



Thinning to Waste 2017
New Zealand

MAXIMISING INCIDENT LEARNING OPPORTUNITIES

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Simple cause and effect incident analyses do not address, understand or explain the dynamic interactions that persist in the complex systems our industry faces each day. The intent of an incident investigation is to prevent reoccurrence and to protect our people from further injury. To effectively prevent future adverse events, we have to be able to learn from the context of each incident.

During 2016, FISC commissioned Scion to undertake a Pilot Project to demonstrate the applicability and practicality of a new approach to adverse event investigation in New Zealand forestry incidents. The Learning Review is a comprehensive, applicable methodology based on dynamic inquiry rather than categorical assessment. Phase II of the work began in January 2017 and includes the completion of five case study Learning Reviews of recent incidents in the forest industry, as well as building capacity within industry to undertake the approach.

Error and uncertainty are unavoidable in the highly complex and dynamic environment in which the forest industry operates. Thus we must assume incidents will happen and direct our resources towards reducing the magnitude of adverse events. The Learning Review has been designed to maximise incident learning opportunities. We can use the process to learn ways to reduce the prevalence of contextual pressures, to allow error to exist without consequence, and to recover and adapt when the unexpected is bound to occur.

Maximising Incident Learning Opportunities Incident 5 Thinning to Waste

The risks associated with thinning to waste silviculture operations form a FISC Critical Risk Area. A number of thinning incidents have been reported throughout the industry over recent years. The catalysing incident for the Learning Review occurred in early May 2015 and therefore it was determined that the incident fell outside the defined Selection Criteria, specifically:

- i. The incident occurred outside the 12-month time period.

This incident learning review is focused instead towards the system to extract potential insights and crucial learnings for the ultimate goal of prevention.

PHASE 1 Information collection



Inquiry, identification of performance influencing factors, information collection and synthesis to create a complex narrative.

PHASE 2 Analysis and sensemaking



Use of focus groups and Subject Matter Experts to develop learnings and recommendations

PHASE 3 Application and adoption



Learning Review learning opportunities are evaluated and adopted by industry



Figure 1. (From left) Post thinning, a variety of wedges; the red/smallest wedge is carried by Thinners, post thinning.

Red is Thinner comments and perceptions

Move up slope/valley through the block. Start at the bottom in the gut, to open the bottom out to have somewhere to drop the trees in to. Drop trees in to holes you've already created.

Wind is an issue and can change plans for how you are going to thin.

Follow the lean of the trees.

Many different ways to move in and work your block.

Perfect world setting move through block in shapes. Do not bother walking up and down too much like the younger guys.

Every tree is different.

Taking more lines than cutting a single line.

Two directions free to fall, more options and visibility.

Select the best looking trees, take the ugly trees out, and leave the best quality tree.

Spacing is the next factor if they are all good.

Quality will bring production. How good you are, not how fast.

Look at them while looking up and notice little things, like dead tops.

Knowing your lean is the most important – Trees grow towards the sun, unless sheltered.

Shave the side you face and scarf the side.

Logging is different from thinning, size of the tree (top heavy or butt heavy) do not fall the same.

Key Decisions in Thinning to Waste Operations

Each morning a Toolbox meeting is held to discuss expected hazards and raise concerns (e.g. hang-ups, northwest wind, trees under tension, terrain – bluffs). Each crew member is given a PDF map of the blocks, which is both accessible by their phone and paper copy. Each Thinner is equipped with knowledge and expectation of stems per hectare and target stocking stems per hectare for their assigned blocks. Preparations are made for the day, and they head off into the blocks.

Movement through Block

Movement methods vary between thinners and are often adapted to terrain, block size, regeneration trees and spacing. It is common for Thinners to move and cut along the perimeter of the block boundary working inwards to create space. Most tended to open up two sides of the block to give more options to fall into. Younger, newly trained individuals tend to walk above a series of rows to determine cull trees in advance. Following cutting, the Thinner would walk back to the beginning and continue to work back along the same contour/row to scope out the next section. In contrast, the older, more experienced Thinners tend to move along a contour in a diamond/chevron pattern to achieve the desired stocking requirements. This method was commonly used in well-configured blocks with minimal undergrowth. In more complicated blocks, the Thinner will move along the block boundary and select the easiest/fastest paths to the trees to be thinned on a case by case basis. This method is used when regeneration trees are prevalent, and/or undergrowth and terrain is hindering. The thinning pattern is changed periodically throughout the day depending on whether the trees are windblown, the lean of the trees, the terrain, proximity of other fallers, size and shape of the block, and wind.

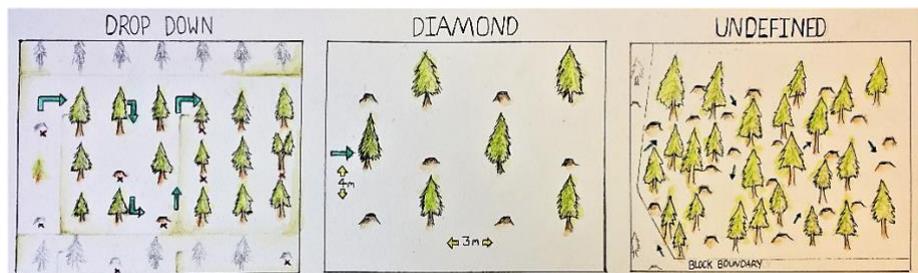


Figure 1. Visual representation of methods of movement through the blocks as described above.

Tree Selection

Thinners compare trees to their neighbours to identify which trees to cut out. Features that determine this decision include spacing, stocking, tree quality and dominance. Trees preferably removed and described as 'ugly' might present with a disfigured form, unhealthy, broken or dead tops, forked or multiple leaders, and/or excessive lean. Lesser quality and dominant trees will be left if stocking requirements become compromised. If two trees are very similar in quality as a crop tree the easiest one will be felled, this includes the consideration of surrounding hindrance undergrowth and the potential for hang-ups.

Preparation for Cutting

Upon approaching the tree, the selection is reconfirmed based on tree health, form, branching, dominance and spacing, and any issues missed from a distanced assessment. A path is made to the selected tree. Hazards and safety issues such as branch hang-ups are evaluated closer to the tree. Vegetation is cleared from around the trees if required. The lean of the tree is identified. The thinner cuts off higher branches that may be in the way and blocking vision (but not lifting the chainsaw to an unsafe level). This allows for an evaluation of felling direction (looking for clear space to drop it into). Then the Thinner moves to cut the bottom branches to access the area where the cut will be placed. Behind the tree is left untrimmed.

Felling the Tree

Less cuts means you are faster and better.

Move anticlockwise around the tree to stop yourself being in-line with the bar if it were to kick back. Cut anticlockwise = kickback hits tree or cut clockwise = the kickback hits you.

Scarfing most trees for more control. Scarfing does not eat in to time. Always scarf unless the tree is under 10cm, in that case just one cut.

Only use a wedge when doing a drive in an awkward position, which only occurs once in a blue moon.

We have to carry 4 wedges with us and a suitable hammer.

Most do not use wedges, only if working next to a road or fence line or you are really fighting the wind or lean. Most just do not bother.

Posting re-gen is standard as it's not easy to put them down in to a space without hanging up.

Looking at the stems to assess stocking, when learning individuals can be disorientated with canopy cover and run the risk of under and over stocking.

Difficult to judge distance accurately of people within two tree lengths.

The first step is to create space for cull trees to fall into and to do that the Thinner must determine the fall direction based on the lean of the tree and effect of the wind. Thinners will work with the lean of the tree, using it to their advantage to drop trees with more control.

Thinners align themselves to the top side/safe side of the tree at an angle for a safe retreat.

Firstly scarfing the tree (with an angled top cut followed by the bottom cut) on one side which creates the angle for the direction of fall. This chainsaw technique involves cutting the tree in an anticlockwise direction for all of the cuts. The Thinner moves the chainsaw to the other side or 'back' of the tree for back-cutting towards the hinge (towards the scarf). The back cut is made above the level of the bottom cut of the scarf.

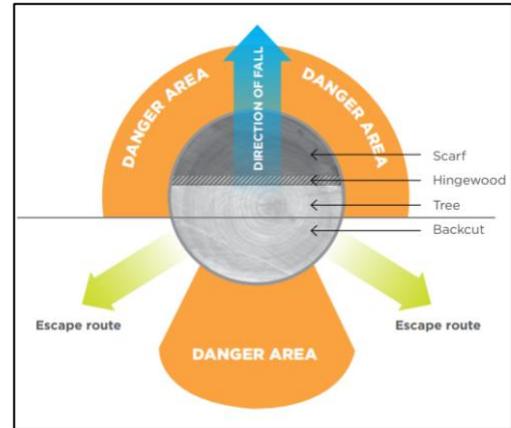


Figure 2. Felling cuts

<file:///C:/Users/hooperb/Downloads/WKS-4-forest-harvesting-manual-tree-felling.pdf> (retrieved 3 December 2017)

Feeling the tree starting to move, the Thinner will remove the chainsaw, place it behind them, and typically returning to the tree quickly to give a push to help the fall, then backs out and watches it fall.

Two commonly used techniques used if the thinned trees are not below the regulation height of 1.4 metre (considered as slash): 'Posting' (cutting successive lengths off a hung up tree) and driving (felling a tree onto another to push the tree over).

Finish Up

Move to the next tree and begin the process again.

ANALYSIS AND SENSEMAKING

3.0

Focus groups were assembled to map/understand the connections between pieces of information gathered in Phase 1 Data Collection and Synthesis. The focus group was made up of twelve experienced silviculturists. The focus group engaged in dialogue and sensemaking exercises around key actions/decisions identified in the incident and considered the complex narrative, standard operating procedures, regulatory requirements and organisational policies. The following analysis will illustrate the conditions which influence thinning to waste operations and meaningful recommendations will be generated predicated on the multifaceted consideration of those conditions. Learning and understanding the complexity of the everyday work that was at play in the event is a part of creating safety, recognising brittleness, and creating resilience in the workplace.

The following description illustrates typical task nuances faced during thinning to waste operations in New Zealand forests. These points were discussed during the sensemaking exercises carried out in Phase 2.

Tree Selection

The primary objective of Thinning is to reduce the density of trees in a stand. By the selective removal of trees, the process of thinning improves the growth rate or health of the remaining trees. Simply put, when smaller trees are removed the left-over trees will be larger and therefore more profitable. After a stand establishes, thinning is the primary method of influencing development and growth. Decisions on tree quality and crop trees is a high stakes game which determines the potential economic gain of a stand. It is the Thinner's responsibility to select trees to be removed (cull trees) and to leave trees (crop trees) that will fetch the highest prices when they are harvested.

The selection decision is based on the following criteria: previously pruned trees, vigour and health, form, branching and spacing. In assessing vigour and health, the Thinner will consider relative dominance of the tree (Figure 3). Importantly, trees are compared to neighbouring trees as opposed to trees in other parts of the stand. Dominant trees are superior in height and diameter than their neighbours. Therefore, dominant trees of good form are selected as crop trees as they will fetch the most value. Co-dominant trees are selected for when insufficient numbers of dominants are present. Dominant trees are usually the largest, capturing direct sunlight across the top and upper branches. The main canopy comprises co-dominant trees that receive sunlight mainly across the top and upper side of the branches. Sub-dominant trees only intercept direct sunlight on a limited area at the top. Focus group members agreed that they make mini-plans for selecting trees by comparing the neighbouring trees and sorting out the worst to take out (e.g. a skinny straight tree is better to keep compared to a fat and bent tree). 'Bad' trees can get better over time too. For example, the first five metres of the tree can be bent with the remaining 25 metres straight and usable.

Two approaches to selecting trees to be removed are described by Gary Kerr and Jens Haufe (2011) in *Thinning Practice: A Silviculture Guide*. Positive selection – is the removal of competing trees (shown in red in Figure 4) to maximise the growth of the 'best' trees (shown in yellow and green).



Figure 3. Drawing of relative dominance of potential crop trees in a stand. Abbreviations are as follows: CO= Co-dominant, SUB= Sub-dominant, D=Dominant.



Figure 4. Drawing of positive (left) and negative (right) selection

The best trees of the stand are identified, and their growth and development is actively promoted by removing competitors. Enabling the maximisation of the growth of the other trees by removing a dominant tree. Negative selection is the removal of suppressed and poorly formed trees (shown in Figure 4) without considering the growth of remaining trees. The removal of undesirable trees improves the quality of the stand. Undesirable trees are those that are of low value due to being badly shaped (such as forked, bent, densely branched) or damaged or diseased.

Unanimously agreed among the focus group members was that the decision making process around removal included consideration of both the trees that would be valuable to keep and the trees that need to be removed. Positive selections are not recorded. When Thinners faced trees of similar qualities, the easiest to fell safely was selected to be removed.

To become a Thinner, training is primarily completed on-the-job. For that reason, tree selection is learned from more experienced crew members and supervisors. Younger, less experienced Thinners are encouraged to complete training to gain NCEA units. All focus group members agreed that it takes at least three years to become a proficient thinner. That is, three seasons as most silvicultural crews are planting in winter. Additionally, focus group members stated that having the experience spending a day in a harvester can assist in knowing what to look for in terms of 'good' crop trees.

The focus group attendees believed that pruning prior to thinning helps their selection of crop and cull trees. A frustration shared by many of the focus group members was that pruning is currently declining across New Zealand. Many felt that it was more challenging to select crop trees now as it is harder to see optimal attributes with branches blocking their vision. Furthermore, when a stand is pruned it is easy to identify which trees to select because the majority of decision making has been made by the Pruner. 'Followers' (unpruned trees) are chosen as cull trees, unless the block is understocked or overstocked.

In a general thinning setting, the aim is to reduce a stand from 850 - 1000 trees (with regenerated/self-seeded trees) down to 500 trees per hectare. Thinners must select the right trees to take out to match stocking requirements for each block. Controversially, some blocks are paid hourly and some per hectare depending on issues with excessive regeneration. Focus members raised concerns about the precedent of always trying to get the work done as cheap as possible. If a crew gets behind in a 'per hectare' block due to weather for example, they will have to work hard to catch up as there is generally no negotiation with forest companies after work has begun. Thinning is ideally carried out when the trees are eight to ten years old but many forest owners vary in thinning age regime. The focus group members cautioned this as problems arise when thinning is conducted too early or too late. Too early can change stocking levels or tree form – so much so that Thinners are required to make a 'best guess' at the trees to leave, and much can change in a small number of years. In contrast, if left too long the trees acquire large branching, significant undergrowth and large amounts of regeneration which can make thinning more difficult.

Thinners determine stand value at clear-fell which is a great responsibility entrusted to them. Overall, focus group members reiterated that they felt great pride in their work and strived to produce the best results. Among experienced Thinners, elite skills are highly respected and earned with pride in their work.

Cutting Techniques

Thinners will work with the lean of the tree, using it to their advantage to fell trees with more control. The knowledge that trees grow toward the light aids the Thinner to determine the lean quickly and the felling direction. The majority of expert Thinners preferred directional felling by scarfing the trees, regardless of whether they are under 20cm or not. Cutting the scarf allows a tree to fall in that direction. An exception occurs when trees under 10cm in diameter can be felled in one cut. Alternatively, the two cut method was mentioned as an option where Thinners can perform a front cut for direction and a back cut to fell. The front cut controls direction of fall and the back cut controls the speed of the fall. Issues with this method are an increased chance of the tree sitting back on the saw, harder to direct fall, and easier to overcut. An overcut is the misjudgement of cut depths resulting in insufficient hinge wood which creates an unpredictable fall. The more hinge wood there is, the more control of the tree the feller has. If a tree has a suboptimal lean or excessive lean, then a quarter cut is used if the direction is crucial. Butt rebound can occur where trees may flick up and back or down banks. A site assessment of the tree should give workers a good idea of the likelihood of this happening.

Wind can hinder thinning operations by creating unpredictability in felling direction. Working in excessive winds is avoided, and crews will relocate to another more sheltered block. If the wind is gusty, then it is likely that only 20% of trees will 'sit up'. If possible, the thinner will make sure he can thin in both directions as increasing options can prevent hang ups caused by the wind.

The Thinner ensures that all felled trees are severed entirely from the stump below the lowest green branch, and are left lying under 1.4 metres to the ground. When regeneration is prevalent, 'Posting' is required which can consume up to 50% of a working day. Posting is required when one tree falls onto another tree and gets hung up. Posting involves cutting the fallen tree down in stages – the standard is in one-metre blocks.

Emergency Procedures

Information collected from focus group members and investigation crews (15 thinners in total) resulted in a potential system brittleness being identified within the emergency procedures. Emergency procedures in thinning to waste are as follows: whistle or radio to notify crew if in an emergency or when communication is not received during the regular radio check when refuelling, which occurs every 15 - 20 minutes. Such procedures are fallible as they do not account for immobilisation or unconsciousness. They also do not facilitate the quick location of a possibly injured crew member with any accuracy. There is lots of trust between workers in a crew. During an emergency nevertheless, technology exists now that can identify when an individual is lying prone for a set time during operations, notifying crew quickly to a possible emergency situation without delay. A 'man down' system is now available in radios, where it sends an alert to others if a worker is lying prone for a specific time. Other technology could utilise a customisation of the PDF block mapping application by overlaying not only your GPS position but also the GPS position of those in your crew. If an emergency alarm is activated, then it would be possible to locate an injured crew member quickly. It was suggested that mobile service could be an issue, and further investigation revealed that there are ways to localise data receiving between devices. Utilising known physical monitors could be an added feature to creating resilience in the emergency procedures.

ACOP

The ACOP (Approved code of Practice) has one line referencing thinning to waste operations, as follows:

10.5.1. A minimum of two people are required on site at all times during a thinning to waste operation.

The ACOP implements an umbrella set of rules for two different operations (thinning and harvesting). This lack of acknowledgement of the difference between harvesting and thinning to waste operations was a common thread across forestry workers interviewed. All suggested there was a need to go beyond tailoring harvesting current standards and develop a best practice guide specific to thinning to waste.

Tree dynamics and environments are very different. There are efficient felling techniques that exist in thinning to waste which if conducted in harvest logging would be implausible and dangerous. An excellent example of a relatively unacknowledged part of thinning is the common practice of Thinners pushing trees to assist in direction of fall. Such a practice used in clear-felling is unacceptable and dangerous, considering the tree size difference. Another example is the requirement of carrying wedges when felling. The ACOP requires harvest loggers and Thinners alike to carry four wedges. However, unlike harvesting where wedges are needed to fell larger trees in a certain direction, thinning operations rarely require the use of a wedge (typically only when working along a roadside or fence line as an added precaution). Many Thinners mentioned they can go months without the use of a wedge.

Two Tree Length Rule

During the review process, the two tree length was highlighted by many workers. The rule states that the danger zone of a felled tree consists of a circle around the stump with a radius equal to twice the height of the felled tree (see Figure 5). This rule takes into account the chance that a falling tree may bring down another standing tree.

Workers currently maintain the two tree-length rule visually by identifying other crew members wearing high visibility clothing and seeing trees falling, as well as through communication via radio transmissions. Workers carry a portable radio with an earpiece and a mouthpiece. Nevertheless, the workers interviewed maintained it can be hard to gauge workers exact locations.

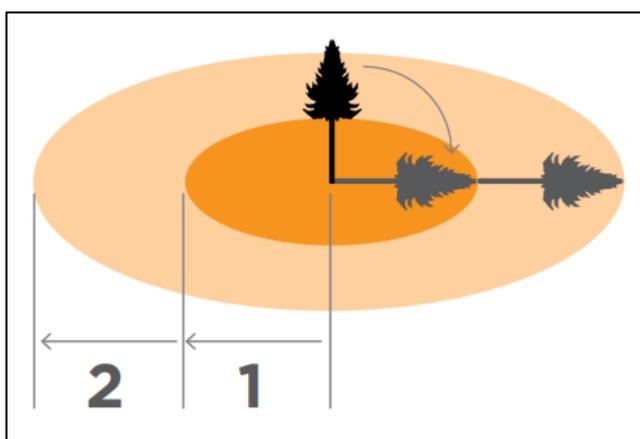


Figure 5. Two tree length rule <file:///C:/Users/hooperb/Downloads/WKS-4-forest-harvesting-manual-tree-felling.pdf> (retrieved 3 December 2017)

Complex tasks can be detrimentally impacted if the worker is tired, ill or a novice. Thinning to waste workers may walk 10 – 25 kilometres in a day carrying 20 - 25 kilograms of gear in a backpack or on a belt, including five litres of gas, 2.5 litres of water, tools

(wedges and a hitting implement), fire extinguisher, first aid kit, and chaps. These factors may influence fatigue levels throughout the day. The ability to judge distances of fellow Thinner can become impaired, especially in a variable environment with visual constraints (slash and standing trees). Moving under trees, a Thinner is dealing with things that can move without notice as well. Usually, the workers are only 50 – 60 metres apart following the thinning edge. Assessing distance is a highly subjective judgement. The two tree length rule may also become a normalised risk. That is, the more a worker operates in close proximity to his crew members without harm occurring, the less aware of the risks associated with that behaviour he becomes.

A technical suggestion gained from the focus groups included a proximity sensor to alert them when fellow workers are within range to prevent accidental 'buddy cutting'. A forest company in the North Island is in the midst of doing just this, with exciting potential for the future that will mitigate a well-known vulnerability across the industry. A beeping in their earmuffs notifies the worker of being too close to another worker. Currently, they are adjusting the distance of the proximity sensor and testing with workers in thinning operations. To reduce the risk of normalisation over time resulting in ignoring the signal, an extra feature was suggested where the beeping activation is logged on a microSD card so activations are accountable. Another suggestion is a remote gradual stall of the revving chainsaws within a 'danger zone' (1 ½ tree lengths) to prevent any chance of accidental buddy cutting. The Thinner will have already been warned by the proximity beeping so if he remains in the 'danger zone', he will be given a five-second warning to retreat and if he does not his chainsaw will stall. This will create a habit by negative reinforcement (and annoyance) where the workers will actively stay out of each other's zones.

Wedges

The ACOP says that trees with diameters over 20cm must be felled with a wedge. It also says that workers must carry a minimum of three wedges (relative to the size of the tree being felled) along with a suitable hammer. Rule 11.3.1 has an exception in thinning to waste for trees of less than 20cm diameters that requires the thinner to carry a minimum of two wedges. However, the use of wedges was rare. Though they are required to carry three wedges for <20cm and two wedges for >20cm trees, they might only use one. Instead of using a wedge, it is common to fell a small tree onto standing up tree. In fact, most experts had no use for wedges in thinning to waste particularly if thinning trees of the ideal age range (8 - 10 years). Several focus group members found carrying the smallest wedge alone was the most practical way to comply with the ACOP requirements and they may use a branch in place of a hammer. Thinning on the roadside or fence line is the only situation where a wedge is realistically required in thinning to waste. The technique of pushing trees over was repeated throughout the review process. Most found helping the tree with some force more efficient than wedging during felling.

PDF Application

Though the PDF app available with the block details on their phones is a decent idea, the feature to identify hazards and mark spots typically are not used. One of the issues raised was the influence it has on the phone battery.

The following recommendations, developed by the project team in conjunction with the expert Thinners and vetted by the New Zealand forest industry representatives, are intended to generate sensemaking, learning and understanding. It is postulated that a natural extension of this process will result in improved system resilience and responsiveness without the over-incorporation of rule-based procedures.

4.1 Operational Recommendations

Recommendation 1	<i>Develop a proximity sensor to assist in the maintaining the two tree length rule.</i>
Expected Responsible Party	FISC/Scion in cooperation with industry stakeholders.

A technical suggestion gained from the focus groups included a proximity sensor to alert them when fellow workers are within the two tree length range to prevent 'buddy cutting'. In addition to this technology, an extra feature is advocated where any activation is logged on a microSD card to assure accountability and prevent normalisation over time. Furthermore, the inclusion of a proximity trigger that automatically stalls revving chainsaws within a 'danger zone' (1 ½ tree lengths) has the potential to prevent any chance of buddy cutting.

Recommendation 2	<i>Explore methods of improving emergency procedures in thinning to waste operations</i>
Expected Responsible Party	FISC in cooperation with industry stakeholders.

A 'man down' system is now available in radios, where it sends an alert to others if a worker is lying prone for a specific time. Such sensors detect tilt, and non-movement in combination. Typically lying prone and motionless for a pre-set period of two minutes, the sensor will enter a pre-alarm phase and start to vibrate in order to make the user aware the device is going to alarm if left unchecked. In the event of no movement for a further two minutes, then it will automatically raise a 'Man Down' alert to other crew members. This can assist the process of getting help to an injured lone worker more quickly – thus allowing for faster emergency response times thereby increasing the chances of a positive outcome to a situation.

4.2 Organisational Recommendations

Recommendation 3	<i>Use a Thinning to Waste Expert Advisory Group to inform the development of a Best Practice Guideline for Silviculture Operations</i>
Expected Responsible Party	FISC in cooperation with industry stakeholders.

One critical recommendation consistent throughout the review was to remedy the lack of tailored Silviculture best practice guidelines. Currently, Thinning is covered under the umbrella of harvest felling in the ACOP. This is creating a lot a confusion and unrest among Thinners in the industry. Experts identified the point of difference between wedges, pushing trees, driving, posting, wind, tree dynamics, and environmental factors in thinning versus clear-fell operations. By treating Thinning as a different challenge with diverse influencers and dynamics, the industry will remove the murkiness and create safer forestry operations.

Kerr, G. & Haufe, J. (2011). *Thinning Practice - A Silviculture Guide*. UK Forestry Commission.

Nielsen (2015). *Health and safety attitudes and behaviours in the New Zealand workforce: A study of workers and employers. 2014 Qualitative Research Cross-sector Report*. WorkSafe New Zealand: Wellington, New Zealand