Eastland Wood Council
Te Kaunihera Pororākau o Te Tairāwhiti

Good Practise Guideline for Catchment Management

for the plantation forestry members of the Eastland Wood Council.

DECEMBER 2022

Executive Summary

Purpose

The purpose of the Good Practice Guidelines for Catchment Management is to improve the environmental outcomes of plantation forestry in the Tairāwhiti/Gisborne and Wairoa districts. Eastland Wood Council (EWC) members commit to a collaborative approach, sharing forest management strategies, and the development and adoption of best practice guidelines to improve environmental performance. The members of EWC strive to be recognised and respected as professional kaitiaki/caretakers of the land within our rohe and for our community.

Reason

The plantation forestry industry in the Tairāwhiti/Gisborne and Wairoa districts is confronted with some relatively unique catchment scale challenges. Large tracts of high-risk erosion prone land were planted in the early 1990s as part of a wider soil conservation programme, mainly in response to the widespread significant damage caused by Cyclone Bola in 1988. These maturing plantation forest areas are being harvested, with significant areas of first rotation forests still to be harvested in the near future. For pine plantation forest on steep and erodible land, also susceptible to slope stability failures, it is recognised that the period after harvest and before canopy closure of next tree crop creates a 'window of vulnerability'.

The need to adopt and adapt practices that recognise catchment level issues has been clearly highlighted by a series of weather events that have caused catchment scale impacts, including the Tolaga Bay storm in 2018. In addition to larger scale soil movement typical of such intense storms, harvest residues migrated downstream, damaging waterways, infrastructure, private properties, and local beaches.

Recognising the unique risks of harvesting on landslide prone slopes, EWC Members see the need to undertake practices that minimise the adverse effects of harvest residue migration, including those associated with landslides. This memorandum sets out a voluntary path for cooperative awareness and advancement in environmental performance.

Commitment

The Eastland Wood Council undertake to give full consideration of the following Good Management Practices while making the best possible decisions for their forests and forestry activities in a wider context. The Good Management Practices are designed to work in conjunction with operational management practices. This guidance is not absolute and may be updated/amended with the agreement of the signatories.

There are six Good Management Practice sections detailing recommendations to mitigate the effect of plantation forestry on steep land predisposed to landslides.

1. **Evaluating Slope Stability when Planning** - Harvest planning should consider aspect, slope gradient, slope length, stability, risk of landslides, potential amount of harvest residues, gradient of gullies and connectivity to water bodies.
2. **Managing the extent of harvesting clearcuts** - Limiting clearcut size, and staging harvests in a larger catchment, to mitigate the risk of a larger storm event causing a significant impact.

3. **Managing harvest residues on landslide prone slopes** - It is important to focus on minimising the volume of large woody debris that creates the greatest hazard when mobilised, especially on areas with slope stability problems identified in 1.
   A good harvest plan should ensure clear parameters to extract the sound windthrow and larger logs, plus ensure slash management requirements that cater for the additional non merchantable wood storage.
4. **Leaving mature trees to help trap slash** - In desirable locations, such as where there is a change of stream gradient at the base of the catchment, leaving large mature trees to act as a live slash-trap can be effective to mitigate migration of the larger harvest residues.
5. **Constructing Slash Traps** - In smaller catchments with risk of harvest residue movement, constructing picket fence' type design slash traps made of rail irons can be effective to mitigate migration of the lighter harvest residues.
6. **Planting new land and/or replant** - The best long-term strategy to mitigate catchment risks of harvest residues migration is through better risk assessment at time of planting and replanting forests. In areas of high risk, identifying future non-production forest/retirement areas, planting live harvest residue traps in non-production species, the use of coppicing species, or increasing setbacks for areas of high landslide risk and instability may be required.

Good Practice Guideline for Catchment Management

Supporting Information

An initiative of the Eastland Wood Council, Environmental Focus Group

The need for Good Practice Guidelines for Catchment Management

The Resource Management Act (RMA), the more recent National Environmental Standards for Plantation Forestry (NES-PF) regulations, and Regional and District Plans as developed by Councils, all aim to protect the environment within the context of sustainable management; defined in the RMA as "managing the use of resources which enable people and communities to provide for their social, economic and cultural well-being, and "sustain resources for the reasonable foreseeable needs of future generations".

Our forests in the Gisborne region provide many benefits to us. They provide stability to our highly erosion prone soils, improve water quality and habitat by reducing sediment inputs and providing shade, absorb carbon to give us clean air and are a large employer of our people. It is however recognised, that forest harvesting can have a negative impact on the environment if not well managed. The primary focus of improved environmental performance has been on reducing the risk of unacceptable levels of erosion that can both degrade the land and impact on water quality. In 1991 the forest industry in New Zealand, adopted a Forest Code of Practice that embedded 'Best Management Practices' (BMPs) aimed to protect the environmental values we hold, including the protection of water quality and soil through reduced erosion (LIRO 1993). It was written with the support of the Regional Councils. The concept of BMP's is well established with expectation that they evolve and improve over time as either practice or research increases knowledge. As such the New Zealand Forest Owners Association updated the guidance with the publication of the Environmental Code of Practice in 2007 and again a series of Forest Practice Guides (NZFOA 2019) that support both the development of plans as well as the implementation of the rules established in the NES-PF.

Even within this context of extensive information and guidance, the forestry industry in the Tairāwhiti/Gisborne and Wairoa districts are confronted with some relatively unique catchment scale challenges. Large areas of high-risk erosion prone land were planted in the early 1990s as part of a wider soil conservation programme, mainly in response to the widespread significant damage caused by Cyclone Bola in 1988. These maturing plantation forest areas are being harvested, with significant areas of first rotation forests still to be harvested in the near future. For pine plantation forest on steep and erodible land, also susceptible to slope stability failures, it is recognised that the period after harvest and before canopy closure of the next tree crop creates a 'window of vulnerability'. The East Coast has always experienced high intensity rainfall events, and such events are expected to increase in both frequency and magnitude as part of the climate change phenomena.

The need to adopt practices that recognise catchment scale issues has been highlighted by a series of weather events that have caused considerable impacts, including the Tolaga Bay storm in 2018. In addition to larger scale soil movement typical of such intense storms, forest infrastructure was compromised, and harvest residues migrated downstream, damaging waterways, infrastructure, private properties, and local beaches.

While most legal and or guidance documents reference the need to manage the catchment, there is little guidance for plantation forestry activities at the catchment scale level. In recognition of the catchment scale risks associated with planation forestry, changes to management practices have occurred on the East Coast, predominantly at an individual company level. It is also recognised that strict compliance of harvesting operations to NES-PF rules, or Regional Plan / Resource Consent conditions, will only go part way to reducing the overall risk of harvest residue mobilisation events.

A combined effort of improved harvest planning and forest establishment strategies are required to not only mitigate effects from harvesting activities but importantly to ensure the next crop of trees planted elevates forestry to superior levels of land protection, sustainability, and improved public image. Recognising the unique risks of clearfell harvesting on landslide prone slopes, EWC Members see the need to undertake practices that minimise the adverse effects of harvest residue migration. This memorandum sets out a voluntary path for cooperative awareness and advancement in environmental performance.

The image on the left shows an aerial photo of Cyclone Bola effects on the predominantly farmed landscape with extensive soil loss. The image on the right shows the effect of the Tolaga Bay storm on a harvested forest. While the planting of forests reduced the widespread risk of Cyclone Bola type effects on the East Cape landscape, the more localised damage was compounded due to the amalgamation of woody debris. The goal of this memorandum is to develop practices that will avoid these catchment scale impacts from plantation forest operations.

Management strategies to reduce impacts of clearfell harvest in catchments with landslide prone slopes

In forestry, the concept of Best Management Practices has always relied on implementing multiple elements to minimise the overall impact of harvesting activities. There has never been a single solution to mitigate the risk of harvest residue leaving a catchment during larger storms, especially on highly erodible soils/geologies. For example, erosion from infrastructure and harvesting is difficult to eliminate and hence is minimised through the correct use of BMPs. The most common concept for managing the adverse effects of infrastructure construction and harvesting is the application of BMP's that reflect our current state of knowledge.

This document provides guidance that specifically recognises the unique risks of clearfell harvesting on landslide prone slopes in the Tairawhiti / Wairoa Region. It is a commitment to undertaking practices to minimise catchment scale impacts such as harvest residue migration associated with managing forests on this challenging terrain. This document should be read in conjunction with existing documented Best Management Practice for forest operations such as the NZFOA Forest Practice Guides.

Five catchment level BMPs have been developed:

1. Considering slope stability when planning
2. Managing the extent of clearcuts within a catchment
3. Managing harvest residues on landslide prone slopes
4. Using live vegetation to trap residues that might become mobilised in the event of a storm during and post-harvest
5. Construction of slash traps, and
6. Evaluating the suitability of planting and replanting

BMPs will evolve over time as our understanding of the interaction between our management activities and risk to the environment continues to develop. They are designed to work in conjunction with operational management practices. This guidance is not absolute. That is, the members of EWC undertake to give full consideration of this guidance while making the best possible decision for their forests and forestry activities in a wider context.

01

Evaluating Slope Stability when Planning

Harvest planning is to consider slope stability, likelihood of landslides following harvesting and road construction that can lead to harvest residue mobilisation.

While erosion is a natural process of soil and rock wearing away, land uses that reduce vegetation cover or disturb soil can lead to an accelerated rate of erosion. This is especially heightened in naturally unstable areas where even relatively minor land use activities can have major impacts. Erosion that has been significantly increased by human activity is called induced or accelerated erosion. Our existing forestry BMPs very much focus on reducing erosion when planning and undertaking operations. Despite effort by landowners who see themselves as kaitiaki, slope failures ('small landslides') during the window of vulnerability post-harvest is a significant challenge in the district, with adverse impacts on waterbodies and coastal environment because of high rainfall events.

The angle of the slope and the strength of the materials on it are two main factors that determine slope stability. Generally, the risk of landslides increases significantly on steep terrain, where soils are shallow and overlaying a harder rock layer of material, where trees stabilising the site have been removed, the soil has become saturated with moisture and shear strength greatly reduced. Identification of these conditions prior to harvest is commonly identifiable with steep slopes, presence of failed trees, shallow root plates, bent trees showing land creep and underlying exposed papa-rock (soft, blue-grey mudstone or muddy sandstone).

Failed production forest on skeletal soil overlaying Papa rock planned for retirement. Broads Forest Waimata Valley Gisborne.

Slope itself is a simple factor, but highly important with understanding risk of landslides. Larger scale forest owners are well equipped with digital elevation models and more recently highly accurate LiDAR data. Smaller woodlot managers who may not have access to this data can measure dominant slopes with abney or clinometer. Slope categories should be be generated during the harvest planning process to identify the steepest slopes and highest risk of landslides posed by slope. Long steep slopes have greater risk of carrying larger volumes of harvest residues than short slopes.

The following terrain stability classes can be used as a good guide to interpret risk.

TERRAIN STABILITY CLASS	CRITERIA	INTERPRETATION
1	**Majority of slopes are <20°** Slopes occur on or near ridges and spurs that are usually >50m from waterbodies, or are not contiguous with waterbodies (e.g. drain onto fans). No evidence of landslides.	**Low likelihood of landslides** following harvesting and road construction. Minor collapse of road batters.
2	**Majority of slopes are 20-45°.** Slopes are usually >30m from waterbodies, in basins with contributing area <50m².	**Moderate likelihood of landslides** following harvesting and road construction. A proportion of landslide sediment will be retained on slope.
3	**Majority of slopes are 30-45°.** Slopes are usually <30m from, and contiguous with waterbodies network, in basins with contributing area >50m². Evidence of landslide activity.	**High likelihood of landslides** following harvesting and road construction. Sediment and debris will enter directly into a stream.
4	**Majority of slopes are >45°** Slopes are usually <30m from, and lead directly into waterbodies, in basins with contributing area >50m² Evidence of landslides entering the waterbody network.	**Very high likelihood of landslides** following harvesting and road construction. Landslides are often large and may contribute to debris flows/floods.

Modified - Landslide susceptibility classification using four terrain stability class categories (Source: after Page and Jones 2013).

On gentle slopes and low risk of landslides leaving woody harvest residues on the soil surface can reduce the raindrop impact, runoff, improve water infiltration and recycle nutrients. Conversely steep, long slopes with high risk of landslides require additional vigilance which may include, removing more harvest residues, limit the clearfell cut area, develop holds, and/or slash traps as defence mechanism. Forest Managers can only control within their own company scale and ownership. On this basis, the planner would evaluate each catchment within their forest boundaries.

A significant part of the risk assessment when planning harvest and/or harvest scheduling is identifying the risk of landslides and potential for associated harvest residues migration. Slope maps can also be created to show the gradient of gullies, side streams and main waterways. This can be helpful to locate potential suitable locations for harvest residues traps and holds.

Appendix 1 provides an example of how Slope, Connectivity to Waterbodies and Aspect can be used as a risk assessment approach.

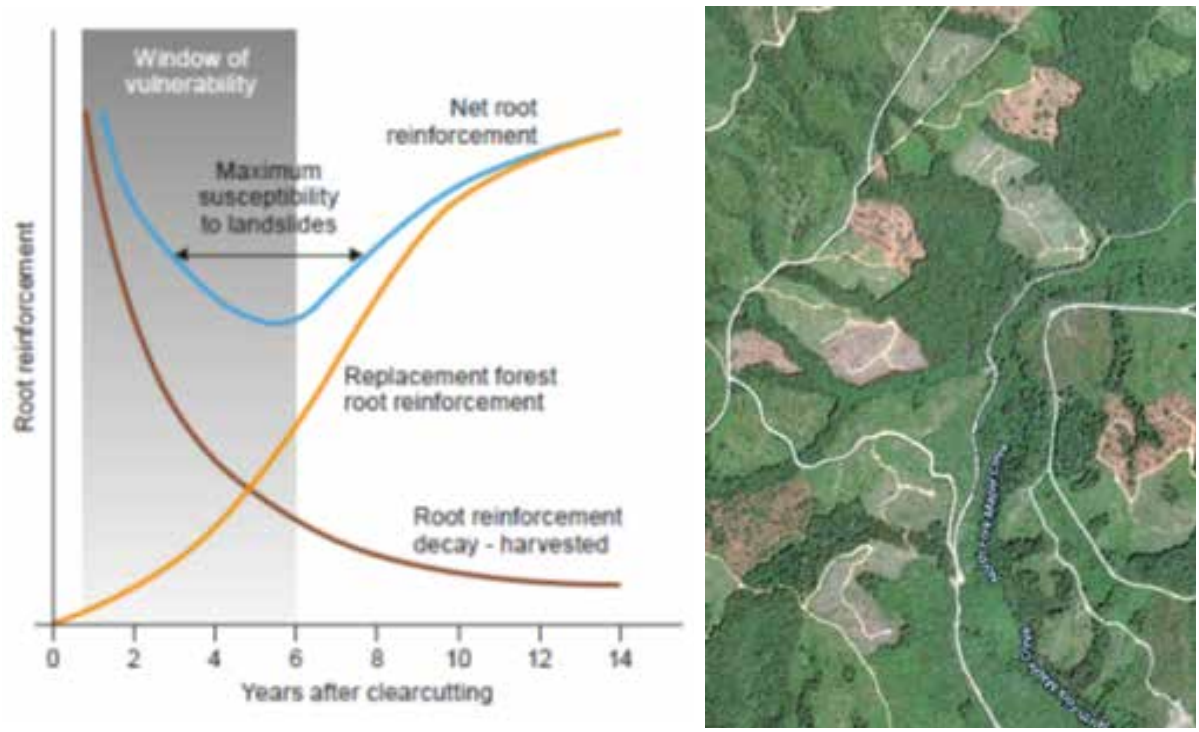
02

Managing the extent of clearcuts

Consider limiting clearcut size, and also staging harvests in a larger catchment, to mitigate the risk of a larger storm event causing a significant impact.

Limiting the area of clearfell harvest and/or partial harvesting of forests at one time can be effective at reducing erosion susceptibility of forest lands. The ECoP guides forestry companies to consider accumulative effects, especially as it is known to alter the hydrological response. Under the Soil and Water Conservation Values section it notes that if more than half of the forest in a large catchment is removed at any one-time during land preparation and harvesting, there can be significant changes in runoff characteristics because of reduced rainfall interception and tree transpiration. It also notes that paired catchment studies have repeatedly shown that removal of less than 20% of the forest cover is generally not detectable in a stream flow hydrograph.

This is consistent with international catchment scale research studies that show that harvesting more than 25% of a catchment increases peak flood flow from a storm, and that in turn can increase the risk of impacts. Minimising large contiguous clearfell areas reduces the risk associated with the window of vulnerability as shown in the image below. Staggering the harvest in a catchment means that only a smaller area is exposed to heightened landslide risk at any one time.



The image on the left shows the typical changes in forest vegetation root strength after timber harvesting (from Phillips et al 2012), and the image on the right shows the approach in the Pacific Northwest to mitigating landslide risk by staging harvest within a catchment.

For high-risk catchments a move towards clear cut limits, using for example 25% of larger catchments could be introduced with an adjacency constraint of 3-4 years. While the window of vulnerability is often referenced

as being 5 to 6 years, post-harvest vegetation in the East Cape re-establishes very quickly. With a typical rotation period of 25-28 years, the transition towards only harvesting 25% of the catchment within a 3-4 year timeframe should still allow for reasonable flexibility in forest management planning While there is no clear agreed definition of what constitutes a 'high-risk' catchment, a reasonable starting point is the NES-PF Erosion Susceptibility Classification Orange > 25° slope and Red zones. Each individual forestry company may choose their own limits around cutting within a catchment using the above provided from international research as a guide.

While moving towards a more mosaic harvesting strategy in the long-term, it is recognised that currently very large single age class forested catchments commonly exist on the East Coast. Achieving clear-cut limits with the first harvest rotation, and whilst matching harvesting and processing logistics may often be unachievable and greater emphasis must then be applied to the other mitigation options. Forest Managers can only directly control what occurs in their own company.

Mosaic harvesting may introduce new risks such as windthrow (more residues), increased earthworks and road maintenance and wider spread of vulnerability and increased harvesting machinery transport costs. However, there are also considerable benefits in spreading operations both geographically and in time including less concentrated pressure on road infrastructure and harvesting. These risks and benefits need to be given serious consideration in the harvest planning process.

The general term given to the area designated to remain standing and not harvested for 3-4 years is a 'hold'.

Figure 1. provides a nice example of a stage clearfell-harvest in a catchment. It shows vegetation that has been protected to help protect the ephemeral waterways, it has been harvested after the adjacent catchment has greened up, and has left the lower part of this smaller catchment for deferred harvest as a live slash trap – that is any migration of harvest residues is very likely to be trapped in that section.

Figure 1: Mosaic of 3 age classes in foreground, with protected poplar along waterways plus holds in located in lower part of catchment.

Figure 2: Example of staged clearfell harvest within a catchment to reduce downstream impacts. (A) streamside vegetation, (B) adjacent catchment green-up, and (C) a 'hold' of the mature stand to mitigate the risk of harvest residue mobilisation. The remaining standing trees (C) will harvested after green-up.

03

Managing harvest residues on landslide prone slopes

Management of post-harvest woody residue is complex, with a balance needed between retaining woody debris for its beneficial effects and avoiding the adverse effects in large storm events (Amishev et al, 2014).

The NES-PF Forest Practice Guides emphasizes that a key way to reduce risk, is to reduce the amount of cut-over slash left on the slope, particularly at places where it is evident that the slope is susceptible to slope failure.

The ECoP provides best practices to mitigate the adverse effects of harvest residues. However, guidance is limited to surrounding landings e.g. 'birds nests' and the material deposited directly in waterways during harvest. There is no specific ECoP guidance in relation to managing harvest residues on landslide prone slopes.

It will never be possible to completely avoid slope failures and debris flows following harvest (Bloomberg & Davies 2012, Philips et al. 2012).

The East Coast Forest sites with unstable soils commonly have high amounts of topple (pre-harvest). Uneconomic returns for the lower value log grades can also contribute to greater volumes left on site at harvest time. High occurrence of slope failures and high volumes of harvest residues are conflicting and good strategies to mitigate the risk of woody debris migration after harvest is important.

Learnings from debris flood events in other regions of NZ have resulted in greater focus on minimising volume of large woody debris on landslide prone sites.

Whilst there is little relevant literature on this matter, it is important to focus on minimising the volume of large woody debris that creates the greatest hazard when mobilised.

A good harvest plan should ensure clear parameters to extract the sound windthrow and larger logs, plus ensure slash management requirements that cater for the additional non merchantable wood storage.

There are currently several initiatives developing more exacting guidance on managing harvest residues (FGR, NZFOA, CU). This document is live and should be updated as and when this information becomes better defined.

Steep slope harvesting Emerald Hills Gisborne. Great effort has been applied to remove large woody residues from slopes and piled centre of landing where safe from collapse.

04

Leaving areas of mature trees to help trap slash

In desirable locations, such as where there is a change of stream gradient at the base of the catchment, consider leaving vegetation to act as a live slash-trap.

Most established plantation forests maximised the use of productive land by planting to the stream edge with little or no setback. Environmental guidance for harvesting around a waterway focuses on felling and extraction practices to minimise the level of streambank disturbance and discharge of sediment. Under the NES-PF there is a legislative requirement for increased setbacks at time of replanting. It should result in fewer streamside management issues during harvest for this next rotation.

The concept of using Streamside Management Zones (SMZs) is a very well-established BMP. In addition, improving the ecology of the waterway, the basic concept is to ensure that operations remain some distance from the waterbody, and that any sediment mobilised in the harvesting area might be trapped in the SMZ. Since 2017 the NES-PF requires planation forestry to be setback either 5m or 10m (depending on stream width) of a waterbody to create an SMZ.

Indigenous understory species such as coprosma, kanuka, mahoe etc provide excellent stream shading and habitat, however they do very little to mitigate woody debris migration. Smaller trees along the stream are at risk of becoming part of any debris flow that moves down the waterbody.

Toppled crop trees along incised gully are creating a hazard well before harvest. Greater setbacks are stipulated under the NES-PF when replanting.

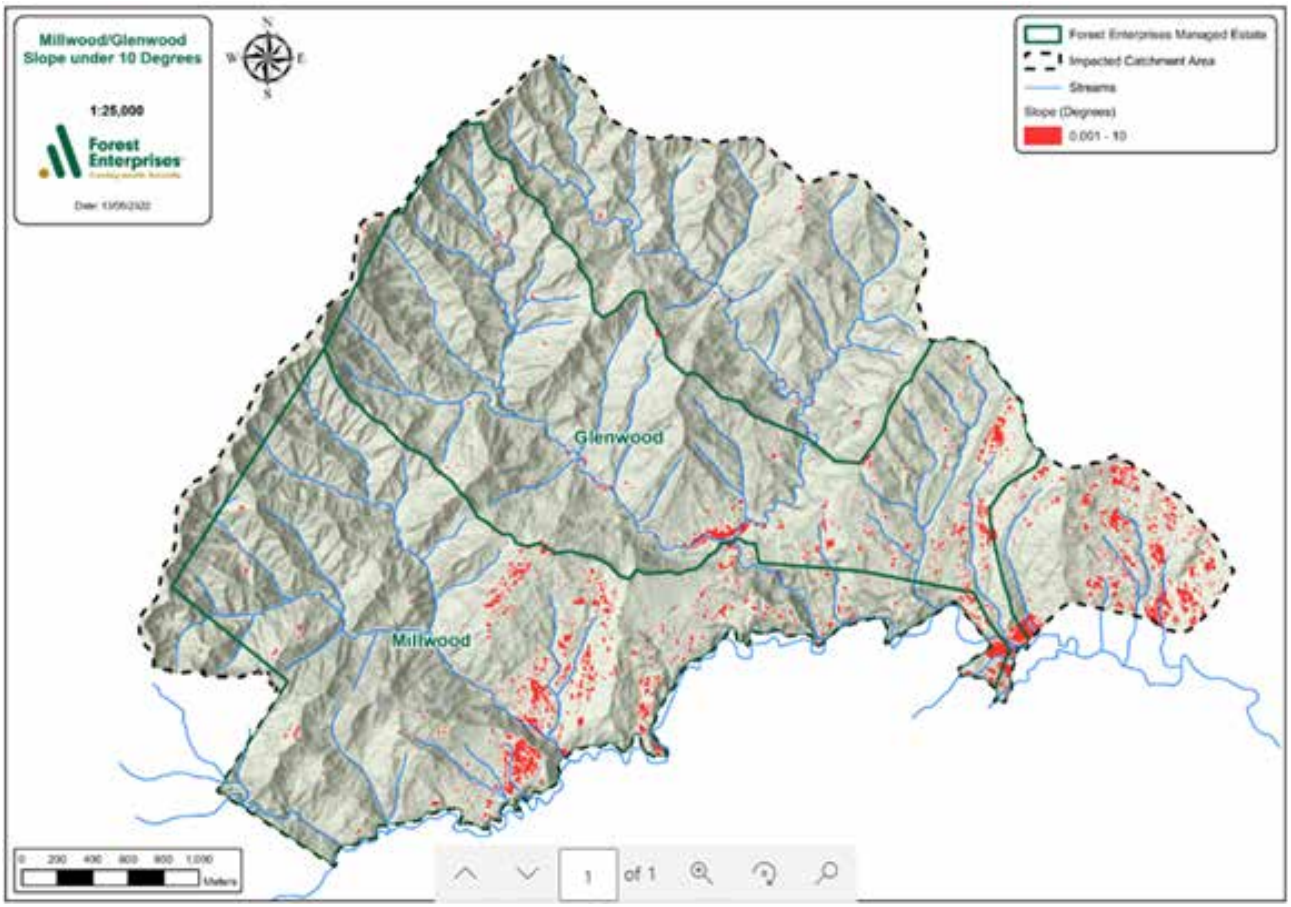
P. radiata live slash trap/hold in the Uawa catchment Gisborne, showing how effective it can be in mitigating the movement of harvest residues out of the forested catchment.

When suitable live harvest residues catcher conditions exist along the valley floor, the harvest planner may consider delaying harvest of the entire setting and/or group of settings in the catchment thus creating a larger hold, creating a cut boundary that may reduce risk of windthrow, delay road construction and maintenance and create a more economic size harvest area. It is an important consideration to ensure that the "hold" does not become inaccessible to future harvesting due to a replanted crop being established in areas that would be impacted by its future harvest.

The principles of good live slash trap require the following:

- Identify where mature trees are located parallel and immediately adjacent the stream bed with careful field validation.
- It is important live slash traps are located where the stream velocity has slowed due to stream gradient flattening and/or widening of the valley floor (floodplain widening). Plus, a meander (oxbow) in the stream is often also useful when coupled with the above conditions.
- Although usually located in the lower part of catchment, multiple live slash traps in the upper parts of catchment may also be highly effective at minimising the potential for landslides closer to the source.

Steep slope catchment management Emerald Hills Gisborne. Live harvest residue trap and hold in lower part of catchment, adjacency constraints and full protection of mature mixed poplar and willow species along waterways using tethered skidder extraction.



An example GIS slope map where a lower slope limit of 10 degrees is used to identify potential harvest residue trap sites along streams.

When the planned live slash catcher crop trees along the valley floor are eventually harvested, replacing with alternative species such as Poplar, Redwood, Eucalyptus or Willow which grow relatively quickly, become large and with excellent rooting capacity should be considered.

Large cluster of poplars on an old gully landslide is mitigating potential harvest residue migration.

Steep slope catchment management Te Karaka Forest Gisborne. The mature indigenous remnant (foreground), cluster of mature mixed poplar and pine located at confluence of two streams (centre), is providing defence from harvest residues migrating downstream to where larger streams converge and have even greater environmental value.

Ideally live harvest residue traps should be located where there is access for machinery to clear harvest residues after being trapped. However, this is not always achievable, and consideration could be given to leaving woody debris in the stream bed when its providing a barrier to sediment being released, stabilisation of banks, enables fish passage and is not at risk of dislodging later. The Council should be notified of any areas where slash has been trapped and remains in the waterbody/is unable to be removed, with ongoing monitoring required.

05

Constructing Slash Traps

In smaller catchments with risk of harvest residue movement, consider constructing a slash trap.

Slash traps can be an effective tool to prevent slash migration. While such 'traps' can range in size from larger scale debris dams, in most New Zealand plantation forestry applications the structures are smaller and hence only suited to smaller catchments. The Gisborne experience is that live slash traps have been more effective at catching the large and most damaging harvest residues. Rudimentary rail iron picket fence style slash traps across waterbodies can become overwhelmed and fail more easily. However, any type of slash trap may be overwhelmed, and the mitigation tools should be well paired with the scale of risk.

The NES–PF requires the following of slash traps:

- **Design:**
  - Allow water to flow freely through structure;
  - Height of structure no more than 2m above stream bed.
- **Placement:** For catchments > 20 ha
  - Structure must be outside the bank full channel width;
  - Machine must be able to access for clearing/maintenance.
- **Inspection and maintenance:**
  - Traps must be inspected within 5 days of a significant rainfall event that is likely to mobilise debris.
  - Must be cleared of debris within 20 working days of a 1-in-20 year flood event.
  - Must be maintained to avoid river bed erosion and to ensure soundness of the structure.

Most designs that have been implemented in the East Coast to date are a simple 'picket fence' type design made of rail irons driven firmly into the ground and linked with wire rope to adjacent anchors. Locating slash traps should use the same principles as discussed above for live harvest residues trap (stream velocity slowed, oxbow, lower part of catchment).

Rail iron and wire rope slash trap.

For more detailed information on designing a slash trap, consider referring to “Design of Debris Slash Traps: Considerations for NZ Plantation Forestry Operating on Steep Terrain”, published as EnviroLink Contract 1968-GSDC158 and the Forest Owners Association Forest Practice Guide 6.4 slash Traps.

Successful retention of woody debris following a storm event.

06

Planting new land and/or replanting

Careful consideration will be given to establishing a plantation forest on new land, or a decision to replant, with regard to catchment scale risk

The greatest long-term strategy to mitigate the risks of harvest residues migration is through thorough risk assessment at time of planting forests. Einstein is credited with saying “the definition of insanity is doing the same thing over and over again and expecting different results”. Strategic planting of non-production species specifically for mitigating harvest residue migration should be a key principle considered in a planting programme along with a strategic consideration of the retirement of previous planted areas.

Planning of planting should include risk assessments, such as harvest risk assessment. Assess the area of single age class planting in one catchment, presence of large mature trees along the stream banks and relieving floodplain, aspect, past landslide events, geology, slope, and connectivity to waterbodies. Downstream values such as infrastructure, wetlands or coastline all increase potential risk at time of future harvest. Overlapping high risks on the same site will help determine the degree of mitigation factors required such as, planting live harvest residue traps in non-production species, or in some circumstances retirement or planting non-production native species on parcels of land where risk is unacceptably high.

Reactivated landslides in the upper catchment may also indicate necessity to replant species that provide better soil stabilisation and/or create live harvest residue traps and contain landslides closer to source, or retire the area from productive land use. Areas such as incised gullies or actives earthflows where crop trees did not establish successfully in first rotation (toppled) should also be considered for retirement and/or replant of non-production species. If a hold was established in the lower valley floor part of the catchment, and it has successfully mitigated the movement of harvest residues, then this would also indicate an ideal location to replant the area with the concept of a live residue trap in mind.

Thorough risk assessment may result in a relatively small area retired (planted in alternative protection species) but provide significant environmental gain.

Pole planting gullies along forest boundary to protect downstream public road infrastructure from landslides. Emerald Hills Gisborne.

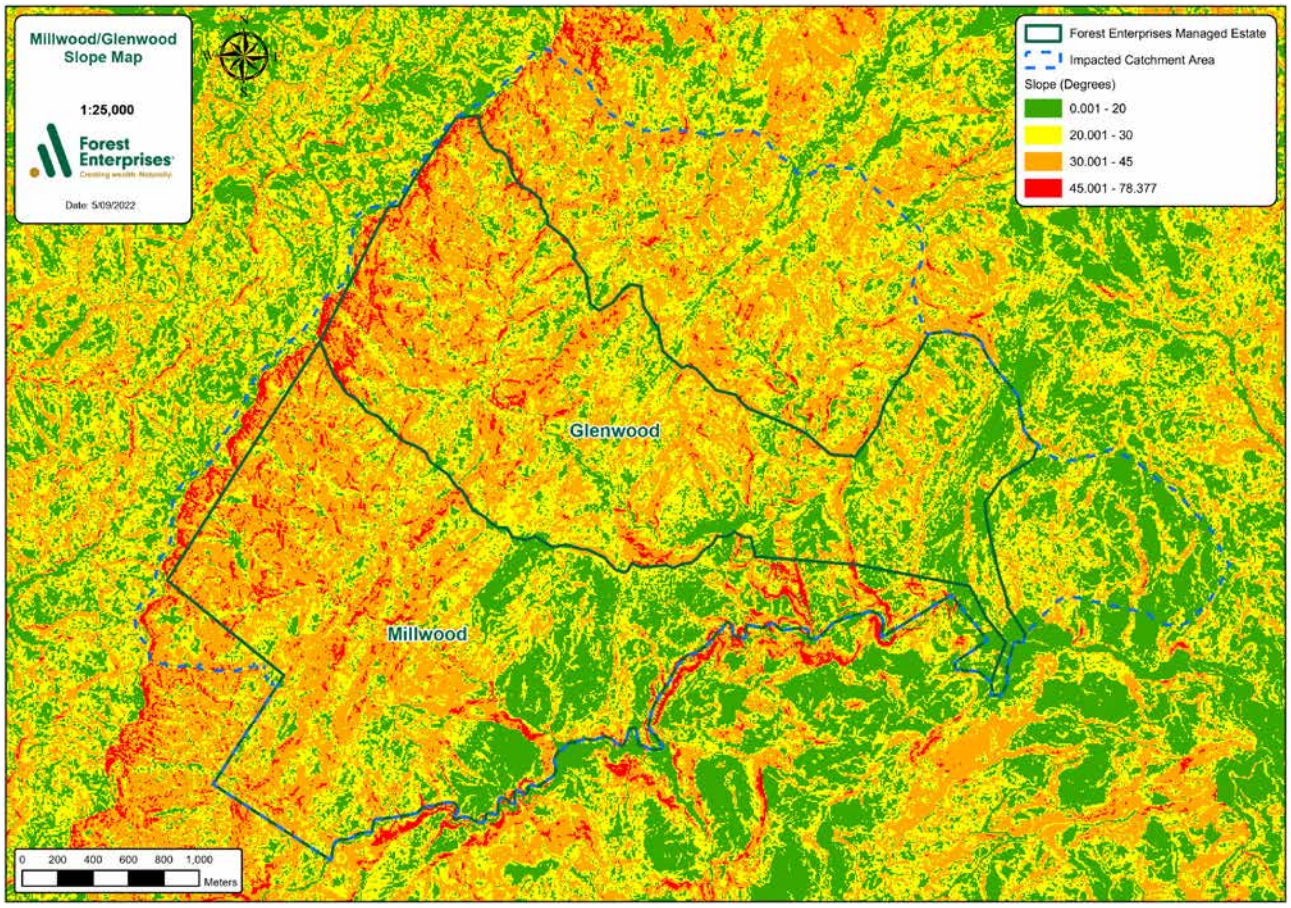
Use of these coppicing species mitigates the window of vulnerability (roots remain alive and canopy closes very quickly), provides an alternative to complete land retirement, provides income from harvest, their rotation lengths are different to radiata and therefore provide a natural method for staggering harvests in catchments.

Appendix 1

Example of Assessing Landslide susceptibility Risk

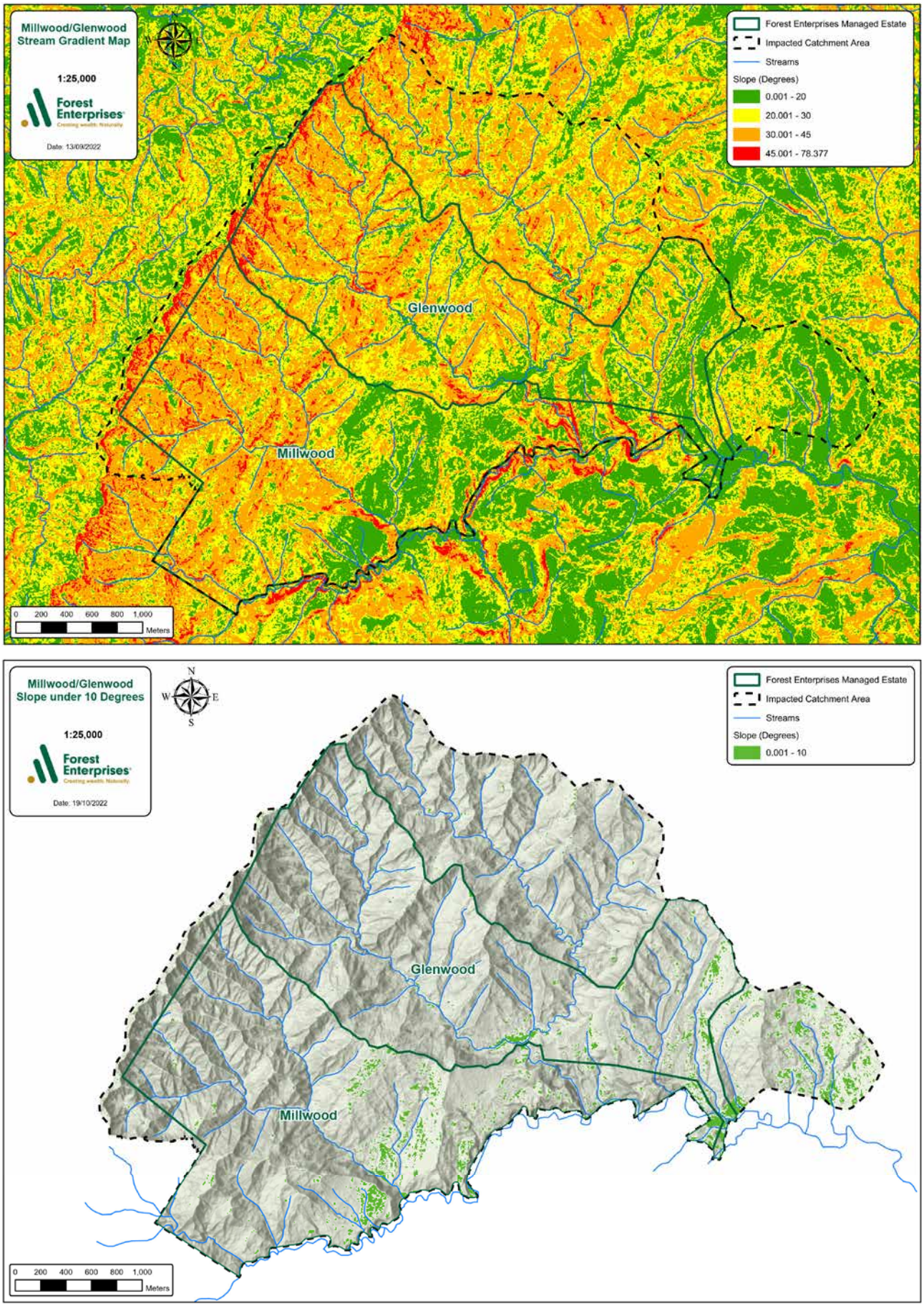
In addition to using the Table in '1 – Evaluating Slope Stability when Planning' to determine landslide susceptibility, GIS tools and concepts can help a harvest planner determine risk for a specific site.

A useful first step is to create a slope map. In the example map below, the orange colouring designates slopes greater than 30 degrees, red colouring designates slopes greater than 45 degrees and hence aligns with landslide risk categories of 3 or 4.



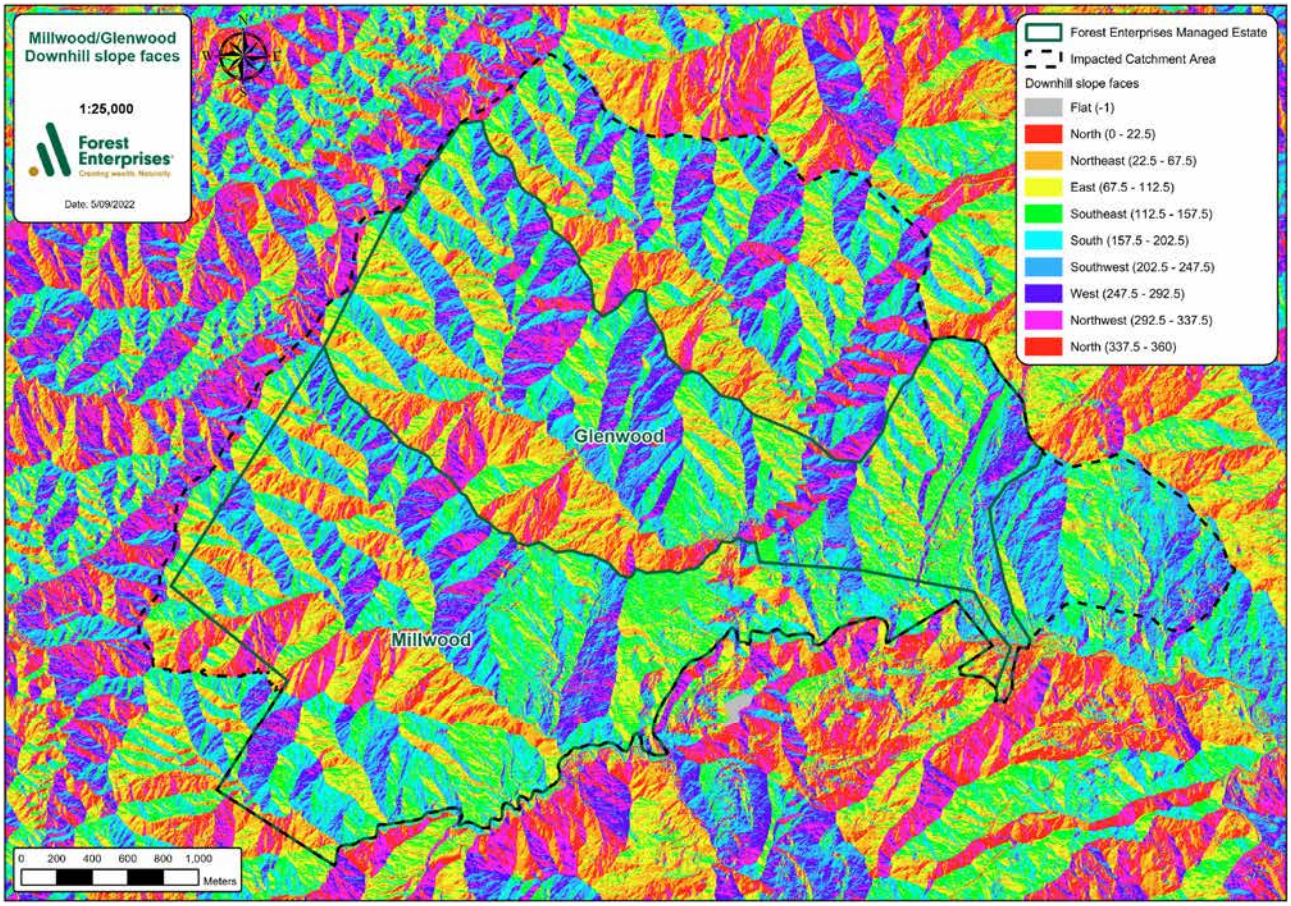
An example GIS slope map using slope categories of 0-20, 2-30, 30-45 and >45 degrees.

Another slope map that can then be generated might include connectivity of steep slopes and waterways.

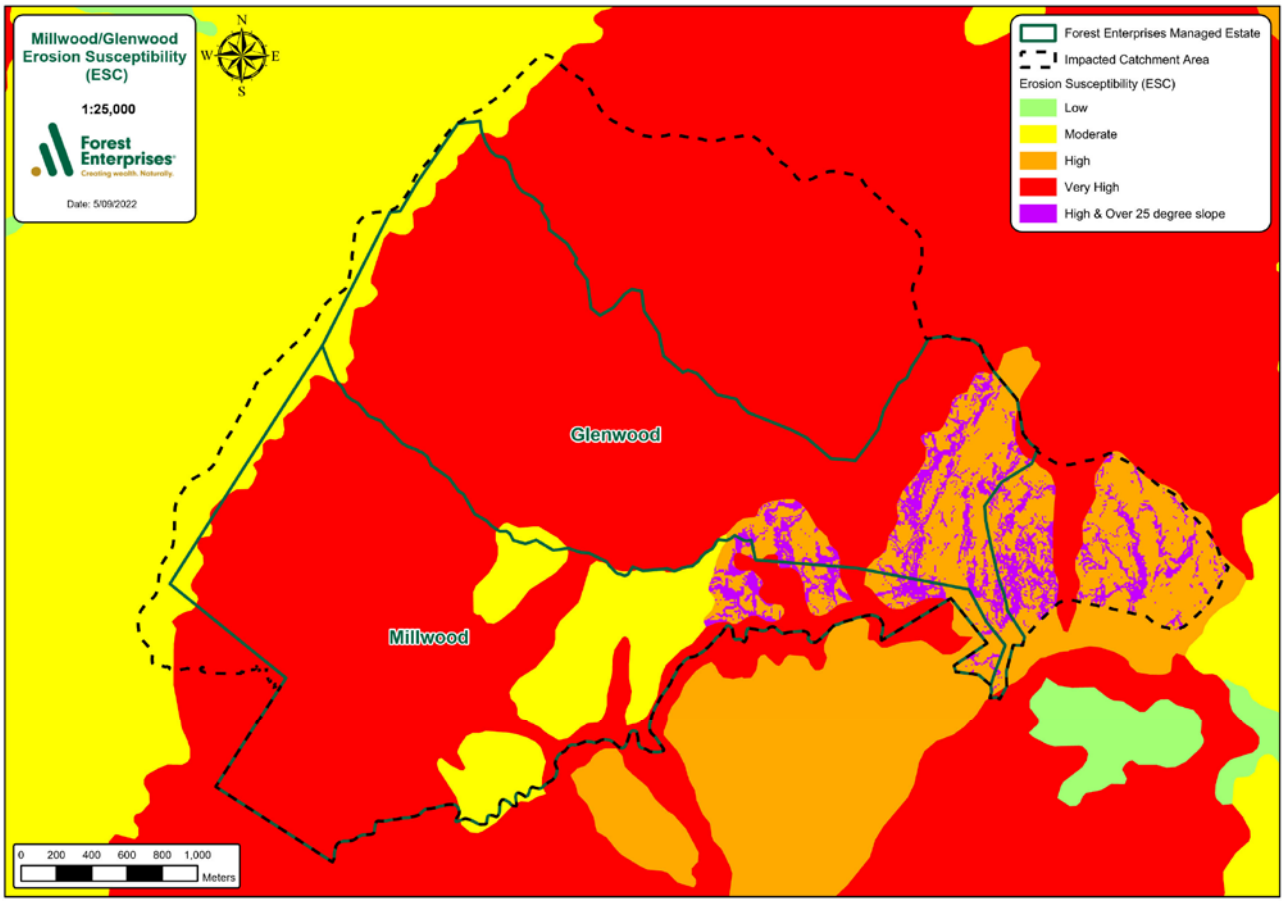


This map was particularly useful to quickly locate where stream gradient had flattened to less than 10 degrees, valleys widened and potential hold sites.

In the Gisborne/East Coast region the most intense storms have been reported to approach from the northwest to southeast aspects. The dominant direction of tropical cyclones has been reported to commonly arrive from the northeast. As a fourth step, a GIS layer can be created to highlight the Aspect of the slope for consideration in the risk assessment.



Example of aspect mapped on GIS. Bands of red, orange, and yellow highlight the aspects with potential higher risk to high intensity storms in Gisborne region.



Susceptibility classification

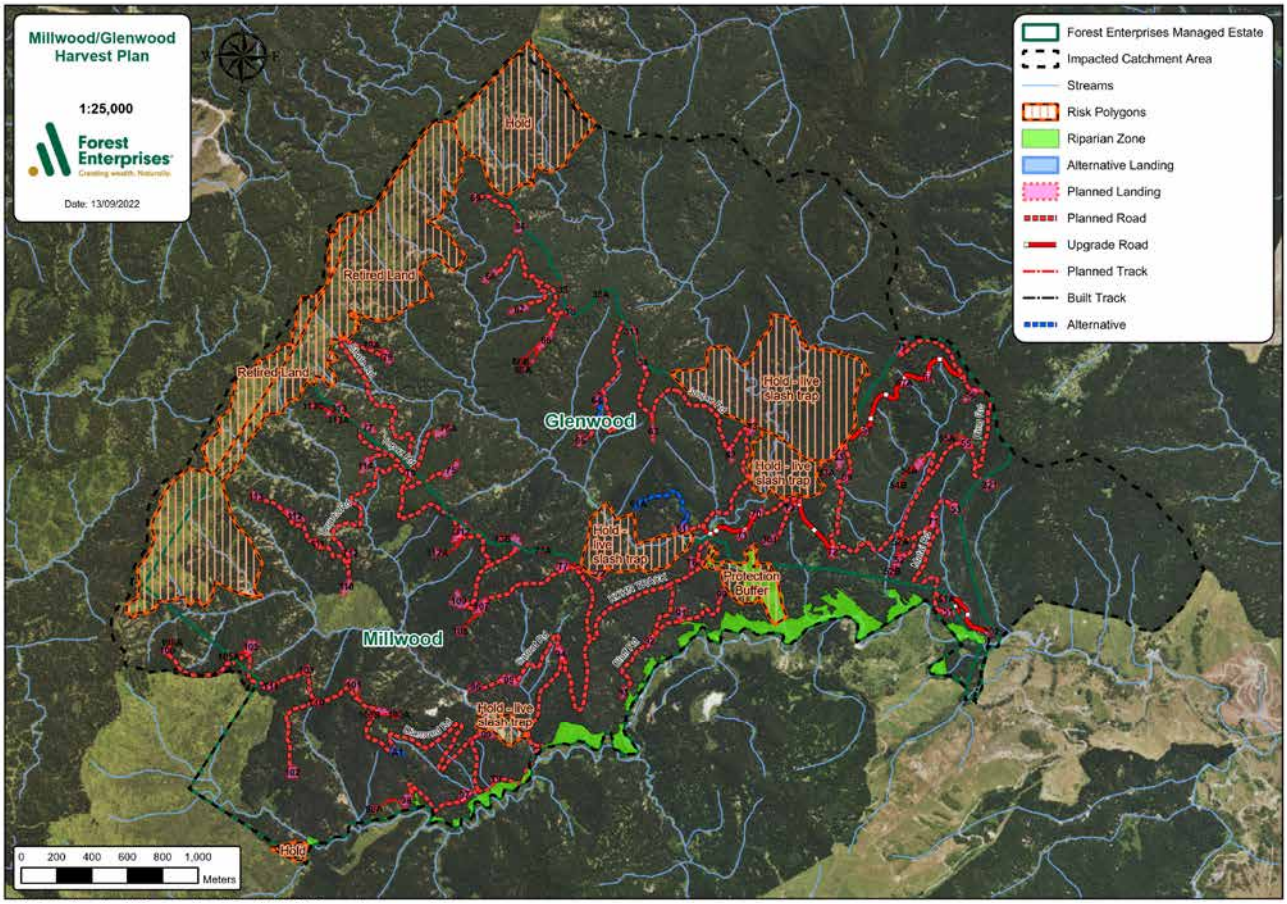
A final step would be to cross reference the GIS map layers with historic landslide activity. Most larger-scale landslide activity will be visible on a shaded LIDAR layer, but access to pre-forested catchment aerial images will also be a very useful reference point to identify the presence of historic landslides. If they connect directly with a waterbody they pose a high risk of harvest residues migration.

Landslide showing connectivity to waterway and coupled with heavy woody material (windthrow) left on the slope after harvest.

The size of clear-cut area, past landslide events, geology, slope, connectivity to waterbodies and aspect are all key points to identify and determine level of risk of landslides and debris flows. Overlapping high risks on the same site will help determine the degree of mitigation factors required such as, reducing the clear-cut area, adjacency constraint's, removal of the larger harvest residues such as windthrow, live harvest residue traps, engineered harvest residue traps, considering alternative harvest or planning options, or in some circumstances retirement where risk is unacceptably high.

In this example, given the above layers of information, the harvest planner recommended:

1. Start harvest early at age 25, stagger the harvest and finish harvest when the trees are 32, spreading the harvest over 8 years (not 1 or 2) and create the largest mosaic of age classes possible.
2. Identification of the medium to high-risk zones to be harvested and minimising consecutive harvesting of these sites through harvest scheduling. Salvage of the sound windthrow trees from highest risk sites during harvest.
3. Holds (mature Poplar and P. radiata) were identified in the mid and lower part of catchment which are well positioned to prevent slash migration. After harvesting these sites are well positioned for planting permanent non-production species in the valley floor as permanent slash catchers for future harvest cycles.
4. Retirement of some unproductive land where soils were too skeletal, and first crop toppled/failed.
5. Retirement of uneconomic land (no harvest) in the upper steepest portion of the catchment where risk of landslides was deemed too high to manage. Long term cover to transition to indigenous forest.



Final harvest plan with risks assessed, controls in place and correlated with neighbouring part of same forest. Emerald Hills Gisborne.

Acknowledgements

Project Leader - Dan Fraser Gisborne & Hawkes Bay Regional Manager, Forest Enterprises.
Review Team - Eastland Wood Council Environmental Focus Group.

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