WINCH-ASSIST HARVESTER:

BEST PRACTICE MANUAL

SPECIAL PUBLICATION SP-533

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This manual is not intended to provide professional advice and is not intended to replace or supersede occupational health and safety regulation provisions or specific instructions from the supplier of the equipment you are using. It is the responsibility of users to exercise professional knowledge and judgment in the use of the information.

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INTRODUCTION TO:
WINCH-ASSIST HARVESTER BEST PRACTICES

Machines and equipment are constantly evolving thanks to technological advancements. As these changes happen, our best practices must change accordingly to ensure optimal safe production and efficiency.

For many years we used tracked carrier harvesters with tilting platforms that are able to perform well in semi-steep ground without the assistance of cable winches. However, as harvesting has continued to take place on steeper ground with short pitches, large cable yarders have not been economical to use and the slopes too steep for normal conventional steep ground harvesters. Conventional type harvesters with an ability to work steeper ground with shorter slopes were needed in B.C.

This style of logging has been taking place in several European countries, Australia, and New Zealand for a number of years, with equipment manufacturers from around the world now having or developing machines with computerized cable winches that work with existing conventional harvesters in such a way that they can safely perform on steeper ground. Wheeled machines are well suited as winch-assist winches as they have better contact with the ground, tend to burn less fuel, and are lighter, quieter, and smaller, creating less ground disturbance. Keeping these machines productive and cost-efficient is achieved by using best practice operating techniques along with appropriate, daily maintenance.

This manual contains techniques and processes developed and implemented by some of the best operators in the world who have achieved high production in the most cost-efficient and safe manner possible. Every stage of felling, delimbing, and cutting product to length is covered.

You may find there will be times when you cannot use every one of the steps included in this manual because of the many variables in our forests. However, any process is considered very successful if it can be used 80% or more of the time. Some operators may find that skipping steps or changing the process makes them feel more comfortable. This, however, can often lead to damaging the machine and reducing production.

These best practices are designed for success and practicing them will help make operators more successful. If you find you have difficulty doing some of the best practices, don't hesitate to ask your contractor/manufacturer for some one-on-one time to address concerns before they become problems. Sometimes it only takes a bit of coaching to get you comfortable with all of the steps of the harvesting process.

IN SUMMARY,
HERE ARE A FEW THINGS TO REMEMBER:

- Machines are always evolving.
- Constantly be thinking about how to keep the cost low.
- Use best practices and follow recommendations.
- Continually be improving operating skills and paying attention to preventative maintenance.
- Practice efficient techniques to improve your bottom line.

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01.
SAFETY

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WORKSAFEBC REQUIREMENTS

There are several WorkSafeBC regulations that are applicable to winch-assist systems. These include:

1. Planning and documentation: OHSR 26.2(1), 26.2(3)(a), 26.2(3)(b)(c), WCAct 119(b)
2. Prime contractor responsibilities: OHSR-26.2(2), 26.2(3)(a), 26.2(3)(b)(c), WCAct 118(2)(a)(b)
3. Employer responsibilities: OHSR 26.16(4)(a)(b), WCAct 115.1(a), 115.2(a)-(f), OHSR 26.16(2-4)
4. ERP (Emergency response plan): OHSR 4.13(1-3), 4.14(1-4)
5. Supervisor responsibilities: OHSR 26.3(1), 16.4, 16.6, WCAct 115(2)(e),117(1)(2)6
6. Operator/worker responsibilities: OHSR 3.12(1), 16.5, WCAct 116(2)(a)(e)
7. Supplier responsibilities: OHSR 4.4, WCAct 120
8. FOPS: OHSR 16.21
9. ROPS: OHSR 16.22
10. Cab guarding:
    - Cab G602
    - Roof G608 or SAE231
    - Boom Side G604 or SAE J1084
    - Front G603 and G604
    - Door and door side windows G603 and G604
    - Back window G603 and G604
11. Emergency escape: OHSR 16.17
12. Slope limitations: OHSR 26.12.1, 26.16 . Exceeding slope limitations requires:
    - risk assessment
    - site-specific written safe work practices
    - must not be operated in a particular location or manner if its stability cannot be assured
13. Worker training: WCAct 115, 26.3, 3.23, 16.4
14. Cranes and hoists: OHSR 14 with 14.9 (14.5 to 14.8) exception for logging
15. Rigging: OHSR 15, including section 3.5 on cable inspection
16. Planning: OHSR 26.2

17. Radio controlled equipment: OHSR 26.12.2 must be equipped with a "fail safe" or "stop" mechanism that becomes operational if the remote control device fails.

18. In addition WorkSafeBC's document *Understanding the Requirements for Mobile Logging Equipment in British Columbia* identifies the following areas of concern that may be dealt with by manufacturer's instructions or written safe work procedures under "Safe work procedures and manufacturer instructions specific to winch-assist equipment" (Figure 1).

19. Snubbing loads on steep grades: OHSR 16.38

OPERATOR CONSIDERATIONS

- The operator must be skilled and competent at working on steep slopes.
- Have an operator fatigue plan in place and follow it as necessary.
- See the BC Forest Safety Council's (BCFSC) *Steep Slope Logging Resource Package* for more information on operator considerations

TRAINING

- Anyone operating machinery on steep ground must receive the appropriat training and be competent to perform the required tasks safely and productively
- New operators must start on lesser slopes and transition to steeper slopes
- Best progression for new operators is
  1. Start on forwarder, no winch
  2. Progress to forwarder, with winch
  3. Then start on harvester , no winch, slopes up to 50%
  4. Progress to harvester with a winch
  5. Bigger wood – this is more difficult than learning to work with the winch

Safe work procedures and manufacturer instructions specific to winch-assist equipment

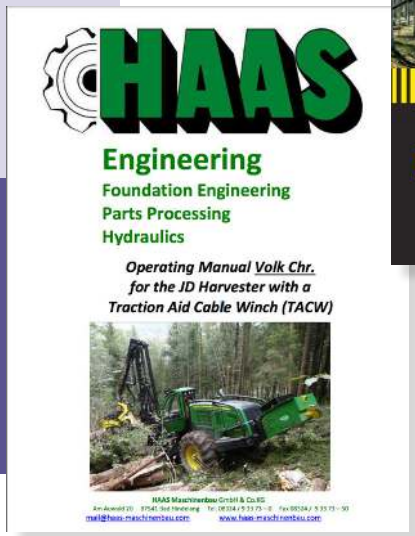
Several additional areas of concern have been identified and may be dealt with in the manufacturer's instructions or written safe work procedures. These concerns are as follows:

- Stump selection and method of securement, as well as frequency of inspection to ensure worker safety and machine stability.
- Winch and cable inspection — how often and to what standard?
- Potential to damage or sever cable with head, boom, or logs.
- Abrasion of cable on rock outcrops and other obstacles.
- Safe work area around machine and cable. Area of no entry may be different than in regular mechanized falling.
- Rescue procedure in the event of breakdown or misadventure. How do you right a machine if it flops on its side?
- Worker training.
- Lockout and de-energization procedures.
- Winch capacity/load rating and safety systems. Failsafes?
- Cable size and strength.

FIGURE 1. *From WorkSafeBC document* Understanding the Requirements for Mobile Logging Equipment in British Columbia.

RISK ASSESSMENT

A risk assessment is an essential component of any steep slope harvesting operation. Use the manufacturer's manual (Figure 2) as part of your risk assessment, to help identify the controls to put in place when operating machinery on steep or difficult ground in the forest.



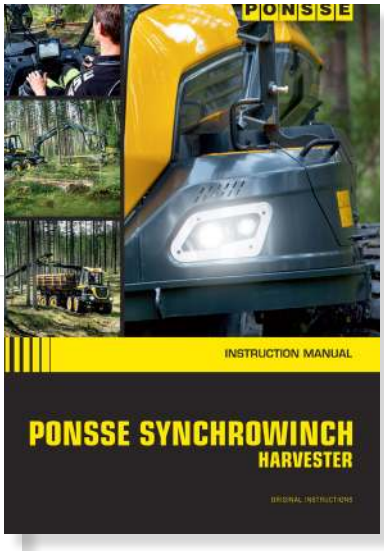


FIGURE 2.
Always refer to the winch manufacturer's operators' manual for recommendations (images courtesy of Haas Automation, Inc. and Ponsse Plc).

WorkSafeBC's regulations 26.16 for slope limitation states:

1. Repealed. [B.C. Reg. 312/2003, effective October 29, 2003.]
2. If the manufacturer's maximum slope operating stability limit for logging equipment is known, the equipment must be operated within that limit.
3. If the manufacturer's maximum slope operating stability limit for logging equipment is not known, the equipment must be operated within the following limits:
   a. a rubber tired skidder must not be operated on a slope which exceeds 35%;
   b. a crawler tractor, feller buncher, excavator and other similar equipment not be operated on a slope which exceeds 40%;
   c. any other forestry equipment specifically designed for use on a steep slope must not be operated on a slope which exceeds 50%.
4. Despite subsections (2) and (3) but subject to subsection (5), logging equipment may be operated beyond the maximum slope operating stability limits specified in those subsections if
   a. qualified person conducts a risk assessment of that operation, and
   b. written safe work practices acceptable to the Board are developed and implemented to ensure the equipment's stability during operation.
5. Despite anything in this section, logging equipment must not be operated in a particular location or manner if its stability cannot be assured during that operation.

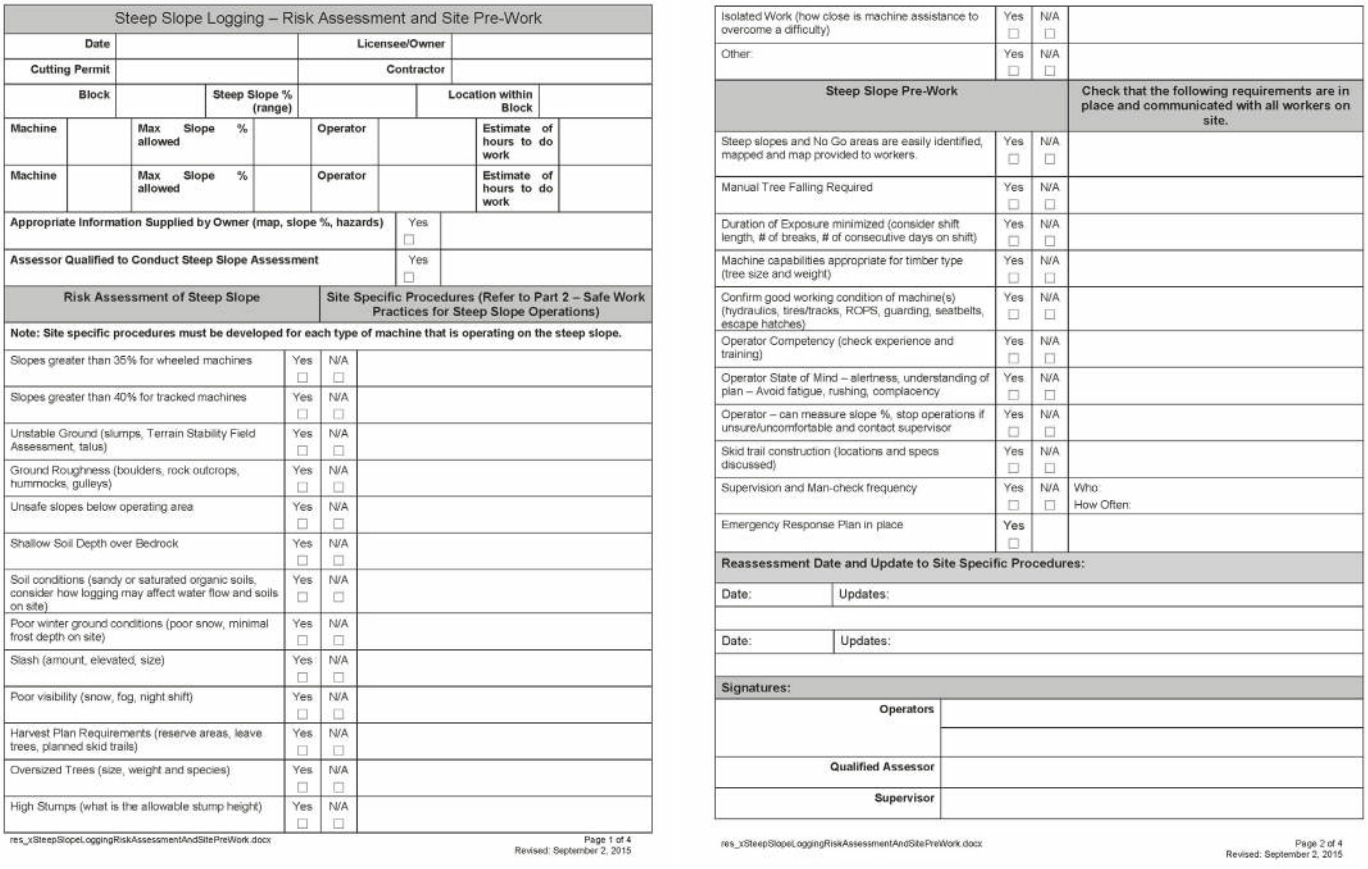
[Amended by B.C. Reg. 312/2003, effective October 29, 2003.]
[Amended by B.C. Reg. 20/2008, effective May 1, 2008.]

The key point is that if the manufacturer's maximum slope-operating stability limit for harvesting is not known, then WorkSafeBC's slope limit for rubber tired machines is 35 % and exceeding these limits requires: a risk assessment, written safe work practices, and no operation in a location or manner where stability cannot be assured.

An increase in slope will mean that you need to plan carefully how the work will be done:

- Choose which machine to use.
- Decide who will be operating the machines.
- Decide how to supervise the work and take account of changing conditions.
- To work safely on steep ground, you must take into consideration the entire harvesting operation, not just one machine. Everyone involved must communicate their work plan and be in regular contact with each other.
- Record how the execution will be planned in the risk assessment and site safety rules.
- Each operation will be different therefore will need to be assessed to control the site specific conditions and variables.

An example of a risk assessment is shown in Figure 3.



Steep Slope Logging – Risk Assessment and Site Pre-Work

Date			**Licensee/Owner**		
Cutting Permit			**Contractor**		
Block		**Steep Slope % (range)**		**Location within Block**	
Machine		**Max Slope % allowed**		**Operator**	**Estimate of hours to do work**
Machine		**Max Slope % allowed**		**Operator**	**Estimate of hours to do work**

Appropriate Information Supplied by Owner (map, slope %, hazards)	Yes ☐	
Assessor Qualified to Conduct Steep Slope Assessment	Yes ☐	

Risk Assessment of Steep Slope			**Site Specific Procedures (Refer to Part 2 – Safe Work Practices for Steep Slope Operations)**
Note: Site specific procedures must be developed for each type of machine that is operating on the steep slope.			
Slopes greater than 35% for wheeled machines	Yes ☐	N/A ☐	
Slopes greater than 40% for tracked machines	Yes ☐	N/A ☐	
Unstable Ground (slumps, Terrain Stability Field Assessment, talus)	Yes ☐	N/A ☐	
Ground Roughness (boulders, rock outcrops, hummocks, gulleys)	Yes ☐	N/A ☐	
Unsafe slopes below operating area	Yes ☐	N/A ☐	
Shallow Soil Depth over Bedrock	Yes ☐	N/A ☐	
Soil conditions (sandy or saturated organic soils, consider how logging may affect water flow and soils on site)	Yes ☐	N/A ☐	
Poor winter ground conditions (poor snow, minimal frost depth on site)	Yes ☐	N/A ☐	
Slash (amount, elevated, size)	Yes ☐	N/A ☐	
Poor visibility (snow, fog, night shift)	Yes ☐	N/A ☐	
Harvest Plan Requirements (reserve areas, leave trees, planned skid trails)	Yes ☐	N/A ☐	
Oversized Trees (size, weight and species)	Yes ☐	N/A ☐	
High Stumps (what is the allowable stump height)	Yes ☐	N/A ☐	

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Isolated Work (how close is machine assistance to overcome a difficulty)	Yes ☐	N/A ☐	
Other:	Yes ☐	N/A ☐	
Steep Slope Pre-Work			**Check that the following requirements are in place and communicated with all workers on site.**
Steep slopes and No Go areas are easily identified, mapped and map provided to workers.	Yes ☐	N/A ☐	
Manual Tree Falling Required	Yes ☐	N/A ☐	
Duration of Exposure minimized (consider shift length, # of breaks, # of consecutive days on shift)	Yes ☐	N/A ☐	
Machine capabilities appropriate for timber type (tree size and weight)	Yes ☐	N/A ☐	
Confirm good working condition of machine(s) (hydraulics, tires/tracks, ROPS, guarding, seatbelts, escape hatches)	Yes ☐	N/A ☐	
Operator Competency (check experience and training)	Yes ☐	N/A ☐	
Operator State of Mind – alertness, understanding of plan – Avoid fatigue, rushing, complacency	Yes ☐	N/A ☐	
Operator – can measure slope %, stop operations if unsure/uncomfortable and contact supervisor	Yes ☐	N/A ☐	
Skid trail construction (locations and specs discussed)	Yes ☐	N/A ☐	
Supervision and Man-check frequency	Yes ☐	N/A ☐	Who: How Often:
Emergency Response Plan in place	Yes ☐		

Reassessment Date and Update to Site Specific Procedures:	
Date:	Updates:
Date:	Updates:

Signatures:	
Operators	
Qualified Assessor	
Supervisor	

res_xSteepSlopeLoggingRiskAssessmentAndSitePreWork.docx Page 2 of 4 Revised: September 2, 2015

FIGURE 3.
Sample risk assessment form (from BC Forest Safety Council, 2015).

GENERAL SAFETY

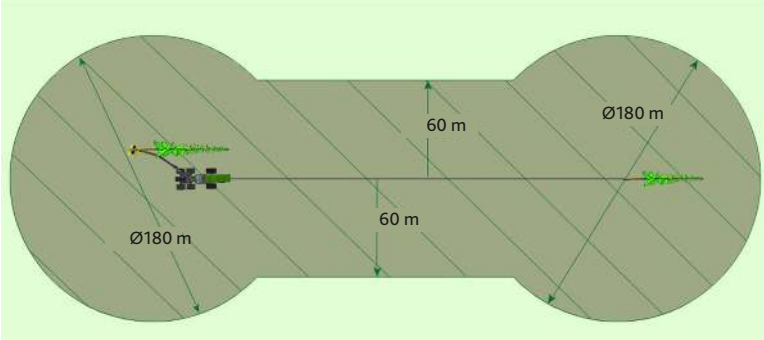
- Safety is always the number one priority when on a work site.
- Winch-assist harvested sites are located on wet, rough, and steep land. This terrain brings a higher risk of machine instability and even possible machine overturning.
- Experience can significantly lower the risk because experienced operators often know how to handle different situations based on former experience. Learning and understanding the contents of this manual will help manage these challenging conditions.
- Any operator not comfortable with the slope that the machine is working on must stop immediately.
- Machines should be operated straight up and down the hill whenever possible, and never across the slope.
- Wheeled harvesters should be equipped with ring chains or wheel tracks on the single axles and bogie assemblies should have wheel tracks. All tires must be in good condition with the recommended tire pressure, and chains and tracks properly adjusted.
- If you are working in rocky or broken terrain, be very cautious of dropping over rock faces or large single rocks.
- Wear a safety belt at all times to reduce the risk of injury if a machine overturns.
- Know where the escape hatches are on your machine and check them on a regular basis to make sure they are working properly. This may save your life in a rollover situation.
- All tools and other heavy objects should be stored in secure tool boxes or somewhere on the machine other than in the cab. Many times in a rollover, the loose objects flying around inside of the cab are the most dangerous and can cause the most injury.
- Read and follow the operator's manual.
- Avoid crossing active roads with the cable. If necessary, clearly indicate the cable location (Figure 4).

FIGURE 4.
Identify any area where the cable crosses a road. Mark the cable with flagging tape to make it more visible.

FIGURE 5.
Brow log to protect the cable at ground break. Sharp rocks can damage or increase cable wear.

Protect the cable from abrasion, infiltration by soil, and sharp bends by placing a brow log at ground breaks (Figure 5).

FIGURE 6.
Tethered harvester safety zone (Haas Maschinenbau, 2015).



EMERGENCY PROCEDURES

Follow any emergency procedures provided by the manufacturers in the event of an incident. Additionally, the following procedures are recommended:

- In the event of cable system failure (may include machine attachment point, connectors, chain, wire rope, and/or anchor[s]):
  - Activate the blade braking device on the assisted machine if available
  - Activate the wheel brakes on the assisted machine
  - Use the head's grapple to hold on a tree/stump or set the head or heel rack (if available) into the ground to provide further braking resistance
  - Exit the cab only if safe to do so once the assisted machine is fully immobilized
- In the event of communication failure between the assisted machine and winch anchor:
  - Follow the manufacturer's operating procedures. With a constant tension system, the winch is generally set up to continue to maintain the tension preset before the communication failure.

SAFETY ZONES

- Operators and other workers should establish and respect a large safety zone around a tethered harvester whenever it is operating or the anchor is under tension (Figure 6).
- A harvester's saw can be very dangerous due to potential chain shot and other flying debris.
- Machines also have safety decals placed to warn against dangerous areas when new but these decals can become worn. Know and follow the manufacturer's requirements for safe work zones.
- Additionally, whenever the harvester is falling trees, all workers must maintain a safety zone of two tree lengths or as specified by the manufacturer, whichever is greater.
- New operators should be given a full orientation of the machine and made aware of all safety zones, safety mechanisms, and lockout procedures.

WIRE ROPE AND RIGGING

Follow any recommended wire rope and rigging specifications and procedures provided by the manufacturers. Additionally, the guide entitled *Wire Rope Integrity in Winch-Assisted Harvesting Operations: A Guide to Wire Rope Handling and Inspection for Machine Operators* (FPInnovations, 2016) describes accepted best practices on this topic and is recommended as an information source. Some general recommendations include, as a minimum:

- Develop and keep written records of formal, periodic, and thorough inspections, and maintenance and replacement schedules of the wire rope as well as all rigging and winch components. These can vary based on the winch type and size, wire rope type, rigging components, terrain, and weather conditions. Keep a log noting dates and details of cable use hours, cable inspections, any cable damage, any shock loading incidents, any cable sections cut out, splices, and end connectors.
- On a daily basis:
  - The first 20–30 m section (used most often) of the wire rope should be carefully and thoroughly inspected.
  - Any events of traction loss or tensions exceeding safe working load must be recorded.
- On a weekly basis:
  - Open all lids, and check the winch drum and tensioning disks (if applicable), guide rollers, fairlead rollers, and connectors for signs of wear.
  - Unspool entire length of wire rope and inspect for signs of damage
  - Test tensioning and remote control devices
- On a monthly basis:
  - Remove the first 3–5 m of the wire rope as it is used the most and is exposed to abrasion and tension. It is at risk of internal damage from bending and fatigue.
  - Dismount and flip the tensioning disk (if applicable) to prevent uneven wear of the disk gouges that may lead to subsequent rope damage. Check the bearings of the pressure rollers and holder for deformations or other damage that would prevent them from functioning properly.
- On a semi-annual or annual basis (depending on the size of rope and conditions):
  - Replace the whole length of the wire rope. If no external damage is noted, electro-magnetic testing is recommended to ensure wire rope integrity and suitability for further use.
  - Replace the tensioning disk.
  - Check all other rigging components and replace if necessary.

02.
ENVIRONMENT

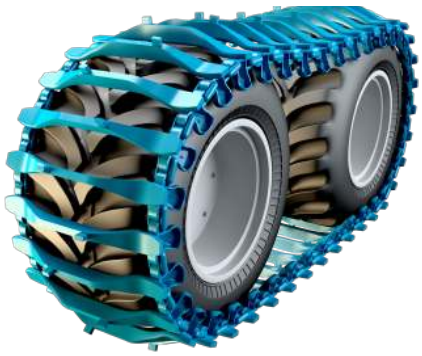
FIGURE 7.
Use wheel tracks to prevent wheel spin in slippery conditions

ENVIRONMENTAL CONSIDERATIONS

Ground-based equipment can potentially damage soils through excessive disturbance, primarily by causing rutting or compaction which can reduce future tree growth. Rutting on steep slopes may also cause water redirection or concentration and result in erosion and mass wasting.

Best practices to limit environmental impacts include the following:

- Use tire tracks on wheels for better traction to help prevent wheel spin (see Figure 7).
- Distribute slash and drive harvester over it in soft ground conditions and rehabilitate afterwards with excavator if necessary (see Figure 8).
- Prevent ruts by placing brush where the machine will travel.
- Align logs and slash so water flow is not concentrated.
- Minimize the slipping of wheels, especially when using wheel tracks.
- Closely monitor operations where track or wheel spin is damaging soils and cease or move operations if necessary.
- Minimize repeated machine passes over the same trail.
- Avoid turning the tracks when working on sensitive soil types as this may create ruts which could direct and concentrate water flow onto slopes.



- Use the winch system wherever an untethered operation would cause soil damage.
- Maintain sufficient and constant tension so the machine does not slip or slide and to prevent wheel spin.
- Be aware of any track or tire spin due to malfunction, unsuitable conditions, or exceeding the limits of the system, and stop before damage is done to the soils.
- Cease operations in very wet conditions. Refer to local wet weather safety shutdown guidelines and procedures, such as provided in BC Timber Sales (2006).
- Recognize that winch assist may not be suitable everywhere and an alternative harvest system, such as hand falling or cable yarding, may still be necessary in some areas. Stop operation if the environmental limits of the system are reached.

TECHNIQUES FOR PREVENTING DAMAGE

- Wherever possible, plan the routes in such a way that forwarders avoid having to climb steep slopes.
- Haul horizontally along the graded section of the slope or on established trails.
- The harvester should clear the trails for the forwarders to limit soil exposure and the obstruction of the natural drainage systems.
- Once the wood has been hauled, all diversionary water systems must be cleared (trenches, raised berms) to divert water flowing along the trails toward surrounding vegetation and to slow water flow and filter water before it returns to waterways. Do so at regular intervals along the trail.
- Reduce forwarder loads using the multi-stage method and avoid making sharp turns.
- Spread woody debris across the site. Piles of debris may be used to stabilize ruts and paths that are at risk of eroding, as well as small ravines.
- Before cutting, wetlands must be clearly located so that operators can avoid disturbing the soil.
- Mark hauling trails before cutting to facilitate the operators' work.
- When building a bladed skid road, always ensure that the route allows for regular water drainage.
- Avoid harvesting on this type of slope during periods when soil moisture is high (consecutive days of rain, fall, etc.).
- Carefully map slopes that can be harvested and include paths, bladed skid roads, hauling trails, streams, and soft ground.
- Walk the entire cutblock to check that the information on the map is correct.
- Use forwarders with tracks on both bogies.

FIGURE 8.
Use slash and debris to protect the soil and prevent ruts on soft ground.

ENVIRONMENTAL PROTECTION
Planning considerations

- Proper planning allows the operator to make full use of harvesting measures to reduce environmental impact.
- Steep slopes are prone to erosion, mass movement, and sinking during harvesting.
- Risks increase with the degree of soil exposure, the severity of the angle of the slope, and fine-textured soil.
- The risk of erosion is greatest on long slopes, regardless of soil texture.
- Forest operations on steep slopes can result in:
    - surface erosion
    - loss of forest floor linked to deep exposure of mineral soil
- When the gradient of the slope is greater than 35% or the soil condition is poor, a logging trail must be built at the bottom of the slope or harvested block. The trail must not interfere with natural water flow or exceed a 25% gradient. A steeper slope will limit the forwarder's efficiency and ability to haul logs. Gather low-quality logs a few at a time to limit return trips to the trail. Use the forwarder's maximum load capacity whenever possible but always consider the terrain surface quality.
- Supervisors must ensure that hauling trails are built with care. Large forwarders cannot perform sharp-angled turns so harvesting trails must be built with exits that access hauling trails.

Following the logging plan

- The logging plan is created to enhance the operator's ability to work the cutblock. There are many different challenges and variables throughout a steep ground operation.
- It is important that operators follow the logging plan, having the most efficient trails for the forwarder in accordance with the terrain and making turns wide enough to accommodate the forwarder.
- When working on steep ground, it is critical for the harvester to make the trails as straight as possible.
- As a result, the contractor/operator must plan and execute the cutting of trails so they run straight up and down the slope with a maximum of 5% side slope.
- The GPS unit can help maintain straight trails and plot or identify problem areas and should be used as a guide. If these tools are not available, then simply walking the trails and using ribbon to mark the problem or potential problems areas is another option.
- This can be challenging, so good planning and communication between the contractor, operator, and supervisor is important to make the best plan to accommodate both the harvester and forwarder.
- Rehabilitation of disturbed areas should be undertaken as soon as practical.

BEFORE STARTING TO HARVEST
Operator considerations

- New operators or operators that are about to run a model of machine that is new to them should always know and understand the features and limitations of the machine.
- Harvesters can have varying characteristics from length of reach to stability of the carrier.
- The operator's manual offers information on features but only experienced operators or trainers can help an operator learn about limitations.
- The manual should remain in the machine at all times to act as a guide for any operator to follow.

Planning the harvest

- The machine working in Figure 9 (right photo) is working on a dangerous side slope that can affect this machine as well as those that follow.
- The harvester is the first machine to work in the cutblock, therefore establishing how all subsequent logging equipment will work in the block. Felling and extraction trails must be perpendicular to the slope at all times on steep ground. This enables all machines to safely perform their duties with a lower risk of rolling over (Figure 10, left photo).
- When the slopes range from 25% to 35%, wheeled harvesters can cut untethered while travelling uphill, starting from the bottom of the slope and working upwards.
- Problems can arise when felling untethered facing downhill with the boom extended (similar to Figure 9, left photo). The weight of the felled tree is combined with the force of gravity. The acting force increases with slope steepness and pulls the machine downward. This can cause the machine to slide or tip over.
- In the pre-planning stage, the contractor must ensure that blocks can be harvested from the bottom on steep ground unless the machine will be tethered. Untethered harvesters must always travel upwards while cutting trees so the harvesters can reverse back down the slope or parallel to the slope after reaching the top. An alternative is building trails using excavators or bulldozers (Figure 10).
- Operate the harvester in low range when working straight up the slope. Keep the front of the harvester low and minimize driving over slippery or unstable materials such as wind falls and rocks.

FIGURE 9.
Working on excessive side slope is dangerous. Working downhill on steep slope untethered can be dangerous.

- Exercise caution when driving the machine near ruts or trails which may force the machine to change direction and follow the contour of the terrain. This is very dangerous and could result in a machine roll over. The operator must use graded trail sections or a trail built for this purpose (see Figure 10).
- When working near the top of a slope or on a shelf within the slope with a tracked harvester where some slope is evident, it is best to take precautions to reduce sliding or roll over. Extending the boom toward the top of the slope will help keep the machine stable (see Figure 11).

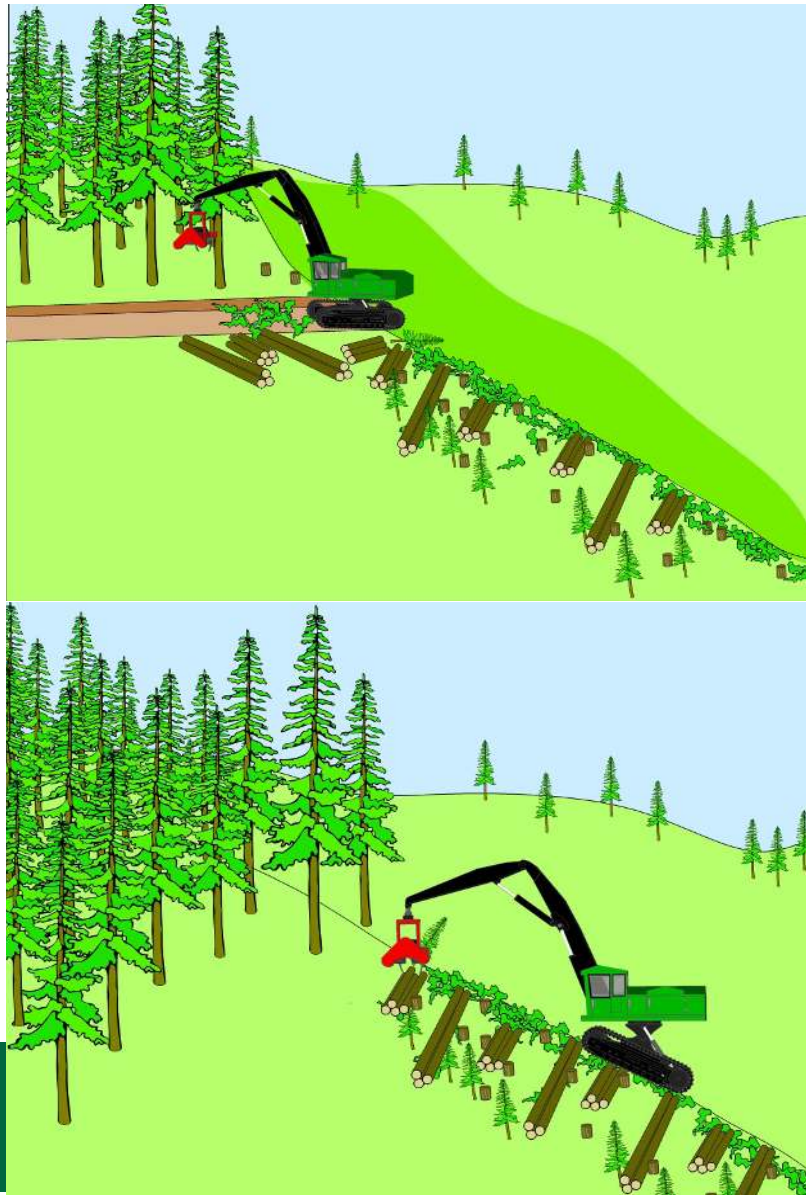


FIGURE 10.
Built trails/roads at the top or bottom of the cut strip. Keep the front of the harvester low and into the hill.

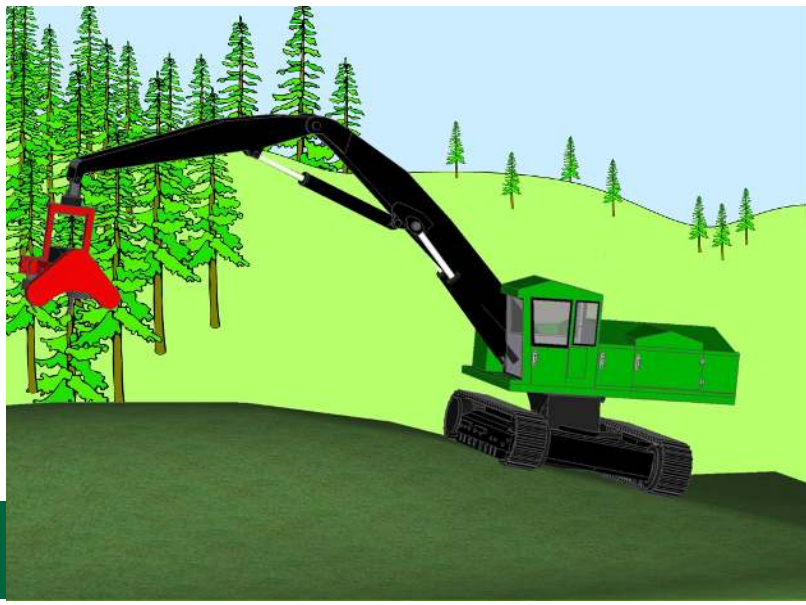


FIGURE 11.
Maintaining stability when moving on the slope.

03.
PLANNING

OPERATIONAL PHASE PLANNING

Operational phase planning is very important in any operation but becomes much more so in a winch-assist operation. In this type of operation, the winch-assisted machines must be able to work on tethered cables without disruption from the other activities on the operation, such as trucks, pickups, and other machines that may need to pass on a road where the harvester is tethered across that road. Therefore, when the initial planning for the cutblock is taking place, the logistics of when and where the machines, trucks, and pickups will be must be considered and planned so that each phase of the operation can work properly without interruption.

There are some rules of thumb that you can follow that will help you make the best decisions:

- A new cutblock/area should be planned well in advance when doing winch-assist logging. Things such as weather and seasons will have an effect, so where the cutblock is located is important.
- Things like where and when to plan anchors, hill access ramps, and forwarder piling areas are important, especially going into a different season.
- Layout must be detailed and the plan should establish which machines are cutting where and if there are conflicts with any other phases of the operation (see Figure 12).
- Areas that are designated for winch-assist machines should be earmarked to be cut as early as possible in the cutblock/area plan.
- These areas should get cut and forwarded before trucking occurs beyond that point on the road.
- Normally, this would mean that designated areas near the front of the block would be cut first and areas near the back of the cutblock or on branch roads would be cut last.
- This would reduce the need for most vehicles to pass the active tethered harvester during its operation.

If the above criteria can be met, the harvester will not be disturbed, thus allowing for good performance and productivity during the work shift. The better the plan is, then the higher the chance of having good execution of the plan. However, good plans do not necessarily result in good execution. It is just as important that there is good communication between everyone involved in the operation. Everyone is a part of the planning process, everyone understands the plan, and everyone agrees to execute the plan as it was designed.

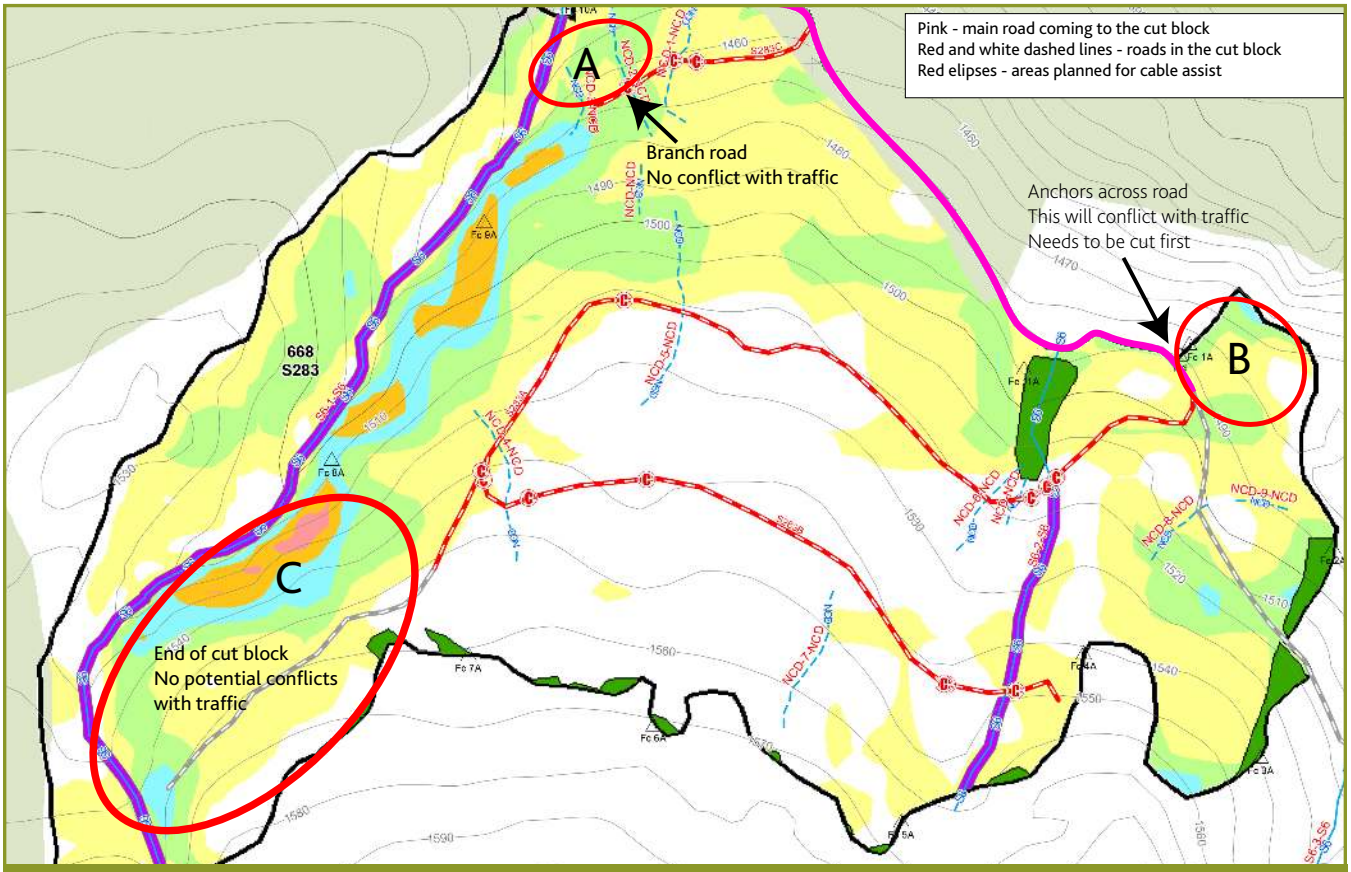


FIGURE 12. *Planning sections of the block on the map.*

Road planning within the cutblock

Roads are a significant part of harvesting every cutblock and even more so when harvesting steep ground. First of all, many mountain or hillside sites will have rock formations. This can add another dimension to harvesting slopes. The ability to access and harvest depends on where the roads are placed. Well-planned roads can make a considerable difference to the ability of trucks and loaders to maneuver without incidents of becoming stuck or not being able to access wood on the cutblock. Road planning and harvest cutblock planning should be done as a joint effort to plan and harvest the cutblock in the safest and most efficient manner. This would include proper truck turn arounds and wide out areas placed at strategic locations that will facilitate good traffic flow on the cutblock.

On-site shop or service facility

There are many other things to take into consideration with a winch-assist operation. Make sure there is an on-site service facility (service truck or trailer, see Figure 13). Along with the normal service tooling required to keep your operation running, a small kit of things such as extra cable, wedge sockets, cable clamps, shackles, and hooks will be required. All of these items are essential to carry out winch-assist logging and if one piece is damaged or broken, the whole operation may be forced to a halt. For more information, see "Chapter 5: Beginning to Harvest with a Winch-Assist Machine."

Preparation for other seasons

As mentioned earlier, planning of future cut areas is critical for winch-assist logging. If the cutblock/area will be harvested during late fall or winter, snow has to be the first consideration. Winch-assist logging works best up to 1 m of snow. If a future cutblock/area is located in higher elevation, it may need to be harvested in the summer season. If this future cutblock/area is designated to be cut during cold weather months and is in a suitable location, then it will be important to dig and prepare deadman anchors, access ramps on the downhill side of the road, and any landings for the forwarder to place piles of wood. For more information, see "Planning a New Cutblock/Area" in this chapter.

FIGURE 13. *On site shop and service facility.*

PLANNING A NEW CUTBLOCK/AREA

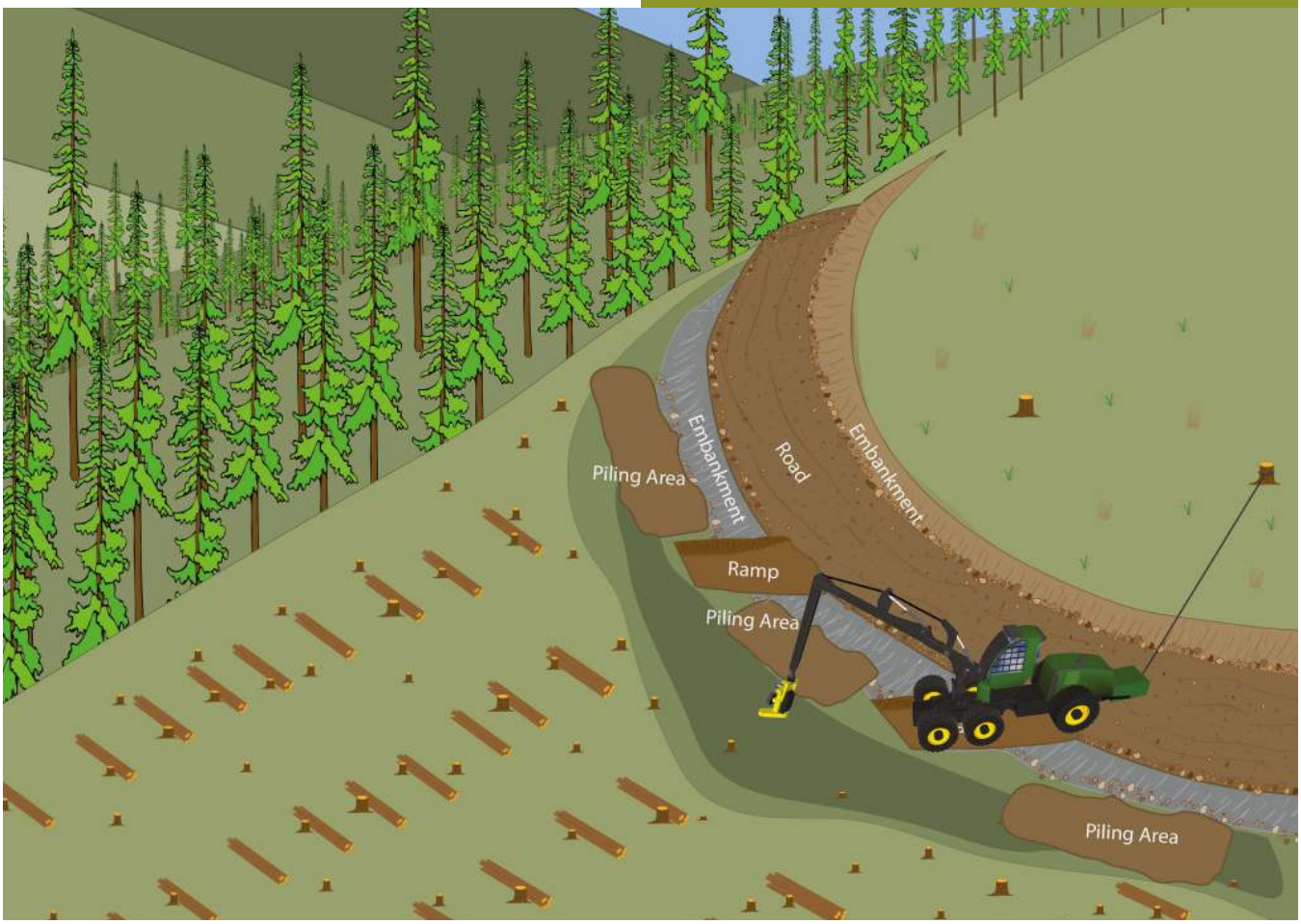
When planning a new cutblock/area, trails need to be planned with anchors, ramps, and piling areas. Anchors will be discussed in "Harvesting with a Winch-Assist Machine" in Chapter 5.

This section discusses building ramps and piling areas for future cutblocks/areas.

Access ramps

- Ramps are small 45-degree trails that are opened up on the downhill edge of the cutblock road to allow both the harvester and forwarder to access the trails below the road. These access points are designed to be small and not cause any loss of integrity of the cutblock haul road.
- Because of their 45-degree design, the width can be kept to a minimum yet accessible for the machines using them.
- They must also be designed as short as possible to minimize the amount of erosion that can take place. By building these ramps short and facing back into the forest floor, any erosion will end here.
- Figure 14 shows a drawing of ramps and piling areas that were planned and installed long before the arrival of the harvesting crew.

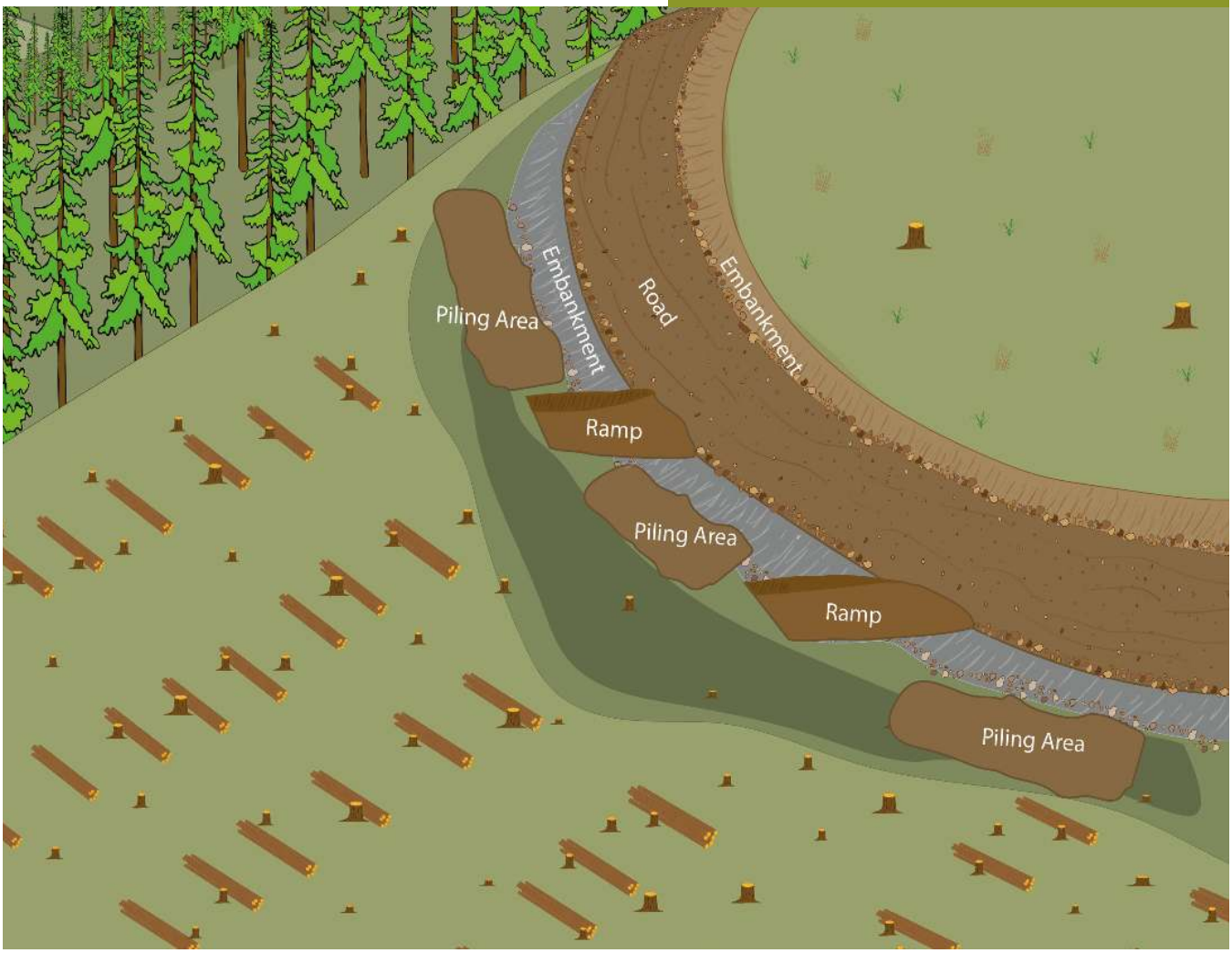
FIGURE 14.
Machine access to the hill below the road.



PILING AREAS

- Piling areas require some planning and are not necessarily consistent due to varying terrain and road systems.
- A piling area may be near the bottom of one of the ramp areas just where the harvest trail will meet the ramp. This is the most ideal location because it allows the forwarder to place wood near the road for loading and reduces the need to go onto the ramp and road, which may lead to damage that could increase road maintenance costs.
- Figure 15 shows a piling area that has been made near the ramp areas.
- Piling space is normally limited in situations where steep ground is being logged. If there is either not enough piling space or no piling space due to terrain issues, then piling locations may be required either at the edge of the road surface or across the road in some cases.
- Where the road has been recessed into the side of a steep hill, the terrain may be steep on either side of the road. This often limits the area where the forwarder can pile wood, so planning must go into how and when trucking will take place to allow for an uninterrupted flow of wood.

FIGURE 15.
Showing placement of the ramps and piling areas.



04.

ANCHORS AND CATCH STUMPS

DIFFERENT TYPES OF ANCHORS AND CATCH STUMPS

There are several different types of anchors that can be safely used to assist with the machine's integrated traction winch or the autonomous stationary winch systems in a variety of situations

- single tree/stump anchors - normal straight slope with single or double cable strap anchor is the simplest and most commonly used
- multiple anchor trees and/or stumps
- deadman anchors
- rock anchors
- machine anchors

Safety should always come first; gloves should be worn any time you are working with steel cable. This section looks at the main types of anchors and uses photos or drawings to help explain how to set them up and use them properly.

Stump and tree anchors

Stumps and trees are most commonly used to anchor winch-assist rubber-tired harvesters. Deadman anchors, rock anchors, and machine anchors may be used in locations where there are no suitable trees or stumps. Follow these best practices when planning:

- Plan trails with consideration of the location of the best stump anchors.
- Anchor straps and rigging must match or exceed the safe working load of the wire rope in use.
- Rig anchors about 18 m (60 ft.) apart, adjusting for boom reach and inaccessible areas.
- Pretension the anchor to 5 or 6 tonnes to test it before beginning work. retension the anchor from a safe position using the harvester winch's remote control and without an operator in the machine.
- Pre-plan anchors in the daylight for night operations. Use headlamps to aid in setting up anchors in the dark.

Selecting the tree/stump anchor:

- Use appropriately sized stumps (Figure 16) and trees. See cable yarding literature for recommendations on selecting a good anchor stump or anchor tree (WorksafeBC, 1993).
- Choose sound trees or stumps in good health and well-rooted, no exposed roots or rocks (Figure 17).
- Choose trees with a healthy treetop.
- Size:
  - larger than 45 cm (>18 in.) diameter—single tree or stump is okay (Figure 17)
  - 30 to 45 cm (12 to 18 in.) diameter – use two trees or stumps

- 20 to 30 cm (8 to 12 in.) diameter – use three trees or stumps
- less than 20 cm (8 in.) diameter – install multi-tree anchor with supervisor or use alternative anchor system

- Species - Douglas-fir is preferred; pine, cedar, and spruce are okay (Figure 17); hemlock should be avoided; balsam fir is not suitable.
- Firm and stable old-growth stumps can still be good for anchors.
- Consider the fact that stumps have limited holding capacity in saturated conditions.
- Ensure anchor stumps are tall enough to prevent the strap from slipping off (Figure 18). Notch the stump if necessary to ensure the strap is secure.
- Avoid stump or trees:
  - with exposed roots
  - on rock or stones (Figure 19)
  - with rot

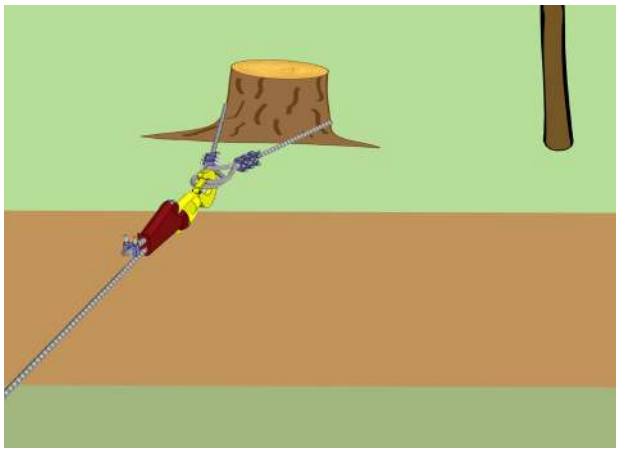


FIGURE 16.
Showing single tree and single stump achor placements.

The most common single stump or tree anchor rigging and setup

- This can have one or two cable loop straps or one large synthetic woven strap, depending on the manufacturer's recommendations for the particular brand of winch being used.
- It is fairly simple to install and secure. Place the cable or woven strap as low as possible on the stump while ensuring there are no obstacles that come into contact with the strap, such as rocks, wood debris, or buildup of snow that could cause the strap to slip or break.
- While standing in the designated safe zone (see "Anchor Test" in this chapter), use the winch remote control to apply the amount of pull recommended by the winch manufacturer to secure the strap (see Figure 17).

FIGURE 17.
Examples of good anchor stumps

FIGURE 18.
Example of an anchor stump that is too short.

FIGURE 19.
Avoid anchor stumps that are perched on rock outcrops.

FIGURE 20.
Pre-rigged anchor tree with extension strap

- Pre-rig anchor trees (Figure 20) with extension straps or wire rope in areas where suitable anchors are located considerable distances from the road or in difficult spots.
- When pre-rigging anchors, it is wise to paint attach points (loops at the end of the anchor) and ribbon high enough near the anchor so it is possible to find should there be snow on the ground when the timber is actually harvested (Figure 20).

FIGURE 21.
Multiple-tree anchor.

FIGURE 22.
One-stump and one tree combined with equalizer block for an anchor in small trees for a small cable-logging system.

Multiple stump/tree anchors or combinations

This is more complicated than a single tree or stump but is still fairly simple to set up. Testing is very important and the use of a monitor can reduce the risk. Always follow the winch manufacturer's recommendations.

- It is important in multiple tree setups to have the primary anchor tree take the highest percentage of the pull but use trees in close proximity to take a smaller percentage of the pulling tension.
- For instance, if two trees were used it should be approximately 60% on the primary and 40% on the secondary (Figure 21).
- For three trees, it may be 60% on the primary and 20% equally on the other two.
- You should always refer to the recommendations of the manufacturer before performing any of these configurations.
- When setting this type of anchor, try to find a larger tree that will take most of the pull, even if it is not directly in line with where you want the cable to run, but use one or more other trees to help direct it to where you do want the cable positioned for the best trail coverage by the harvester.
- Use multiple stumps or trees (Figures 22 and 23) as necessary, using accepted rigging and tie-back procedures. Refer to the *Cable Yarding Systems Handbook* (WorkSafeBC, 1993).

FIGURE 23.
Multi-stump/multi-tree anchors used with winch-assist systems.

- Where necessary, notch stumps following standard cable-logging methods.
- Use caution if rigging a block to redirect the rope as forces on the anchor can become large, depending on the angles, e.g., the force on the anchor can become doubled.
- If rigging standing tree anchors, rig with "deflection" stumps/trees so the direction of force will not pull the tree toward the machine.
- Tie back tree anchors (Figure 24) if they may fall into the working area or required by regulation.
- A stump monitor to notify the operator notification of stump movement is recommended (Figure 25).

FIGURE 24.
Anchor tree (bottom) and tie-back tree (top) with synthetic tie-back strap.

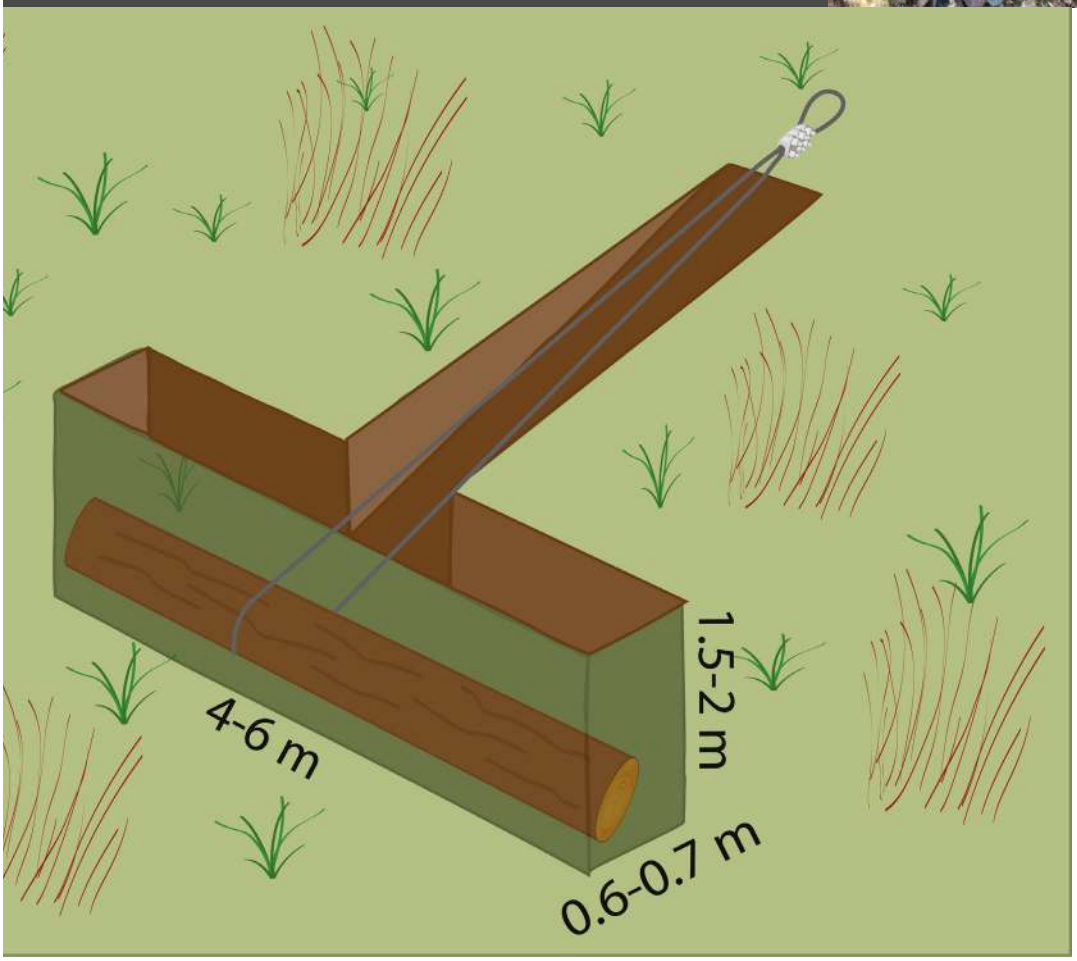
FIGURE 25.
Device to detect stump movement.

Deadman anchors

Deadman anchors may be used where adequate stumps, trees, or equipment anchors are not available. Additional instructions for selecting and installing deadman anchors can be found in the *Cable Yarding Systems Handbook* (WorkSafeBC, 1993).

- A deadman anchor can be made by digging a 6 m long trench.
- Bury deadmen 1.5 to 2 m deep.
- Bury a large, sound 5.0 m long log placed lengthways in the trench with a cable wrapped around the log's mid-point.
- Bury the log with the cable end extending above the ground for attachment to the winch wire rope (Figure 26).

FIGURE 26.
Completed deadman hook-up with strap.



Rock anchors

Rock anchors (Figure 27) have had some, but limited, use in cable logging.

- They have strong tensile strength but weak shear strength.
- Drill access to site or portable drill is required.
- Untrue drillholes or non-cylindrical holes will reduce holding power.
- Avoid fractured rock, or drill beyond the fractures or grout the fractures.
- The number of bolts required depends on the load.
- Use equalizer blocks or turnbuckles for multiple bolts.
- Bolt should point in the direction of pull.
- Torque and test before use.
- A safety factor of 3 is recommended.

Different types (expansion bolts, grouted steel pins, unwedged, or ungrouted steel pins) have different advantages and disadvantages that should be considered.

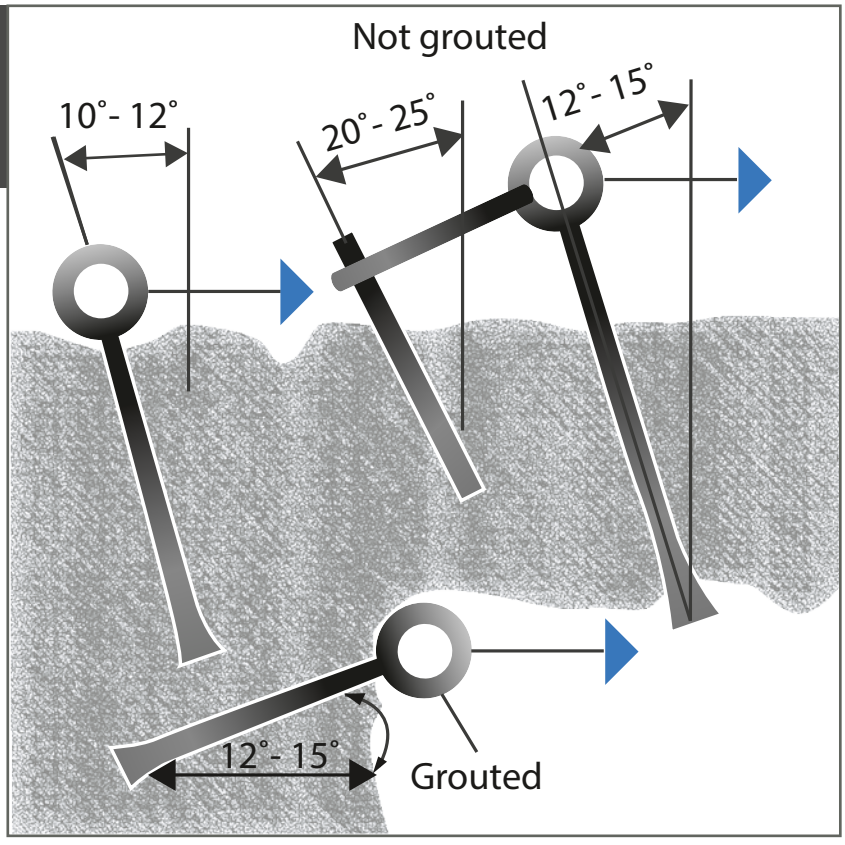


FIGURE 27.
Rock anchor example.

Machine anchors

Typically, an excavator or bulldozer is modified to act as a machine anchor (Figure 28). Use a machine with a low centre of gravity and attach the cable to a low point on the anchor machine to prevent it from overturning. Ensure the attachment point is engineered to support the expected load. These setups should be certified by a manufacturer.

Smaller, low centre of gravity, remote-controlled units like the "T-Winch" are starting to emerge (Figure 28). These machines are typically easier to move around, have a very low centre of gravity, and are easy to set up. They are typically designed to work with smaller machines like rubber-tired harvesters.

- Position the anchor machine on level or upsloping ground whenever possible. For downsloping ground, place the anchor machine in the least downsloping position and secure it using one of the methods below.
- Position and secure the anchor machine to prevent any sideways rotation or downslope movement.
- Always position the anchor machine with the harvester to prevent overturning.
- Apply the anchor machine's track brakes.
- Use the anchor machine's blade or bucket to secure the machine by placing the blade or bucket against a stump or tree, or dig it into the ground, as necessary. For bulldozer-style blades, force the anchor machine's blade at least half-way into the soil. For excavator-style anchor machines, reversing the bucket can improves its purchase in the soil.
- Guy the anchor machine to one or more stumps, trees, or other suitable objects on the machine's uphill side with one or more guylines as necessary to prevent anchor movement. Ensure guyline(s) are tight and the forces are equal (if using more than one guyline) before operating the harvester.
- Install and use anchor movement alarm (break away switch) that signals the operator if the anchor machine moves.
- Take extra care to secure the anchor machine adequately on frozen ground.
- Take extra care to secure the anchor machine adequately on frozen ground.

FIGURE 28.
Various machine anchors used in the industry today.

GETTING ANCHORED

Because of the synchronized pull of both the winch and the transmission of the assisted machine, proper traction and stability is achieved within the recommended degree of slope the machine is working. Various techniques can be applied to winch-assist logging to further increase the benefits over conventional steep ground logging.

The steps to using the winch assist for the harvester are as follows:

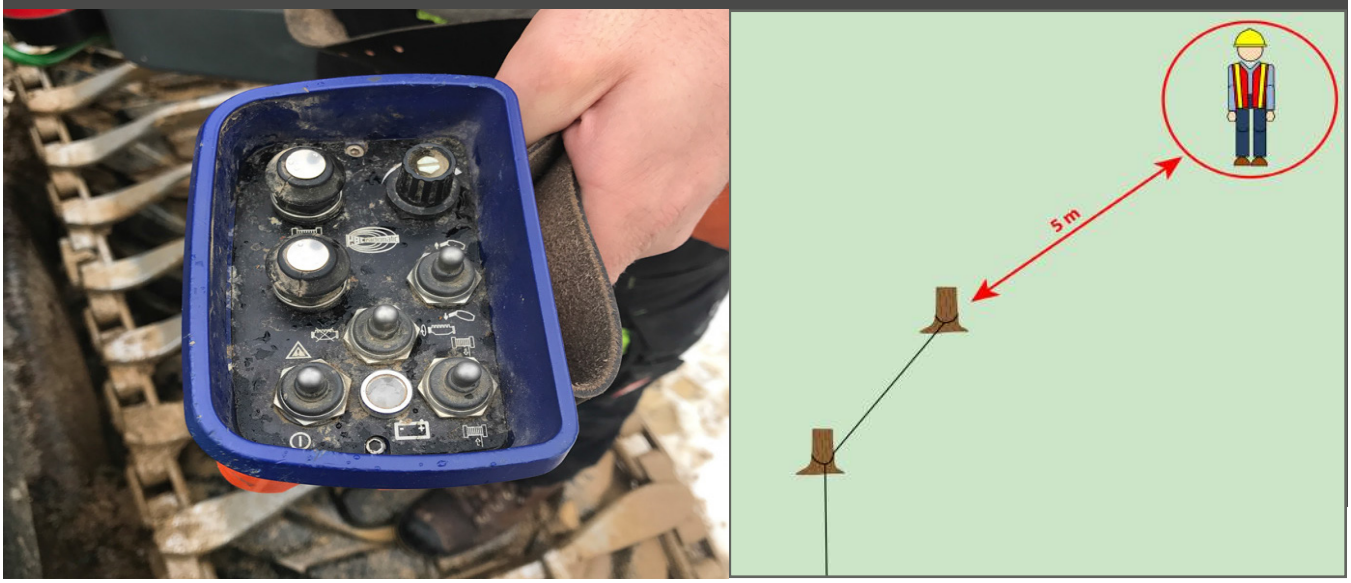
1. Finding a proper anchor for the current trail before starting. It is smart especially in the beginning that the contractor/operator plan these anchor points in advance. The earlier you can find and mark these anchor points, the less time will be wasted looking for and deciding on anchors later when the machine may get held up due to no anchors being available.

2. Once you know your anchor point, the cable loop strap or synthetic strap will be placed around the anchor point by the operator. Using the remote control as shown in Figure 29, the operator will stand in the safe zone (check winch manufacturer's operators manual) and tighten the cable to the recommended test pressure. Always wear gloves when handling steel cable. It has a tendency to have steel wire fragments protruding from it as it wears.
3. If the anchor is safe and fully secured, the operator can now go to the machine and start working.
4. When walking to the machine along the route that the cable lies, it is best to check that the cable will have a clear path back to the machine.
5. The cable can be used as a support mechanism to assist the operator back to the machine when the ground is steep and/or rough. Always use gloves.
6. Once in the machine, the operator will set the winch using the manufacturer's recommendations, then start working.
7. See the following section, "Anchor Test," for the exact steps in testing the anchor.

Anchor test

1. Stand outside the machine, 5 m away from anchor tree, and at a 45° angle above and behind the uppermost stump or tree in the anchor system.
2. Use the remote control to engage the winch on the harvester and pull on the anchor with a maximum force of 3 tonnes.
3. Watch the upper part of the root for movement during the test.
4. If there is movement in the ground, stop and find another anchor tree or stump.
5. If there is no movement, increase the winch force to 6 tonnes.
6. If there is no movement, then the harvester can be operated using a maximum winch force of 5 tonnes.
7. If there is no movement, increase the winch force to 9 tonnes.
8. If there is no movement, then the harvester can be operated using a maximum winch force of 7 tonnes.
9. Always maintain a 5 m safety zone around the anchor when it is under tension. Do not stand below the anchor (Figure 29).

FIGURE 29.
Example of remote-control device for testing the anchor (left). Example of safety zone when testing anchor (right).



Catch stumps (also referred to as redirects)

To harvest and forward wood on steep ground where the slope may change incline as well as direction, several techniques may need to be employed. One of these is working with catch stumps where an operator can safely and successfully harvest and forward slopes within the safety criteria laid out in earlier sections of this manual. Please also refer to recommendations regarding rope management when catching around stumps described in FPInnovations (2017).

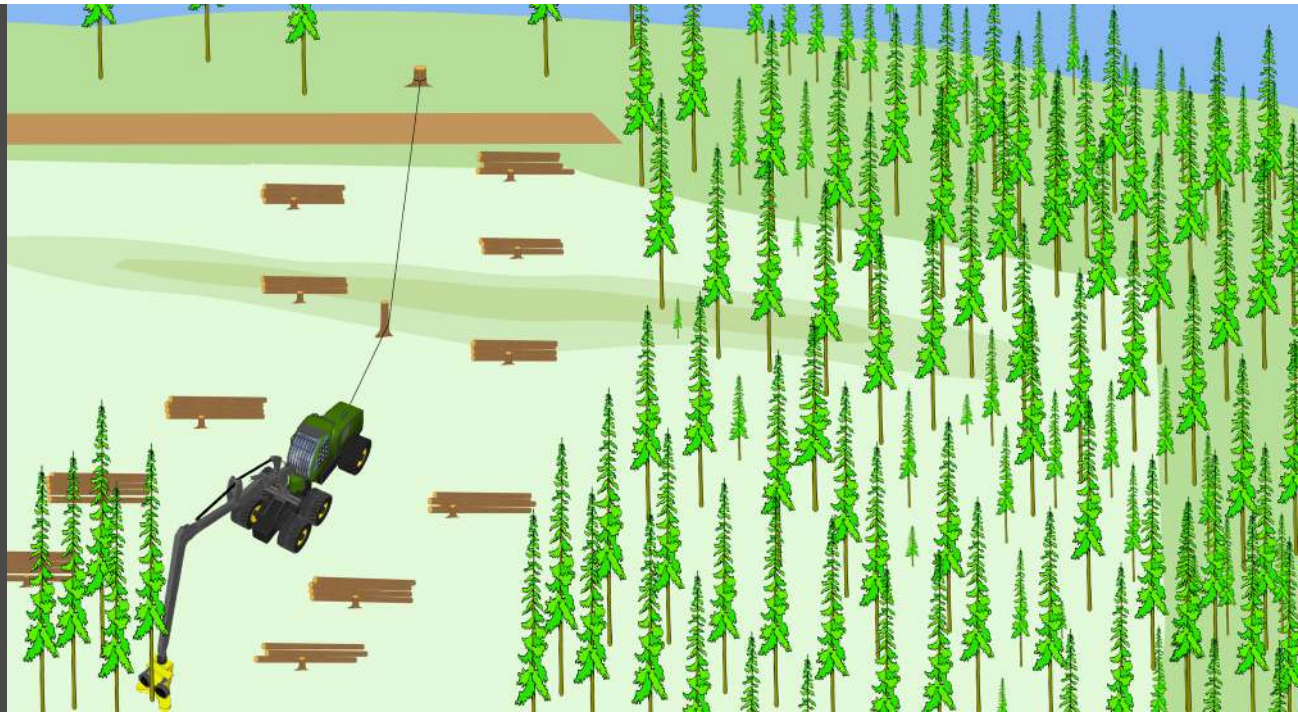
- one catch stump part way down the hill for a redirect (shown in Figure 30)
- multiple catch stumps for multiple angles of slope
- a valley in a slope with one or two ridge slopes that require multiple short trails from each ridge (shown in Figure 31)

Single catch stump

One catch stump part way down can allow the machine to redirect for the following situation:

- This type of anchoring is used when you find that part way down the hill, the slope of the hill changes direction slightly so that the machine must change course.
- In this case, a high stump can be left at or near the breaking point of the angle change that will allow the cable to be placed around this stump to make a straight line in that direction, as shown in Figure 30.
- This can only be used to change the angle a few degrees so the harvester and forwarder will be able to work on the face of the slope with no side slope.
- If the stump is prepared to the right height, the operator can use the lift of the winch enclosure to place the cable around the stump and get it off the stump when coming back up the hill.
- This is a safer option because the operator does not have to leave the cab in order to place the cable.

FIGURE 30. *Single catch stump part way down the hill.*



Catch stumps on secondary slopes

A valley in a slope with one or two ridge slopes that require multiple short trails (see Figure 31):

- This scenario is slightly more complex in that it is used not to make a trail redirect but only to redirect the harvester a short distance to reach wood from small ridges within the hill.
- In this case, the harvester operator would leave a high stump on the opposite side of the trail to allow the harvester to redirect down the slope of the ridge and either place the wood at the bottom to a trail or feed it back to the main trail that the operator was working on.
- If the required deflection angle is smaller than recommended by the manufacturer, associated hazards such as abrasion, high temperatures, tension differences, and catch stump failure could lead to unsafe consequences. For such situations, installing a block for running line configurations is recommended.
- The process is to cut the full length of the trail but leave openings on the side to be cut every 16–18 m, depending on the distance you normally leave between cut strips.
- Across from each one of these trails, you will need to leave a high stump that you will later use to redirect.
- Once the main trail is cut, then you will use the high stumps you left on the way in to redirect down the hill to cut the small section between the trails.
- This is a necessary method any time there are ridges that protrude out of the hill going in the same direction as the main slope.
- Remember that none of the wood cut on this redirect should be left on the redirect trail because the forwarder cannot reach or drive to this wood.
- This method is only for the harvester to be able to place wood he cannot normally reach and place it to either of the two adjacent trails.

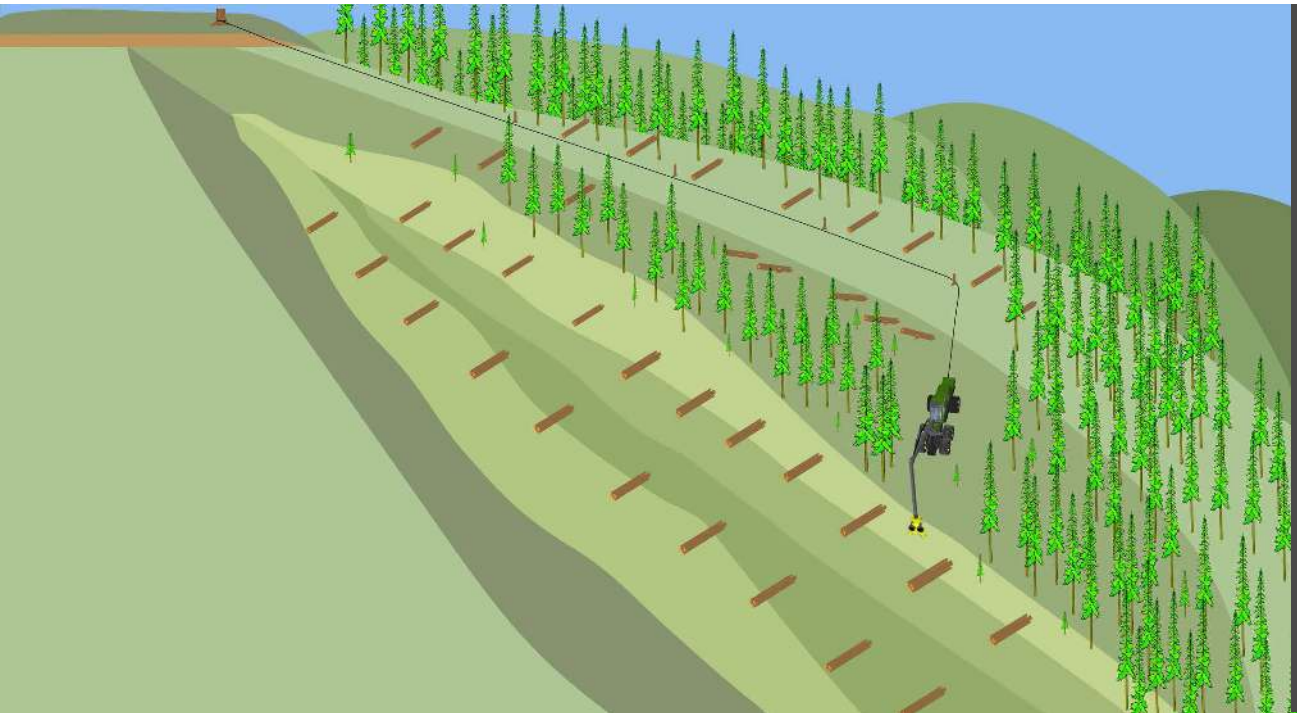


FIGURE 31.
Machine using catch stumps to work a secondary slope.

05.

BEGINNING TO HARVEST WITH A WINCH-ASSIST MACHINE

FIGURE 32.
Machine can lift or lower the winch to change pulling power and traction.

USING THE WINCH

Before operating a winch-assist machine, training must take place as to the proper operation, anchoring, safety measures, and features that will allow the operator to competently operate the machine.

- Working down the hill, the winch enclosure can be held high to help increase the downward pressure to the wheels of the machine, helping to increase the overall stability. See Figure 32.
- Depending on the pitch of any particular part of the hill, drop off, or rocks that may become obstacles, a high stump or two may need to be left in strategic spots to maneuver back up the hill.
- You must also be careful not to leave high stumps in any key locations such as the crown of a hill where the cable can become caught behind stumps, resulting in the operator getting out of the cab to remove the cable from behind stumps manually.
- Any time an operator is out of the cab on steep ground, the risk of injury from slips or falls increases. **Always call an operator in another machine to tell him/her you are going to be out of the machine and check in as soon as you return to the machine.**

- Experience will greatly expand the operator's ability to manage obstacles, but some areas may need to be avoided in the beginning, after closer inspection. These areas should be left for the more experienced operator.
- Once the harvester is established in the cut strip and working on the general pitch of the hill versus steeper terrain areas, the winch enclosure can be lowered so the cable is running straighter to the winch drum. This will provide better pulling power of the winch and reduce ground pressure in areas where it is not required. See Figure 32.
- It is normally best that the most experienced operator cuts the tougher terrain until the less experienced operator has gained the confidence and experience required.
- As in any harvesting operation, it is recommended that if the machine is going to work two or more shifts, the operator working the dark hours would work on the best ground.
- If the night shift operator comes to uncertain or challenging areas during the shift, it is recommended to leave this for daylight or the next shift to work that area during daylight hours.
- Trails requiring a redirect (catch stump) should be planned for daylight hours as well. Planning and executing a redirect in the dark is not practical or efficient.

HARVESTING WITH A WINCH-ASSIST MACHINE

Now that we have talked about the planning, anchors, and how to safely set the anchors, we are finally ready to start harvesting. Here we discuss the harvesting steps that are more specific to winch-assist logging:

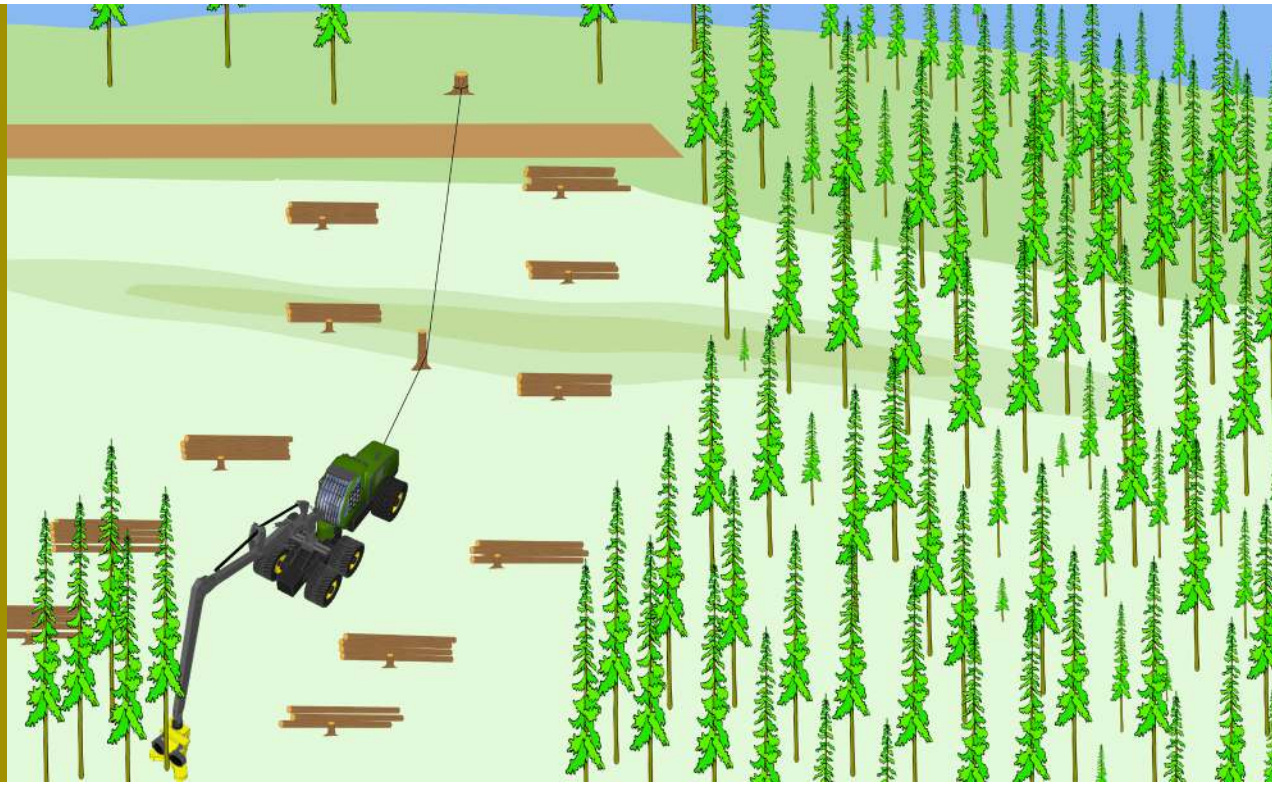
- Regardless of the type of anchor being used, the harvesting is basically done in the same manner.
- One anchor can often be used for multiple short trails up to 200 m but this can depend on the steepness of the ground, the obstacles on or near the trail, and the type of winch-assist machine being used.
- For instance, a rubber-tired harvester with an on-board winch can be fairly flexible, whereas a track machine with an anchored winch at the top of the hill may have more limitations due to the fact that the cable is moving in and out with every machine move.
- One thing to always keep in mind is that **the machine should always be able to sit stable on the hill without the support of the winch.**
- Longer trails will require a single anchor for each of the trails.
- When harvesting trees on hills with more than 20% slope, the wood should be piled on the uphill side of the stumps to support the piles, and the piles should be at or near 90 degrees to reduce sliding and moving of the logs.
- Wood should be placed in piles on both sides of the machine when possible and placed on the same side as it was cut.
- Often when working at high elevation on mountains or large hillsides, there can be a considerable amount of wind. Because the trees are tall, the wind can make it difficult to manage them; felling the trees with the wind will make the task much easier and safer.
- In this case, the operator must alter his method to pile all of the wood on just one side. This is not as efficient, but safest and most practical for the conditions.
- Erosion can be an issue any time the machine comes in contact with the soil, so it is extremely important to manage the brush so it is placed under the machine with the smaller woody debris under the track area. Any large woody debris should be removed from the trail area to reduce the chance of sliding or creating an unbalanced trail.
- Smaller trees can often get knocked over or windthrown during the harvesting process. Merchantable product should be taken from those trees when possible and all smaller debris should be placed in the trail.
- Avoid pulling trees out by the roots as this disturbs the soil surface which can lead to problems with erosion.
- Once the trail has been cut and it's time to exit the trail, it is best to place the boom closer to the machine and head just high enough to clear the ground, brush, etc. This will help stabilize the machine as it travels back to the road.
- Avoid travelling with the boom extended to the side as this can make the machine unstable.
- On the normal slope of the hill, maintaining a level winch enclosure helps extend cable life and increase pulling power of the winch.
- In areas that may be rougher or have higher stumps or rocks, the winch enclosure should be raised near the top position so it pulls the machine down for better traction and stability where it is required.
- This process comes with experience so newer operators should not start on challenging trails until they have mastered this procedure.

TRAIL ORIENTATION IS CRUCIAL WHEN STEEP GROUND/WINCH-ASSIST LOGGING

There are some rules of thumb that you can follow that will help you make the best decisions:

- The anchor stump/tree/deadman anchor should be located in a centred position if using the anchor for multiple trails.
- Trails must follow the terrain to reduce the amount of side slope for the machine. The forwarder is much more sensitive to this since the centre of gravity is higher on a loaded forwarder than on a harvester.
- In the past, many cutblocks were planned on longer, more continuous slopes. Many of these shorter slope cutblocks can either be broken or change direction for short distances. When the side angle of the slope changes, "catch stumps" should be left just before the side angle changes. Catch stumps, as they have become known, are stumps that are left about one metre high where the cable can be placed with the machine to redirect it on a different angle from the anchor, as shown in Figure 33. These stumps must be large enough to support the machine while it is working on the changed angle.
- Remember that the higher the cable lies on the stump and the greater the angle of redirection, the larger the stump that will be required to support the machine. The location of the catch stump is critical to getting the cable as low as possible on the stump.
- Care must be taken to orient the trails from a common anchor so the distance between the trails does not become wider than the machine has the ability to cut.

FIGURE 33. *Machine using catch stumps to work a secondary slope.*



06.

PLANNING THE HARVEST IN THE TRAIL

FIGURE 34.
Machine failed to regard the side slope safety recommendation.

FOLLOWING THE LOGGING PLAN

Is the operator using tools to make straight trails and following the logging plan having the most efficient trails for the forwarder in accordance with the terrain? There are many reasons for having straight trails:

The straighter the trail, the less backing up and shunting to correct the trail. The extra movement can cause exposed soil, reduce stability, increase fuel cost, and lower productivity.

- Straight trails increase the amount of wood the machine is able to capture from the predetermined strip width, allowing for a more consistent tree line on the next trail, which overall increases production and reduces the number of overall trails.
- Straight trails increase forwarder productivity and reduce chances of losing wood due to the forwarder running over it or becoming buried in brush.

So now that you can see the benefits of straight trails, how can you make them? There are several tools we use:

- Computer tools, such as GPS, where lines and/or crumb trails are effective in helping keep the machine on a straight course.
- Regardless of the tools you have, it requires the ability of the operator to keep the machine straight on the trail. The straighter the machine travels, the easier it is to remain straight on the trail.
- There are also some tips that can help, such as checking that your machine is straight before you move, looking back at the trail to get your alignment, and always trying to align with a tree in front of you to keep moving straight toward it.
- Remember that this is something that gets better with practice, so don't get discouraged if you struggle with it in the beginning.
- One last thing to remember about trails is that only a 5% side slope is allowed. This is for both your safety and the safety of the forwarder. The contractor/operator must plan and execute the cutting of trails so they run straight up and down the slope with a maximum of 5% side slope.
- Areas such as shelves, that can be within the trail part way down the hill, or at the ends of trails must not exceed 3% slope to provide a safe environment in which to change course or turn the machine. Failure to adhere to this rule of safety may have catastrophic results Figure 34).

In areas where turns are required, the side slope should not exceed 3%.

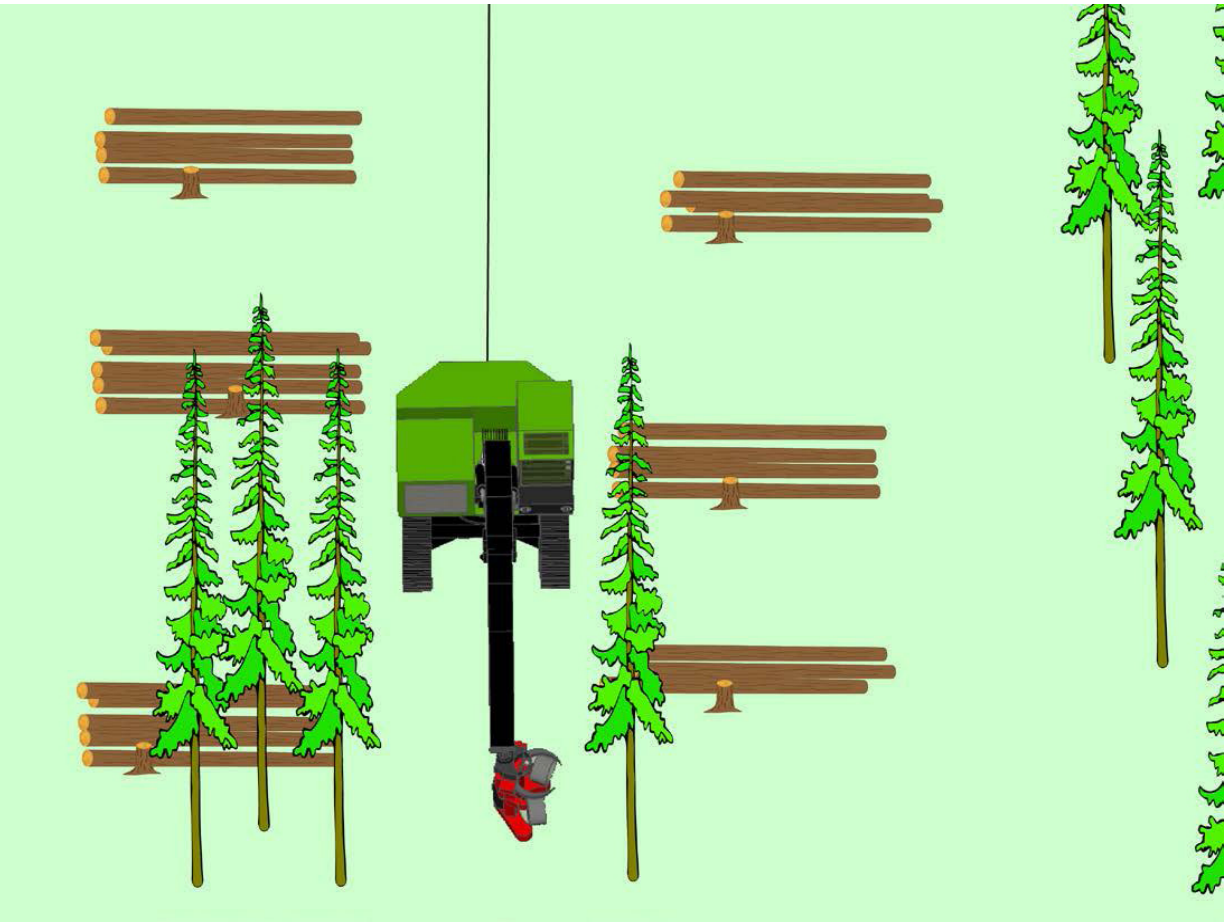
PLANNING EACH TREE TO CUT

- To be efficient and productive, it is essential for the operator to plan moves and target goals in advance.
- The further in advance the operator can plan, the faster and more accurate he/she will become. When planning tree selection, there are three key components:
  - tree species/product
  - piling area
  - felling target (the hole)
- It is best practice to be planning the trees during the harvesting process when there is the least amount of decisions to make. Three examples of these times are:
  - when travelling the machine
  - when felling the tree
  - when processing and cross cutting the tree
- Having the ability to plan multiple tasks simultaneously is extremely important to ensure operating efficiency and high quality.

MAKING ROOM FOR PILES

- One of the first steps is to make the decision where to process and pile the tree before cutting it off the stump.
- In many cases, the setup will begin by cutting a tree in the piling area to avoid placing wood directly beside a tree which will need to be cut later. Placing wood directly beside a standing tree can create an issue whereby the wood piled against the tree will not allow the operator to get the stump low enough when the tree is cut.
- The piling area should also be free from unmerchantable stems, rocks, and other obstacles which could cause wood to slide on the hill and other issues for the forwarder.
- A typical pile setup should look similar to Figure 35, which shows a clear area to pile with a harvest tree removed which opens the area to allow for the piles coming from the different sectors and/or required sorts.

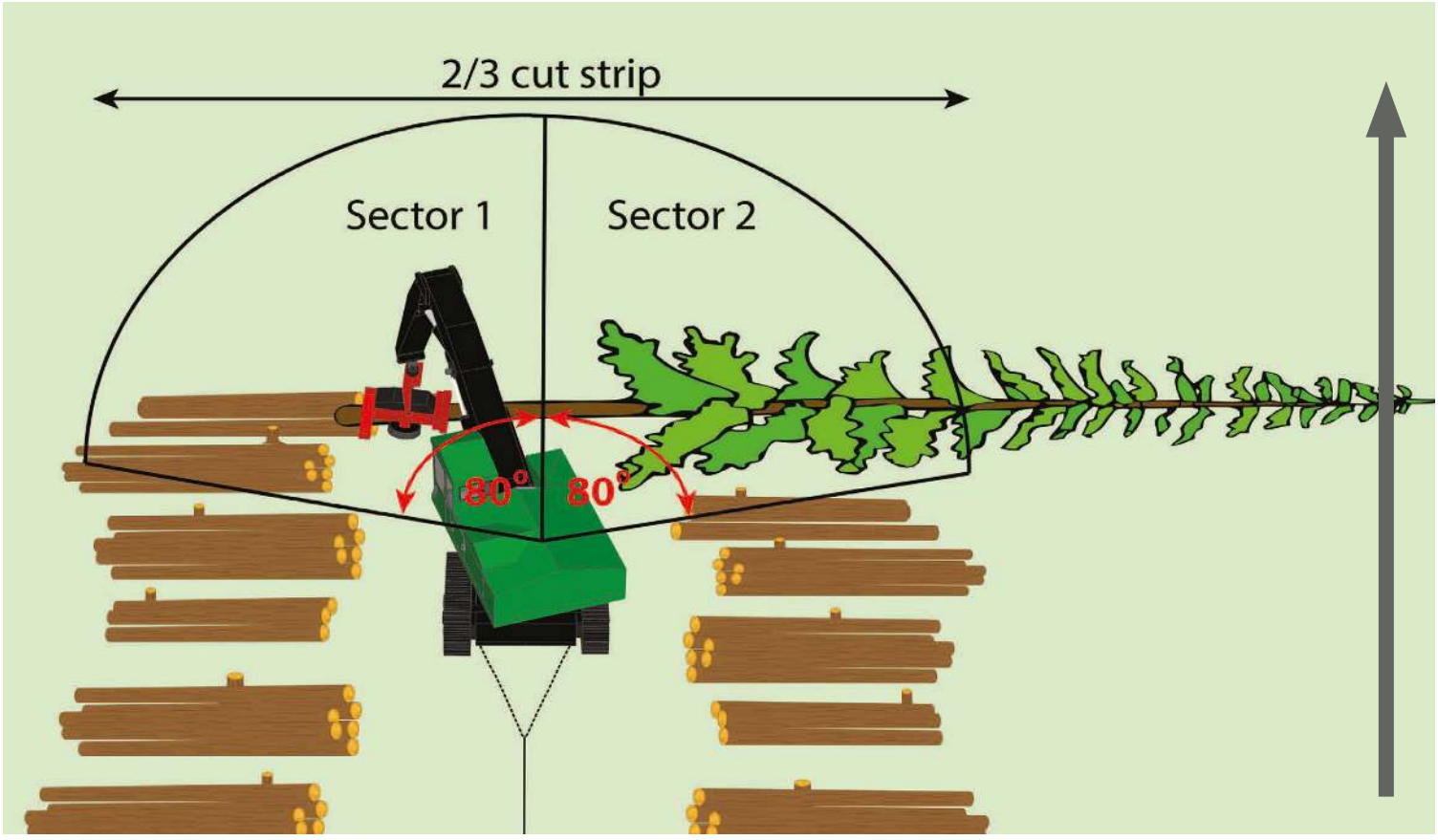
FIGURE 35.
Making clear areas to pile without trees or brush.



WORKING THE SECTORS

- When cutting in a pattern using two sectors, it is important to always stay in the sector until all of the trees are cut in that sector. Staying in the same sector allows the operator to be as efficient as possible (see Figure 36).
- Each sector spans 80 degrees to each side from the centre.
- Cut strip should be a maximum of two-thirds the width of a normal cut strip
- In some cases, the operator will encounter times when he must take a tree from one sector to another. Examples are:
  - when harvesting large diameter tree that is easier to process in another sector
  - when a leaning tree has been encountered
  - wind conditions are too great to maintain control of falling trees
  - terrain conditions
  - scattered tree species
- Working (staying) within the sector as much as possible will minimize the distance that trees are moved after the felling cut. The further that trees are moved, the more time it will take to finish processing the tree.

FIGURE 36.
Machine staying in the sector until it is finished.



PLANNING THE PILE

- Having the proper amount of space for piling and sorting all of the products is necessary to ensure quality piles are created for the forwarder.
- If the operator doesn't allow enough space between products, it causes the wood to run together which makes it very difficult for the forwarder to distinguish one product from another.
- Advanced planning to decide the required space necessary for the products gives great advantage in regards to minimizing movement and maximizing space during the piling and sorting steps.
- When working on steep ground, piling space is limited; therefore, it must be used efficiently.
- Judging between the available space and the amount of wood that must flow into the space is part of the planning that must be done.
- Planning the pile so the first pieces of wood are placed against an obstacle or depression can help build a stable pile. The pile should always be built upwards from this stable point.
- Some techniques that can be used to achieve a good pile structure are as follows:
  - Always make a good base by placing a number of sticks in order on the bottom (see Figure 37, left drawing). This configuration is for flat ground and will help to keep the pieces in the pile parallel to each other and avoid cross piling.
  - On the other hand, the pile in Figure 37 (lower drawing) is constructed quite differently if you look at the order of the sticks in the pile on steep ground. The wood always must be piled from the bottom upward to avoid rolling and crossing. A stump can help keep the pile in place.
  - Keep the harvester head low when feeding and cross cutting. This will help control brush or limbs and also lower the risk of pieces bouncing or kicking, which can result in poor quality piling.

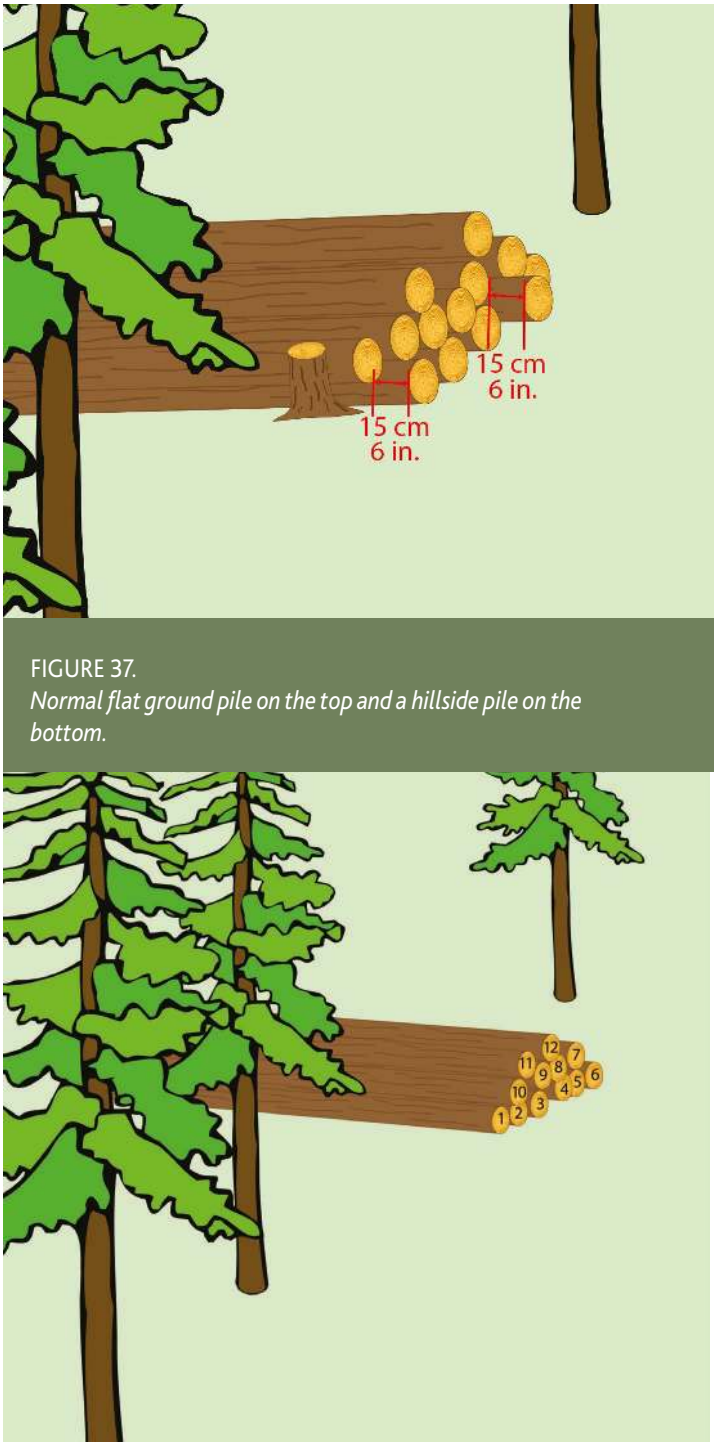


FIGURE 37.
Normal flat ground pile on the top and a hillside pile on the bottom.

- Try to predict the amount of space you will require for each product sort. This will help keep space between products, making it easier for the forwarder operator to distinguish the products. This becomes even more important doing commercial thinning when working with multiple products and finding space to place them among the residual trees.

07.

DOUBLE-DIRECTIONAL STEEP-SLOPE FELLING

FOLLOW THE WOOD

- Using both sides of the harvester trail to pile wood is always the most efficient and effective method (see Figure 38).
- The first step in the process is to plan ahead and realize which side of the trail should be used.
- In many cases, operators will encounter situations where the majority of the wood is standing on one side. In these cases, it is best to place the wood on the side with the most standing trees. The goal is always to minimize the distance which you move the tree after felling so this is by far the most efficient method.
- Also, it improves the forwarder productivity as the average pile size increases dramatically due to placing all of the wood on the side of the trail that has the most trees.

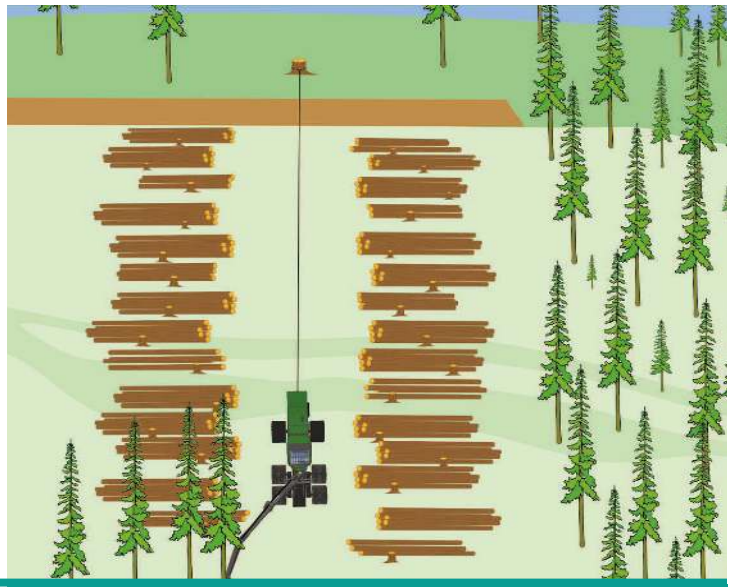


FIGURE 38.
Harvester following the wood, placing wood on both sides of the machine.

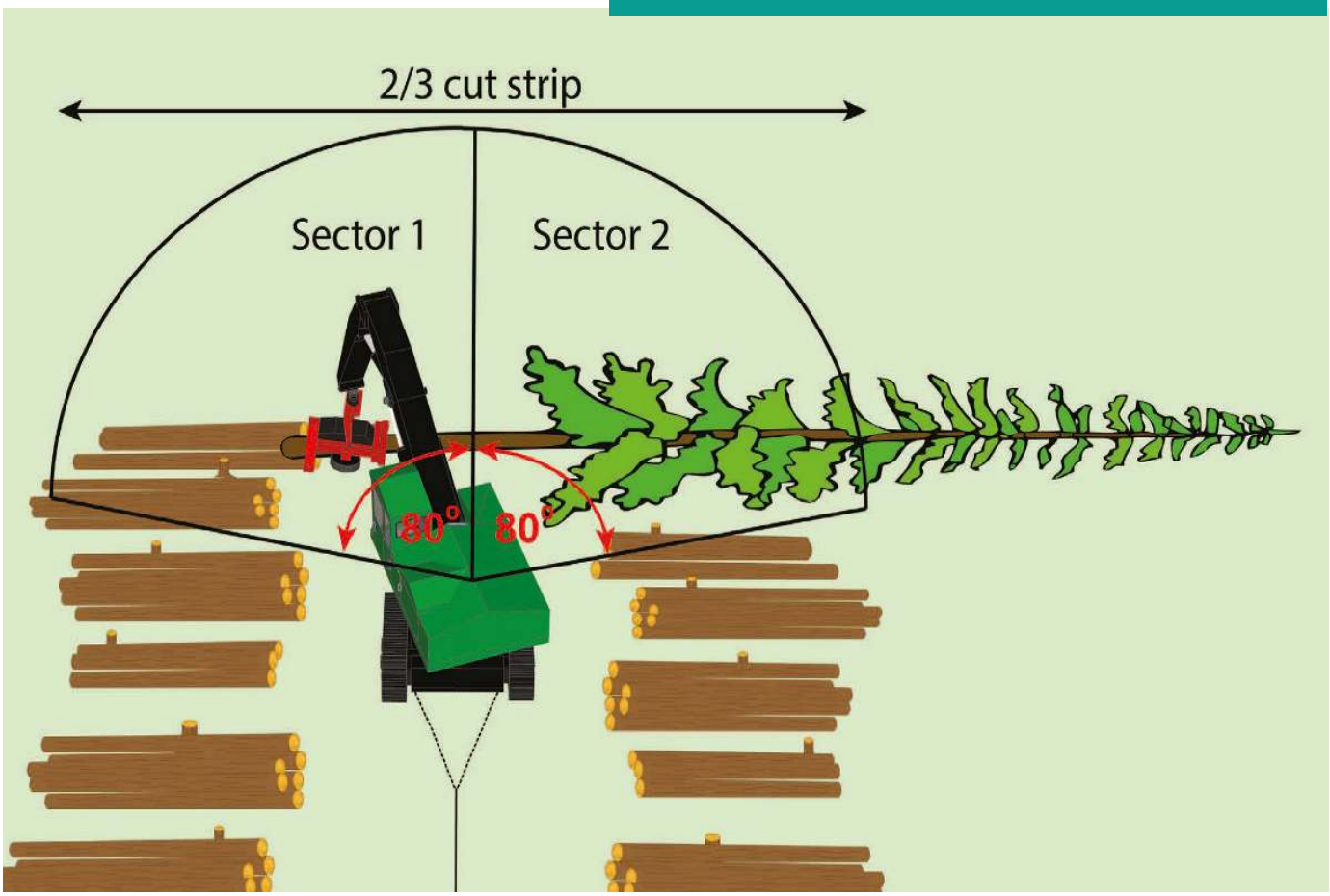
Trail brush mat management is an area that is much more critical on steep ground. There are some simple guidelines that you can follow that will help you make the best decisions:

- Manage the brush in front of the machine as much as possible. This will provide a full and more even brush mat where the machine will be driving.
- All large debris such as broken tops, wind felled trees that are non-merchantable, or rotten butt cuts should be moved out of the path of the machine so they don't create hazards for the harvester. This type of debris can cause poor footing, rollover, or sliding hazards if they come in contact with the harvester wheels.
- Often the terrain surface can have rock and/or holes which can either present hazards or make it difficult to maneuver. Filling the larger holes and filling around rocks with brush and some smaller woody debris will make a better working surface for both the harvester and forwarder.

PILE LOCATION AND POSITION

- When cutting trees going uphill, it is best practice to fell the trees forward on an angle. However, most tethered machines are cutting downhill and tethered from the rear of the machine.
- Similar to cutting trees going downhill with a non-tethered machine, the operator should place the wood on or around 90 degrees to the slope (Figure 39). This avoids the situation of felling the wood down the hill at which point gravity is pulling on the tree, thus requiring the machine to work much harder to get the wood uphill to the pile.
- This can cause increased wear to the machine and burn a lot more fuel.
- Cutting on and piling at 90 degrees both sides of the trail can be tricky at times because the tops can tend to get on the piles on the opposite side of the trail.
- Many of the tops will be short enough to fit within the piles from one side of the trail to the other. Once the operator is comfortable with this method, management of tops becomes part of the task of levelling the trail for the forwarder whenever a longer top is encountered.
- The most important part of the brush management is to place tops going in both directions on an even brush mat to cover rocks, holes, and other obstructions to reduce compaction and the chance of erosion.

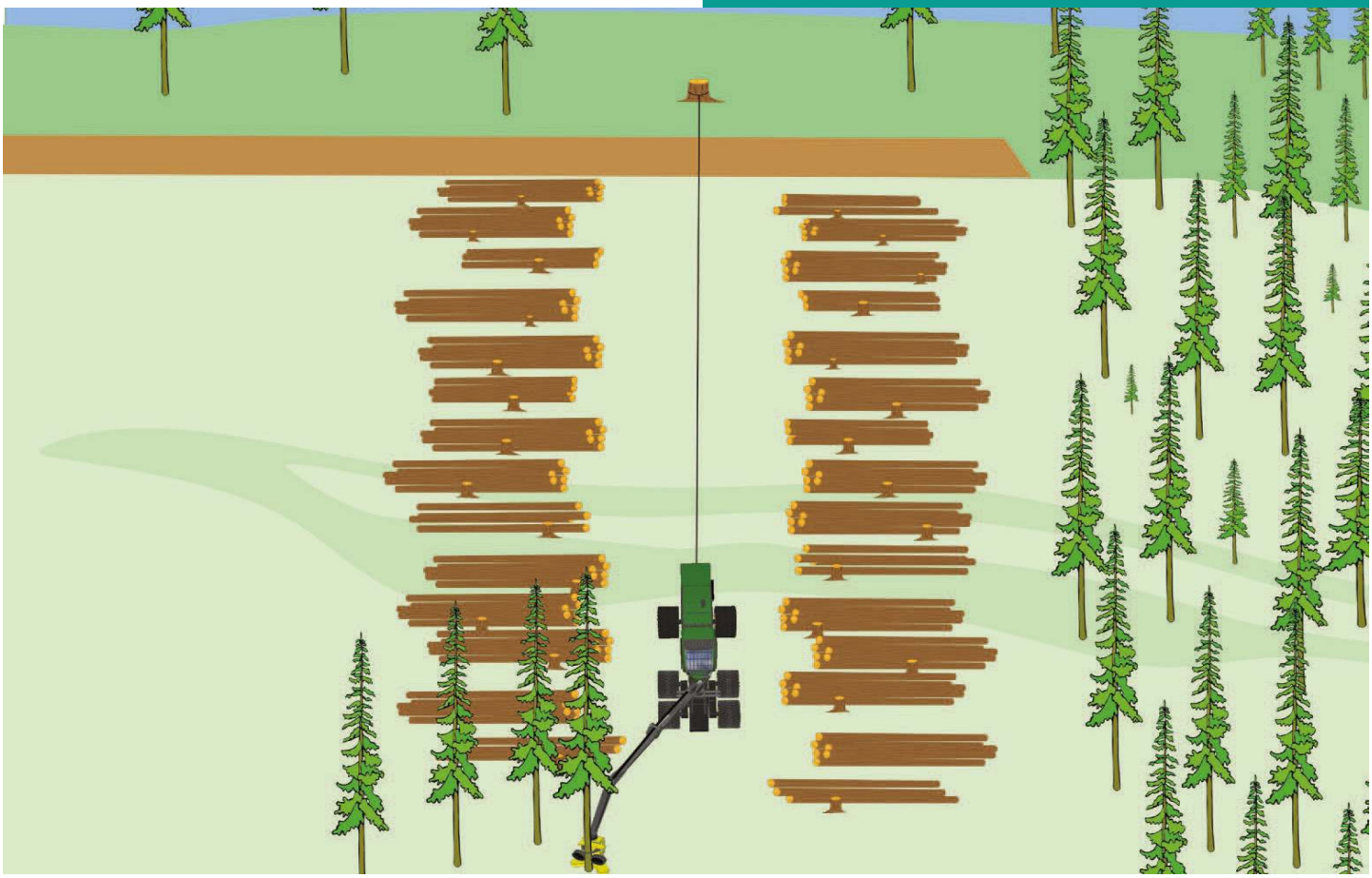
FIGURE 39.
Harvester felling and piling at 90 degrees to the trail.



WOOD PLACEMENT

- Wood placement along each side of the trail helps determine many important factors such as:
  - keeping the brush in the trail
  - keeping the wood at the correct distance for the forwarder to avoid over reaching
  - maintaining good pile offset making it easier for the forwarder operator to distinguish between products
  - good alignment, making it easier to load the wood on the forwarder which helps increase production
- Placing the wood 1 m away from the tracks with a 0.7–1 m offset between the piles is ideal and should be maintained whenever possible
- A stump or small space between each pile can also promote easier loading for the forwarder—see Figure 40 which shows stumps, spaces, pile offset, and distance from the machine. Wood that rolls downhill into the next pile will reduce forwarder productivity and may result in poor sorts at the roadside or mill.

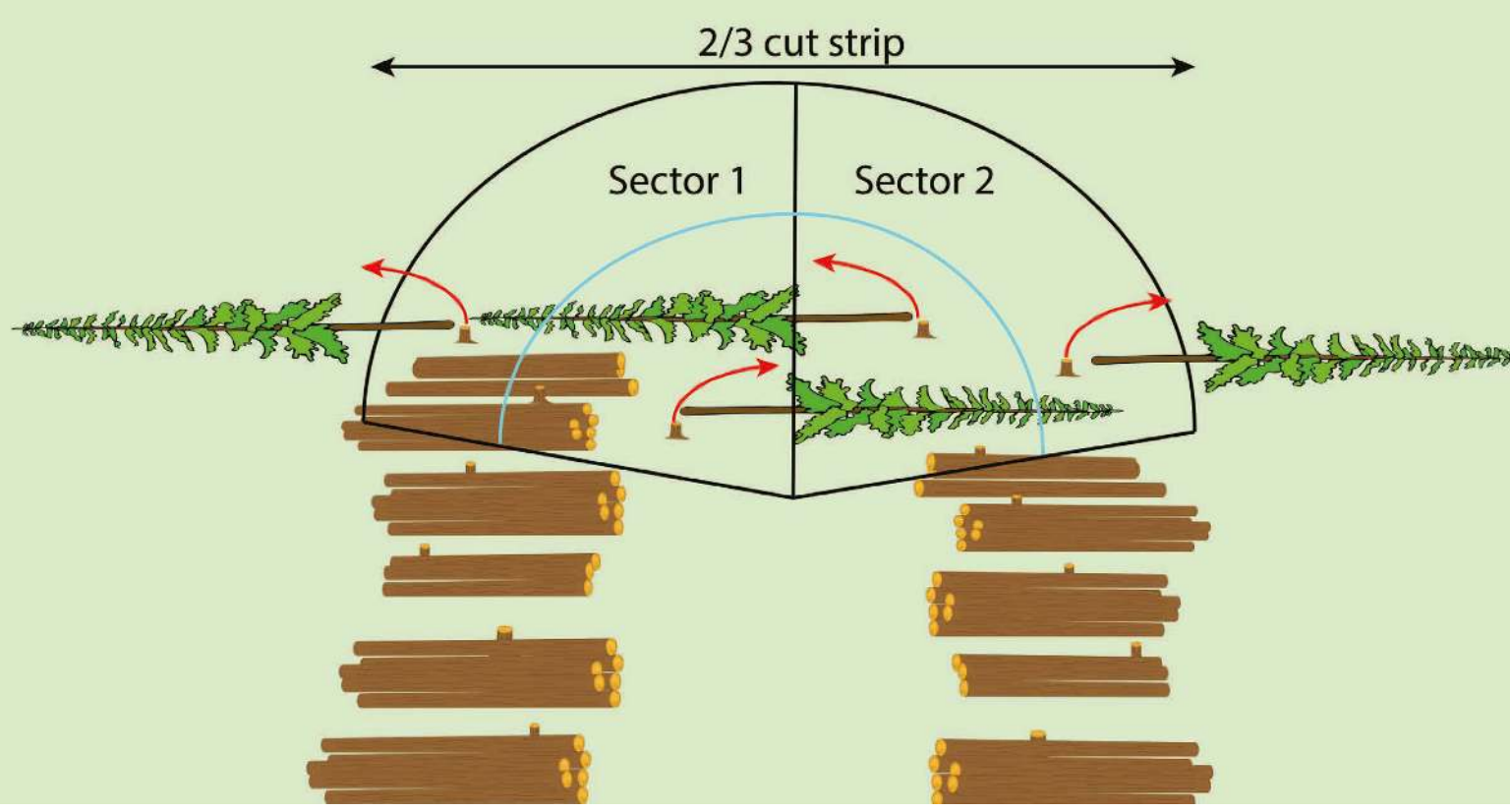
FIGURE 40.
Placing wood 1 m from the wheels and an offset of 0.7–1 m.



CUTTING IN A TWO-SECTOR PATTERN

- There are many challenges when working on steep ground with a slope of 25% or more.
- For winch-assist machines, this is even a higher % of slope. When an operator encounters this situation, using a two-sector cutting pattern is typically the most effective method. This ensures the machine stays stable as the operator is not reaching excessively beyond the piles.
- Only when necessary, it is acceptable to use a cross-trail technique to handle large-diameter trees that are 50 cm (20 in.) and larger leaning trees, or when harvesting scattered species.
- For the most part, cutting a two-sector pattern is still about keeping the trees on the same side as they were cut, most of the time.
- In Figure 41, you can see that the majority of the trees from centre to half way the pile would fall across the trail and pile in the pile nearest to where the tree was cut. The trees from half way would fall outward and feed into the piles. Big or leaning trees, wind, or scattered stand conditions will need to be treated in the most practical and safest method possible.
- Utilizing the inner/outer same side felling technique will help the operator be more productive and reduce wear to the machine and fuel costs per unit of wood produced.

FIGURE 41.
Cut pattern for cutting inside and outside trees.



MANAGING UNCONTROLLED FELLS

- There may be situations when the original plan to fell a tree must be modified by the operator due to uncontrolled circumstances.
- This can be more evident when working on steep ground as maintaining control of trees can be more difficult.
- If a tree must be released from the head during felling or falls in the wrong location, it is best for the operator to reposition the tree at the correct angle to a pile before processing it to length. This will make sure the pile alignment stays consistent.
- Figure 42 shows that if the operator pushes the tree forward down the hill and drops it, he/she can reposition the machine further down the hill and process it straight into the pile.
- In the case where it is not possible to reposition the tree to align with a pile, the operator may need to:
  - wait and manage the tree from an adjacent trail
  - take it to an existing pile that may be up or down the hill
- Most importantly, the operator should make the decision that is the safest and then the most efficient for the situation.

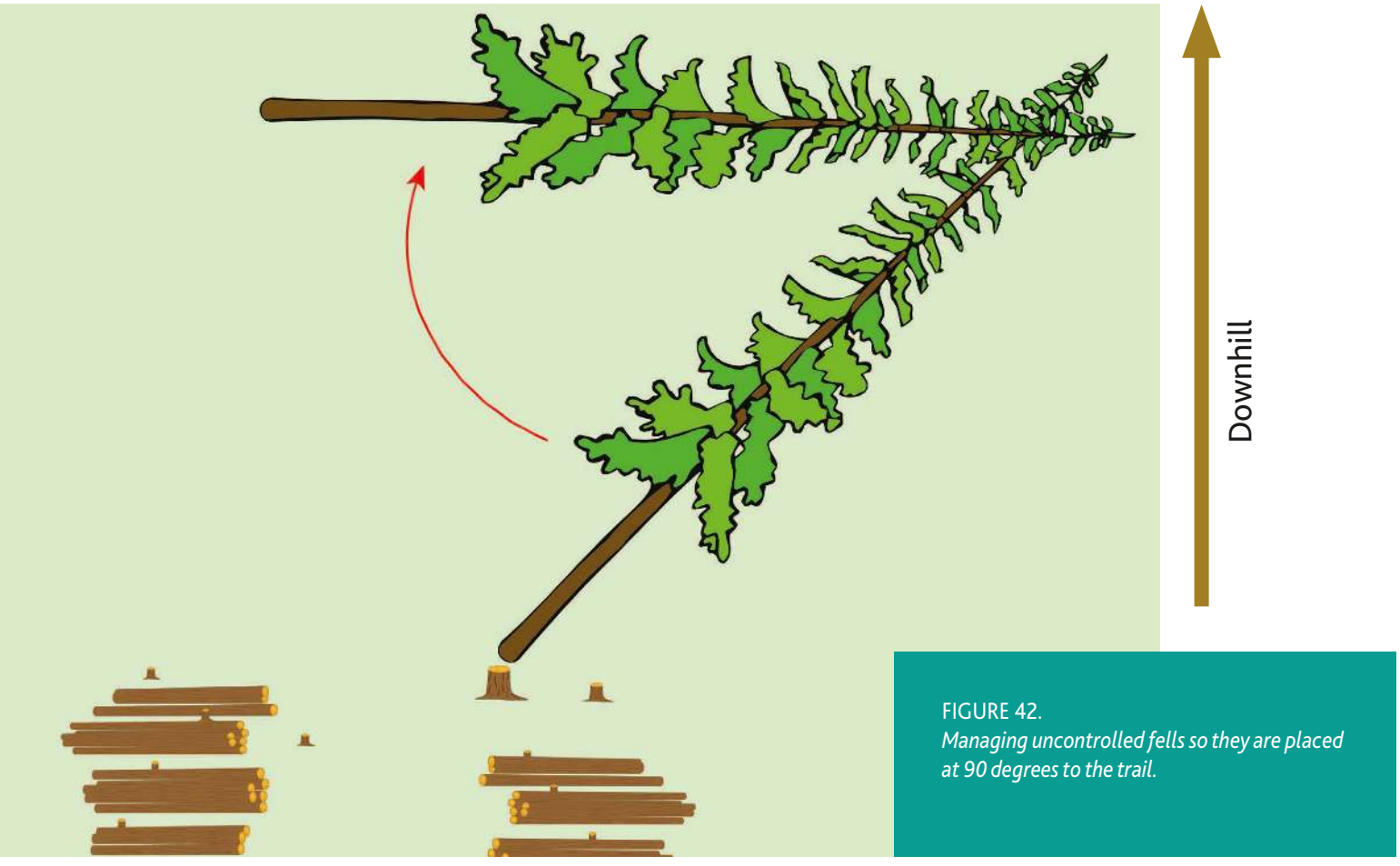


FIGURE 42.
Managing uncontrolled fells so they are placed at 90 degrees to the trail.

SWINGING BUTT AWAY FROM STUMP

- Sometimes, to maneuver a tree into the correct location, the operator must take steps to manipulate the tree by swinging the butt away from the stump immediately after the felling cut has been completed.
- Using this technique, an operator can direct a tree to the desired location by swinging the butt to align with a pile and therefore hit the felling hole more accurately. The felling hole is a term that is used to describe the targeted area where you wish the tree to fall, which is normally between two other standing trees.
- This becomes even more critical when working on steep ground where it can be more difficult to control and maneuver trees.
- If the operator swings the butt of the tree in the direction of the pile and uses the boom in or out to direct the top to the location you want the tree to fall, this will help direct it into the hole.
- As you can see in Figure 43, as the butt is swung to the left, the top can be directed between the two trees which is the hole targeted as indicated by the red "V."
- It is only possible to direct the tree when it is falling from 10 to 30 degrees where the tree is nearly weightless as it starts to fall. Once the tree is beyond about 30 degrees, the tree becomes more top heavy and less able to control.

FIGURE 43.
Maneuvering a tree into the felling hole.

08.

DEALING WITH UNMERCHANTABLE TREES

FIGURE 44
Manage umts that are in the trail but leave those that are outside of the piles.

MANAGE UNMERCHANTABLE TREES (UMTS) IN A TIMELY ORDER

Unmerchantable trees (umts) are normally undersized trees with no usable wood fibre as they do not meet any product specifications. This may also be dead wood or undesired species.

- Ideally, the operator should avoid dealing with umts whenever possible because they offer no financial gain to the operation. In fact, they are one of many direct impacts to reducing productivity.
- In certain situations, there is no choice but to manage some umts. Understanding the appropriate amount of time to spend successfully managing umts while maintaining a high level of productivity is the key.

LEAVE UMTS THAT DON'T AFFECT OPERATION

- It is best to avoid umts that don't hinder either the harvesting or the forwarding operation (Figure 44).
- Some situations where operators must manage umts are as follows:
  - directly in the piling area
  - in the centre of the trail where the machine will travel
  - around the butt of trees that you wish to harvest

AVOID CUTTING UMTS

- It is best practice to avoid cutting umts with the saw whenever possible.
- As previously mentioned, umts add no value to the operation; therefore, operators should avoid spending time managing them but it is especially important to avoid cutting them with the saw.
- Using the saw to cut umts has many negative effects such as:
  - increased fuel consumption
  - wear to the bar and chain
  - wear to the saw motor
  - wear to the hydraulic components
- Using the saw to manage umts offers no financial return to the machine so should be avoided whenever possible.

USING A TREE TO MANAGE UMTS

- There are several methods to manage unmerchantable trees other than with the saw.
- Figure 45 is an example of how to manage unmerchantables without reducing productivity or causing damage to the harvesting head.
- Care should be taken to practice this very slowly in the beginning.
- Figure 45 is showing the unmerchantable trees being pushed over on an angle.
- Once the head is about half way up the tree gently sit the head down on the unmerchantables.
- This will push the umts flat to the ground.
- Managing umts in an "X" formation in the trail in front of the harvester will ensure the umts stay down and become part of the brush mat.

PLACEMENT OF UMTS

- When working on steep ground, operators should avoid using umts as skids.
- Occasionally, operators will push umts over parallel to the trail and then pile products on top. This method is not recommended when working on slopes as the products can potentially roll down the slope, causing poor pile quality, sorting issues, and potential safety hazards.
- Managing umts in the "X" formation when harvesting on steep ground becomes even more important to avoid projectiles that may affect the forwarder.
- If umts are cut, they should be placed into the brush mat to help protect the thinner layer of soil on the steep ground.

FIGURE 45.
Manage umts with a tree when possible.

09.
FELLING TECHNIQUES

MINIMIZE STUMP HEIGHT

- High stumps are not permitted by the forest company (see Figure 46).
- They are a waste of the high volume area of the tree.
- The standard regulation for stump height is no more than 15 cm (6 in.) above the root collar. Operators should always keep in mind that stumps are best cut as low as possible without running the saw into the ground

FIGURE 46.
Extremely high stumps. Managing stumps after cutting a tree.

- High stumps can also pose a dangerous obstacle for the harvester, which can result in the machine overturning.
- They are also dangerous for other machines such as the forwarder, skidder, and any land preparation equipment, especially when located on the trail.
- Keeping the stumps as low as possible on the trail is critical for the safe operation of every machine that will be working in the operation.
- If a stump is too high in the trail area, it should be managed by the harvester operator. In Figure 46, the illustration shows two different cuts that are possible to lower the stump height in the trail:
  - placing the edge of the frame of the saw box on the edge of the stump either to the side or facing downhill and physically tipping the head by maneuvering the boom then sawing it off
  - cutting the stump as low as possible on the high side then going a few inches lower on the front and making another cut; the piece of stump may or may not come off but it doesn't matter because the machine will break it off as soon as the underpanels touch it
- Both of these methods work well but the operator must leave the knives open if the harvester head has lower knives, as they will catch the top of the stump and bind the saw.

FINDING THE FELLING LOCATION (THE HOLE) EFFECTIVELY

- It is important that the operator select the hole before cutting and felling the tree.
- As shown in Figure 47, the green arrow indicates a good hole while the red arrow indicates a poor location to fell the tree.
- It is important that the operator learns to read the hole without seeing the top of the tree as he/she will normally only see part way up the tree in the dark.
- Using the felling hole enables the tree to fall easily to the ground and promotes good pile alignment only if each tree in the set is felled into the same hole.
- When working the harvester on steep ground, after the felling cut has been completed, it is best practice to keep the tree as low as possible to the ground. Keeping the head low enables the operator to better control the tree and get it safely to the pile.

HEAD POSITIONING FOR FELLING

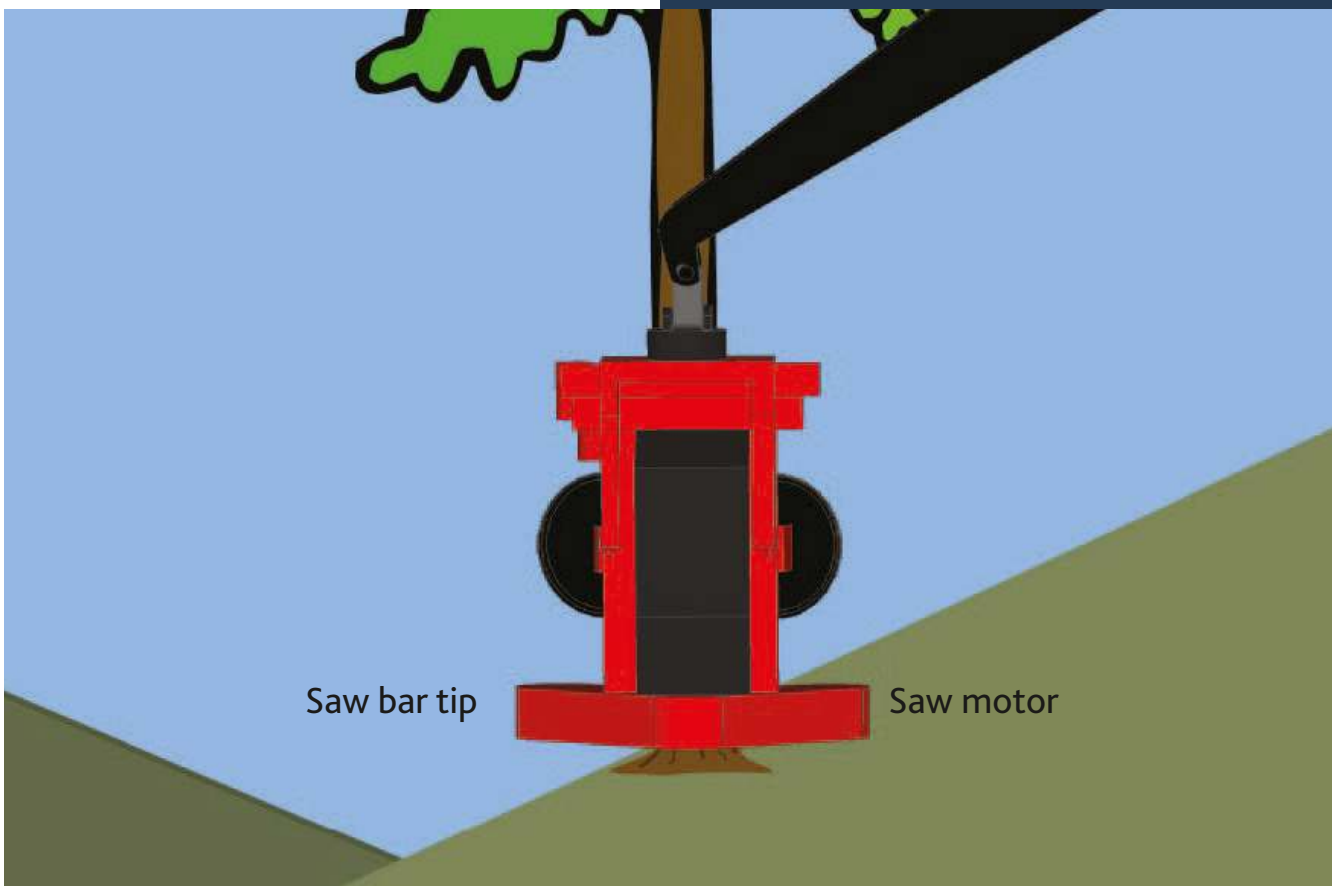
- When the operator is positioning the head, he/she must always consider the best location to avoid running the saw into the hillside and causing damage to the bar and chain.
- By placing the head at 90 degrees to the hill (or the high point on the stump), then simply rotating the head to the desired position to perform the felling cut will also help avoid running the saw into the ground.
- As you can see from Figure 48, the operator places the head so the saw motor is next to the hill and the saw bar tip is away from the hill.
- However, this only works part of the time so for less experienced operators it can be best to begin in this position, and turning the head while staying at the same level can help you judge where you should be on the tree when you cut it to get the lowest stump height and reduce the risk of hitting the ground with the saw chain.

FIGURE 47.
Planning and finding the felling location (hole).

MAKING CLEAN CUTS

- Making clean cuts on steep ground can be more difficult so it is very important to ensure that no damage is done to either the harvester, saw bar, chain, or tree.
- To accomplish clean cuts, the operator must consider many factors, such as:
  - condition of the bar and chain
  - ensuring that the machine and head are set up to the proper specifications
  - debris and unmerchantable tree management around the butt of the tree
  - the angle which the saw bar exits the saw box can determine what type of pressure should be applied to the bar to help finish the cut—understanding this angle can help avoid issues such as over-pressuring
  - whether or not the head has a firm and proper grip on the tree before cutting
  - perhaps it may need to have multiple cuts to reduce the overall size for the final cut

FIGURE 48.
Keeping the sawbar tip away from the hill (out of the dirt).



MULTIPLE CUTS ON LARGER TREES

- Multiple cuts, or double and triple cutting, are techniques used mostly when harvesting oversized trees. This is still the case when working on steep ground; however, a smaller tree will be considered "oversized" in steep terrain.
- Because of the challenges when harvesting on steep ground, depending on an operator's skill level, it may be necessary to double cut trees in the range of 38 cm (15 in.) to 50 cm (20 in.) and triple cut trees 53 cm (21 in.) to 76 cm (30 in.). This ensures that:
  - no damage will be done to the bar, chain, and tree during felling because there will be no chain exposure to the ground
  - the operator will have more control of the tree during the cutting and felling cycle
- The proper procedure for performing the double cut is to make the first cut on the side that the bar tip will be passing by when the operator performs the second or final cut (Figure 49). The proper procedure for performing the triple cut is to make a triangular formation with the final cut being in the direction which the operator wishes the tree to fall. As shown in the bottom image of Figure 49, the first cut is made on the tip side of the above-mentioned triple cut. Then, cut #2 and the final cut #3. The stump in the photo in Figure 49 was cut with the three-way or triple-cut method.

FIGURE 49.
Cutting oversized trees.

10.
MACHINE POSITIONING

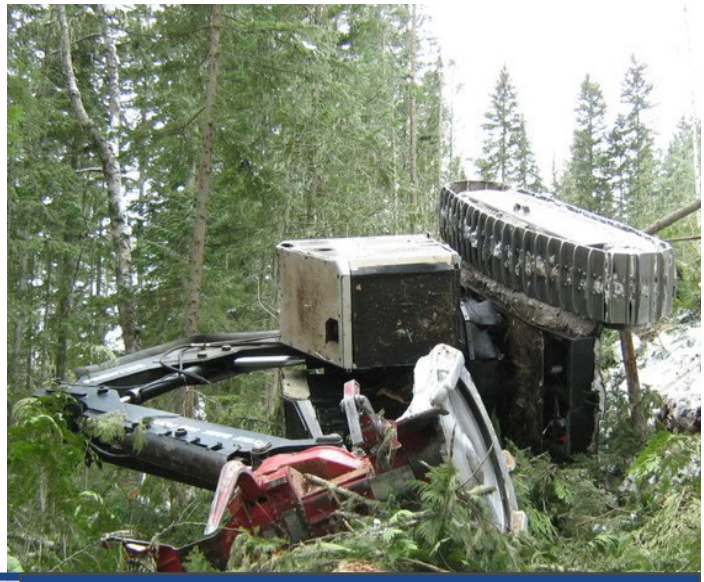
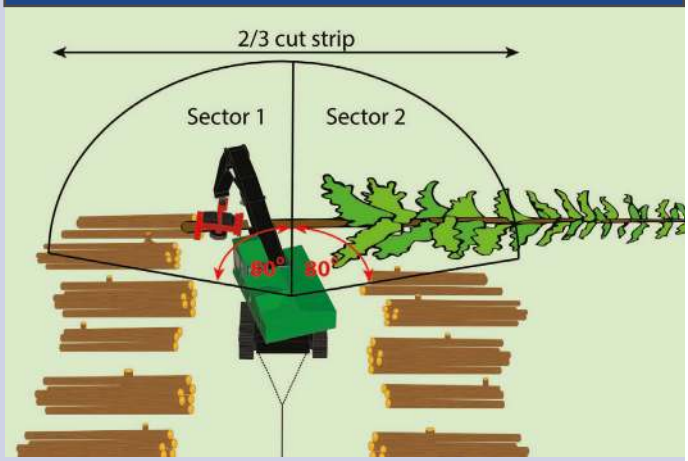


FIGURE 50.
Choosing a safe cut strip width in accordance to the steepness of the slope.



CUT STRIP WIDTH

- When working the harvester on slopes of 25% or more, it is best practice to avoid extending the boom more than 70% of its capable reach and also avoid swinging the machine boom more than 80 degrees from the centre to each side.
- If the boom swings more than 80 degrees to either side of the centre point with the boom outreached more than 70% of its full extension, the machine can become unstable and difficult to control (as shown in Figure 50).
- This practice works in both uphill and downhill harvesting scenarios.

MACHINE STABILITY

- Maintaining solid machine stability can become challenging in good terrain. In steep ground conditions even more challenges become apparent; therefore, extra care and attention must be taken to work safely.
- It is important to make adjustments to the track position (or bogie of rubber-tired machines) as you travel to avoid climbing onto stumps and other obstacles that could make the machine unstable.
- Levelling the machine, cab, boom (levelling machine only) during travel can help to speed up the harvesting process but it also helps the machine keep stable on rough terrain due to proper weight distribution.
- Tilted forward maintains the maximum weight on the front of the tracks when climbing a hill. The machine in Figure 50 tipped over as a result of not keeping the front of the tracks low and solid on the ground. Often the weight of the boom can be used when moving to help maintain good stability.
- And, vice versa when descending the hill. The weight of the machine stays at the rear of the tracks which, when descending, is critical.
- When operating a rubber-tired harvester, keeping the boom base level can improve stability especially when harvesting trees (perpendicular to the standing trees).
- Refer to "General Safety" in Chapter 1 for safe track information.

CONTINUOUSLY ADVANCING THE MACHINE

- It is always considered best practice to continuously advance the harvester so the operator is not required to overreach forward to cut trees.
- When working on steep ground, an operator should always plan the distance that the machine must be moved to find a stable position before harvesting can begin again. It is the ground conditions that will dictate the distance that must be travelled. When terrain conditions are extreme, it is typically best to harvest as many trees as possible when the machine is positioned firmly, even though some overreaching may be necessary to the forward sectors.
- Keep in mind that the parameters in the "Cut Strip Width" section in Chapter 10 must be followed.

PROPER CUTTING ARC

- Operators must always remember that machines swing on a bearing; therefore, they swing in an arc formation.
- Reaching to the corners is unproductive and causes instability of the harvester so should be avoided whenever possible.
- This practice is even more apparent when cutting on terrain in excess of 25% slope, as minimizing reach and staying within the 80 degree swing arc then become requirements.

TRAVELLING

- It should always be the objective for operators to avoid excessive travelling of tracked machines as the design is steel on steel. Minimize travel to help reduce wear of the metal components.
- Continuously travelling forward, keeping the machine straight, and not backing up offer a major gain in regards to the reduced amount of undercarriage wear caused to the machine. Also, passing over terrain only one time minimizes the ground disturbance and erosion, especially on steep ground.
- This can also apply to rubber-tired harvesters equipped with bogie tracks working on steep ground.
- If used properly, rubber-tired harvesters can have less impact than tracked harvesters due to the difference in their weights. However, care should be taken to not track excessively because rubber-tired harvesters can spin much easier, especially on steep ground.
- Due to the weight transfer caused by swinging the boom on a rubber-tired harvester, it becomes very important to make sure the boom is directly in front of the machine when travelling.
- The operator should always avoid pushing the machine with the head as this can cause damage to the harvester head and also raise the centre of gravity which can cause the machine to become unstable and potentially tip over.
- Working on steep ground can sometimes present an occasional situation where the operator, depending on his/her skill level, may be required to maintain stability by using the head and boom to pass over an obstacle.

11.
PILING TO STANDARD

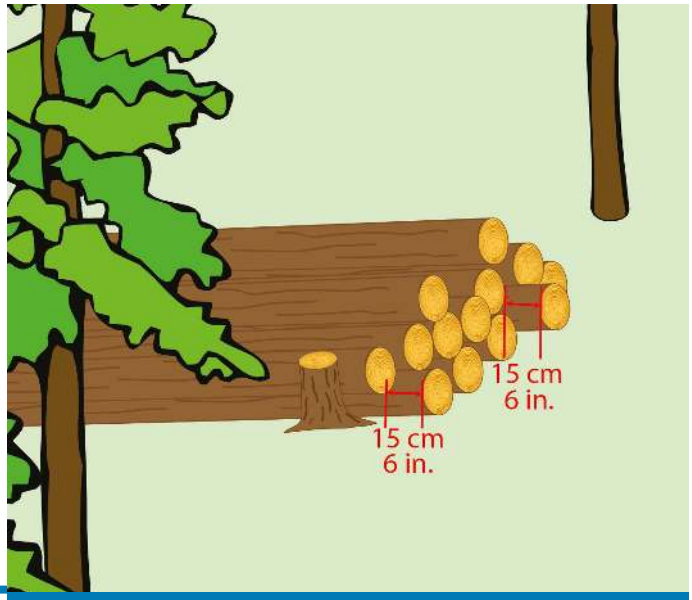
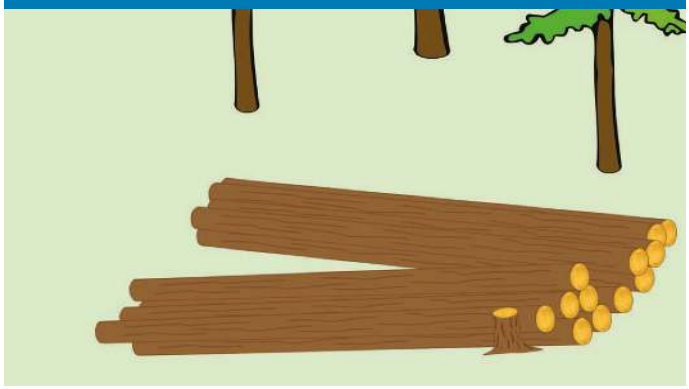


FIGURE 51.
Top showing indexing to +/- 6 in. Bottom showing wood alignment in the pile up to 20 degrees.



PILE ALIGNMENT

- Maintaining good pile alignment is attainable by keeping all the pieces in a pile parallel to each other and at plus or minus 15 cm (6 in.) in the squared portions of the pile (see Figure 51). This is a standard specification so you should consult your contractor for the correct specification for your operation.
- Doing a 20 degree cross as would normally be done on flat ground is not acceptable on a steep ground operation. However, placing two separate piles in close proximity but on different angles not exceeding 20 degrees will help avoid rolling or sliding wood (Figure 51, bottom illustration).
- When working on steep ground, planning to place the first pieces of wood against an obstacle or depression can help build a stable pile. The pile should always be built upwards from this stable point, which enables the operator to maintain good pile alignment (Figure 51, top illustration).

PILING TO MINIMIZE BRUSH

- Brush and tops can be controlled through good planning and consideration for the forwarder.
- Providing a brush-free area to construct the pile also dramatically improves the working environment for the forwarder.
- It is much more productive for the harvester to manage brush and tops by forward planning and considering future moves in advance by:
  - avoiding delimbing over the pile
  - raising the head slightly when the brush and tops start to build up at the end of the pile so brush cannot get pulled into the pile during processing
  - avoiding pulling brush into the pile with the butt of the tree when felling trees just to the outside of the pile
- If a small amount of brush does find its way onto the pile, the operator can place the head in front of the brush and sweep it away. There are several techniques that can be used either with the head or a tree in the head to manage unwanted brush.

TRAIL BRUSH MAT MANAGEMENT

Trail brush mat management is an area that becomes much more critical on steep ground. There are some rules of thumb that you can follow that will help you make the best decisions:

- Manage the brush in front of the machine as much as possible (see Figure 52). This will provide a full and more even brush mat where the machine will be driving.
- All large debris such as broken tops, wind felled trees that are non-merchantable, or rotten butt cuts should be moved out of the path of the machine so they do not create hazards for the harvester This type of debris can cause poor footing, rollover, or sliding hazards if they come in contact with the harvester wheels.
- Often the terrain surface can have rock and/or holes which can either present hazards or make it difficult to maneuver. Filling the larger holes and filling around rocks with brush and some smaller woody debris will make a better working surface for both the harvester and forwarder.

SORTING PROPERLY AND IN THE CORRECT ORDER

- Sorting and separating the products is part of the normal quality standard. It is important to have a method that helps the forwarder identify differences between products that have been processed.
- In many situations, offsetting the products is a very effective method to help sort the wood. If working downhill where the wood will be 90 degrees to the trail, a separation between piles will be beneficial.
- Beginning with the heaviest product closest and sorting away from the machine is the most efficient method and also reduces the amount of strain on the machine (Figure 53, right illustration).
- If spaces are used between products, they may touch at one end or the other but multiple products should not be crossed or run together.

FIGURE 52.
Controlling brush so it is placed in the trail area and not in and around wood piles.

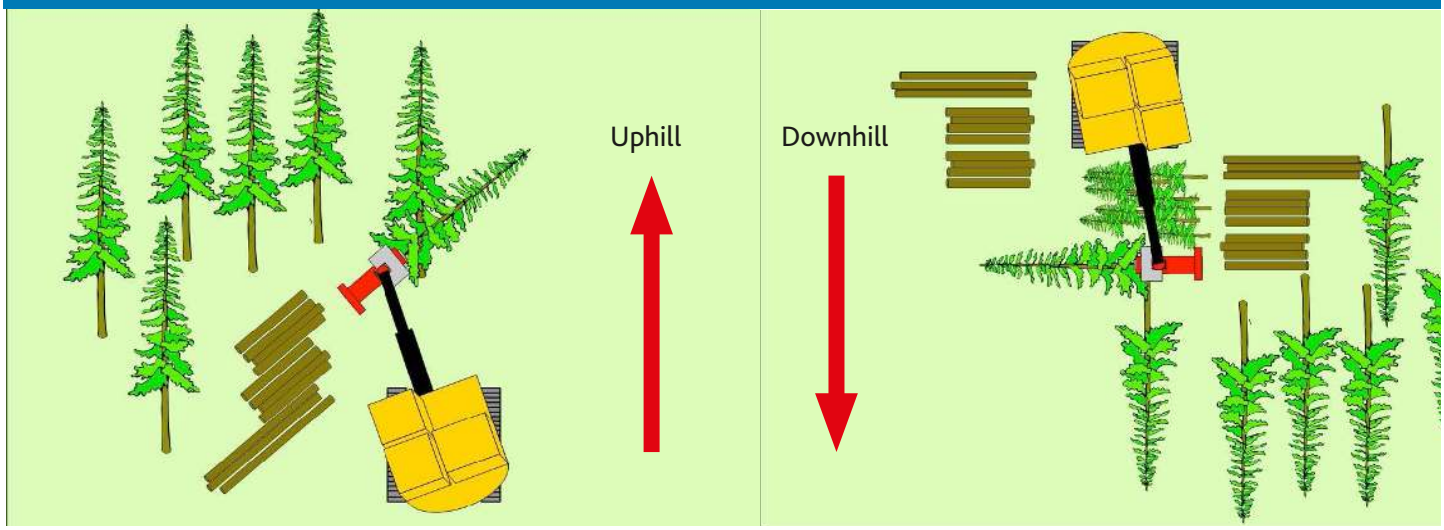
PILING AREAS THAT AVOID OBSTACLES FOR THE FORWARDER

- Selecting the pile location is a critical step in regards to the forwarder.
- Placing piles too close to obstacles such as standing trees, rocks, or very large stumps can make it difficult for the forwarder to pick up the wood.
- Using smaller stumps and small umts to pile the wood against can help when working on steep ground and uneven terrain.
- Always keep in mind to cut stumps as low as possible and avoid piling beside larger umts which would make it too difficult for the forwarder to work around when picking up wood.

REMOVING THE ROT TO SPECIFICATION

- Taking the proper steps to reduce rot will help ensure the production of quality products. With ever-changing customer specifications, it is important to review these specifications with the contractor/supervisor on an ongoing basis.
- Assuming that the operator is using the current rot specification, there are specific steps to easily and effectively spot and manage rot:
  1. If cutting uphill or on flat ground, wood can be felled at approximately 45-degree angle into the trail, making it possible to see the butt regardless of which side of the trail the tree will be piled (see Figure 53, left illustration).
  2. Sometimes the butt or the pieces being processed cannot be visible to the operator. Looking at the stump or the colour of the sawdust being produced during cutting can help indicate if rot is present.
  3. If the tree appears to have rot, then it should be moved to a location where the butt can be seen to make the proper decision as to how it should be managed.

FIGURE 53.
Uphill and downhill wood placement with proper sorting.



12.
DELIMBING

FIGURE 54.
How knife sharpness, adjustments, and technique can affect quality.

REMOVING ALL OF THE LIMBS

- There are three main factors related to making clean limb-free products to meet the required quality standard set by the mills:
  1. The delimbing knives must be maintained to the manufacturers' specifications. The top photo in Figure 54 shows poorly delimbed wood from poor technique or dull knives, whereas the knife in the right photo inset is well maintained and delivered perfect results.
  2. The operator/contractor will need to make certain the knife settings in the harvesting head computer system and the hydraulic pressure is set correctly.
  3. The operator must use the delimbing technique following best practices to delimb the tree properly.
- The branches must be cut clean and close to the main stem and all the limbs must be removed from the products created.

SWINGING THE HEAD WHILE FEEDING BUT ONLY WHEN NECESSARY

- Minimizing movement to accomplish tasks should always be the goal. Movement equates to time and time equates to money; therefore, when operators are able to perform tasks with minimal movement, it typically delivers better results.

- On steep ground, operators should avoid pre-delimbing trees more than 5 m (16 ft.) as this can cause instability issues with the machine.
- Operators should keep in mind that when working on steep ground, more help may be required when delimbing but shorter feeding strokes should be used to reduce the effect of gravity and stability.
- The biggest reasons for this are:
  - Gravity may at times be working against the harvester feed wheels, which increases drag and resistance if the tree was felled slightly downhill.
  - Machine stability will be reduced, so swinging while feeding but in short strokes can help reduce resistance and drag, and it can help keep the machine from becoming unstable.

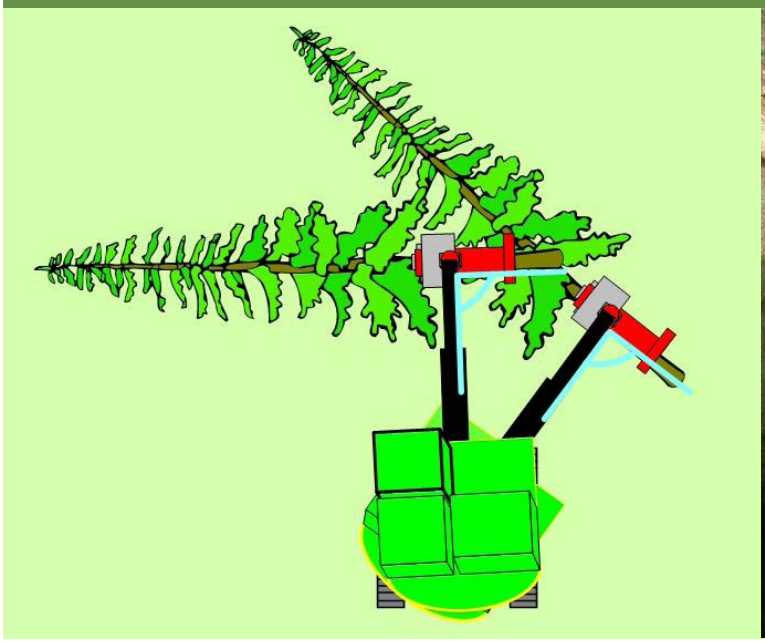
USING THE SWING TO HELP DELIMB

- Large trees or trees with large limbs can be more difficult to delimb. If the operator encounters a tree with one of these challenges, it is always best to swing the boom with the head as it feeds forward or reverse.
- Maintaining the head at 90 degrees to the boom will also help this process by allowing the operator to use only swing and feed to delimb. This should be performed as shown in Figure 55 (left illustration) when working uphill or downhill and straight or angled cutting.
- This action of the boom helps the harvesting head gain momentum that can significantly increase the amount of force during delimbing.
- As shown in the illustration, the tilt link is in the forward direction or the direction of feeding. This lowers resistance and improves feed speed and power.

HOLDING THE HEAD STEADY WHEN SAWING

- Too much movement while sawing can result in the weight of the log opening up the gap too fast, which then causes the top of the log to split (see Figure 55, right photo).
- When a log is split, the sawmill then must cut it back to the next available product length. In doing this, the value of the log drops dramatically and it also causes lost time (i.e., productivity) at the mill.
- It is also more difficult to manufacture good quality piles when the head is moving or swaying back and forth.
- During cross cutting, it is important for operators to hold the head steady or for more experienced operators to get their timing down perfect so the last section of the log is cut when the momentum is at zero during the swing and aligned with the pile.
- This sounds tricky and it is; that is why we only recommend this for experienced operators. Think of this motion as the rising and falling tide. The last part of the log can be sawed off without issue just at the moment when the head stops swinging, similar to when the tide is at its highest just before it begins to recede.

FIGURE 55.
Left illustration shows head at 90 degrees being the most effective during delimbing. Right photo shows split log from boom movement.



13.
BOOM CONTROL

WORKING AT THE PROPER SPEED

- Running the machine at the proper speed can have different meanings depending on the operator's skill level. The goal should be to operate the machine as quickly as possible but maintain control at all times.
- If the operator is making mistakes, then he/she probably is working too fast for his/her ability.
- Keep in mind that this could be partly related to the setup of the controls or even be stand-related.
- When working in varying cutblock conditions and/or steep ground, the chances are greater that certain steps will need to be modified to safely control and maneuver the machine functions.
- There is always a fine line between working the machine too fast or too slow. Too slow can result in low productivity with potentially higher quality. Too fast can result in higher productivity but potentially lower quality.
- Find a balance, so the operator understands that accuracy and control with an efficient work plan will produce more volume than speed alone
- With time, practice, and coaching, the speed and control of the machine will continue to increase.

MULTI-FUNCTIONING

- Multi-functioning is the combining of the machine functions by the operator to create a fluid motion from one point to another with the harvesting head.
- Multi-functioning the controls of the machine is vital to smooth operation, resulting in high productivity and reduced damage along with minimal wear and tear to the machine.
- Once an operator has targeted a tree to cut, the goal should be to arrive at the point where he/she plans to cut the tree with one fluid motion. To accomplish this, an operator must use many of the boom functions simultaneously such as stick boom out, main boom down, extension out, and head rotation to precisely locate the head at the desired point on the tree.
- When an operator has fully accomplished good multi-functioning, the boom and head functions will appear as if they are an extension of the operator's arm and hand.

BEING SMOOTH

- It becomes increasingly important when working on steep ground to be smooth and accurate before trying to be fast, even for an experienced operator.
- Trying to be too fast too quickly often results in damage to the harvesting equipment and an increased risk of instability.
- Being precise and smooth with the machine allows the operator to be more productive through less movements by maintaining control of the boom and head.
- In many cases, when operating too fast, operators may miss the target they are aiming for, resulting in several attempts to do the same function which causes lost time and can also cause unnecessary wear to the machine.

AVOIDING SWINGING INTO OBSTACLES

- Operators should always be aware of their surroundings, especially on steep ground, and maintain control of the machine at all times.
- It is very easy to lose orientation during the swing function even on flat ground, but working on steep ground presents an added dimension that can easily confuse an operator and cause a momentary loss of the machine position which can quickly result in the machine becoming unstable.
- An operator's goal should be to avoid hitting the head or boom on trees, rocks, and other obstacles.
- Most operators who make unnecessary contact with obstacles are not paying enough attention to their surroundings and/or could be operating the machine beyond their ability.

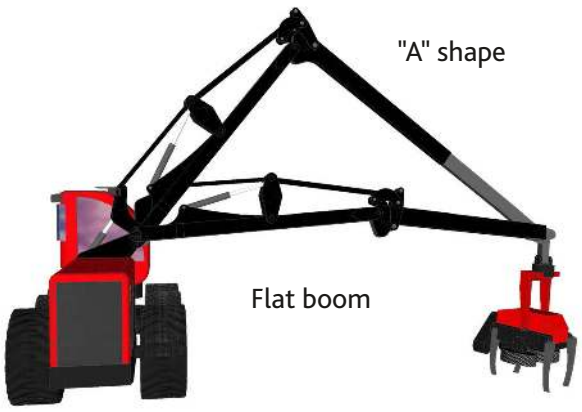
WORKING IN THE COMFORT ZONE AND MAINTAINING A LOW CENTRE OF GRAVITY

- Working within the boom envelope is simply referring to not forcing the boom to working near its minimum or maximum reach (the comfortable working zone).
- It can be very damaging to boom cylinders, pins, and bushing when the boom is forced to its maximum reach or any time a function is forced to a point where it becomes mechanically stopped (when the piston hits the end gland).
- When harvesting on steep ground, the maximum working reach is limited which helps ensure the greatest level of stability by avoiding maximum reach and keeping the head low to maintain a low centre of gravity (Figure 56, left photo).
- Both are critical for a safe and productive operation.

USING THE EXTENSION BOOM

- The extension boom on machines that have them are one of the best tools on a harvester. They are very beneficial to smoothly go to the tree much faster than normal.
- After the tree is cut, retracting the extension will help get the head to the pile quickly.
- Proper operation is to start the extension going slowly when leaving the pile after finishing the last tree. As the head is going out to the next tree to cut, the extension boom should be at least half to three-quarters of the way out, depending on how far it travels to the next tree.
- This will help maintain a hip or "A" shape to the main and stick booms. Keeping the boom in the "A" shape as much as possible allows the operator to maneuver the head around much easier and faster, due the geometry of the boom.
- When the main and stick booms are laid out too flat from reaching, the boom becomes extremely slow and awkward to maneuver properly (Figure 56, right illustration).
- Many operators tend to cut as wide a cut strip as possible, but when you try to reach too far the boom becomes very slow on the last metre or two.

FIGURE 56
Maintaining stability of machine when working on steep slopes (left). Maintaining an "A" shape to the boom (right).



14.
HEAD CONTROL

FIGURE 57.
Above: Tools for sharpening knives.
Below: The result of having sharp knives using these tools.

SHARPENING KNIVES AND USING THEM

- Manufacturers of harvesting heads have tools available that help make it faster and easier to maintain the knives on a daily basis, which is essential to achieving top performance of the harvester head in terms of:
  - measuring accuracy
  - delimbing quality
  - productivity
  - speed of processing
  - minimal head and boom wear and tear
  - reduced fuel consumption
- Knives are a particularly important component of the harvesting head that is directly related to its performance, and therefore requires maintenance not only on a daily basis but any time during the work shift when an event has occurred in which the knives have potentially sustained damage.
- Only a few simple tools are necessary to sharpen the knives (see Figure 57).
- For that reason, it is best practice to train the operators and place the responsibility of knife maintenance directly on them which enables operators to maintain top performance of the head at all times (Figure 57).
- In regards to using the knives, most harvesting heads today have default knife functionality, meaning that when the harvester head begins to feed, the knives pulse open automatically. However, because all trees are not of perfect form, an operator must set the default knife setting for the majority of trees and learn to use the manual pulse functions to achieve the best results of both good delimbing quality and processing speed.

- However, because all trees are not of perfect form an operator must set the default knife setting for the majority of trees and learn to use the manual pulse functions in order to achieve the best results of both good delimbing quality and processing speed.

DELIMBING KNIFE PERFORMANCE

- Regardless of the feed force of the head, delimbing performance is directly related to the condition and pressure of the knives.
- Manufacturers make only general recommendations in their manuals because the variation in delimbing depends on factors such as species, area, and temperatures. If these recommendations fail to give you the performance required, contact your local dealer for advice on sharpening for your conditions.
- Do not use a grinder on harvester knives unless you absolutely know what you are doing. Regular grinding wheels heat the knife edge very quickly, which can change the properties of the metal. Often, this can change the performance of the knives forever.
- Knife maintenance is best performed by simply maintaining the original shape of the knife edge by using a large flat file and a hammer (tools shown in Figure 57).
- Maintain your knives on a daily basis. Knives continually need minor attention even though they may appear sharp.
- Edges tend to get wood dull in the same way a saw chain can. Even though they may appear to be sharp, they are not going to perform perfectly.
- Many manufacturers now provide a gauge to measure the knife edge for the correct angle and bevel of the blade (see Figure 58).
- Not maintaining knives for long periods of time requires drastic action such as grinding. This can severely reduce performance and life of the knife due to removing excessive material and/or heating. See Figure 58 for an example of a poorly maintained knife.

FIGURE 58.
Left illustration shows angles for sharpening knives and knife gauge. Right photo shows very dull knives.

AVOIDING OVER-ROTATING AND HOOKING TREES

- Rotating the head excessively when grabbing a tree is referred to as over-rotating or hooking.
- When an operator does no over-rotating (hooking), he avoids:
  - strain on the hydraulic hoses that can lead to premature failure
  - the possibility of pulling electrical wires causing computer issues and downtime
  - felling trees towards the machine which could cause damage
  - potentially causing butt damage to the tree and/or damage to the bar and or chain
  - missing the felling location (the hole) due to having less control during felling
- Over rotating usually does not produce good results and, therefore, should be avoided if possible.

TOP SAW USE

The top saw is an excellent tool to have on a harvester head. If used properly, it offers many advantages:

- It can improve length accuracy when processing a broken piece or fork (see Figure 59). It can be used for the last piece of the tree to help avoid breaking a small-diameter product.
- It is an excellent tool to help remove forks or large branches from the stem:
  - Forward feed to the forked location, then cut just before the fork approximately three-quarters through one side of the stem, reverse a short distance, and finally continue to forward feed to break the limb off. Using this method will avoid jamming the saw.
  - As a large top is being sawed, rotating the head and slightly swinging the machine will help open the cut and again avoid saw jam.
- It allows an operator to accurately obtain the maximum merchantable saw material when processing trees with large crooks, and small or broken tops.

FIGURE 59.
Example of a top saw being able to manage broken trees/tops.

RESETTING LENGTH MEASUREMENT

- While it is important to never lose the length measurement while delimbing a tree, unfortunately, sometimes it is unavoidable.
- If the tree is dropped or the measuring wheel slips on the tree, the correct length measurement can be lost. When this happens, the operator will be required to reset the measuring wheel length before reprocessing the tree.
- To reset the length, the saw cut edge of the butt of the tree should be aligned with the saw bar. Then, use the zeroing function of the computer to electronically reset the length in the control system to avoid:
  - cutting a slice of wood from the butt of the tree which is better known as "cutting a cookie"—this can reduce saw material value and, at the very least, waste good fibre which equates to losses for the contractor, forest company, and land owner
  - causing wear to the bar, chain, and machine components, which add to the operating costs
- To do the proper reset, the operator should always align the bar as close to the edge of the butt as possible before resetting the length (see Figure 60). Swinging the tree so it is possible to look directly at the saw bar can help get a quick alignment.

CLEARING THE SAW BAR

- Occasionally, the saw bar will become stuck under the butt of the tree after the felling cut. This typically occurs due to too much lift force being placed on the tree, movement during felling, or unmerchantable material around the butt of the tree.
- All harvester control systems are equipped with a function to allow the operator to lower the saw bar without turning the chain and reverse feed the head slightly to allow space for the saw bar to come back into the saw box to the home position.
- Often, it can be an operator's first instinct to function the saw right away which may cause the chain to be thrown from the bar, creating a possibly dangerous and unproductive situation.
- Contractors should ensure they are familiar with this function and make sure their operators are fully trained in how to use it.

FIGURE 60.
Left photo shows operator cleanly cutting with saw. Right photo shows an example of the saw getting caught against the tree.

15.

FINAL TIPS FOR WORKING ON STEEP GROUND

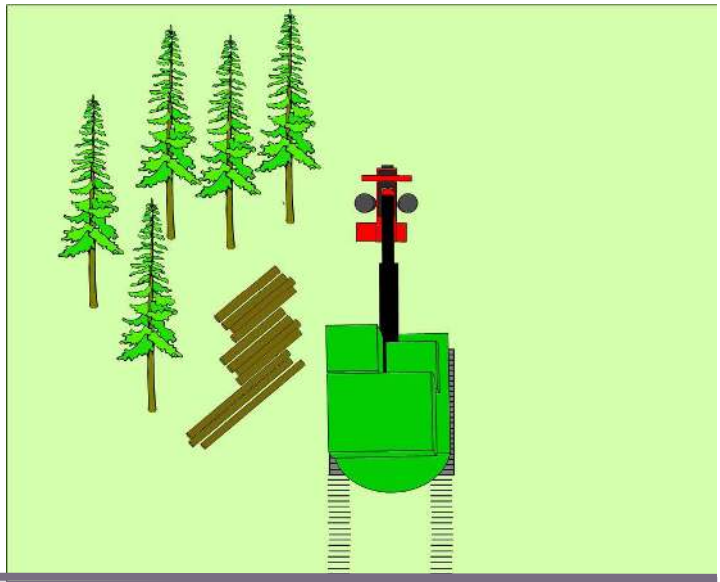
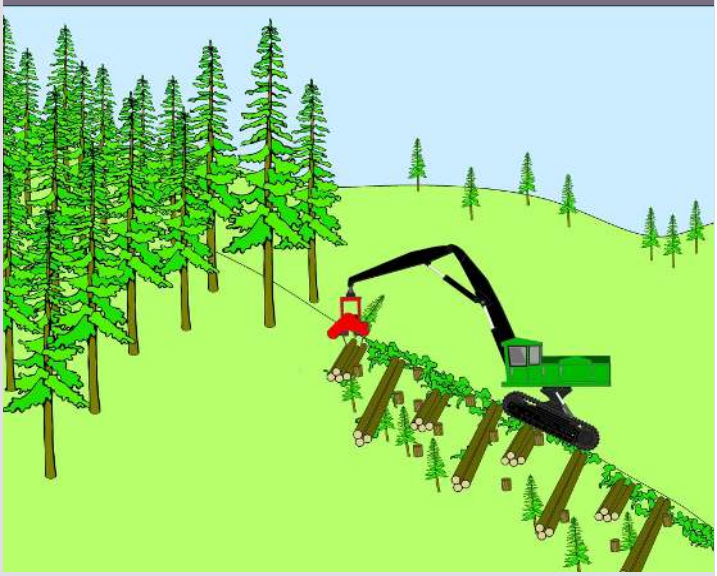


FIGURE 61.
Above illustration shows operator tracking straight. Below illustration shows an example of a machine encountering a large top on a steep slope.



TRAVELLING THE MACHINE STRAIGHT IN LOW RANGE

- While travelling any machine, speed is always a factor when traction and stability are concerns.
- Keeping the travel speed in the LOW position ensures 100% available traction and control of the machine.
- When travelling in high gear, the harvester tends to jump and jerk which makes it harder to control, and causes the engine and hydraulic system to work harder due to the increased pressure required to turn the tracks.
- Also, travelling as straight as possible enables the machine to hold its maximum stability. Once you begin to turn the machine left or right, stability becomes compromised as the traction and centre of gravity can start to shift (see Figure 61).

PLACING LARGE TOPS

- Keeping the front of the tracks as low as possible is critical in keeping the machine stable, if untethered.
- When harvesting large topped or forked trees, it is always best to keep the top off of the trail. If the operator attempts to travel over the top, the machine will not have any part of its tracks planted firmly on the ground; therefore, instability and a potential rollover will be more likely.
- Planning these large trees ahead of time is crucial for more easily managing the top. Placing the majority of the wood on one side and leaving the opposite side open for top placement is one of several solutions.

PILING WOOD ON THE HIGH SIDE

- When choosing a pile location, the harvester operator must always consider whether or not the forwarder can safely and productively load the wood being harvested.
- When working on uneven/rolling/steep terrain with some side slope, it is most effective to pile the wood on the high side of the hill.
- This ensures the forwarder maintains stability and can safely pick up the wood to load it in the bunk.

HEAD LOCATION WHEN TRAVELLING

- Steep slope operation has components that are comparable to normal harvesting operations. However, there are modifications and adjustments that operators must make to ensure safety.
- Machine stability is the most significant factor in that the operator must modify how the machine is travelled and the boom is used.
- When travelling the machine, the operator should always try to keep the head inside of the tracks, i.e., placed straight in front of the machine with the head close to the middle of the machine.
- When an operator swings the boom outside of the tracks during travel, the machine becomes much more unstable. It can then roll up onto a stump or obstacle, causing weight transfer that can make the machine unstable very quickly without a lot of notice.

HEAD PLACEMENT WHEN TRAVELLING DOWNHILL

- Similar to head location above, head placement when travelling is a critical factor.
- When harvesting or travelling downhill, keep the head low to the ground and out in front. This can aid the operator in maintaining control.
- Think of the boom and head as being a crutch. Some harvesting heads can support the full weight of the machine while others cannot. Depending on the machine, an operator may be able to take some of the weight on the head and make adjustments with the boom to maintain control.
- It is important to know if the harvester head is capable of bearing a load. If not, then avoid pushing down hard as it can cause damage to the rotator, felling link, and other machine components.

16.
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