Part B

Other factors

(for a well-run winch-assist operation)

Chapter 8

Risk assessment and management

In this chapter you will find out:

- ✓ Some of the hazards and risks you need to manage.
- ✓ Ways to reduce them.
- ✓ Some useful reference material.

Hazards and risks

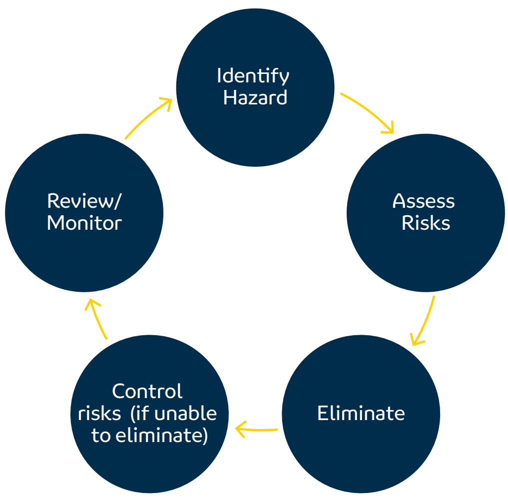
Hazards have the potential to cause harm including serious injury or death.

Risks are what could happen if someone is exposed to a hazard.

Risk considers both the likelihood and consequences of exposure. Risks can be to people, environment, and property.

Risk management process

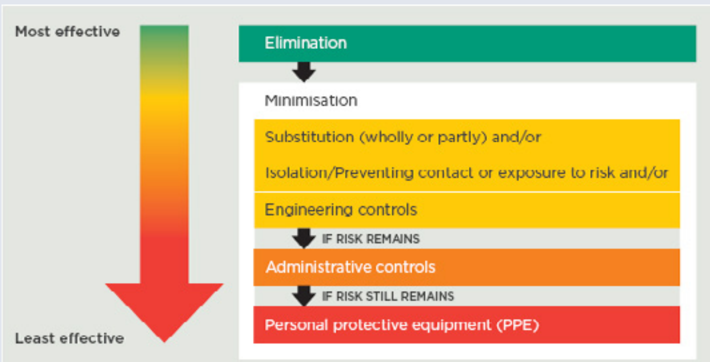
The risk management process should include the following steps:



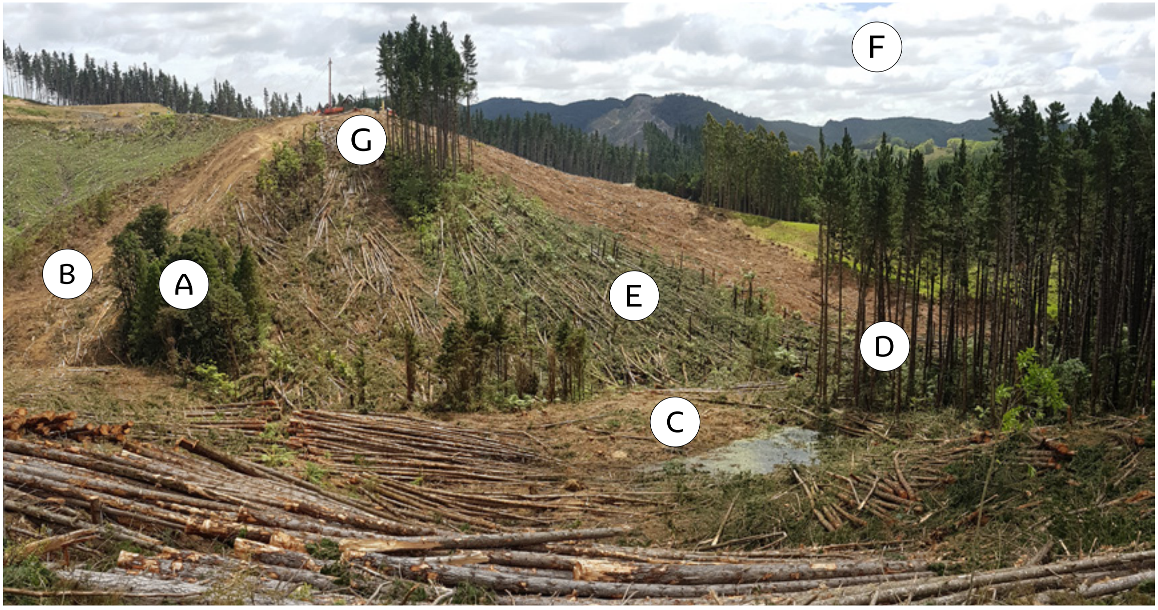
A risk assessment will help decide:

- How severe is a risk.
- How likely it is to occur.
- Whether existing control measures are effective.
- What additional action needs taking.
- How urgently it needs doing.

The following table provides information on each of the steps in the above diagram.

Process	Consideration
Identify Hazards	Find out what could cause harm or damage to people, property and the environment. For example: – Physical work environment including site factors – People and tasks – Work design and planning – Plant and equipment
Assess Risks	Understand the harm that could be caused by the hazard, how serious the harm may be, and the likelihood of it happening.
Eliminate Risks	It is best to try and **eliminate risk**. If eliminating the hazards and associated risks is not reasonably practicable, you must **minimise** the risk by one or more of the following control methods: 
Control Risks	If it is not reasonably practicable to eliminate the risk, implement effective control measures to **minimise risk**. (Refer to the hierarchy of control measures in the above diagram). Ensure the controls are: A Fit for purpose B Suitable for the nature and duration of the work C Installed, set up and used correctly D Understood by those exposed to the hazard. Also consider whether your preferred control measures introduce new hazards or unintended consequences.
Monitor / Review	Monitor controls, and periodically review them. This helps ensure they remain fit for purpose, are being implemented correctly and are working effectively. Also, consider if there are any new risks. Where relevant and available, reviews should include inspection, consultation, testing and analysis of records and data.

Potential hazards



A Native vegetation and fish habitat

B Soil and rock type

C Rivers and wetlands

D Diameter and height, and spacing of the trees

E Steepness and ruggedness of the area

F Amount of rainfall and storms

G Rolling debris

Risk likelihood/consequence matrix

A common way to determine the likelihood and consequence of a risk is through a standard risk matrix. It is a way to assess the potential seriousness of a possible incident. Once the risks are understood, appropriate controls or protection can be put in place. The greater the risk, the stronger the controls need to be. The following is an example of a risk matrix.

Likelihood Increasing

Consequence Increasing	Negligible	Unlikely	Possible	Likely	Almost Certain	Certain
Catastrophic	Medium	High	Extreme	Extreme	Extreme	Extreme
Extreme	Medium	Medium	High	High	Extreme	Extreme
Major	Low	Medium	Medium	High	High	Extreme
Moderate	Low	Low	Medium	Medium	High	High
Minor	Low	Low	Low	Low	Medium	Medium
Insignificant	Low	Low	Low	Low	Low	Medium

Bowtie risk assessment

The bowtie diagram is a form of risk assessment. It helps to visualise the risks, causes and controls on a single page.

The centre of the bowtie is a main hazard. To the far left are potential threats or causes for the central hazard. To the far right are potential consequences if the central hazard happened. For example, in the bowtie diagram below, injury and machine damage can be caused by weather and site conditions, who is doing the work, how it's planned and what equipment you are using. As a consequence of injury and machine damage is a trapped or injured operator, a damaged machine including fire, an environmental incident, and a legal problem.

Preventative controls on the left side interrupt the threat so it either does not occur, or if it did, does not result in an injury or machinery damage. For example, in the top left gold box is poor site conditions and weather. There's several preventative measures that include stopping work by either not working or moving to safer part of harvest area. Recovery controls on the right side make sure that if the central hazard does happen, it either does not escalate into an actual incident, or if it did, the impact of the incident is minimised. For example, the recovery controls for a trapped and injured operator are one or more of the recovery controls which include: multiple access to the cab, and having someone onsite that can give first aid.

Cause or threat	Prevention controls			
Physical work environment				
Poor site conditions eg. high wind, rain, soil type and moisture, slope	Avoid or reduce operating in high-risk conditions	Follow the adverse weather policy. Check the weather forecast. Meet the environmental standards		Cease work – leave or move to safer part of block
People and their tasks				
Impairment eg. fatigue, health, drug and alcohol	Follow fatigue management plan. Health checks	Complete 'fit for work' on the day (unit 22994)	Cease or suspend work	Monitor operator logbooks
Operator lacks competency, is inexperienced or inadequate supervision	Work practices are monitored (SBO)	Follow business induction, training and operational requirements		In-cab device to monitor working slope & rope tension
Rules, policy, guidance not followed eg. ACOP/good practice guides/regulations/ manufacturer's documents		Stop work, reassess plan and risk controls		Practices/guidance is periodically reviewed
Work design/planning				
Work plan poor or flawed	Have detailed and agreed harvest plan for block. Eg. slope map, no go zones	Review felling plan daily. Monitor via SBO/ site visits		Operator awareness of site hazards/risks & how to manage them
Plant & equipment				
Mobile anchor moves or tips over	Follow process to monitor anchor integrity/stability	Test initial position stability	Install auto stop braking mechanism	Minimum of 1 layer wrap on winch drum
SSH tips over while repositioning	Follow manufacturer's guidance	Move one machine at a time. De-tension rope		Develop procedure to manage machine repositioning
Anchor machine power loss		Check machine daily		Install over-riding drum braking system
Harvester forwarder, or skidder power loss				Install over-riding braking system to stabilise machine
Winch-assist system failure eg. rope, connector, or fitting	Comply with the CP ENG certification and the Worksafe fact sheet		Active operational monitoring eg. rope, fitting & connector checks	Manage rope 'bight'
Machine failure through general machine wear & tear	Undertake required inspections specified by the designer, manufacturer or supplier			
SSH hit by object and cabin penetrated	Cab guarding meets industry standards. Structural damage assessed and repaired in a timely manner		Ensure 'working alone' process in place	

Note: Using this guide will help develop preventative and recovery controls for many of the threats and consequences. Winch-assist contractors are advised to complete their own risk assessment.

Personal injury and/or machine damage

<table>
<tr><th colspan="4">Recovery controls</th><th>Consequences</th></tr>
<tr><td rowspan="6">Investigate incident</td><td colspan="2">Minimum 2 (preferably 3) emergency exits with two accessible from the outside.

Follow Emergency Response Plan (ERP) including emergency procedures</td><td>Provide first responder assistance</td><td>Trapped or injured operator that can't exit machine</td></tr>
<tr><td rowspan="3">Follow ERP safely</td><td rowspan="2">Recover machine</td><td>Ensure fire suppression available.

Test periodically</td><td>Machine fire damaged</td></tr>
<tr><td>Find alternative work or temporary stand crew down</td><td>Machine damaged (no fire)</td></tr>
<tr><td>Notify relevant persons/ authorities</td><td>Provide first responder assistance.

Ensure site is frozen</td><td>Worksafe notifiable event</td></tr>
<tr><td colspan="2" rowspan="2">Undertake remedial work</td><td rowspan="2">Advise management.

Seek advice</td><td>Environmental damage</td></tr>
<tr><td>Prosecution, fine, notice, or another liability</td></tr>
<tr><td colspan="4">Assess risks and plan and implement alternate work methods</td><td>Loss of production</td></tr>
</table>

Emergency plan

General emergency plan

- Follow the crew emergency response procedures.
- If a winch-assisted machine operates across multiple crews, then the emergency plan followed is with the machine's crew.
- Display emergency procedure stickers prominently on the worksite and in all vehicles and machines.
- If an emergency occurs, ensure emergency services are contacted and dispatched as soon as practical.
- GPS Emergency location coordinates must be current for each work site for emergency services. These are often on the harvest map or plan or written up on the crew container white board.
- Know your nearest Emergency meeting point (if that system is used) or the identified helicopter landing area.

Know the emergency plan.

Emergency preparedness

- Test check-in procedures.
- Inspect and test escape hatches. Schedule drills to ensure that the operator can fit through the hatch.
- Have a plan for evacuating an operator off the hillside.
- Have a plan for repairs and delivering heavy parts to a downslope machine.
- If possible, move machines to safe areas to perform maintenance. Ensure machines are de-energised and stable.
- Clean and inspect build-up of flammable materials or leaks within the engine compartment.
- Fire suppression systems should work in any orientation.
- Have procedures for using and maintaining a handheld tool for the operator to cut their way out in the event of a rollover or rescue procedures for crews to cut operators out.
- Check that the two escape hatches can be accessed outside the cab.
- Know what to do if there's a loss of communication between the WAM and the mobile plant being assisted.

A machine in an unstable position

Evaluate different scenarios and come up with emergency plans for the most likely. Make them part of the general emergency plan. An emergency plan could have the following:

- Stay in the cab. Exiting the cab often is a poor decision as it may increase the risk of personal safety.
- Secure yourself against injury should machine movement occur.
- Establish radio contact with your supervisor or onsite contact.
- Identify your location, explain the situation, request assistance.
- Evaluate the situation, e.g. will releasing the load improve or reduce machine stability? Will raising or lowering the blade/boom/attachments increase or decrease the likelihood of a rollover?
- If the evaluation comes up with some solutions, attempt to improve the situation, e.g.
  - Activate the blade braking device on the assisted machine if available.
  - Activate the track or wheel brakes on the steep slope harvesting machine.
  - Use the head's grapple to hold on a tree or stump or set the head or heel rack (if available) into the ground to provide further braking resistance.
- Wait for assistance to arrive.
- Exit the cab only if safe to do so once the assisted machine is fully immobilised.
- If your assessment determines the least risk option is to exit the cab, first survey the area for hazards, e.g. uneven ground, falling or rolling debris, unstable logs. Communicate your plan before exiting.

When to stop winch-assisted felling?

Operators must be clear about under what conditions operations should cease. These might include:

- Changes in weather that increase the risk to an unacceptable level, e.g. high winds, heavy rain, thick fog, darkness.
- Changes on the felling face, e.g. saturated or unstable soils, storm damage, rock, steepness.
- Damaged equipment, e.g. radios, electronics, hydraulics, damaged safety features.
- Fatigue, e.g. unable to maintain concentration or focus.
- Operator confidence.

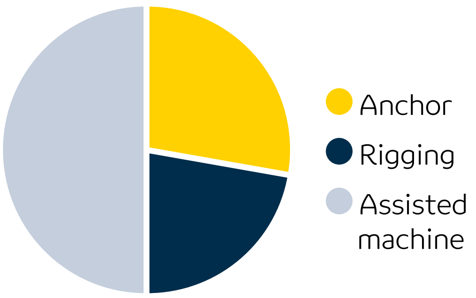
Unplanned events, or changed plans, can lead to accidents. If something changes, stop work, and review the plan with others.

Don't be pressured into felling more when you have decided to stop.

Winch-assist incidents

It's best practice to consider findings from accidents and incidents and apply these learnings to operations. The Forest Owners Incident Reporting and Information System (IRIS) records incidents for a range of activities and periodically publishes its findings. Analysis of IRIS data shows the recent WAM incidents are split between the key three components.

Winch-assist incidents



Anchor set up, and anchor components were about **a third** of all incidents. This included winch components, controllers and site factors. Anchor lead angles incidents were included.

Rigging related incidents were about **one in five** incidents. This included ropes, chains, connectors, and unintentional factors like binding and redirects.

Assisted machine (most commonly a harvesting machine) accounted for **half** the incidents. This covered harvester stability, trees falling onto the machine, other felling issues, cab and operator specific incidents like slips, trips and falls.

Safetree Reference: How to... manage forestry risks

safetree.nz/wp-content/uploads/2017/03/Managing-risk-in-forestry_March-2017.pdf

Regulations

Two recent regulation examples that will impact on winch-assisted harvesting are the General Risk and Workplace Management (2016) and the Plant and Structures Regulations currently under development (at 06/22). The former requires businesses to manage risks associated with remote or isolated work, working under raised objects and falling objects.

The latter will likely require plant registration (design and item of plant), periodic inspection and installation of safety devices.

Harvesting activities must meet many regulatory requirements including the Health and Safety at Work Act 2015. Refer to chapter 11, page 113.

Chapter 9

Steep slope harvesting and the environment

In this chapter you will find out:

- ✓ How winch-assist can affect the environment.
- ✓ Why winch-assist can create a lighter footprint on the ground than an unassisted machine.
- ✓ Ways to improve environmental outcomes.

Environmental challenges of winch-assisted systems

Environmental problems usually only occur when things are pushed, rushed, wrong options are chosen, or when people don't know or care.

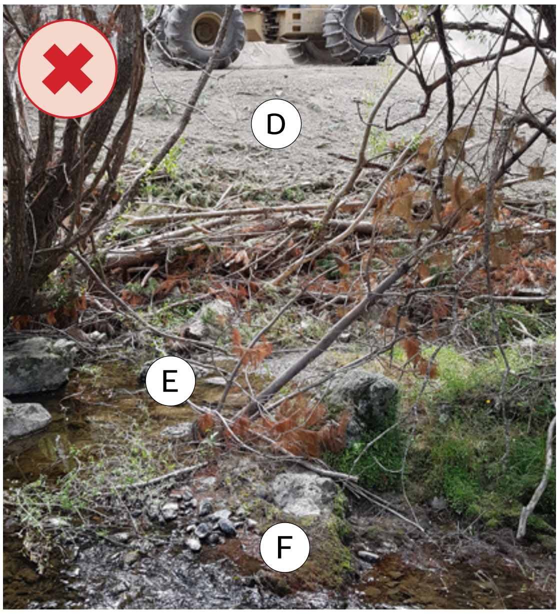
Many companies aim to fully mechanise felling and extraction for health and safety and other benefits.

At times, this has put pressure on environmental outcomes. Winch-assist puts machines in places previously not accessible. For example, shovel logging, especially uphill, can lead to heavy rutting.

- It was logged in the wet so the SSH had poor traction.
- The good soil has gone and the tracks struggle to grow grass.
- The tracks channeled rainwater and they've scoured.

Many parts of New Zealand have thin and relatively fragile soils, and when exposed to heavy rainfall, it can create erosion and sedimentation. Ground-based equipment can potentially damage soils through excessive rutting or compaction. Rutting on steep slopes may also cause water redirection or concentration and result in erosion and sedimentation. Soil damage will affect the growth of the next rotation.

Poor winch-assist planning creates environmental risks, especially where winch-assist is in conjunction with traditional ground-based grapple extraction. This typically leads to downhill logging and extraction. Tracks are often a significant source of sediment, which can impact waterways. Also, mid-slope contour tracks may be needed, especially where the slope is longer than the winch rope. These open steep slopes to erosion, often by soil slip.



A The winch-assist operator did a good job

B An extraction track was built in a perennial river

C The loggers didn't remove the crossing

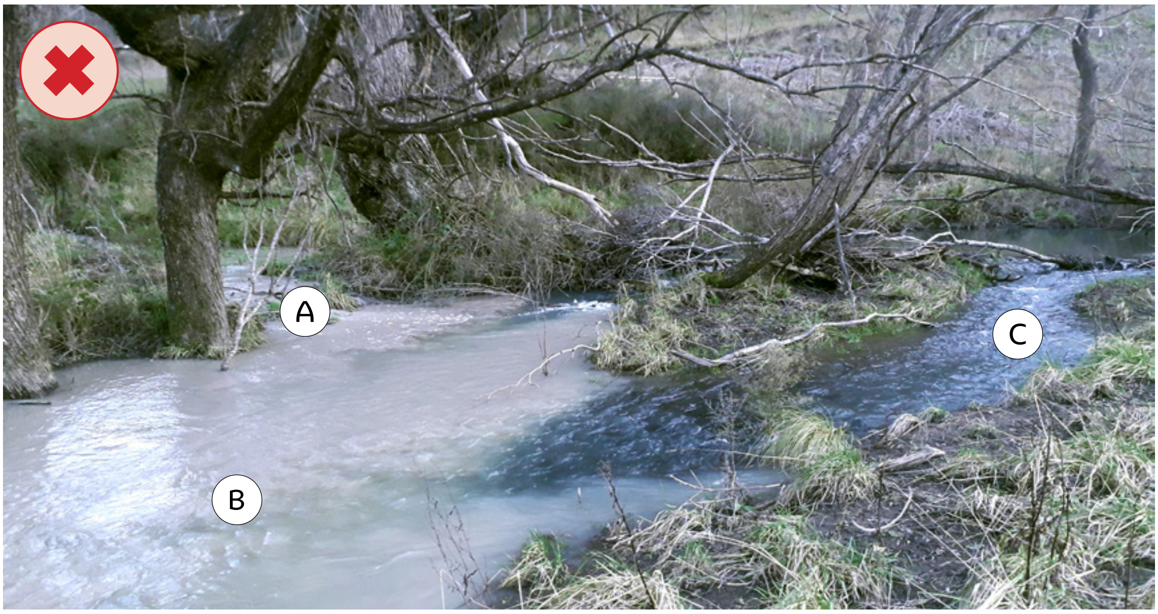
D The track is too close

E Debris in a river

F The river turns to mud when it rains

Also:

- Downhill logging to the waterway created environmental non-compliance.
- Improved planning and operational management could have created a much better outcome.

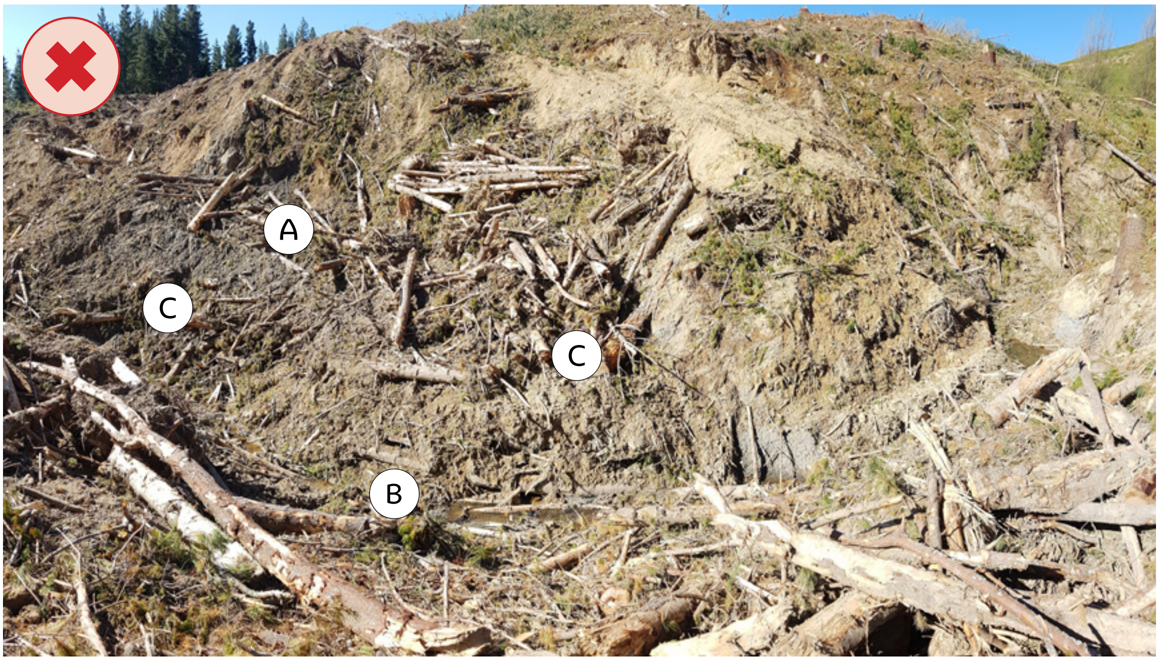


A A light rainfall created sediment into the side creek that went into the main river

B The river has silt over the stones and is not good habitat for fish, even a km downstream

C The trout river upstream is clean and good for fish

Machine felling does not always give the best environmental outcome, especially for the tricky areas that machines either struggle to access or require tracking.



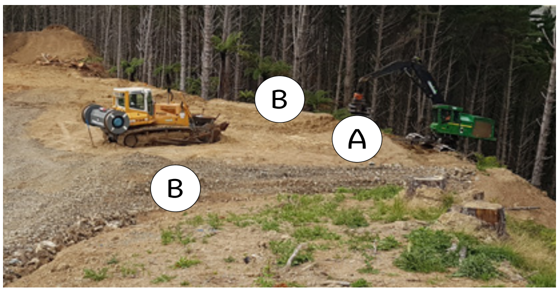
This small 0.2 ha area could have been hand felled, then extracted with the hauler, rather than tracked and machine felled, leading to NES-PF non-compliance.

A The track was cut for the felling machine

B The creek has fill in it

C Logging slash is in or could slip into the workway

Winch-assist rope is often dragged through the edge of landings and roads. This is because the anchor machine needs to sit back far enough so the steep slope harvesting machine can be lowered off the slope, and the road because landing edges are often built of fill that lacks good anchoring strength. This creates an erosion and sedimentation problem if the site is not remediated after harvesting.



A Ropes are carving through bund and landing fill. These need to be rehabilitated after harvesting

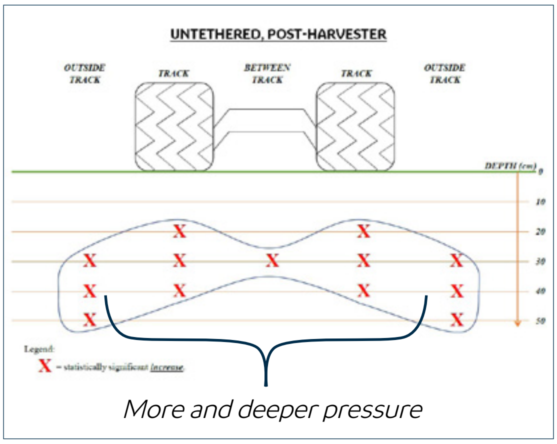
B The road and landing have been engineered to control water, and reduce sedimentation as required by the NES-PF

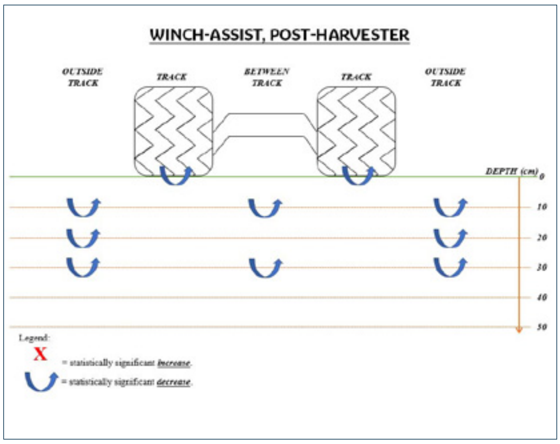
Winch-assist has a lighter footprint than other ground base systems

Winch-assist decreases the machine's tracks pressure on the soil. It also improves how pressure is distributed. These increase machine mobility and stability. The reduction in ground pressure and reduced track slip and rutting also helps reduce soil disturbance.

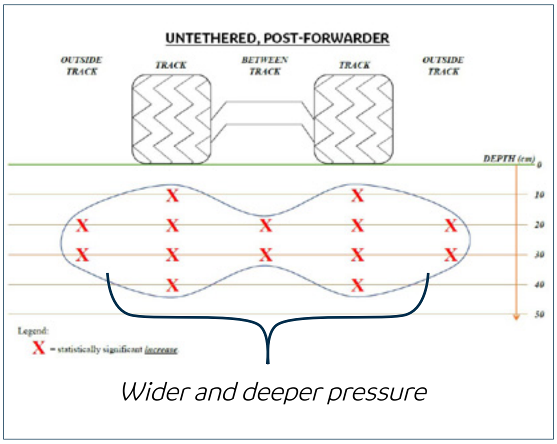
When moving downhill, tracks are engaged better throughout their entire length giving better mobility. Also, ground pressure concentrations decrease, creating less soil disturbance and more stability.

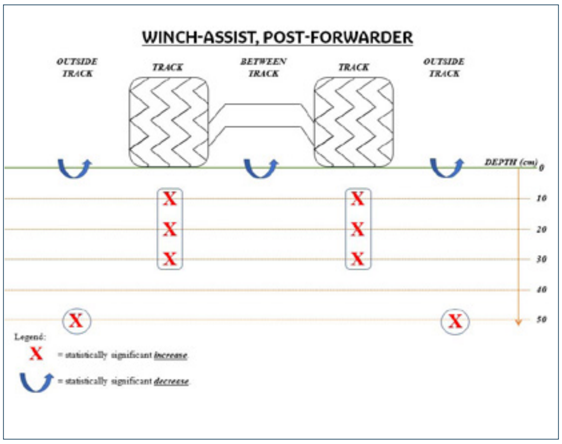
Uphill operation is improved by better distributing ground pressures.





Left: This diagram shows the pressure distribution from the machine's tracks. Right: on winch-assist both the amount of pressure reduces and the impact of soil pressure in deeper soil.





Left: An untethered forwarder has a much wider and deeper pressure distribution than a winch-assist, at right.

Five critical environmental questions for operators

Operators can make a big difference in how the job finally looks. Maintaining the soil for future forests, and reducing the impact on our waterways for kaimoana, are important operator responsibilities.

1. Is it too wet to work without heavily damaging the soil through slipping?
2. If ruts were made, would they concentrate water and scour out?
3. Could your ruts lead to sediment in a waterway?
4. Are your company's wet weather guidelines right for the location you are in, or are you stopping when it is too wet?
5. What thing can you do to minimise your machine's impact on the soil?

Don't work when it's too wet. You'll make a mess—work easier areas if possible.

Put slash on your tracks. It's easy to do.

Environmental guidelines

The National Environmental Standard for Plantation Forestry (NES-PF) requires a management plan for almost all forestry earthworks and all harvesting. Putting in tracks for the anchor machine or extracting logs is considered to be earthworks.

What the management plan says and what happens in the field need to be the same. Operations in the field need to meet the requirements of the NES-PF permitted activity conditions or the resource consent.

- Planning must incorporate the potential environmental risks of winch-assist. Understanding the impact of winch-assist on steep environmentally sensitive soils is fundamental to the task.
- Communicate site-specific environmental requirements to the harvesting contractor. Incorporate into operational paperwork.
- Monitor operations and stop when working would cause unreasonable soil compaction and erosion and sedimentation. Resume when site conditions are satisfactory. Closely monitor operations where soil compaction or erosion and sedimentation are likely to be an issue.
- Limit loss of traction. Operators must reduce slipping, e.g. maintain a constant tension and not push the machine too hard, instead rely on the rope.
- Use slash across any ruts to reduce the impact on the soil when the harvest area is not hauler logged.
- Use tire tracks on wheeled machines to help prevent wheel slip or spin.
- Rehabilitate winch-assisted machine ruts as they are finished. There is unlikely to be a cleanup machine.
- Use winch-assist on less steep ground than normal if without it would otherwise cause unreasonable soil damage.

The rope gives extra traction and reduces rutting and slipping.

Chapter 10

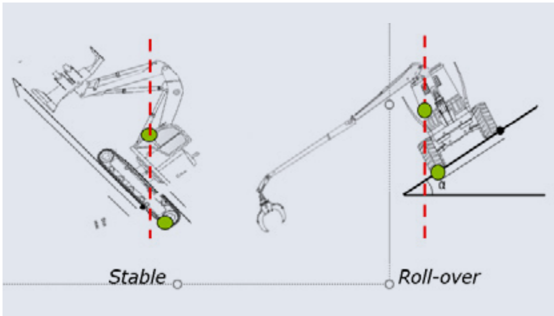
Stability and traction

In this chapter you will find out:

- ✓ How gravity changes stability.
- ✓ Things to watch out for that affect machine stability.
- ✓ How traction changes with slope and soil conditions.
- ✓ Why a winch improves traction.

Stability

Stability measures how likely it is for an object to roll-over when pushed or moved. Stable objects are difficult to fall over, while unstable objects topple over very easily. A machine rolls over when they are out of balance. That's technically when the centre of gravity is 'outside' the base, or edge, on which it balances.



Machines rarely just fall over, and an operator can often act to stabilise the machine. The risk of a rollover increases on slopes of more than 50% (28 degrees).

! Beware of SLIP-SLIDE-TIP.

What affects stability

A loss of traction is the most significant cause of a loss of stability. Any factors that reduce traction efficiency impact traction. Refer to the 'what affects traction' section.

- Most rollover accidents are caused by loss of traction. The steep slope harvesting machine begins to slide, and then the tracks/wheels hit an object like a stump, log or rock. This leads to a change in stability and rollover.
- A change in slope can also affect stability because the machine's weight and centre of gravity may change rapidly, e.g. dropping off the road near the anchor onto the felling area.
- The machine type and where the load's position influences stability too.

Loss of traction causes most rollover accidents.

Traction

Traction is the 'grip' the machine has on the slope. The primary purpose of the winch-assist is to help improve traction. Maintaining traction is essential to control the machine's stability.

The section explains what affects traction and explains in detail how soil strength, slope steepness and the cable itself can affect a machine's ability to climb.

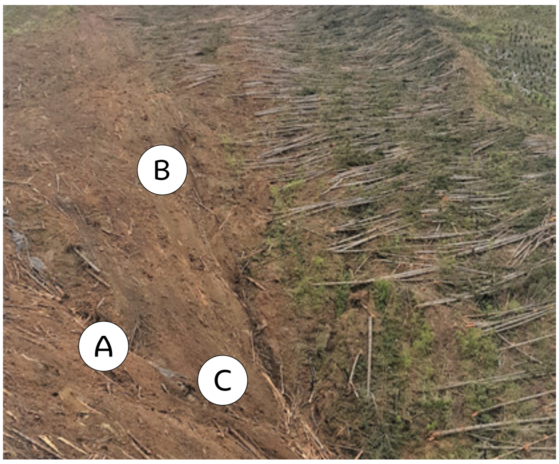
What affects traction

Traction constantly changes. Four main factors can affect traction. Some of these can combine to either make traction significantly better or worse. Two factors we can't change, and these are the:

- Harvest area's site considerations like the soils, geology, slope, aspect, windthrow, and terrain features.
- Environmental factors like rainfall, sunshine, wind, fog or darkness.

The other two factors the contractor and operator have some influence over and can adjust or modify. These are the:

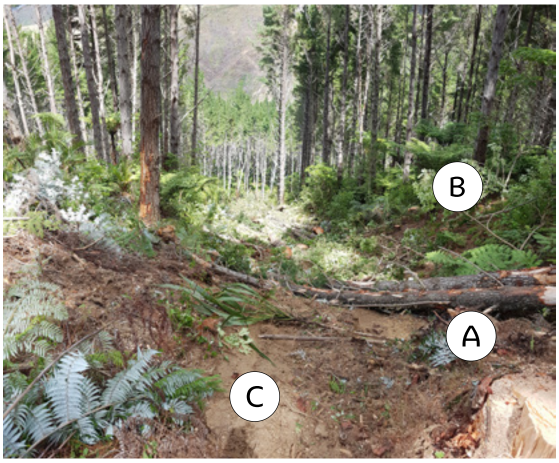
- Machine, e.g. type and weight, grouser size, machine limitations, and maintenance.
- Operator experience and care, e.g. amount of tension applied by the winch through the cable.



A Terrain – boulders, rock, thin soils and gullies

B Wet locations – aspects that get less drying, or poorly drained soils

C Steep slopes especially over 35% (20 degrees), and long steeper slopes



A Windthrow, stumps, and woody debris
B Dense scrub that obscures a ground view
C Soil like clay or black soil, that are worse when wet

Also:
- Strong winds and poor visibility
- Heavy rainfall, or increasingly wet weather conditions

Common natural hazards are stumps, holes, rocks, drop-offs, windthrow and thick scrub.

Loss of traction

Slipping indicates the tracks are losing traction. Slipping reduces soil strength because the tracks cut through the slash and vegetation that help support the machine. During high slip, the spaces between grousers can become packed with soil, and they stop biting into the ground. Machines can slide even on moderate slopes of 30-40% (17-22 degrees).

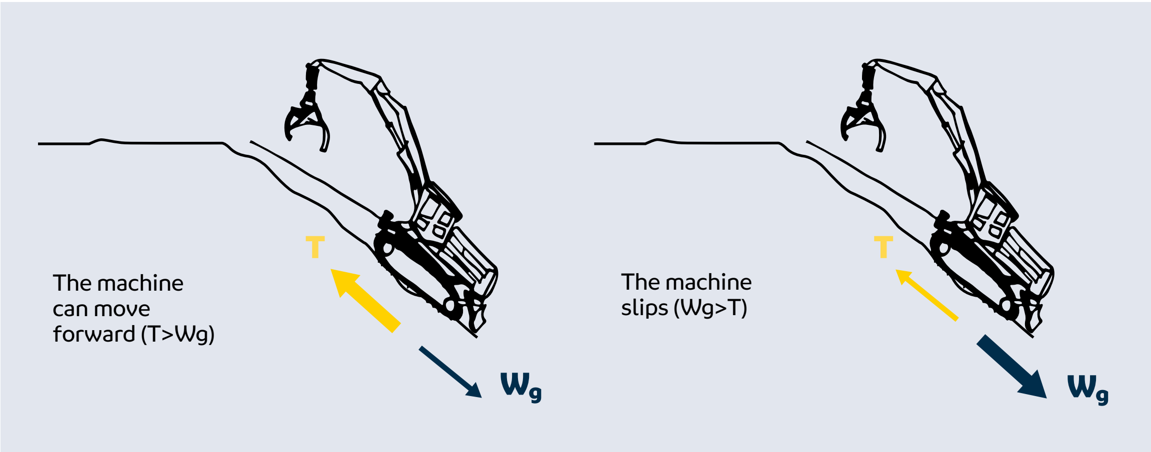
Loss of traction can lead to machine rollover.

Why traction changes with slope

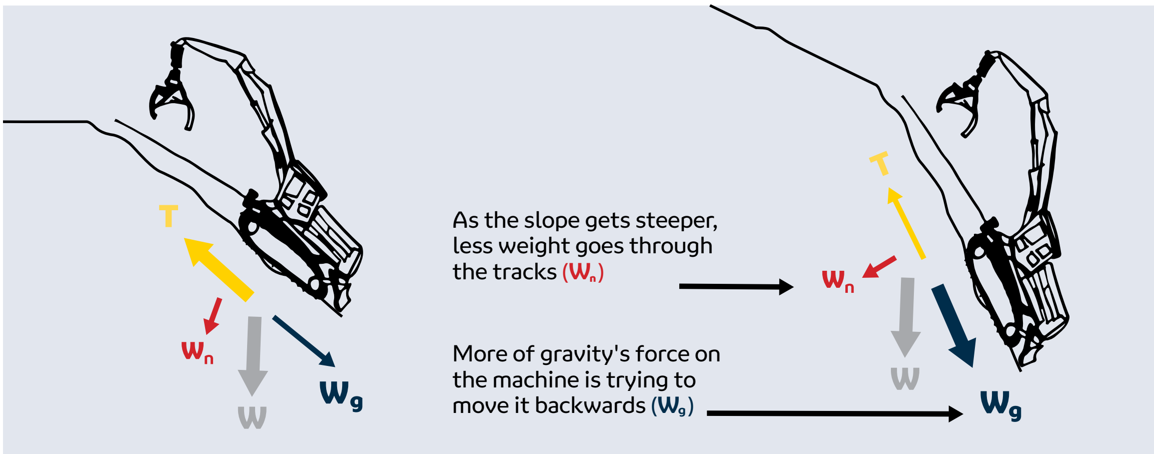
Slope affects traction. As the slope increases, the machine's tracks are more likely to slip.

This is because the steep slope harvesting machine must fight gravity to climb. Gravity is trying to slide it down the slope.

1. Traction is lost when the force of gravity (Wg) is greater than the machine's ability to go forward (traction force or T).



2. Traction reduces as slope increases.

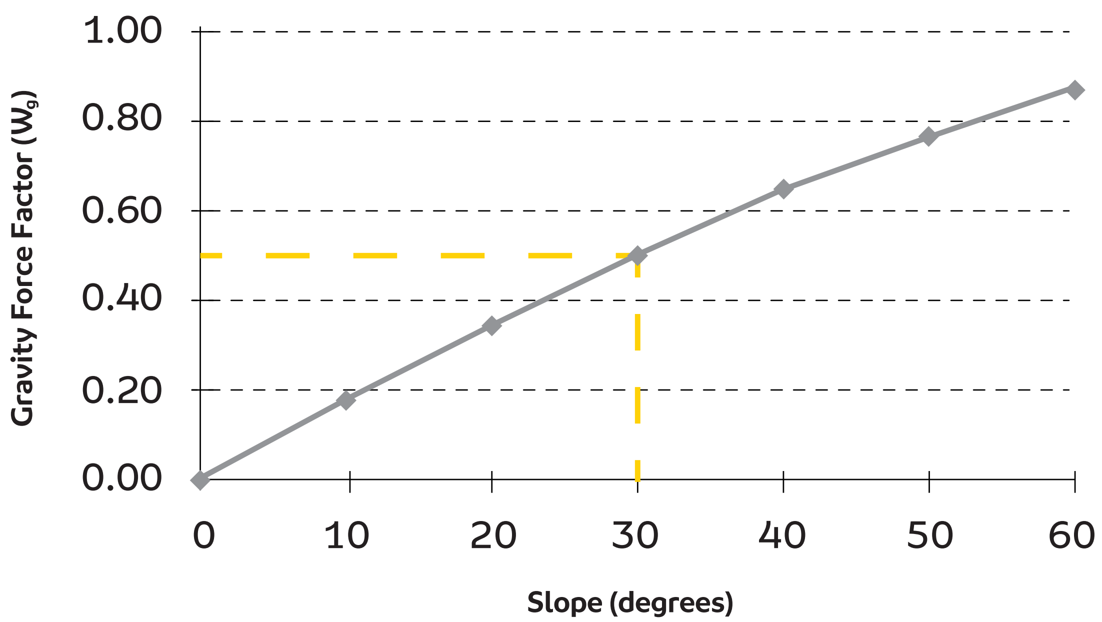


Machines are much less likely to slip on a flatter slope than a steep one, all things being equal. The reason is due to how gravity behaves. On a flat surface, gravity pulls down directly. On a steepening slope, less of gravity's force gets to go directly down through the tracks. The force directed on the tracks is called gravity normal force or W_n.

As the slope gets increasingly steeper, less force goes through the tracks (W_n), and more force is trying to pull the machine backwards (W_g), as seen in the diagram below. The equations are:

Normal force (W_n) = machine weight x cos (slope angle)

Gravity's force (W_g) = machine weight x sin (slope angle)



At 30 degrees, the gravity's pull on the machine is already 50% of the machine weight!

How to measure slope

Slope is easier to measure over long distances than short ones. However, the slope immediately around the machine is what's really important to know especially if it is steep. The dominant or long-distance slope gives an indication of overall steepness. A recent study indicated that the machine's slope is often different than the terrain slope.

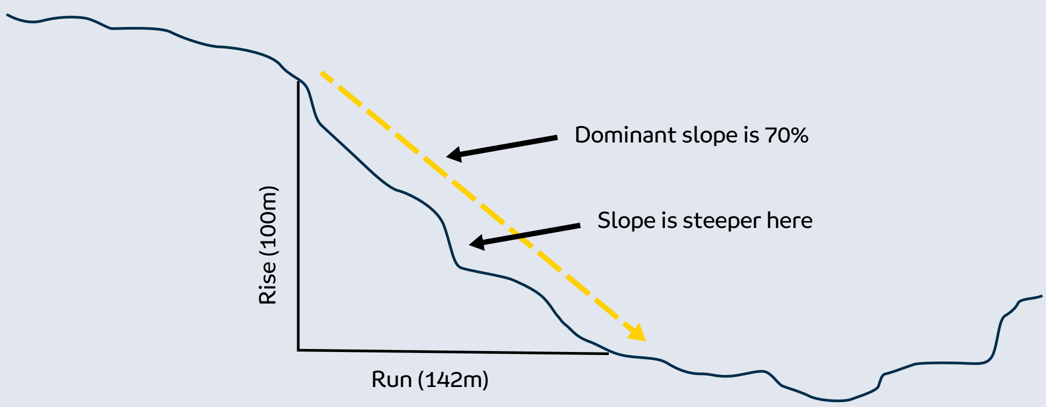
Slope is commonly referred to in two types of measurement units. These are degrees and percent. While degrees are often still used in New Zealand, percent is recognized internationally. See page 100 for degree/percent comparisons.

Calculating Slope

Slope can be measured off a contour map:

- It is best to start on a contour and finish on one.
- Measure the ground distance (also called the 'run') between the contours.
- Next count the number of contours (called the 'rise').
- Dividing the rise by the distance will give you the slope in %.

In the following example the map scale was 1:10 000 and the contour interval was 10m. If there were 10 contours crossed the rise, is 100 metres (10 contours multiplied by 10). If the ruler distance was 14.2mm, then this equals 142 metres on the ground. The slope is 100/142 x 100% = 70%.



Dominant slope = Rise divided by run **100/142 = 0.7 or 70%** **70% = 35deg**

How steep is too steep?

Many factors other than slope affect safe machine operations e.g. soil condition, operator skill, the machine, and the roughness of the slope. Operators say productivity drops on slopes greater than 42 degrees.

The following chart gives some indication of boundaries.

Slope (degrees)	Slope (%)	Consideration
17°	30%	This is considered a limit for when a wheeled ground-based machine can start to slide under poor conditions.
22°	40%	This is considered a limit for a tracked ground-based machine. It can start to slide under poor conditions.
28°	50%	Most purpose built forestry machines, with good operators in good conditions can work up to this limit. Beyond this slope it is wise to consider using winch-assist.
35°	70%	This is considered the absolute upper limit for ground-based machines without winch-assist. Only under very favorable soil strength condition, with a purpose built steep slope harvesting machine and a very experienced operator, and then only traversing directly up or down the slope.
42°	90%	A realistic upper limit for all winch-assist operations.
45°	100%	Considered the absolute upper limit for any winch-assist operation. If any part of the rigging fails, a machine roll-over would be difficult to avoid.

The following table shows that on steep slopes maintaining traction is essential, otherwise the anchor and rigging can carry loadings higher than the SWL of the rope. If the SSH machine slipped and created a shock loading too, then the weight would be much higher.

Traction is lost when the force of gravity (W_g) is greater than the machine's ability to go forward (traction force or T).

Slope (degrees)	Gravity's force trying to pull it backwards (% of machine weight)	Gravity's force trying to pull it backwards (tonnes, on 45t SSH machine)	Winch tension Average operational setting	Tonnes>W_g Good soils 90% Traction efficiency	Tonnes>W_g Poor soils 50% Traction efficiency
30°	50%	23	8	19	3
35°	57%	26	8	13	-1
40°	64%	29	8	8	-6
42°	67%	30	8	6	-7
45°	71%	32	8	3	-10
50°	76%	35	8	-2	-14

Assumes the machine's weight is 45 tonnes, plus 2 tonnes of working force to shovel or hold a tree, and all other things are constant like the traction efficiency and the soil conditions.

The ability for the machine to go forward **is limited** without addition winch pull (tonnes)	(light yellow)
The machine can't move forward and requires additional winch pull (tonnes)	(dark yellow)

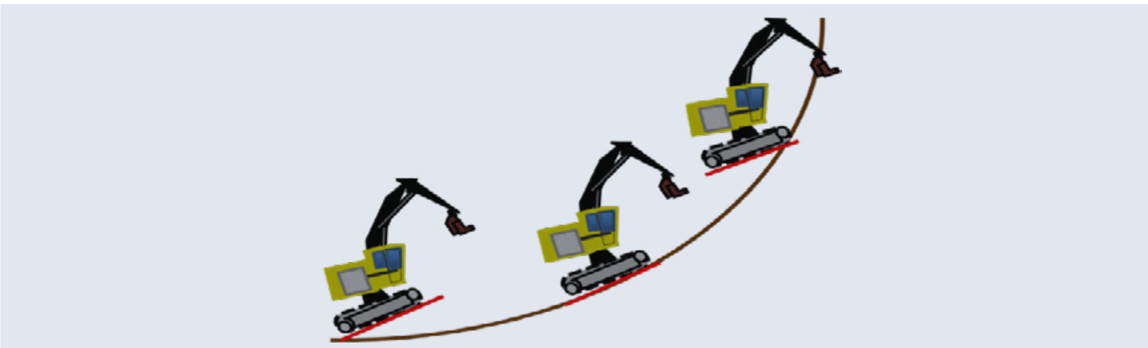
! SSH machines must only be operated in locations and with techniques that assure stability.

The difference between machine slope and terrain slope

The machine's angle or steepness can be different from the terrain steepness. The main reasons are the resolution in the terrain slope data and the operator's skill. Even with LiDAR slope maps, each pixel, or smallest coloured square, maybe 10m x 10m. A machine's track base is much less than a pixel or the dominant slope. Good operators on steep terrain manage slope by using minor slope changes like flatter areas for the machine.

The University of Canterbury studied 22 machines during normal steep-terrain operations and recorded both terrain and machine slope:

- Terrain and machine slope are nearly always different.
- Machine slope was higher than terrain slope except for steep sites.
- On steep slopes, machine slope was less due to operator management.



Machine slope can rapidly change on broken ground.
Watch for holes, drop-offs, and old tracks.

Why traction changes with soil strength

Understanding soil strength is important because it affects traction and stability. Weak soils can make working on flatter terrain tough going, yet strong soils on steep terrain can work well. Regularly evaluate soil and its ability to provide good traction.

Saturated soils are very weak.

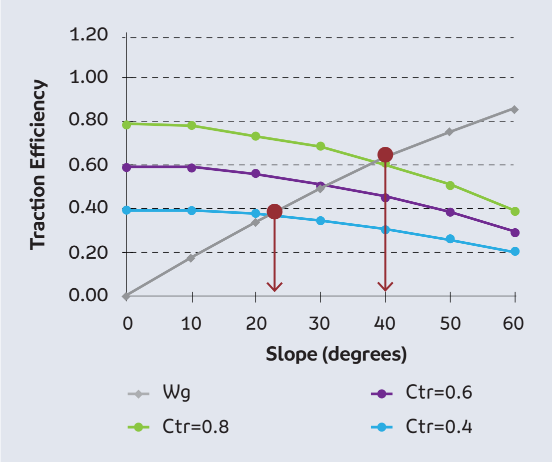
Strength varies between different soils.

Even the same soil's strength changes depending on wetness.

How do you know the strength of soil?
Traction efficiency (CTR) is the interaction between the track type on the soil composition. The following is a guide for traction efficiency:

- **40% – Weak soil =** sandy, loose, or wet soil. They are easy to move with a shovel.
- **60% – Firm soil =** shovel goes in when you use your foot.
- **80% – Strong soil =** tightly bound gravelly soil with clay. Hard for a shovel to go in.

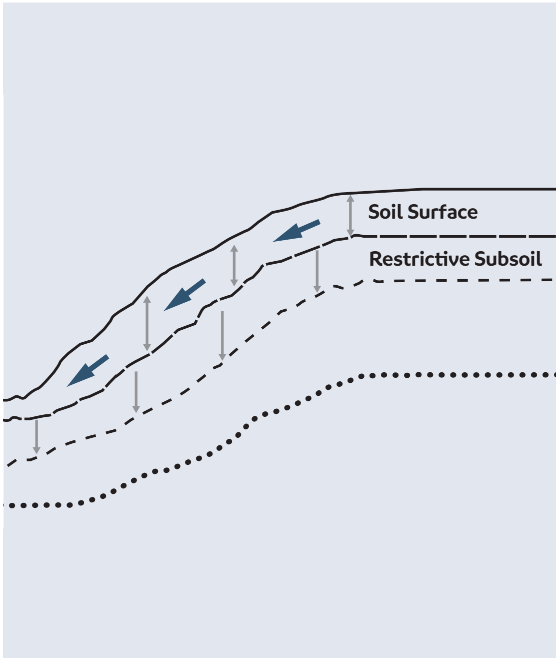
For example, extended grousers can increase the traction efficiency on weak soil as it penetrates further into the ground to increase its holding capacity. Conversely, extended grousers can decrease traction efficiency on strong soils as they ride on the tips of the grousers.



Poorer traction due to wet or weak soils means machines should only work on less steep terrain.

Tracked machines typically have a tractive efficiency of between 0.4 and 0.8. The difference in the value depends on the soil and track type. A weaker soil gives the machine less traction before it slips. In the example, it is the difference between working on a slope less than 22 degrees or one of 40 degrees.

Watch for springs or where water runs just below the soil surface. In ash and papa (mudstone) country, water runs where the soil hits the papa rock. This creates a slippery surface called a greasy back.

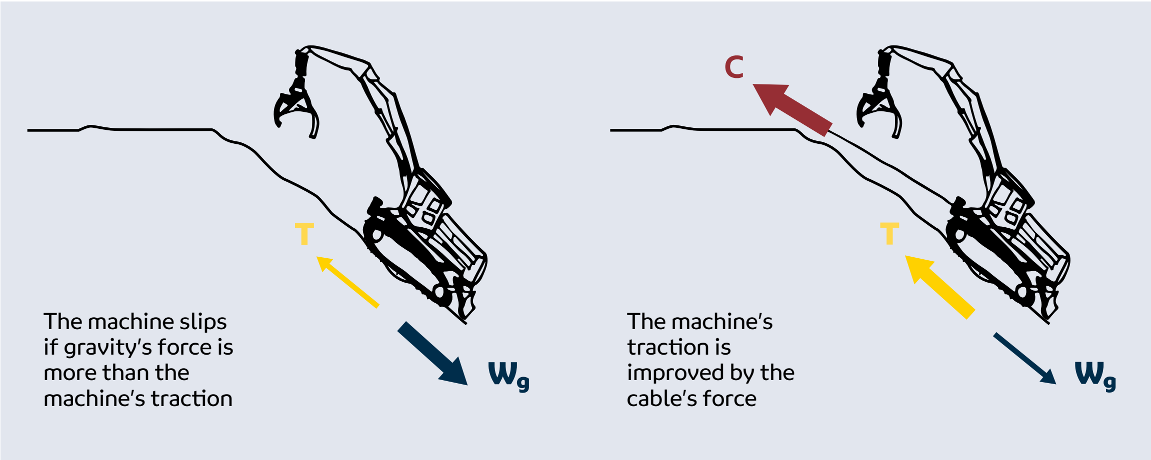


Left: When water hits a restrictive subsoil (blue arrows), it creates slippery conditions.
Right: Track slipping creates safety and environmental concerns.

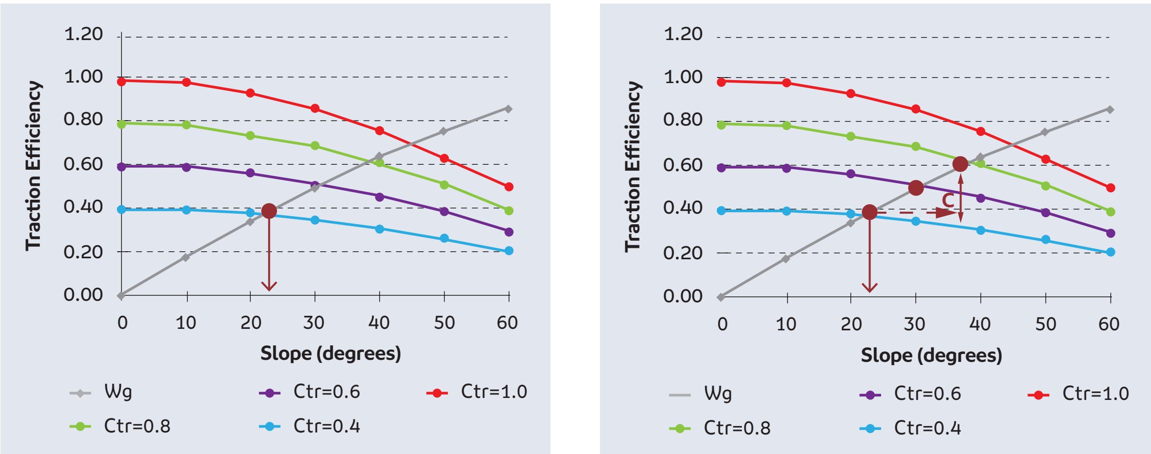
If it is too wet, don't work.

How traction assist increases slope capability

The force in the cable offsets some of the gravity force acting on the steep slope harvesting machine. Also, a cable better distributes weight on the tracks. This increases traction because it gives additional traction force.



Left: With no cable tension, if gravity's force on the machine, W_g was greater than the machine's traction, T, then the machine would slip. With cable tension, the machine's traction is improved. This is because of the winch-assist force, C.



The graphs above show the effect of cable assistance on the operating slope for a 45 tonne machine.

Left: without a cable, on weak soil (0.4) a machine can work up to about 22 degrees.

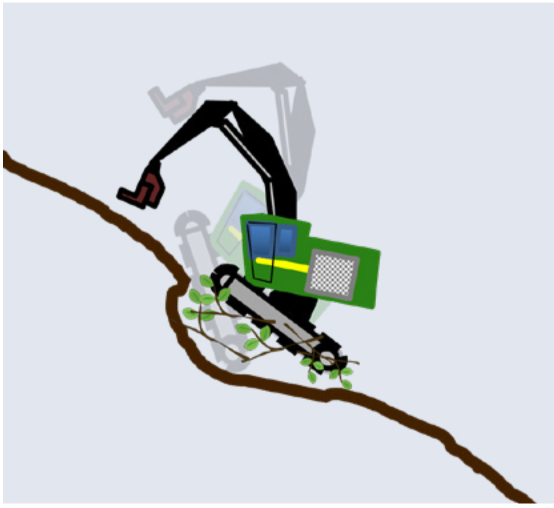
Right: on the same soils with cable assistance, of approx 8 tonnes, the machine can now retain traction at 31 degrees. With 12 tonnes of assistance, traction is maintained to 36 degrees.

Some tables and spreadsheets can help calculate the forces on winch-assisted machines.

Why traction increases with a slash mat

Using some slash can increase traction on most soils. This is because slash can help bind the soil and increase its strength. It is good for the environment too, because slash helps reduce wheel rutting, erosion and sediment.

Slash can also be used to fill holes to smooth terrain.



Slash mats can slip on high clays soils.
Larger woody debris can reduce traction through slipping.

Guidelines to help prevent machine rollover

Moving – all machine types

A Only turn around on a steep slope when there's a flat and wide bench

B Cut and move away woody debris that could affect traction and stability

C Keep boom stationary when moving otherwise weight and traction on each track changes

D Keep the saw head or grapple close to the ground to provide quick stability support

E Going over steep terrain lower boom and head and use for stability

F Before moving into the harvest area, pre-tension ropes to immediately support the machine. Check lead angles are OK

G Keep tracks parallel to the slope so the grousers or tyres provide resistance to sliding

Also:

- Avoid terrain that could affect traction and stability.
- Remove dense understory that blocks a clear view of the ground.
- Keep within the lead angle.
- Check rope and connectors are secure and not damaged.

Felling – all machine types

A Work straight up or down the slope, never across it

B Cut stumps off low to the ground

C Fell, lift, and lay trees that are within safe reach

D As slope increases fall narrower strips for machine stability

A Make machine stable before swinging wood.

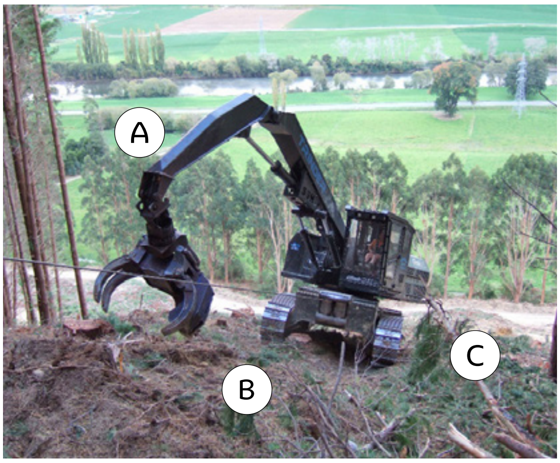
B Keep to the machine's cutting diameter and lifting limits.

Also:

- Lift trees no higher than necessary and not more than 3 m.
- Avoid swinging trees to the downhill side of the machine.

- Avoid lifting the boom straight up and tilting trees back over the machine (to the downhill side).
- Position cut timber from 10 o'clock to 2 o'clock when working uphill.
- Face the boom downhill on slopes greater than 30 degrees.
- Use multiple cuts only to fall a tree directionally. The equipment must have sufficient pushing power to direct the tree against its lean. Sufficient holding wood should be maintained until the machine is positioned to make the final cut.

Tracked machine – moving



A Ensure the boom is facing the right direction before engaging the winch.

B Keep the tracks parallel to the slope so the grousers provide resistance to sliding.

C Use single bar grousers for the best traction.

Chapter 11

Planning winch-assist operations

In this chapter you will find out:

- ✓ What makes a good plan.
- ✓ Planning starts well before the felling starts and finishes after the machinery leaves.
- ✓ Your role in the planning process, whether planner, contractor, or operator.

All blocks need careful harvest planning. This chapter goes through how to make a good plan. Planning is much more than just the company paperwork the contractor gets at the start of the job.

Planning should start well before the machines arrive and end after the machines leave. Risk management needs to integrate into all levels of planning.

The steps in good winch-assist planning.

The harvest plan

The planner must understand harvest options and keep up with the rapid evolution of techniques. Planners need to consider all phases from falling, extraction, processing, and loading.

It is essential to understand pre-existing erosion features and erosion prone material (loess, air-fall tephra, unconsolidated marine sand). Plan for re-working ruts so they don't turn into erosion gullies.

Winch-assisted extraction down an ephemeral water way creates a pathway for sediment to reach a stream.

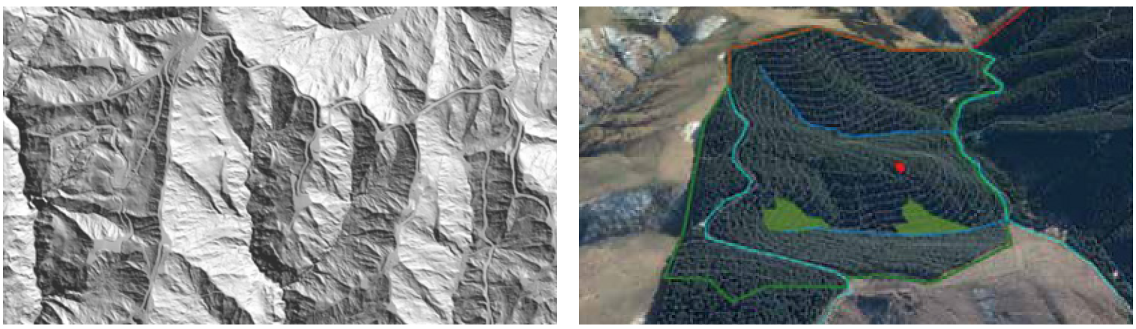
The office or 'paper' plan

The office plan's purpose is the first cut at harvest layout by piecing together information that helps develop the plan. It consists of collecting data that helps understand the block and things that affect layout design like the type of equipment available, extraction method, extraction distances, and the crew's capability. There are six steps to a good office plan.

1. Understand the block

Use data to find out as much information about the block before you visit the field.

- Geology.
- Soil type and soil depth, and strength and susceptibility to rainfall.
- Topography like slope and length, and terrain features like rocky outcrops, incised gullies and benches.
- Ground Roughness.
- Terrain Stability / Classification.
- Aspect.
- Climate and potential timing for operations.
- Infrastructure including old tracks.
- Ground cover and debris.
- Forest resource including stem size, stocking, height.



Old tracks can easily be seen with LiDAR, even with the trees still standing.

2. Know different winch-assist options and methods

There has been a swift expansion to winch-assist since 2010 and the change is still rapidly happening. Planners need to keep up with the changes. Forestry and harvest companies need to lift staff knowledge. Learning opportunities include industry conferences, University of Canterbury harvest courses, and regional wood councils for field days.

3. Understand the crew and their machines

Winch-assist planning isn't generic ground base planning that was typical in the past. Slopes are steep. If known, incorporate information on the crew and the machine types. They are experts in their fields.

- Understand the crew's knowledge, skill and ability and account for it in the plan.
- Use individual contractor's preferences when designing blocks.
- Know the machine capability, and if you don't, learn from operators and contractors.
    - Machine capability on different terrain, soil and slope.
    - How different ground conditions and other factors affect stability and mobility.
    - Machine technical specifications, e.g. manufacturer's rope length, slope limits.
    - Economics vs. safety.
- Don't push or exceed the operator or machine limits. Recognise that some areas are not suitable for mechanical operations. Designate these as 'NO GO' Zones and develop an alternate harvest solution.

4. Identify hazards

Identifying site hazards and understanding the risks is a critical part of your work. Refer to the hazard and risk chapter that identifies winch-assist hazards.

5. Understand laws, regulations and standards

Understanding the legal requirements is critical. Consents and approvals may also be required. Laws and regulations include:

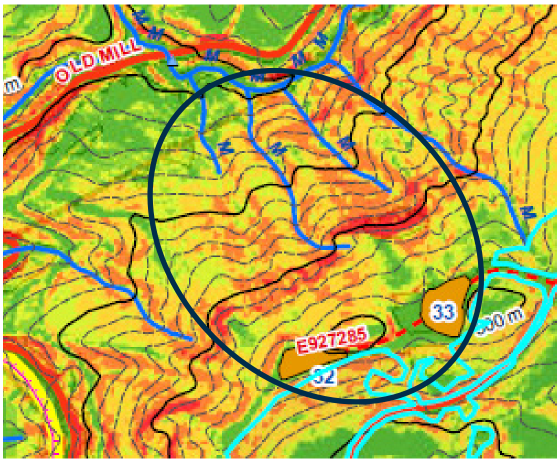
- The Health and Safety at Work Act (2015) and related regulations. They set out health and safety responsibilities and focus on managing work risk. It requires those who create the risk to manage the risk.
- The National Environmental Standards for Plantation Forestry (NES-PF). These forestry specific environmental regulations include harvesting, harvesting tracks and temporary river crossings. Most activities are permitted in low and moderate risk areas without consent if they comply with the permitted activity regulations. Part of that is having an earthworks and harvesting management plan available at the council's request.
- The Heritage New Zealand Pouhere Taonga Act for activities that could disturb or modify archaeological sites. Obtain an authority from Heritage New Zealand if you might damage, modify or destroy an archaeological site.
- The Approved Code of Practice for Safety and Health in Forest Operations (ACOP) provides guidance to undertake any forest activity.

6. Create the office plan

Work with the knowledge gained in the above five steps to develop a plan. This includes draft planning notes and maps. Use for the plan's field verification.

- Locate proposed roads and infrastructure.
- Identify what needs to go uphill rather than downhill, e.g. shovelling more than about a tree length uphill, is very challenging.
- Locate critical anchor and 'corridors'.
- Locate proposed harvesting trails.
- Determine if redirects are needed.
- Identify any possible winch-assist 'no-go' zones.
- Determine if any manual or hand-felling is needed and how this ties in with machine felling.
- Produce maps.
  - Harvest maps.
  - Slope maps useful for operators and preferably electronic. If paper, then at a scale matching the block's base data resolution, e.g. 1:5000 minimum scale, or prefered at 1:2500.
  - LiDAR maps.
  - Aspect maps, especially if this helps determine different soil moisture patterns.
- Identify the initial components of a hazard mgmt plan.

Walk the harvest block to identify hazards.



Use slope maps in conjunction with other mapping tools like LiDAR. The steepest section may limit the setting. For example, is this area a steep soil slope, or is it a rock bluff band?

The field verified plan

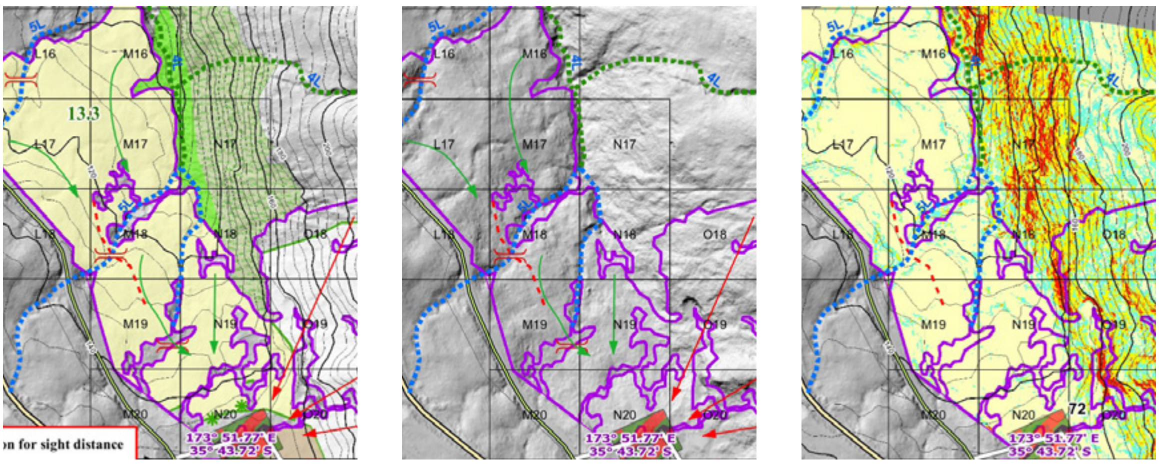
The office or 'paper' planning notes and maps needs field confirmation. The field plan needs to be site specific rather than general. There is no substitute for 'walking the block'.

Field verification should also incorporate ideas and suggestions from the supervisor, contractor and operator. Involving them helps make a better plan. They may not be able to come out with you, so give sufficient time for them to assess the plan and request any changes.

However, this is often not always possible as the layout may be several years before harvest, crew scheduling is not known, contractor equipment changes or the block is tendered.

Field check:

- Confirm if soil, geology, terrain and other site features match the plan's base information.
- Visit proposed landing, road and track locations and confirm these are acceptable.
- Agree that winch-assist is the prefered harvest method, and review the office plan.
- Confirm plan layout, e.g. how to harvest gullies.
- Walk challenging areas, especially those that could impact traction and stability, e.g. poor or wet soils, bluffs or rocky areas.
- Decide on any NO GO zones, and how to manage these.
- Visit and confirm identified hazards along with agreed control measures, e.g. steep faces, rockfall, fences, powerlines, houses, council roads. Additional safety plans may be needed, e.g. Temporary Traffic Control, Electrical Hazard Management Plan.
- Visit key terrain control points, e.g. anchor locations, redirect points.
- View restricted areas and discuss how these are managed, e.g. historic sites, ephemeral or permanent streams.
- Discuss ways to reduce environmental risk, e.g. erodible soils and damage caused by machines on steeper slopes.
- Confirm what maps to supply.



The harvest, hill shade and slope maps, along with the boundary between cable and groundbase provides an operator with valuable information. The maps are also on the operator's cellphone and GPS located.

If the contractor is known, get their advice as they are experts.

Pre-harvest planning

The pre-harvest meeting and sign-off operationalises the plan. The meeting is generally between the forest and the harvesting company.

It typically involves the harvesting manager or supervisor and the contractor. Any changes going forward need to be justified and approved.

Harvest plan meeting and sign-off

The pre-harvest sign-off is a formal agreement around how the block is harvested. It is also a legal requirement under the HSWA section 34 duties to consult, co-operate and coordinate activities. Section 2.4.4 of the ACOP covers the principal's duties on identifying and jointly determining measures to control site specific hazards. The meeting will go through the harvest plan and maps, specific plan requirements, stand information and site hazards. The specifics differ between companies. Both parties must agree on the plan.

Sign-off is simplified if the contractor has been involved in the field verification of the harvest plan. There should already be an agreement on most aspects of the job. Where they have not been involved in the planning, follow the steps identified in the field verification process above. If necessary, refine the plan.

Give maps to the contractor, foreman and operator that show essential information for their jobs. These should be at the scale they want. Electronic maps are most useful. These incorporate into phones or tablets apps with a GPS location, e.g. Avenza. Make sure operators understand the maps.

Decide or confirm operational aspects like how to open up the block and hazard management. Confirm the machinery and crew skills are suitable for the plan.

Get all the information and maps you need to help make good operational decisions.

Ensure you've been involved in the overall planning.

Contractor felling plan sign-off

The harvest plan shows WHAT needs felling. The felling plan describes HOW it is felled. Best practice is to mark up features of the felling plan on a suitable map, e.g. a slope or contour map at a scale of 1:5,000.

The contractor needs to decide how the block is felled, like anchor locations and main corridors. They need to consider:

- Terrain, e.g. soil, steepness, and gullies.
- Trees, e.g. volume, stocking, piece size, and tree lean.
- Machine or operator capability issues, e.g. under training, give easier areas.
- Felling method. In mixed method felling, the order of hand felling is a key consideration.
- Hazards.
- NO GO zones or protected areas, e.g. waterways, native vegetation, bluffs.
- Block adjacency or neighbour issues, e.g. roads, powerlines, fences.
- Road closure or traffic management requirements.
- 'Wet' and 'dry' weather options.
- Shared boundaries with adjacent harvesting operations.

Planning during operations

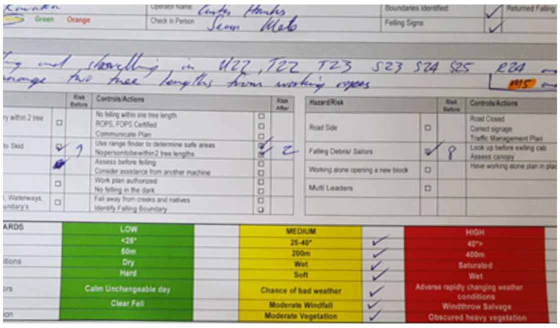
Day-to-day planning during the job is essential. Think ahead.

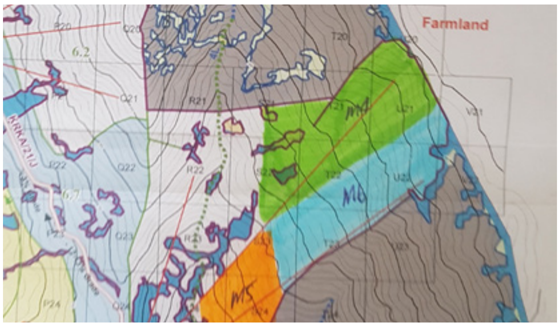
Plan for the day

- Ensure everyone knows the day-to-day plan. Have tailgate meetings to discuss and agree on the plan. Get everyone to confirm their understanding by signing the meeting record.
- Discuss safety, environment, production and other important information:
  - Harvest changes that could affect machine operations, e.g anchor shifts, lead angles, or rope redirects.
  - Any situations or challenges that apply to the current day, e.g. traffic management, or interaction between different parts of the operation.
- Hazards and their controls.
- Machine and rigging inspection, maintenance and servicing.
- An alternative plan if conditions change, e.g. rain, or wind.
- Operators understand when to call for assistance and when to suspend work.
- Emergency response procedures.
- Check everyone is fit for work and if there's anything that could affect the job. See the operator and crew chapter.

FISC has detailed information that helps prepare for daily crew meetings.

safetree.nz/resources/tailgate-resources/





Examples of a felling plan map and daily plan

Stop felling if hazards can't be managed as planned.

Always have a Plan B in case things don't go according to the plan.
Consider alternatives to mech felling on challenging sites including hand felling, delayed felling, pull over with the yarder ropes, or leave standing.

Operational coordination

Clear operational coordination is critical. This could come from the harvesting PCBU, the woodlot manager, or the woodlot owner. They visit the operation to make sure harvesting is according to the plan.

Three additional important tasks are to:

- Ensure production pressure isn't compromising safety and environmental standards.
- Keep current on conditions at the worksite, e.g. machine breakdowns, staff changes, new equipment, and production factors.
- Work with the harvest planner and the contractor to ensure any plan changes are agreed upon and signed off.

Post-harvest review of the planning

Reviewing the job after completion is a great way to incorporate learning into future operations. The planner and contractor should assess the block and discuss what worked and didn't and how planning and layout can be improved going forward.

Planning responsibilities

Harvest planners must:

1. Plan all blocks and thoroughly field verify.
2. Involve the contractor in the planning process.
3. Understand the crew and machinery capability.
4. Meet and sign-off the plan before work starts.
5. Provide useful planning notes and maps.
6. Learn from each job to improve the plan's quality.

Contractors must:

1. Plan ahead.
2. Every day have a crew pre-start meeting to discuss and agree on the day's plan.
3. Make sure everyone knows their part.

Supervisors must:

1. Make sure the plan is followed.
2. Approve modifying the plan when there are good reasons.
3. Monitor the work.

Operators must:

1. Follow the plan, suggest and get confirmation of plan changes.

Chapter 12

Machine and rigging inspection, servicing and maintenance

In this chapter you'll find out about:

- ✓ Regular inspections for:
  - Winch-assist machine.
  - Supported machine.
  - Ropes and connectors.
  - Non-winch-assist machine anchor.
- ✓ Servicing, including annual inspections.
- ✓ Guidance to help safely undertake repairs and maintenance.

This chapter provides an overview of general inspection, servicing and maintenance for the winch, the steep slope machine (harvester, forwarder, skidder) and rigging. Irrespective of the machine's brand, the chapter highlights the important things to check. There's a significant risk for the machine operator if a system failure occurs. Also, machinery damage is often expensive and time consuming to fix.

There are three ways the machine can fail and any of the three can create significant hazards. These can be structural, mechanical, and control element failures.

Structural components don't move. Mechanical ones move, e.g. they rotate, extend, retract. Control elements are the devices and systems that cause the mechanical parts to start, stop, change speed or direction.

It is best practice for the operator to be familiar with safety critical elements and for the machine owner to oversee and support regular inspection, service and maintenance of these.

Note: The guidance does not replace the Original Equipment Manufacturers' (OEM) requirements and recommendations. If in doubt always refer to OEM manuals, guides and induction materials.

Regular Inspections

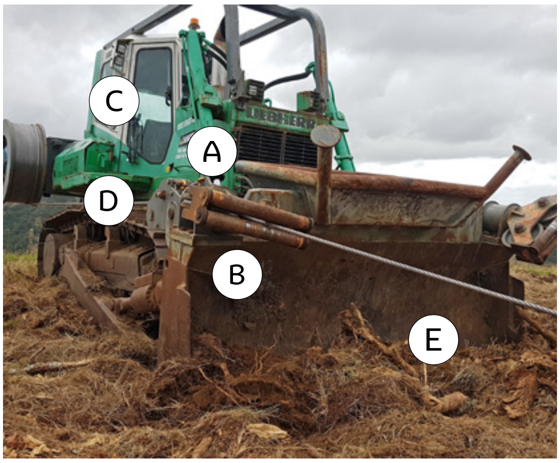
Winch-anchor machine

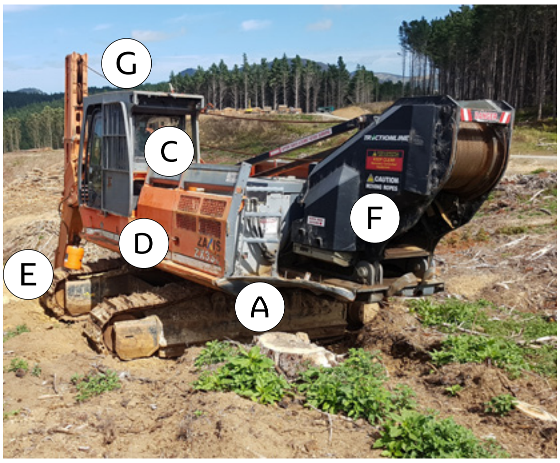
The winch machine should be checked daily. The things to check will depend on the type of WAM and the manufacturer's requirements, e.g. anchor winch or winch on the steep slope machine.

Look carefully, especially in areas that are subject to:

- Wear and tear.
- Changing forces and tensions.
- Areas that are known to need maintenance.

On the following pages, photos show examples of components that should be regularly inspected.





A No fluid leaks

B Fairlead rollers

C Electronics working

D Fuel and oil levels OK

E Anchored and braked?

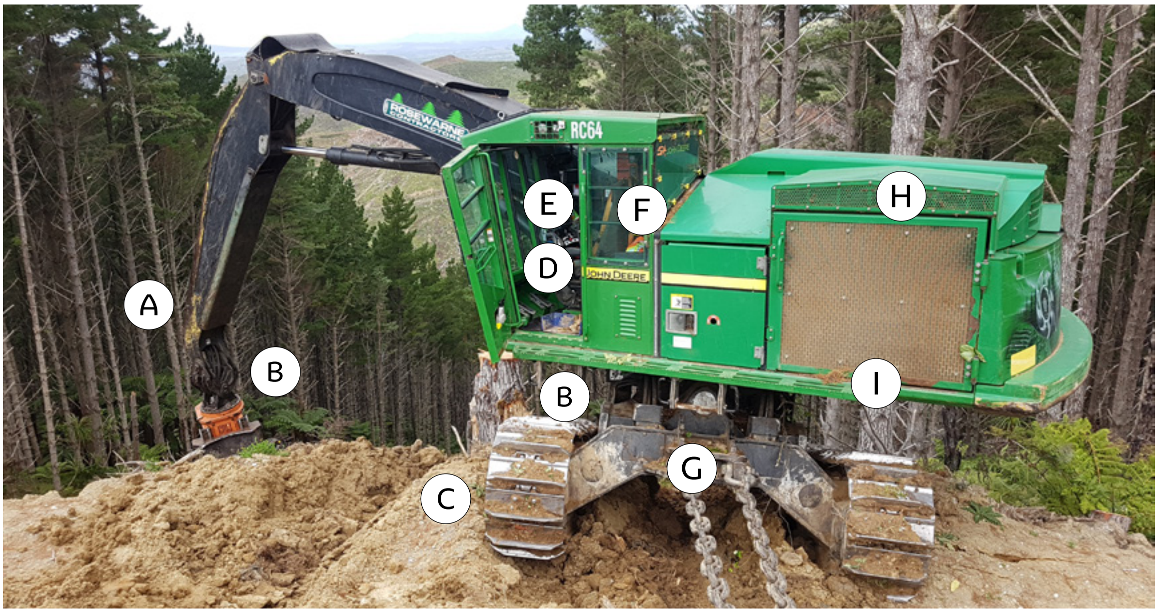
F Winch mounts/ attachment points OK

G Tower/guides/ sheaves

Also:

- No metal or hose cracks.

Steep Slope Harvester (Harvester, Forwarder, Skidder)



A Boom and attachment OK

B No fluid leaks

C Track gear good

D Controls working OK

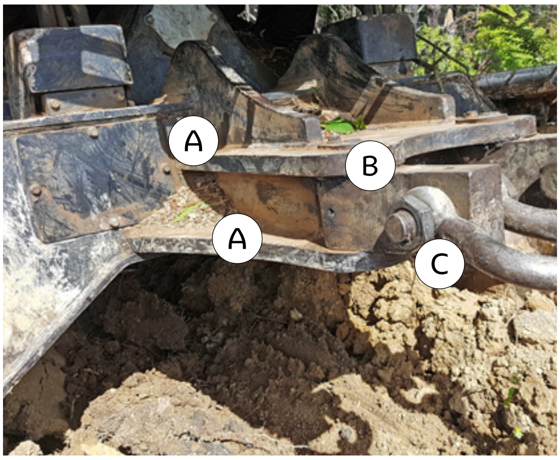
E Electronics working, e.g. radio, remote control system

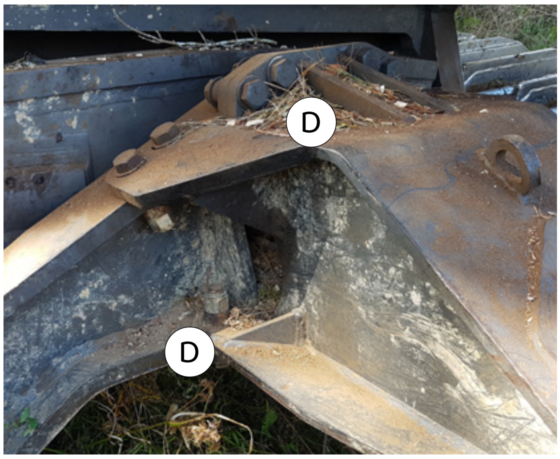
F Windscreens clean?

G Winch mounts/ attachment points OK

H Fuel, oil and water levels OK

I No guarding damage



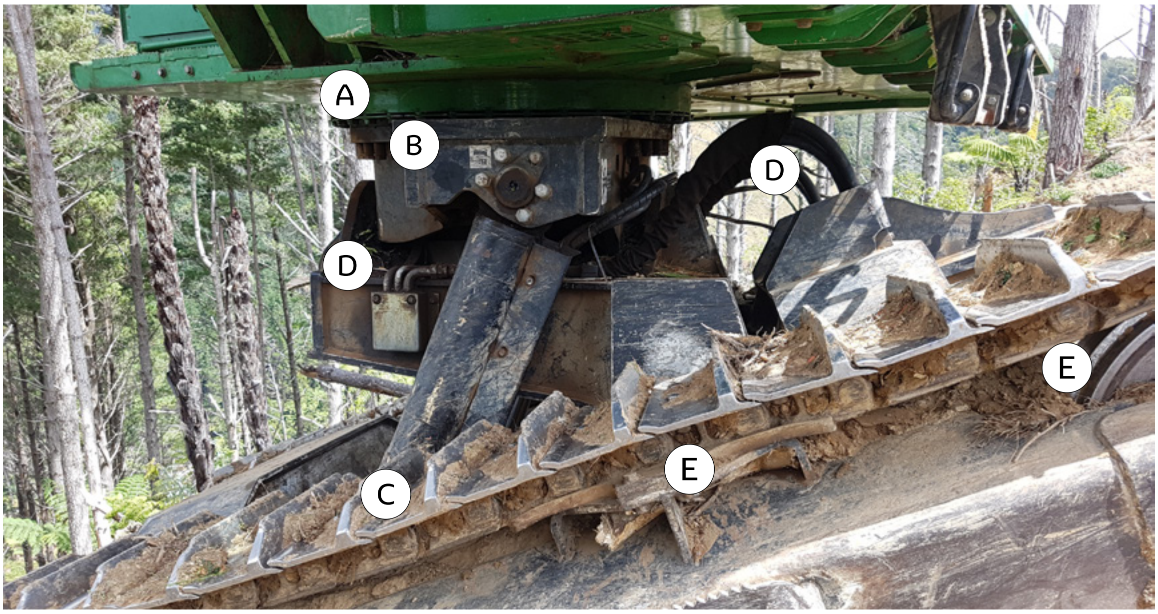


A Winch-assist attachment welds no cracks

B Pivots pins no cracks and greased

C Shackle has grommet of bolt, shackle wear OK

D All winch mounting bolts tight and not sheared off



A Slew bearing OK (noise, play, etc.)

B Turret bolts tight and none snapped

C Grousers OK

D No fluid leaks, hydraulics

E Rollers, sprockets and idlers all good?

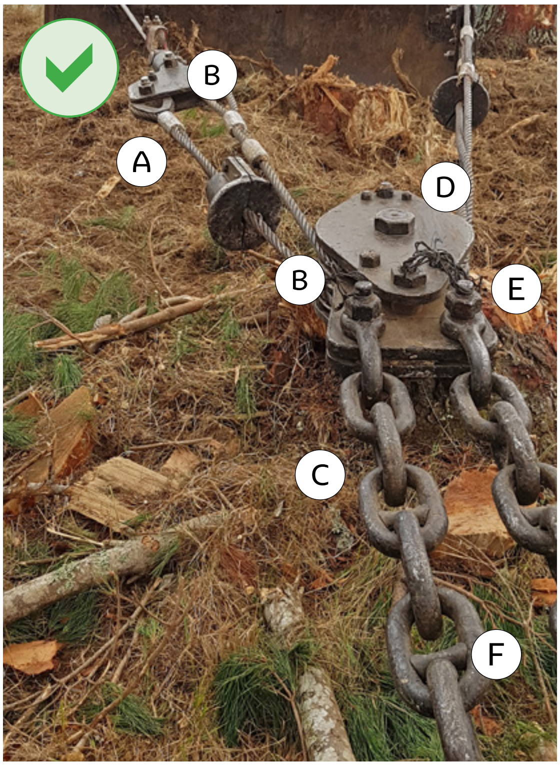
Connectors

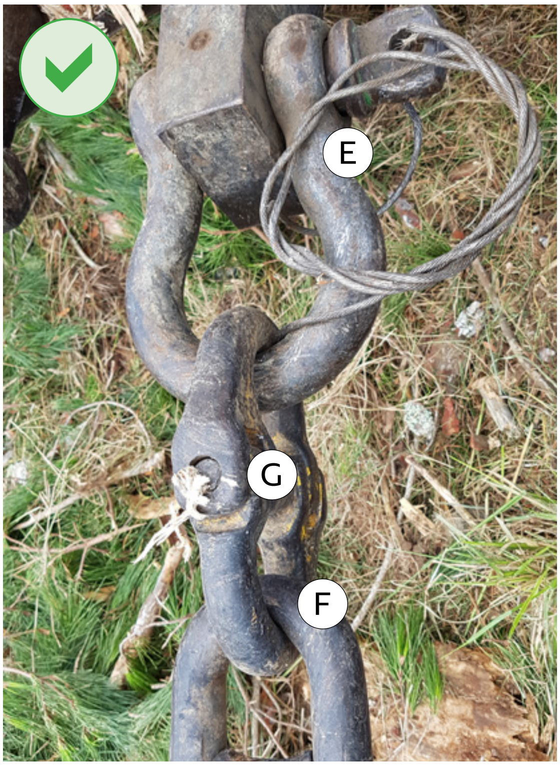
Thoroughly check the rope connection points, fasteners, chain, shackles, and hammerlocks. Rigging wears out over time. Make sure that all parts in the tether system still meet the manufacturer's tolerances. The type and amount of rope and rigging wear and tear will vary depending on the location, terrain, and soil types. Specifics around wire rope are discussed in a later section.

Daily inspect every connector and wire rope attachment point for wear or damage:

- Inspect the chain regularly for wear or damage, e.g. measure the chain's length and the links hole diameters to check for stretch using a simple gauge. Replace the chain if it appears worn, damaged, or stretched beyond the manufacturer's recommended limits.
- Inspect the wire rope connectors for surface wear, nicks, cuts, broken wires. Replace accordingly. Some types of cable, e.g. swaged, may appear fine when they are worn out, so know the wire's characteristics.
- Keep a list of all rigging components, their breaking loads and deployment date.

Stop work and check connectors and rigging if a stress event or damage occurs. Assess, and replace the component immediately, if necessary.





A Ferrules good?

B Other connectors in good condition?

C Chain bridle good?

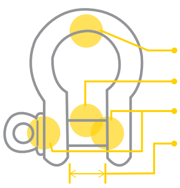
D Blocks OK

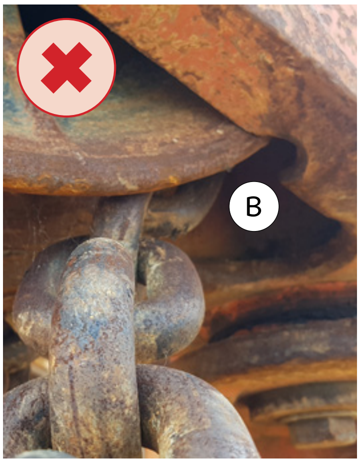
E Shackles with grommets or bolts, wear OK?

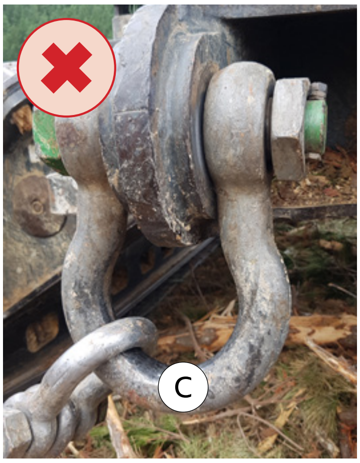
F Chain wear OK? Stretched, worn, bent or gorged out?

G Hammerlock good?

Never replace a shackle pin with a bolt. It will bend.







A Hammerlock worn by rubbing against machine. This happens when going to flatter slopes below steeper ones

B Excavator anchor fairlead shows significant wear caused by a rope riding off the sheave

C Shackle is worn here but elsewhere too?

End Connector Inspection

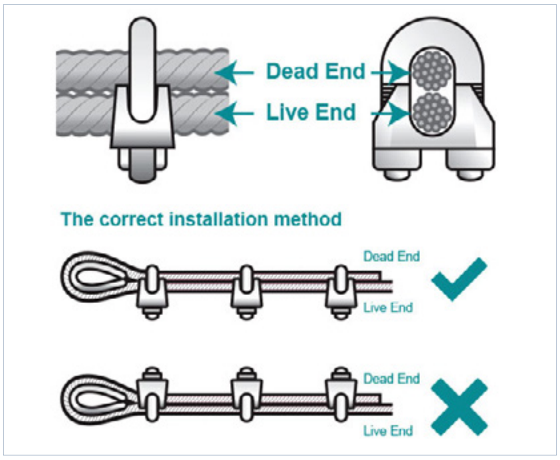
Some common types of end connectors:

These connectors should be installed correctly and in good working condition. Make sure to inspect pressed eyes, thimbles, ferrules and other metal components for excessive abrasion and fatigue cracks. The following are best practice guidelines examples for correctly installing end connectors:

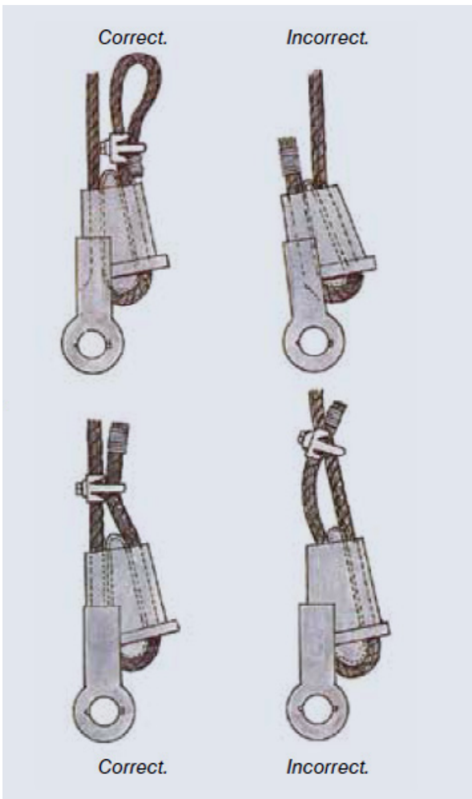
Loggers eye splice
A loggers eye splice should be tucked three times on one side and two on the other (ACOP, 2012)

Split wedge ferrules
The strands of wire rope should protrude roughly 1/4″ past the top of the wedge button. Once the first load is applied, the wedge will seal firmly into the wedge button.

Wedged sockets and Cable Clips



Remember the saying "Never saddle a dead horse!"



Wire Rope Inspections

What causes wire rope failure?

Ropes can fail through abrasion, tensile overload, and temperature damage.

1. Abrasion occurs when the rope rubs an external source like a rock outcrop, a different section of the rope, or a component of the rigging.
2. Tensile overload occurs when the rope experiences an axial load that overwhelms its strength. The result may be a loss of rope strength or even rope failure.
3. Wire rope can also be damaged by exposure to extreme temperatures, which can occur when the rope rubs against trees or stumps during operations.

How to extend a rope's life

Reduce or eliminate the three points listed above that shorten a rope's life.

1. Abrasion damage

- Avoid running the rope on the ground, over rocks, or around sharp bends.
- Use a heavy-duty chain segment near the harvesting machine and in other high-wear areas.
- Move the anchor or anchor machine as needed to prevent cable contact at ground breaks.
- Before every use, inspect the wire rope for surface wear, nicks, cuts, broken wires, or changes in diameter.
- Take care when lifting/repositioning wire rope. Use mechanical attachments to grab a chain segment rather than the rope.
- Don't run over the rope with wheels or tracks.

2. Tensile overload

- Working tension affects rope life. Use a tension monitoring and recording system. Review tension log data daily, and whenever shock loading is known or suspected to have occurred.
- Avoid loading or shockloading the rope, or the weakest rigging link, above the safe working load specified by the manufacturer.
- Cease operations and replace the rope if tension ever exceeds the elastic limit. If tension exceeds the rope's endurance limit, its lifespan is reduced.

3. Temperature

- Heat affects rope strength. For IWRC wire rope, temperatures over 93°C reduces the rope's strength.
- Look for wood charring where the rope has contacted a tree or stump. Charring occurs at 120 to 150°C.

Who should inspect wire rope?

A competent person needs to inspect a rope. They consider the different types of deterioration and assess the 'combined effect' of the wear on the rope. This requires knowledge and experience.

When to inspect a rope

Use the rope manufacturer's recommendation for rope inspections and discard requirements, e.g. Some manufacturers recommend end for ending rope after 1000 hours and replacing rope after 2000 hours.

Otherwise:

- Inspect the rope's working length monthly, or at minimum of every 500 hours, unless there is a reason to do it before that.
- Use the inspection and discard criteria outlined in ISO 4309:2010.
- Inspect ropes and connectors after an incident involving visible damage to the rope or suspected shock loading above Safe Working Limit (SWL).

Check the rope thoroughly. If you are unsure about something, get a second opinion.

Joining splices should not be used to join broken or damaged winch ropes.

What to look for, and when to discard?

If significant changes in a rope's condition are seen, the rope may need replacing. If the damaged section is near the working end, it may be possible to remove the damaged section. This shortens the working length of the rope.

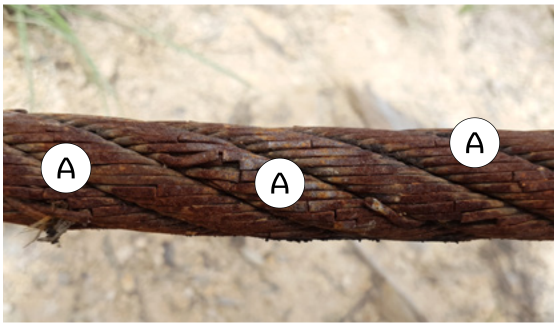
The ISO 4309-2010 document explains in detail rope inspection and when to discard. Always inspect a rope with the tension off. If you see breaks on the outside, there will be more broken on the inside.

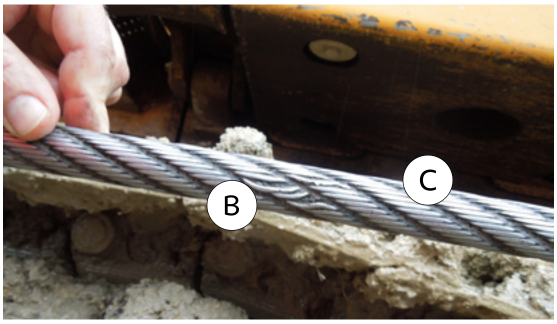
The 9 key points of ISO's discard criteria are:

1. Randomly distributed visible broken wires and valley wire breaks.
2. Local groups of visible broken wires.
3. Visible broken wires near the rope termination.
4. Local decrease in diameter (core failure).
5. Uniform decrease in diameter (wear).
6. Internal corrosion.
7. External corrosion.
8. Deformations.
9. Thermal damage.

Replace ropes if there are concerns. Visual inspection only shows the condition of the outer wires, only 20% of the rope's area. A marlinspike helps see more, but for only small sections.

Always consider swapping the rope out sooner than later to give it a second life in a less safety critical work area.



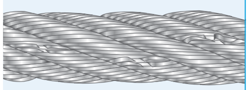
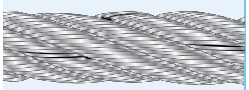


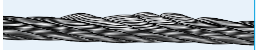
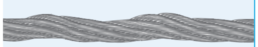
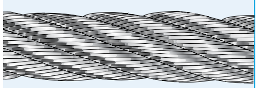
A Randomly distributed visible broken wire

B Local group of visibly broken wires

C External wear

Below are some common defects and their discard criteria as outlined in ISO 4309:

DEFECT	DISCARD CRITERIA
 Breaks: crown wire	Discard or remove section if: • 6 or more randomly occurring wire breaks are found over a lay length, or • 3 or more breaks occur in a single strand in one lay, or • 2 or more wire breaks occur at termination points.
 Breaks: valley wire	Discard or remove section if: • 2 or more valley wire breaks occur over a lay length, or • 2 or more wire breaks occur at termination points.
 Corrosion	Discard rope if wire surface is heavily pitted and slack, and corrosion cannot be wiped away. Perform internal inspection if signs of internal corrosion (such as corrosion debris exuding from between strands) are visible. Discard if internal corrosion is confirmed.

DEFECT	DISCARD CRITERIA
 Flattened portion	Flattened portions wear more quickly. Inspect them more frequently for broken wires and corrosion damage.
 Changes in rope diameter	Discard the rope or remove the section if there is an obvious localized decrease in diameter caused by failure of a core or rope centre, or by a sunken strand. When non-localized changes in diameter are found, discard the rope if the changes in diameter exceed 7.5% of nominal diameter.
 Waviness	Discard the rope or remove the section if the gap (g) between the underside of the rope and a straightedge is 1/10 of rope diameter (d) or greater.
 External wear	External wear will cause the diameter to decrease and will result in broken wires. See discard criteria for wire breaks and changes in diameter, above.

Source: FPInnovations 2017, "Wire rope integrity in winch-assisted harvesting operations"

Servicing

The following advice should be followed:

- The anchor and the steep slope harvesting machine must be serviced according to the Original Equipment Manufacturer's (OEM) specifications, recommendations or instructions.
- The machine owner is responsible for ensuring specified components are replaced in accordance with manufacturer's recommendations.
- All sensors, alarms, and controls fitted by the manufacturer must be monitored and in working condition.
- Structural repairs or modifications must be approved by the OEM or their local representative and may require inspection and approval by a certified professional engineer. This includes repair to an operator protective structure.
- The machine owner should keep servicing records.

Manufacturers recommend doing a pull test before starting work and after completing daily checks, and hitching is done. Refer to your operator manual for instructions, including tension pre-sets and instrumentation to monitor.

The inspection form below gives an example of a regular weekly or monthly check. Manufacturers will often provide their own inspection forms.

OPERATOR DAILY / MONTHLY CHECKS			
Date: ________ Machine Model: __________ Machine Hours: _______ Winch Hours: _______	Daily (8 hrs)	Monthly (160 hrs)	Notes
Independent or integrated Winch Machine			
Rollers and Sheaves (check for movement, wear, damage)	○		
Rollers and Sheaves (grease)	○		
Sheaves (check for damage cause by lead angle rub)	○		
Tension monitor (visual check that rollers are turning)	○		
Winch Mountings (visual inspection of bolts and/or weld integrity)	○		
Fairlead and Boom (wear, damage, cracks, loose bolts)		○	
Fluids – Check all oils, water and fuel levels. Check for leaks (hoses, pipes and tanks)	○		
Grease / Lubricate points (as per Manufacturer's instructions)	○		
Electronics/Software (Various prestart checks and warning features checked)	○		
Movement sensor check (attachment points and cable tightness). Pull the lanyard to active the anchor/ motion switch, the warning sign should be activated on the main screens in the machine cab	○		
Supported Machine (Harvester, Forwarder, Skidder)			
Drawbar (check for wear, cracks and that pins are in correctly)	○		
Drawbar (winch mounting bolts tight and not sheared off)	○		
Fluids – Check all oils, water and fuel levels. Check for leaks (hoses, pipes and tanks)	○		
Operator Protection (in good condition)	○		
Electronics/Software – Various prestart checks and warning features checked	○		
Fuel, oil and water levels OK	○		

OPERATOR DAILY / MONTHLY CHECKS			
Date: __________ Machine Model: __________ Machine Hours: ________ Winch Hours: ________	Daily (8 hrs)	Monthly (160 hrs)	Notes
Slew bearing OK (noise, play etc.)		O	
Turret bolts tight and none snapped)		O	
Emergency exits functioning		O	
Ropes and Connectors			
Hammerlocks (check for wear and cracks and check that pins are in correctly)	O		
Shackles (visually check for cracks or galling on pins and grease)	O		
Wedge Socket (visually check pins for wear, cracks, and galling – change if necessary)	O		
Wedge socket (suggest cutting 50cm off rope as internal defects difficult to identify, refit, clip)		O	
Stud Link Chain (visually check for cracks, bad nicks or cracks or damage from grapples or hot saw chains – change if any major defects	O		
Rope (check for wear around connectors)	O		
Rope (zero the rope distance counter)	O		
Rope (visual inspection of working length)		O	
Other End Connectors (check for wear and tear)	O		
Non-WAM Anchors			
Deadman (4m deep, 5m long and > 50cm diameter, in-lead)	O		
Stumps (fresh, >50cm or multiple stumps, strong soils, not excessively worn by rope or socketing due to tension)	O		
Stumps (movement monitor device if any potential concerns)	O		
Mobile Anchor (sufficient size/weight, blade in the ground, in-lead, (device employed to monitor movement)	O		

Note: For further guidance on non-winch-assist machine anchor types refer to the Cable Logging BPG and section 14.3 of the ACOP.

safetree.New Zealand/resources/best-practice-guidelines

Check your anchor, machine and rigging thoroughly. Don't take shortcuts and 'tick the boxes' with maintenance or service checks.

Annual Inspections

- All mobile plant with an integrated or attached winch system should have an initial annual inspection.
- The inspection can be in isolation or as part of warranty or a service agreement provided by the OEM.
- After the initial inspection, a documented inspection should be carried out every two years.
- If the OEM specifies components requiring more frequent calibration or checking, their requirement and recommended interval should be followed.
- A competent person familiar with the plant and systems should do inspections. A competent person could be:
  - The OEM or their local representative.
  - A qualified technician approved by your service agent.
  - A person with suitable product knowledge, e.g has specific PLC programming and technical knowledge.
  - A chartered professional engineer.
- The inspection should cover:
  - All mechanical aspects, e.g. winch mounting, brakes, sheaves, rollers and bearing condition.
  - Function tests of systems, e.g. the movement sensor, hydraulic and communication systems.
  - Alert systems, e.g. engine oil pressure, high temps, low hydraulic level).
- Use an inspection checklist provided by the OEM due to differences in machines and operating systems.
- The machine owner should provide previous servicing and inspection records to the person conducting the inspection.
- The machine owner should get a copy of the inspection result, including any recommended corrective actions.

Second-hand plant

If purchasing second-hand plant:

- Ensure that the machine's structural, mechanical, and control elements meet the same standards expected of new equipment.
- A competent persons should inspect the machine to assess that all safety and operational features are working as designed by the OEM.
- Once the inspection is completed, it is recommended future inspections meet the service and annual inspection requirements within this guide.
- Ask for servicing and inspection records, operating manuals and induction materials.

All secondhand bases converted to a WAM should undergo a "pre inspection" to ensure all safety and operational functions work as the OEM intended. Visually inspect and check:

- Hydraulic hoses and components.
- Mounting points and critical welds.
- Hydraulic bypass test on all cylinders.
- Leak tests on all cylinders.
- Measure play in all pins and bushings.
- ROPS, OPS, FOPS.

Second-hand plant generally changes hands on an "as is basis". This does not prevent the buyer or seller entering into an agreement regarding future warranties.

Repairs and Maintenance

Repair and maintenance need careful management otherwise there are serious risks including severe injuries.

Repairs and maintenance shouldn't need to be done on slope, only remedial work. It is always best if you can safely get the machine to level ground with nearest access possible for maintenance vehicles.

Major and minor repairs
Repairs should be identified as major or minor. A major repair must be done otherwise a part of the winch-assist system will fail. Minor repairs are important to fix, however, the problem will not directly cause a machine failure. Major work should be approved by the OEM or their local representative. Major changes are always major repairs and need signing off by a chartered professional engineer. Minor work is non-structural and does not change or alter any part of the winch system, e.g. replacing a damaged sheave.

Use a lockout system
The guide recommends using a lockout system that prevents machines or their energy sources from being accidentally turned on. Lockout is essential for operators and mechanics to safely and confidently work on machines.

Common steps include:

- Shut down machinery and ensure that a responsible person removes and maintains possession of the ignition/master key.
- Apply brakes, swing locks, etc.
- Place the transmission in the manufacturer's specified park position.
- Lower to the ground or secure each moving element like the booms, grapple, bucket, saws, to prevent a release of stored energy.
- Engage hydraulic safety locks when applicable.
- Relieve pressure on hydraulic or air systems by bleeding tanks or lines.
- Place lockout device.

Before the lockout device(s) are removed and the machinery started, check that the site is safe.

If the steep slope harvesting machine is being worked on down the slope, then the winch-assisted system needs to be locked out to eliminate the risk from the anchor machine. Make sure trees or debris on the uphill side of the machine are stable.

Energy is a hazard and comes in many forms. It could be electrical, pneumatic, hydraulic, mechanical and stored energy like heat. Isolate or remove all energy before starting maintenance.

Only work on the machine if it is stable, has zero energy, and it's locked out.

Repairing machines on unlevel ground
Sometimes machines cannot be repaired on level ground. Have a procedure or system to ensure the machine's stability before shutting down for remedial work or repair. This will create a consistent and safe approach to repairs.

This should include:

- Ensuring all parts of the machine have zero energy before starting work.
- Having the winch wire anchored.
- Putting the blade down (where applicable) or the boom/arm lowered with all attachments on the ground in a safe state.
- No lose debris upslope of the machine that could come down.
- Operator or mechanic safety, e.g. access to a harness if working on top of machine, or suitable guarding / fall protection installed.

The following accidents have occurred doing R&M on harvesting machinery:

- Arm became trapped in processor.
- Technician crushed and fatality injured during repairs to a logging processor head.
- Hose blew off just missing my head.
- Slips, trips and falls off cabs, tracks, and other machine parts.
- Crushed fingers.

Six key safety considerations for machinery repairs
The following table is a guide to safely work on machines.

	Six key safety considerations for machinery repairs	Responsibility
PREVENTION CONTROLS	SKILLS and COMPETENCY and TOOLS and RESOURCES	
	Worker has the skill set and experience to do this job correctly and safely.	Operator
	Correct tools and operator manuals are available.	Foreman, Operator
	PPE (e.g. gloves, eyewear) is available and worn.	Operator
	A suitably experienced person available to assist (if required).	Foreman
	External Service providers have received site access instructions (i.e. R/T Instruction or meet at gate) and contractor provides site induction.	Foreman, 3rd party
	TIME PRESSURE	
	If there likely to be a production impact, advise the foreman. This may need to be escalated to the forest owner/manager.	Operator, Foreman
	If the machine will be out of commission for an extended period, the foreman will ensure that any temporary manual work is planned, organised and undertaken by competent persons. Risks will be assessed and supervision provided (if necessary).	Foreman
	When testing a repair, keep body parts clear of nip / crush points. If multiple workers are assisting, every worker must be crystal clear about their role in the diagnostics / live check.	Operator, Mechanic
	WORK AREA	
	Raised objects must be appropriately supported. Ensure that no raised object can fall and crush any person assisting with or in the vicinity of the RandM task.	Operator
	Assess the work area for Falling objects. Ensure that no overhead hazard can fall on and injure any person assisting with or in the vicinity of the RandM task.	Operator
	Check that the machine is free of trip, slip, fall hazards.	Operator, Mechanic
	(Hydraulic fluid, diesel and oil leakage increase the chances of slipping on or falling from mobile plant or into moving parts).	Operator
	If there is a chance that another machine / vehicle will come into the work zone, Isolate (tape off) the work area.	Operator
	If the machine has broken down in an area difficult to access and repair, can it be recovered to a safer location before the repair is undertaken? Foreman is involved in any decision involving the recovery of a machine.	Foreman
	Weather conditions – if poor light, visibility fog, rain, dust, heat will affect your ability to complete the task safely, then delay the work until conditions are suitable.	Operator

	Six key safety considerations for machinery repairs	Responsibility
PREVENTION CONTROLS	MOBILE PLANT AND EQUIPMENT PREPARATION	
	If more than one person is involved in the task, 1 PERSON will take charge. That person will ensure each person clearly understands what is expected of them.	Operator
	The person doing the work knows how to engage the machine's lock-out / de-energise / disable features. Lockout prevents a machines or its energy sources being accidentally turned on. Lockout is essential for operators and mechanics to safely and confidently work on machines.	Operator, Mechanic
	Stored energy is released before starting the job (tension or fluid pressure). A sudden or unexpected release of hydraulic fluid release onto the body can result in severe injury including blood poisoning.	Operator
	Clothing or hair is not at risk of getting entangled.	Operator
	Important: Modern mobile plant may have as many as 5 energy systems to consider before starting RandM work (e.g. hydraulic, pneumatic (air), mechanical, electrical (incl computer) and heat. And always respect gravity!	
	SPECIFIC RISKS	
	Hot Work (e.g. welding, gas work) MUST be managed to prevent fire. Fire season requirements (including notification) are to be followed.	Operator, Foreman
	Smoking is an ignition source. No smoking while refueling or around petrol, diesel, or oil.	Operator
	Manual handling – if components or liquids > 25kg are being handled, share the load, break the load into small units or use another mechanical device to lift or assist.	Operator
	PREVENTATIVE MAINTENANCE	
	Daily Checks and Servicing are undertaken in accordance with manufacturer and company requirements.	Foreman, Worker, 3rd Party
RECOVERY	WORKING ALONE	
	If a worker is working alone, an effective call-in arrangement must in place. (e.g. includes weekend or after-hours work).	Foreman, Worker
	FIRST AID and EMERGENCY RESPONSE	
	Minor injuries (e.g. cuts / puncture wounds) must be treated with appropriate first aid to prevent infection.	First Aider, Worker
	In the event of an accident follow your emergency procedures. Review Emergency Procedures after an event (as part of the accident investigation).	Foreman, Worker

If Prevention Controls fail, it is critical that effective Recovery Controls are available to manage issues. Recovery controls are the things that manage an accident.