

Hand-bucking

Hand-processing, or "bucking," consists of cutting trees into logs of specified length and diameter classes using a chainsaw. Hand-bucking is usually associated with large timber or low-production systems, and is more common on the Coast than in the Interior. If the timber is hand-felled, it is also likely to be hand-processed.

Bucking is usually done on the landing or roadside before the logs are loaded onto the trucks; therefore, it must be well coordinated to blend between extraction and loading without delaying either of these phases. The bucker must be aware of all machines working in the vicinity, and the machine operators must be aware of the bucker's location at all times to avoid accidents. The risk of accidents increases any time that people work on the ground near heavy equipment.

Figure 92
A landing bucker working in a coastal cutblock.

The trees are spread out on the ground, which allows the worker to determine their size and quality. The trees are measured with a tape, then cut to the proper length, and tops and branches are removed. Any unacceptable defects such as broken or shattered ends, rot, and crook are trimmed from the logs. After the logs are removed for storage or loading, the skidder or loader removes the debris and piles it away from the work area.

Bucking can occur in various locations

Bucking can take place at the stump, at roadside or landing, or in a central landing. In many coastal operations, the faller bucks the trees into logs that can be handled more easily by the extraction equipment — see the section on hand-falling for further information. Even when the faller does the initial bucking, a landing bucker is often required to remove defects overlooked or inaccessible to the faller. On the other hand, if the faller performs no bucking, then a landing bucker is required.

The challenge with roadside bucking is to provide the bucker with access to all the trees — only the top tier is accessible without help. Consequently, the bucker must work with a loader or other machine. Typical procedure is for the loader to place several logs on the road, then wait for the bucker to be finished. Consequently, the loader is limited to the production rate of the bucker and the bucker cannot work any faster than the loader. Both characteristics are diametrically opposed to the concept of having each phase work at its own best rate to minimize costs.

In landing operations when bucking and loading happen at the same time as extraction, proper planning ensures maximum productivity and safety. Reducing the delay times for the extraction equipment is especially important, and landings are often organized with a specific area for the extraction equipment to drop the logs then return quickly to the cutblock. The bucker must keep clear of this zone when the extraction equipment is near the landing.

Hand-bucking can be especially difficult with cable systems on steep terrain. For example, environmental regulations and construction costs limit the landing size, making it difficult to provide adequate space to park the yarder, loader, and log truck and still leave enough room to process and stockpile the logs. One technique is to process the logs in the loading zone while the log trucks are absent, which limits the available productive time for the bucker. An alternative is to forward the logs with a skidder to an adjacent landing away from the yarder. Safety is also a concern on small landings — the “pinch zone” between the yarder and loader is a very hazardous location for any on-the-ground worker. The machines must be positioned carefully to ensure that the gap between them is always large enough to meet safety regulations.

Hand-bucking on landings for ground-based equipment may be easier because there are fewer machines on the landing, there are more options on where to place the incoming trees, and the terrain is usually less severe. However, proper organization ensures that the bucker keeps clear of the skidder and loader at all times, for reasons of both safety and productivity.

Hand-bucking in central processing yards is normally a final upgrading procedure to maximize the value derived from the logs. Since the traffic is often heavy in central yards, strict procedures must be established to ensure safe working conditions.

Bucker can view the logs at close range

With hand-bucking, every log can be examined closely to detect any subtle defects, and can be viewed from all sides if required. Such close viewing can be an advantage compared with mechanical processing where the logs are viewed at a distance. On the other hand, the bucker seldom has any mechanical aids to help determine the log grade, and must usually rely on his experience and knowledge, guided by a set of corporate standards. Some programs are available for handheld computers to calculate the optimal bucking locations, but are rarely used in British Columbia.

Capital costs and productivity are low

Like hand-falling, the capital investment for hand-bucking is low, requiring only a chainsaw, measuring tape, corporate bucking standards, and safety equipment. However, the low capital costs carry the limitations of low productivity and safety hazards. A chainsaw being operated close to legs and feet always presents a safety risk.

Low productivity with buckers may not be an issue if the productivity matches the other phases. If more production is required to match the other phases, and where room is available to establish additional safe workplaces, more buckers can be added easily.

Mechanical Processing

Mechanical processing equipment elevates the bucker off the ground, with all the safety benefits of enclosing a worker in a protective cab. As well, productivity is increased, allowing the economic benefits of higher-capacity machines in the extraction and loading phases to be realized.

Many types of mechanical processing equipment are available, although not all are commonly used in British Columbia. The dangle-head processors and stroke delimbers are widely used in both roadside and landing operations, as are feller-processors, a variation of the dangle-head processor. Less common are pull-through delimbers, slashers, and "tray-based" processors. Other machines such as chain-flail delimbers and chippers are used for specialty operations.

These machines share some characteristics that apply to processors as a whole, as well as other characteristics that distinguish the various machines from one another. These characteristics will be discussed in the next two sections.

Common Features of Mechanized Processing Equipment

In general, mechanized processing equipment is faster and safer than hand-buckers, and the machines can be used at night for round-the-clock operations. They almost always have the ability to sort the logs, and they can be computerized to help with log measurement and bucking decisions. This section will discuss how each of these features affects the operational and environmental risks for the machines.

Figure 93
A stroke delimber working on a roadside log deck. These machines can process up to three trees per minute, with the operator fully enclosed in a protective cab.

Figure 94
A dangle-head processor working from a roadside pile. Trees are pulled from the large deck on the right, and the processed logs are piled to the left of the machine.

Faster, safer, and more capital intensive than hand-bucking

As with falling, the introduction of a machine into the processing function increases productivity and reduces the safety hazard — an on-the-ground worker is no longer required to work near heavy equipment on a busy landing. Instead, the worker is enclosed in a protective cab, free from the risk of being cut by a chainsaw or being struck by another machine.

High-productivity skidders and loaders require mechanical processing equipment as part of the harvesting system because hand-buckers are unable to keep up — the higher productive capacity of the skidders and loaders would be wasted without mechanical processing. Not only is mechanical processing equipment more productive on a per-hour basis, but it also increases the number of available working hours per day. With the operator enclosed in a cab, processors can work at night, allowing for higher machine utilization.

However, the capital costs for most mechanical processors are also significantly higher compared with hand-bucking. This higher productivity is not only possible, but is required to amortize the equipment at an acceptable cost. Most mechanical processing equipment is unsuitable for low production; see the description of pull-through delimbers for an exception.

Processor can move logs for sorting

Mechanical processing equipment can usually move logs both before and after processing, which allows the equipment to be separated from the skidding or loading phases. Each machine can work at its own pace, without interference from the other phases — such separation is often impractical with hand-buckers because they cannot pull the logs out of the piles for processing.

The processors can also sort the logs as part of their normal function, although the number of sorts is usually limited to four or less. Limiting factors for the number of sorts include the amount of space available for the different products, reduced productivity while sorting, and the relative volume of each sort — complete truckloads of each sort are usually required for efficient loading and hauling. Although most processors can sort to some degree, they differ in their sorting efficiency, as will be discussed later.

Mechanical aids are available for length and diameter measurements

Most recent mechanical processing equipment can measure the log dimensions, either by digital encoders or fixed-length benchmarks built into the machine. Length measurement is most common, while some more sophisticated machines can also measure diameters. A computer can be used to optimize the bucking decisions, or the raw information can simply be displayed for the operator to make the decision.

However, the measurements do not come without cost — both for purchasing and operation. The extra hardware needs to be operated properly and calibrated regularly to ensure accuracy, and it may be prone to failure.

Distinguishing Features of Mechanized Processing Equipment

There are several distinct classes of processing equipment, including the stroke delimbers and dangle-head processors commonly used in British Columbia. Other distinguishing features besides the processor type include the method for measuring the logs, the mechanisms used to feed the log through the processor, the machine size, and the carrier type. These characteristics can influence the success of using a particular type of processor on a given site.

Processor type

The market offers a variety of machines that are grouped here as "processors." These machines use different processing methods and generate different products, factors that should be considered before selecting the type of processor to use. The size and form of the timber are also important factors to consider. Stroke delimbers and dangle-head processors can delimb and produce measured logs. Stationary delimbers remove limbs but usually cannot cut the logs to length, while slashers only cut the logs to length. Debarkers and chippers complete the spectrum — they are used to produce chips for pulp mills.

Stroke delimber Stroke delimbers have a sliding boom with a grapple at the end for picking up the logs and removing the branches. After the log is lifted from the pile, a second grapple mounted on the fixed portion of the boom holds the butt end of the log while the grip on the top-end grapple is relaxed. As the boom is extended outwards, the sharp edges of the grapple arms cut off the branches. When the boom reaches the top of the tree, the saw or shear is activated to cut off the top. The butt portion of the log continues to be held in the grapples, and logs longer than a preferred length are cut into shorter logs as the boom is retracted. The tops and short logs fall away from the head into the log deck. Finally, the butt log is discharged into a pile, usually near the location where it was picked up originally.

Figure 95
A stroke delimber working on a landing. The butt end of this large log can be seen protruding from the end of the tunnel on the left.

For logs that are longer than the single-stroke capacity of the boom, stroke delimbers can pull the log back through the machine by alternating the grip on the top-end and butt-end grapples while moving the boom. Very long logs can be processed by repeating the in-and-out action several times.

Some stroke delimbers incorporate powered rollers to feed the logs through the machine and reduce the amount of stroking required by the boom. Stroke delimbers are manufactured in both single-piece and telescopic boom models — the single-piece booms offer increased strength for larger timber, but their reach and speed is less compared with telescopic-boom models.

Stroke delimbers usually have a second saw on the fixed portion of the boom for trimming the butt-end of the logs. Trimming is done before starting the delimbing function so that the length-measuring system can start measuring from a known point. The various options for measuring systems are discussed later.

When working in roadside systems, strokers travel on the road surface and work on logs piled immediately adjacent to the road. Strokers work equally well from landings, processing logs from piles or from single logs as they are dropped by the skidders. The range of vertical movement of the boom limits the maximum sideslope where stroke delimbers can work successfully. About 20% immediately adjacent to the road is the maximum sideslope for successful roadside operations. Similarly, the maximum boom elevation limits the maximum height for piling logs.

Although typically built on standard excavator carriers, stroke delimbers are purpose-built machines that are dedicated solely to processing.

OPERATIONAL

Since strokers deposit processed logs close to their original location, they are well suited to roadside processing. Skidders can drop the logs at the road's edge, and the processor can work from the road surface. The typical procedure is to travel along the pile of logs, with the whole trees on one side of the processor, a working area in the middle, and the processed logs on the other side. The machine typically swings only 20–30 degrees during the normal operating cycle, making it highly productive.

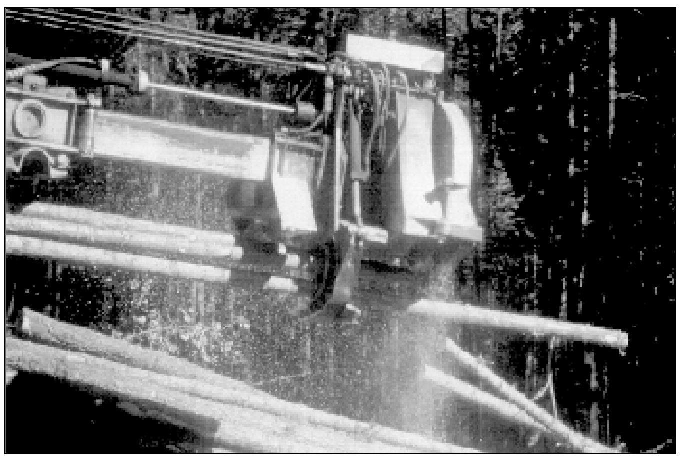

Figure 96
The stroke delimber continues to hold the butt end of the log after cutting off the top. Several trees can be cut simultaneously.

Sorting the logs is usually accomplished by staggering the butts at various distances from the road's edge, or by piling one sort on top of another with an obvious angle between the two sorts. Two or three sorts can be accommodated quite easily. For additional sorts, logs can be piled in the ditchline, on the road surface, or on the opposite side of the road.

Stroke delimbers require two passes over each log, providing both a cost and a benefit. Two strokes over the log require more time than one stroke (as with dangle-head processors), which can become a significant factor for small logs. However, two strokes also provide the opportunity to measure the log before cutting. With sophisticated computerized measuring systems, this provides the opportunity to optimize the bucking decision based on the actual log measurements.

The maximum log size limit for strokers is determined by the tunnel diameter through the machine — the butt of every log must fit into the tunnel. Stroke delimbers are typically more robust than dangle-head processors, and can handle larger limbs, such as those found on hardwood stems, more easily.

Because of these features, strokers are used more often for larger timber than dangle-head processors. Larger stroke delimbers can accept logs to about 70 cm diameter. Strokers are less efficient than dangle-head processors for timber under 30 cm butt diameter.

ENVIRONMENTAL

Stroke delimbers operate from the road surface; therefore, they do not cause soil compaction adjacent to the road. Furthermore, the skidders travel all the way to the road before dropping their load of logs, and they turn around on the road surface. The amount of traffic immediately adjacent to the road is reduced compared with dangle-head processors.

Furthermore, material that is trimmed from the logs' butts falls to the ground near the road surface, and may end up in the ditches. Post-harvesting cleanup must include clearing the ditches of this debris. The branches and tops are spread over a tree-length strip out from the road.

Dangle-head processor Dangle-head processors consist of a processing head mounted at the end of the boom, often mounted on an excavator-style carrier. The processing head includes grapple arms, delimbing knives, a cutoff saw, and a drive system for moving the logs through the processor. The various drive systems are discussed later.

Figure 97
A dangle-head processor working at roadside in a typical, small-diameter stand appropriate for this type of equipment.

In the typical cycle, the processor lifts a tree from the pile and trims the butt if required. Then it swings towards the output pile while engaging the head's drive system, causing the tree to move through the head and the delimbing knives to cut off the limbs. Long trees are cut immediately into measured logs as the head reaches the correct length. Upon reaching the top of the tree, the cutoff saw is engaged to make the final cut. As the carrier swings back towards the input pile, it discards the top into a debris pile. Unlike stroke delimbers, dangle-head processors move the logs lengthwise from one location to another during processing.

The carrier can be used for other types of operations by replacing the dangle-head processor with other tools.

Feller-processors are similar to dangle-head processors, and are sometimes used only for processing. However, they may have difficulty grasping trees from a log deck because the grab arms are designed to grasp standing trees. Feller-processor heads are discussed in more detail in the section on mechanized felling equipment.

OPERATIONAL

Dangle-head processors are inherently faster than stroke delimbers because they make just one pass over the log. Although important when processing small timber, this advantage tends to be lost as the tree size increases because the trees are not moved as easily. For large trees that cannot be held in the processor, they can be rested on the ground and the processor passed over them by swinging the carrier.

The single-pass mode of operation has implications with regard to log-size optimization because the processor must cut the logs before the full length of the tree has been measured. In contrast, stroke delimbers measure the entire tree before cutting the logs. Therefore, optimizing functions on dangle-head processors will tend to be less precise than stroke delimbers because they are based on estimates of the tree profile. However, the single-pass mode is not an issue if the cutting decision is based on length or diameter, instead of the tree profile.

Together, these factors mean that dangle-head processors are better suited to smaller timber than to larger timber. Trees in the 20–40 cm butt diameter class are ideally suited to processing with typical dangle-head processors.

Depending on the configuration of the grapple arms and drive system, dangle-head processors may have some difficulty picking up logs from a pile. Some designs have drive-wheels on the arms, which make them bulky and awkward to pick up the logs. Generally, dangle-head processors pick up logs more easily from loosely packed piles.

Dangle-head processors are better suited than stroke delimbers for cutting multiple short logs from a tree because of the different ways the trees are held and cut. With dangle-head processors, the log is cut from the butt and the remainder of the tree is held in the head, ready to continue processing. With strokers, by contrast, the top part falls away, and the butt portion is held in the grapples. Since bucking should proceed from the butt end of the tree, the first log has to be discharged and the top picked up again before a second log can be cut.

Sorting the logs into more than two piles is more difficult with dangle-head processors than strokers because of the way they hold the trees. The trees in the input pile should line up with the logs in the output deck, and variation of log position within the deck is limited. Stroke delimbers, on the other hand, can vary the angle of the logs more easily. Therefore, dangle-head processors are less suitable to operations where multiple sorts are required.

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Dangle-head processors require a different skidding layout for roadside processing than stroke delimbers. The trees must be dropped by the skidders about one log-length away from the road edge — processing the logs takes them the final distance up to the road edge. This means that skidder traffic for turning around and aligning the butts occurs off the road surface, in contrast to stroke delimbers where this traffic occurs on the road surface. The extra traffic may lead to increased soil compaction on the area adjacent to the road.

Pull-through stationary delimbers

These delimbers work with another machine in either the cutblock landing or a central sortyard. The auxiliary machine, which can be a skidder or hydraulic loader, pulls the trees past a set of delimbing knives to remove the limbs. The delimber may also include a saw for topping the trees. Without a topping saw, another method such as a hand-bucker must be provided to cut off the tree tops.

When used with a measuring rack and cutoff saw, these systems can also cut the trees to length. The measuring racks are configured with one or more fixed-length gaps, and the loader simply butts the trees against a stop-plate to measure the correct log lengths. Both machines are operated by remote control by the loader operator, either via radio or direct cable hookup.

The benefit of these delimbers is their low capital cost compared with dangle-head processors and stroke delimbers, and their low labour cost compared with hand-buckers. The low cost makes these delimbers suitable for low-production operations.

Figure 98
This simple, pull-through delimber uses the weight of the logs to close the delimber arms — no power or remote control is required. The loader simply pulls the logs through the delimbing arms. The tines on the bottom of the delimber work themselves into the ground to prevent the delimber from slipping.

Other processors

The following processors are not commonly used in British Columbia, being limited to specialized applications. As environmental regulations make it increasingly difficult to host large, industrial operations anywhere but a centralized sortyard, their usage within cutblocks is becoming even more rare. Centralized operations eliminate rehabilitation work on the landings and create economies of scale by servicing a wider area from a single location.

Chippers Chippers can be used for chip production from raw logs or from salvage and debris cleanup. The choice between these functions is partially determined by high-level forest policy. The sawmills in British Columbia can produce lumber from the smallest trees; therefore, the primary goal is to maximize the amount of sawlogs delivered to the mills. Consequently, chippers are used mainly for cleanup or salvage operations. However, the primary use of the small trees in other jurisdictions is for pulp chips, so in-woods or "satellite" chipping operations are more common.

Figure 99
This mobile drum chipper was used to convert roadside and landing debris into pulp chips.

Figure 100
A large, integrated chipper, debarker, and delimber operating at roadside. This chipper was operating outside British Columbia.

Transportation costs can be reduced by sorting the raw logs closer to their source, then producing chips and shipping only usable material to the mills. This strategy is especially important where the fibre source is highly decadent.

There are two types of chippers — disc and drum. The main differences between them include the amount of energy consumed to produce chips and their ability to produce chips of uniform size and shape from different size logs. Disc chippers require less energy because of the kinetic energy stored in the quickly spinning disc. They can also produce more uniform chips than drum chippers from larger-diameter logs, but they do not perform as well for short pieces. Disc chippers are preferred for long logs, while drums are preferred for cleanup operations.

Chippers can be integrated or stand-alone machines. The integrated models incorporate the functions of delimbers, debarkers, and chippers, while the stand-alone machines are used with separate delimbing and debarking machines, or with screens for removing the debris after chipping.

Trucking is an important component of the chipping operation because a chip van must always be present for the chipper to operate. Without a chip van on-site, the chipper must stop production or store the chips in a temporary location such as a surge bin.

Chain-flail delimbers Chain-flail delimbers can be stand-alone machines, or integrated into chippers. Chain-flail delimbers remove the branches from trees by means of chains fastened to one or more rotating drums. The branches are literally beaten off the stems by the force of the flailing chains. The chain-flail has two variations — the stationary version which pulls the trees through a chamber that encloses the drum, and a mobile version which is carried by a wheeled loader. The loader drives over the trees to perform the delimbing.

Figure 101
A mobile chain-flail delimber.

These machines were originally developed as a method for delimbing small trees. However, chain flails cannot cut the tops off the trees, so additional processing is still required after they have completed their work. Because of this limitation, chain flails are seldom used except as part of an integrated delimber-debarker-chipper machine.

Debarkers, hoggers Separate debarkers are required for chipper installations that do not use multi-function chippers. Chain-flail debarkers are similar to delimbers, but they are purpose-built, and have more aggressive settings for removing bark. Other debarkers resemble the machines used at sawmills (i.e., ring, drum, or cradle debarkers). These machines are large and heavy, and are usually seen as part of a semi-permanent installation.

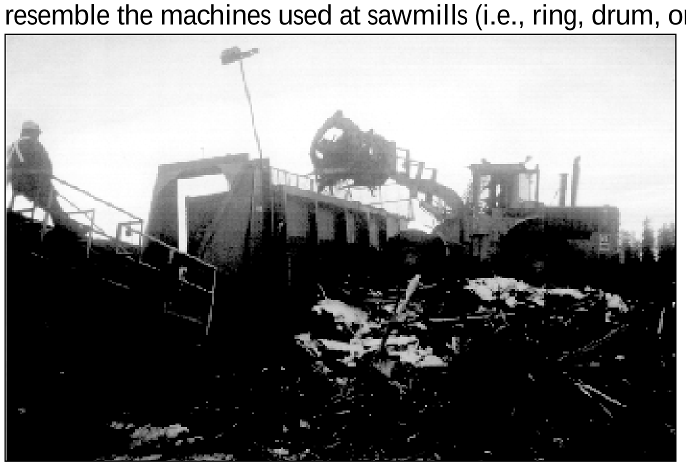

Figure 102
A cradle-type debarker used in a satellite processing yard. The cradle contains rotating serrated discs, and is slanted towards one end. The logs are tumbled inside the cradle until they emerge, debarked, from the low end of the cradle.

Hoggers are used to grind waste material into a mixture that can be used for fuel in various power-generation plants. Hog fuel derived from sortyard waste has also been used as a carbon source in composting operations. Sortyard debris is a candidate for hog-fuel production, but experiments have also shown that landing or roadside debris from logging operations can also be converted into hog fuel.

Figure 103
This machine produced hog fuel as part of a debris-management program at a coastal sortyard. The hog fuel was used as an energy source at a nearby pulp mill.

Slashers Slashers are used to cut trees into short logs, usually several trees at a time. These machines are common in eastern Canada where the more extensive infrastructure can deliver short logs to the mills. However, slashers have been used in western Canada for processing hardwood bolts. Slashers are appropriate where the requirements are for a high volume of a uniform product with little sorting.

"Tray-based" processors Processors that feed the logs through a central "tray" in a stationary chassis have been labelled "tray-based" for this handbook. With features of both slashers and stroke delimbers, these machines can delimb, top, and measure logs. They have only a limited ability to sort the logs, and require an auxiliary machine to bring the trees to the processing site and remove the manufactured logs. The logs are fed longitudinally through the machine, so it must be parked crossways on the road when used in a cutblock. This feature limits their usefulness to central sortyards with ample room to maneuver the logs.

Log-measurement methods

Sawmills usually require the logs to be measured and cut to preferred lengths before delivery, and minor length variations are significant — 5 cm is a typical allowance for under-length logs. Many lumber products are sold in 60-cm increments rather than random lengths, and logs that are cut too short for one length will result in wastage as the boards are cut to the next-shorter length. Log lengths for panel-board plants are even more critical because shorter panels are completely unacceptable. Also, provincial regulations limit the overall length for trucks travelling on public highways, so the logs must be cut to lengths that are legal to haul on public roads.

The length-measurement system must be indexed to the end of the tree before measurement starts. Photocells that sense the end of the tree are commonly used, and they must be kept clear of debris to function properly. Photocells are sometimes fooled by bright sunshine. Some stroke delimbers use a butt-plate over the tunnel as a fixed measuring point. These systems are foolproof providing the log is butted against the plate, but work well only for short logs because the butt-plate must be moved away from the tunnel for long logs.

Feller-processors can be used for processing only, but may not be optimal for that task because they are designed to grasp standing trees. Feller-processors often use the chainsaw blade as the zero-point — they presume that the chainsaw is positioned at the end of the tree immediately after falling. If the feller-processor is used for processing trees out of a pile, then an extra step is required to index the saw blade to the end of the tree.

All log-measuring devices rely on sensors and encoders to translate various physical measurements into estimates of the log length. Many dangle-head processors use spiked wheels that roll along the logs. These systems work well when kept clean and in proper contact with the logs. However, bark, snow, and ice can accumulate in the spikes to cause slippage and incorrect measurements. Errors can also be introduced if the encoder wheel bounces over knots or limbs. Other dangle-head processors use encoders on the drive system; these types are subject to errors when the drive wheels slip, such as when encountering an oversized limb.

Stroke delimbers typically use encoders that measure the extension of the boom, and translate the boom position into the log length. These encoders are less susceptible to slippage than encoders that ride on the log, but they also require an accumulating function for when the tree is stroked back and forth in the machine. If the tree slips in the grapples, then measurement errors will be introduced.

Regardless of the underlying technology used to derive the log length, the best precision for any system will occur when the system is checked and calibrated regularly.

Fixed-length measuring systems such as those used by slashers and measuring racks result in the most reliable length measuring, but they are limited to the number of log lengths that can be measured. When only one or two lengths are required, then these systems may be adequate.

Most processors can measure the minimum top diameter, and some processors can measure the log diameters continuously. Integrating length and diameter measurement with a computer results in log-profile measurements, a rare feature in the processors used in British Columbia.

Diameter-measurement systems can be more or less complex than the length-measurement systems. Knowing the diameter at any point along the log is difficult to obtain accurately — variations or inaccuracies in log-diameter measurements are caused by surface defects, non-circular cross-sections, and variations in bark thickness along the stem. In practice, continuous diameter measurement is required only if the processor is configured to buck according to log-value tables that are based on diameters. On the other hand, knowing that the log's top diameter is not less than the minimum acceptable diameter is important information. Such information can be obtained with a simple limit-switch on the grapple arms to signal when the arms have closed beyond a certain point. This type of measurement can be obtained easily from either stroke delimbers or dangle-head processors.

Feeding mechanisms

Dangle-head processors and some stroke delimbers drive the tree through the head to perform the delimbing action. This requires that the machine grips the tree with some mechanism to move it. Also, the type of drive mechanism can affect log quality and length-measurement accuracy.

The drive mechanisms can be broken into two groups: wheels or tracks. Wheels are more compact and of simpler construction, but their contact area with the log is limited. On the other hand, tracks have more contact area, and thus have less slippage on the tree, but they are bulkier and more complex.

Various wheel modifications are used to reduce the slippage. These modifications, which include adding spikes, ribs, or knobs to the wheels to increase their grip, can also increase the risk of damaging the outermost fibres on the logs. Since the highest-value boards are cut from the outside of the logs, spike-roller damage to the logs can be significant, and should be avoided for sawlogs. However, spike-roller damage is inconsequential if the trees are used only for pulp. Scandinavian equipment commonly uses rubber tires instead of steel wheels to provide a softer grip to the logs, thus reducing damage to the logs. However, the rubber wheels have less grip on the logs, which can impair the ability to remove large limbs, and may reduce the maximum feed speed. Rubber tires are usually fitted with tire chains to improve traction.

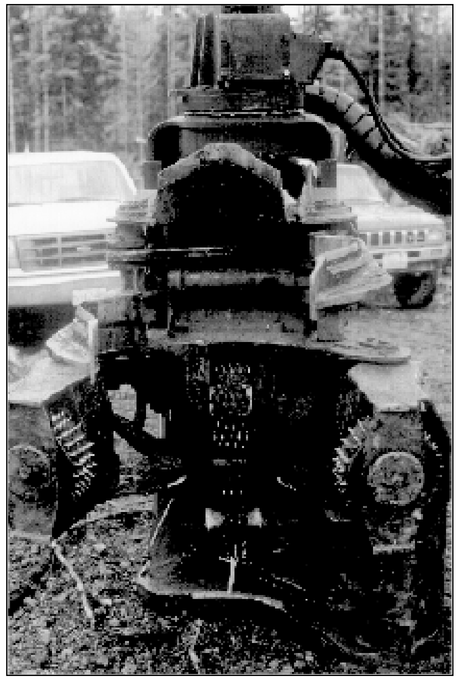

Figure 104
A single-grip feller-processor head showing the feed rollers on movable arms. The encoding wheel for length measurement and the third drive wheel are located in the centre of the machine.

Some dangle-head processors have drive mechanisms that engage only the top of the log, while others have drive wheels on the grapple arms so the log can be driven from three sides. The multi-side approach improves traction, and the ability to remove larger limbs without slippage, but it also makes the grapple arms bulkier, and makes it more difficult to penetrate the log deck to pick up the logs.

Size

The operating conditions for processors are generally less variable than the conditions for other phases. For processing, the primary determining factors are tree size and limb size, not terrain and soil conditions. Consequently, the decision is often whether to use mechanical processing at all, not to select the proper size of processor; or, a decision may be required regarding the type of processor. As discussed previously, dangle-head processors work better for small trees than stroke delimbers, and vice versa for larger trees.

Where processor size is an issue, the processor must be able to handle most trees over the long term without experiencing mechanical failure or unacceptable costs. Occasionally, large trees can be processed manually, and too many small trees with a large processor will increase processing costs. Manufacturers offer a range of sizes for some processors, but the range is generally limited compared with the equipment for other phases.

In some hardwood stands, the average tree size may not be large, but the trees may have large-diameter limbs. Further, hardwood limbs are generally regarded as difficult to remove and hard on equipment. A large, robust delimber is required for these conditions. As an alternative, some companies use hand-buckers to cut the tops off the trees to reduce the wear and tear on the processors.

Carrier

Most processors used in British Columbia are mounted on excavator carriers, although a few are rubber-tire mounted. Rubber tires allows for quick moves between work sites, an advantage for small cutblocks that are located within a few kilometres of each other. Tracked machines would require a low-bed over the same distances. However, tracked machines provide a more stable work platform, either on the road or at the stump.

LOADING EQUIPMENT

Earlier in the forest industry's development in British Columbia, rail, flume, water, and animal transportation systems were used to transport logs. These methods have now largely disappeared in favour of trucking. Some operations do not use trucks (e.g., helicopters flying directly to water drops), but mostly, the final phase of harvesting is to load the logs onto a truck using a loader.

Loaders fall into two categories: front-end loaders, which travel between the log pile and the truck while loading, and swing loaders, which remain more-or-less in one location while loading. Swing loaders include both hydraulic loaders and line loaders. The amount of space required for efficient operation differs significantly between these two types of loader, and is the primary factor for choosing the type of loader. The loader's maximum reaching distance and height and the ability to reach below grade are also important. Other distinguishing characteristics are the carrier type and the size.

Common Features of Loading Equipment

Although the task for loaders seems simple — put the logs onto the trucks — it can be complex. They must load the trucks for maximum payload within the legal limits and sort the logs or keep previously sorted logs separated during loading. The loads must also be safe (i.e., balanced side-to-side with no loose or protruding logs that would pose a safety hazard to other traffic). The logs should not be damaged, their ends should be aligned as required, and the operating cost should be minimized.

Often, the ratio of butt-ahead and butt-back logs on the truck must be balanced to maximize payload. With swing loaders, the logs are simply turned end-for-end as they are being loaded, but front-end loaders cannot accomplish this task as easily. The logs must be turned end-for-end away from the truck before approaching it for loading. Turning the log involves setting it on the ground, and driving to the other side before picking it up again. Alternatively, large landings are required so that the truck can be parked in the middle of the landing, allowing the loader to work from both sides.

Sorting logs requires room to store the various grades in separate piles before they are loaded onto the trucks. Safe loads are built tightly, with long logs on the outside, and shorter logs inside. All safety regulations must be observed.

The common feature is that larger landings usually permit loaders to work more efficiently.

Efficiency for loading is usually maximized when the loading is separated from the extraction and processing phases. However, the loader cannot be separated from the truck fleet, and scheduling the log trucks for maximum efficiency can often create conflicts. Ideally, the loader will work continuously, never having to wait for trucks. But if too many trucks are assigned to the loader, they will be forced to wait. Having more than one loader in an operating area can help with scheduling; however, this setup may be difficult to achieve with independent logging contractors and is more feasible with single-company operations.

Distinguishing Features of Loading Equipment

Machine mobility

As a rule of thumb, front-end loaders are used on flatter terrain where large landings can be built relatively easily, while swing loaders are used on steeper terrain where small landings are more common.

Front-end loaders Front-end loaders, both tracked and wheeled, require a significant amount of space for operating. They load the log truck from the side, and need enough room to turn between the truck and the log deck. Consequently, front-end loaders work better for landing operations than roadside operations.

Figure 105
A front-end loader operating from a landing in a cut-to-length operation.

OPERATIONAL

Front-end loaders are relatively easy to operate, partly because they grasp the logs firmly in large forks. This action provides the operator with positive control of the logs as compared with line loaders in which the logs have more freedom to move. Several logs can be picked up simultaneously for quicker loading.

Front-end loaders require flat ground for operating — any side-to-side motion caused by uneven ground is amplified in the logs as the machine travels over the ground.

Most front-end loaders are rubber-tired, so they are quick to move between operating areas. Low-bed transportation is not usually required unless significant distances (over 20 km) are involved.

ENVIRONMENTAL

The amount of space required for sorting, storing, and loading logs means that front-end loaders typically need large landings. Furthermore, the large amount of traffic on the landings causes severe soil compaction, unsuitable for growing another crop of trees. Rehabilitation measures such as ripping and recontouring the land may be required.

Swing loaders Swing loaders, which feature a rotating superstructure mounted on a rubber-tired or tracked carrier, remain more-or-less in one spot during loading. The logs are picked up in a grapple and swung around onto the truck, either from the end or from the side.

Figure 106
Line loaders are common in coastal operations. This loader is modified with a "super snorkel" to extend its reach to about 50 m from the centre of the road.

Swing loaders have two distinct classes — line or heelboom loaders and hydraulic loaders. Line loaders are more typical in coastal operations, while hydraulic loaders are used throughout the province. Line loaders are typically larger than hydraulic loaders.

The grapple in a line loader is supported by two or three cables that are attached to drums on the winch. By reeling in or releasing the cables, the grapple can be opened or closed, raised or lowered. During operation, the logs are grappled off-centre such that the butt-end is higher than the top. The butt is pivoted, or "heeled," against the underside of the boom, which prevents the log from pivoting in the grapple.

Being attached to cables, the grapple can be "cast" 10–20 m to retrieve logs that are outside the loader's immediate reach. This capability is especially important on steep cutblocks where the logs can easily slide off the landing after unhooking.

Line loaders are difficult to operate, and require a lengthy training period for the operator to become proficient. Skilled line loader operators are highly valued.

Figure 107
A hydraulic loader equipped with a shortwood log grapple. This grapple does not require a "heel" because the logs are short and easy to balance.

Hydraulic loaders are easier to operate, accounting for their widespread use. Most hydraulic loaders pick up the logs lengthwise, similar to line loaders; the difference being that the grapple is attached firmly to the boom, instead of with cables. Hydraulic loaders are also easier to move, being mounted on excavator-style carriers. However, unlike line loaders, they are limited to grappling logs within their immediate reach. Hydraulic loaders are available in a wide variety of models and sizes.

A distinct style of hydraulic loader was developed for roadside logging. This type of loader, called the "butt 'n top" loader, grasps the logs in the middle, which facilitates loading from the side of the truck. Butt 'n top loaders can also turn the logs end-for-end to equalize the payload between the truck and trailer. Outrigger arms on the grapple balance the logs.

Figure 108
A hydraulic "butt 'n top" loader in a roadside operation. The butt 'n top can load trucks from the side, and turn the logs end-for-end as required.

OPERATIONAL

Cable yarding systems often require a swing loader. As the logs are unhooked from the chokers, the loader moves them to a temporary storage location where they can be bucked to length, and otherwise processed.

The sorting capacity for swing loaders is limited somewhat by the number of logs that can be piled in the area immediately adjacent to the loader. Furthermore, swing loaders tend to concentrate activity in one area — unhooking, processing, sorting, and loading all must occur close together. This congestion can lead to hazards and production inefficiencies, and makes swing loaders less favourable than front-end loaders with ground-based extraction on landings.

When these loaders work with cable yarders, breaks in yarding activity are commonly used to pick up timber from nearby areas. This practice can help to lower the overall costs by providing more consistent production. These loaders are also used as primary transport machines in their own right, either as loader-forwarders, cherry pickers, or super snorkels. These uses are discussed under ground-based extraction equipment, elsewhere in the handbook.

ENVIRONMENTAL

Swing loaders can operate from smaller landings than front-end loaders of equivalent capacity. This feature is especially important in steep terrain where building large landings is difficult, expensive, and environmentally intrusive.

Line loaders are typically very heavy machines, and require a high road standard to support their weight. Hydraulic loaders are more mobile, and may be able to operate from less substantial road surfaces.

Carrier

Both types of loaders (front-end and swing) are available on either rubber-tired carriers or tracked carriers. The intended use for the loader determines the choice of carriers.

Wheeled Rubber-tired carriers are faster to move between work sites, but they also require better running surfaces than equivalent tracked machines. Wheeled loaders are used for various loading tasks, both in the Interior and the Coast, and are some of the most common machines in the logging industry.

Figure 109
A rubber-mounted line loader. This type of carrier provides more mobility than tracked designs.

Swing loaders, both line and hydraulic, can be mounted on rubber-tired carriers. These machines require retractable stabilizer pads to reduce the bouncing effect caused by the rubber tires. The stabilizers typically reach outside the machine's wheelbase, which must be accounted for in the road specifications. Steep, narrow roads are especially problematic for rubber-mounted line loaders because of their large size, height, and weight.

Rubber-tired carriers for small hydraulic loaders can be either factory-built or truck-mounted. Neither type is very common in British Columbia, and they are usually used only for specialized applications.

Tracked Common at one time, tracked front-end loaders are seldom used in British Columbia anymore. These machines can work under more adverse soil conditions than wheeled loaders, but this ability is no longer an advantage because of the more stringent soil disturbance limits in place today. Tracked machines are also slower and more expensive to maintain than wheeled loaders.

Tracked carriers are the standard for swing loaders, both line and hydraulic, because they provide a more stable operating platform than rubber-tired carriers. Butt 'n top loaders that work in roadside operations must be track-mounted to travel over the unprepared surface adjacent to the road.

However, tracked carriers also incur higher costs as compared with wheeled carriers for travel between work sites, an important factor to consider with small cutblocks. Hydraulic loaders may be moved short distances under their own power, but line loaders are typically moved on a low-bed even for distances less than 1 km.

Self-loading trucks Some trucks have an integral hydraulic loader for loading and unloading logs, independent of any other equipment. Self-loaders are usually smaller that stand-alone loaders, so their reaching and loading capacity is less, and the truck payload is reduced by the loader's weight. The boom design, which is different than typical hydraulic loaders, gives the operator less control over the log. As well, the operator is usually exposed to the weather.

Figure 110
The self-loading log truck can operate anywhere the truck can drive. Self-loaders can pick up scattered loads without the expense of moving a loader.

The advantage of self-loading trucks is that they can pick up loads from scattered locations and transport them to equally diverse locations without the extra costs of hiring and transporting a loader.

Some self-loading trucks are especially configured for shortwood operations, with a truck and full trailer. The loader is mounted at the rear of the truck so it can reach both the truck and trailer sections.

The self-loading truck is indispensable for specialized operations where the production is scattered among several small piles in various locations (e.g., thinning). Self-loading trucks are usually associated with low-volume or cleanup operations, although some companies use self-loaders as their primary truck fleet.

Size

Because the equipment size governs the maximum lifting weight, the loaders operating on the Coast are often large to lift the large, old-growth logs. However, the loader must also lift the trailer off the log truck in preparation for loading. In many cases, the trailer is the heaviest load for the loader to lift, and the loader must be sized accordingly.

Size also affects the reaching distance and the cost. Reaching distance is especially important on steep terrain, where the loader may be required to grapple a log that has slid off the landing. If the log is beyond the loader's reach, then rehooking it with the yarder may be required. Cherry pickers are large to maximize the amount of timber that can be reached from the road.

Lastly, size determines the loader's agility. Small loaders can operate within partial cuts without damaging the residual crop. When working with a yarder, the loader must not rub against the guylines — large loaders may cause an accident if they were to catch one of the guylines.