Manaaki Whenua
Landcare Research

Steepland plantation forestry: what can we manage, and will it make a difference?

Chris Phillips

NZIF Conference "Emerging Stronger", June 2025

Napier


Photo: Kit Richards

Photo: Jo Field

Photo: Kit Richards

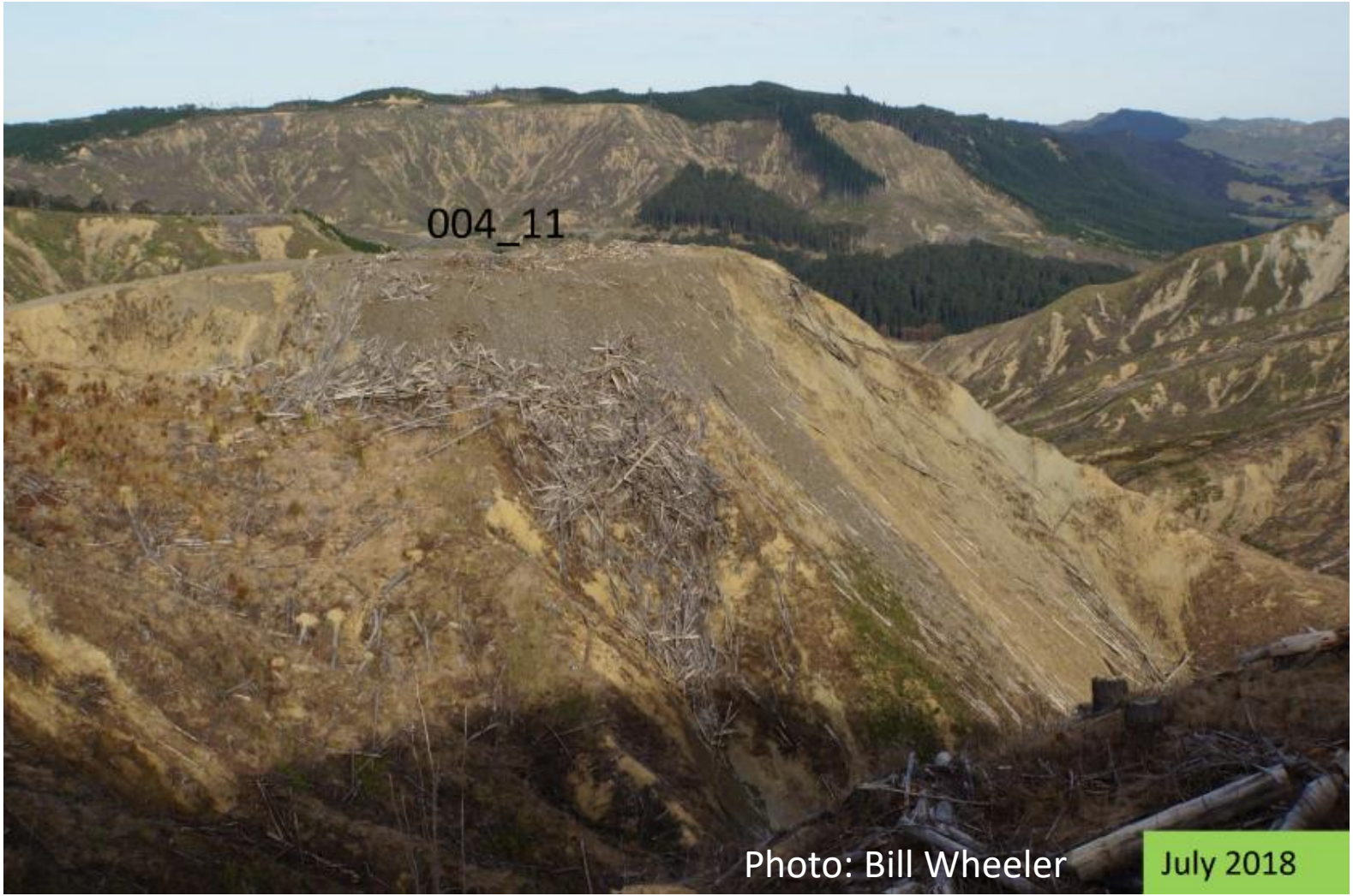

004_11
Photo: Bill Wheeler
July 2018

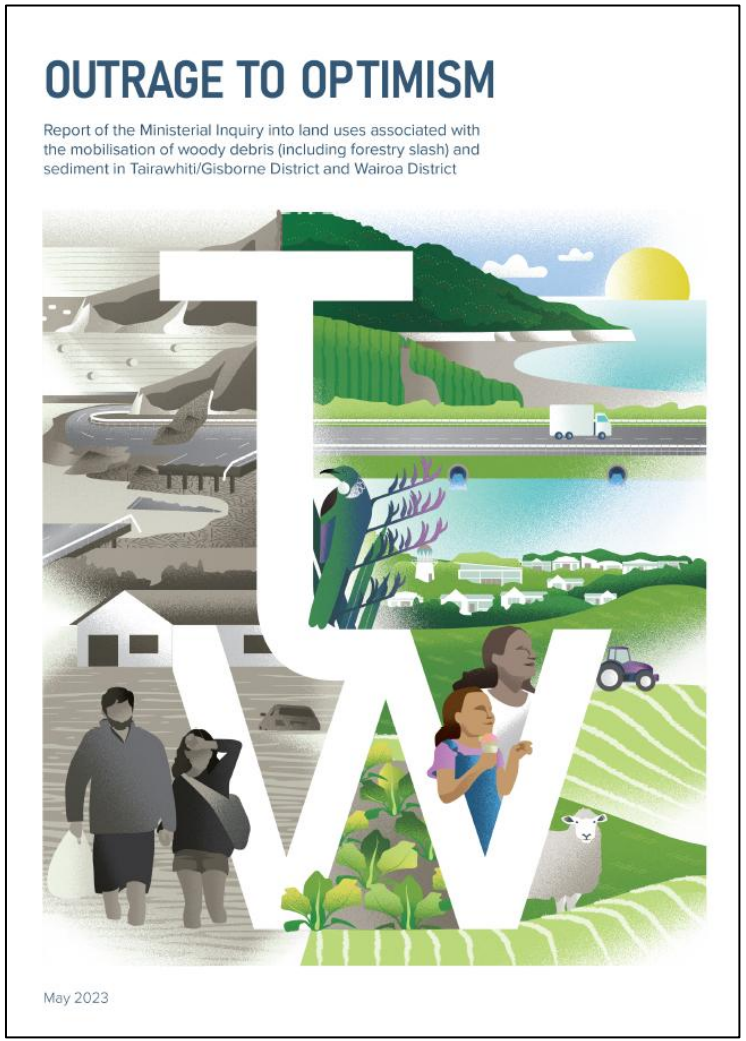

Photo: Barry Foster

Photo: East Coast MP Kiritapu Allan

Photo: Peter Scott


Photo: Peter Scott
www.abovehawkesbay.co.nz

Steepland plantation forestry: what can we manage, and will it make a difference?

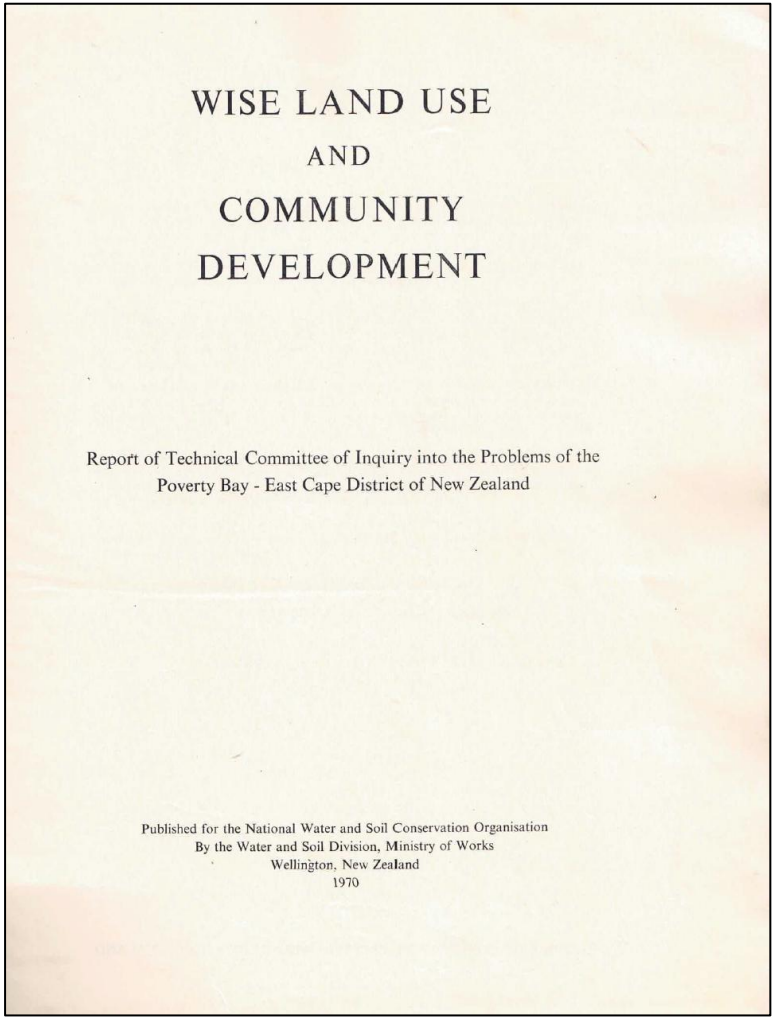


2023

"Papatuanuku is battered and bleeding, Ranginui a fury, and Tane Mahuta bent and breaking"

"This is a moment in time that demands an urgent reset"

"we have 5 – 10 years to turn this environmental disaster around"



1970

"problems of exceptionally severe land erosion"

"diversified development is considered to be essential. Large sections of the back country are unsuited to farming but can be effectively afforested"

"the problem cannot be solved in piece-meal fashion by small-scale operations. Only a unified large-scale attack will result in success"

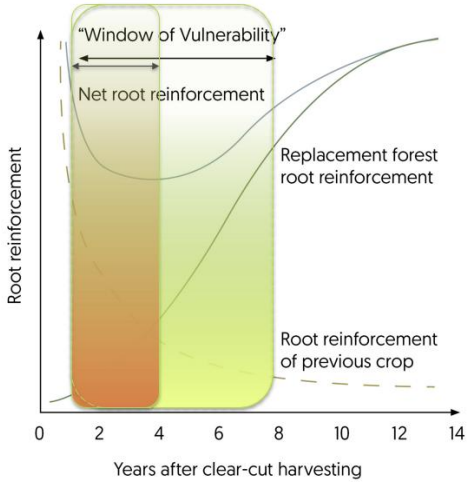
"these problems call for urgent attention"

Outline

- Problem overview
- Not a new issue
- Are we different?
- Concepts
- What to manage to?
- How do we mitigate?
- What might we accept?
- Takeaways

Problem overview

- Historical legacy of our steeplands
- One third of plantation estate on steeplands
- Problems emerged on harvested steeplands
- Large rain events can cause natural disasters
- More trees now than at any time in last 100 years
- The issue will not disappear nor can be reduced to zero
- Climate change – is it leading to cascading geohazards?
- What should we manage for? Big vs small-moderate events?
- 2 parts to the problem for infrastructure - recruitment and then transport (interception)



Not a new issue..

Wood in rivers and on beaches

Is this unique to New Zealand?

Switzerland

The landslide in the Wagenrunse devastated the Herren and Plattenau districts in Schwanden GL (municipality of Glarus Süd) on 29 August 2023. (Photo: GFO Glarus Süd)

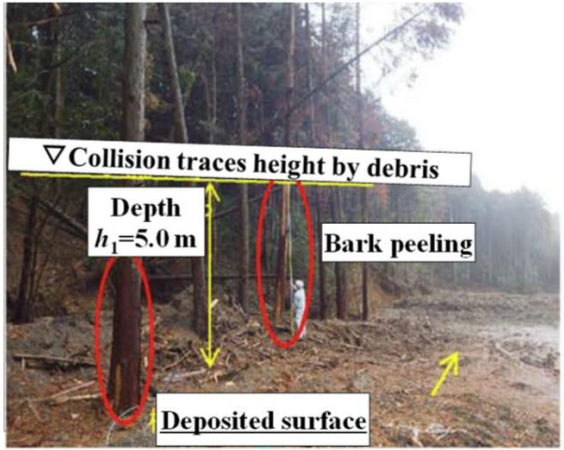
Photos: Sandra Melzner

Japan (WLDF - not WTF!)

Survey of driftwood in Asakura city, Fukuoka prefecture

(a)

Figure 9. Woody debris flow damage immediately upstream of Sugawa sabo dam I.



(b)

Koyanagi K, et al. (2022); Harada et al. (2023).

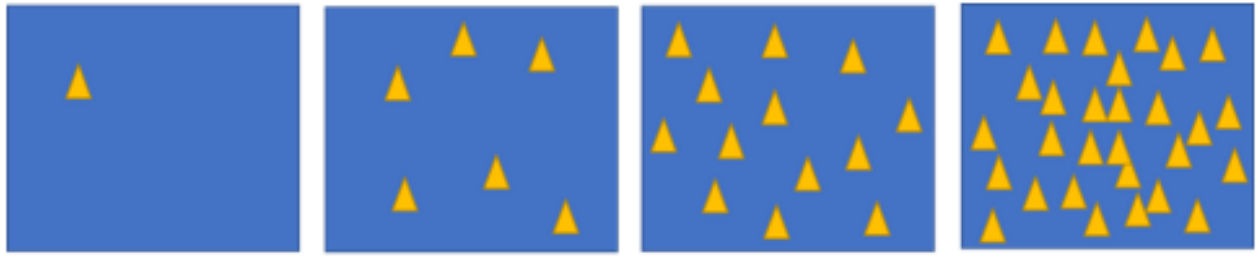
Concepts – event recurrence

ARI

An annual recurrence interval is also known as 'return period'. It is **the average number of years that it is predicted will pass before an event of a given magnitude occurs**. For example, a 50 year ARI event would on average happen every 50 years.

AEP

An annual exceedance probability (AEP) is **the probability of an event occurring in any given year**. i.e. A 1% AEP means there is a 1% chance in any given year of the event occurring. This means that on average 1 event of this size will occur every 100 years.



ARI 1 in 1 **AEP 100%**

ARI 1 in 5 **AEP 20%**

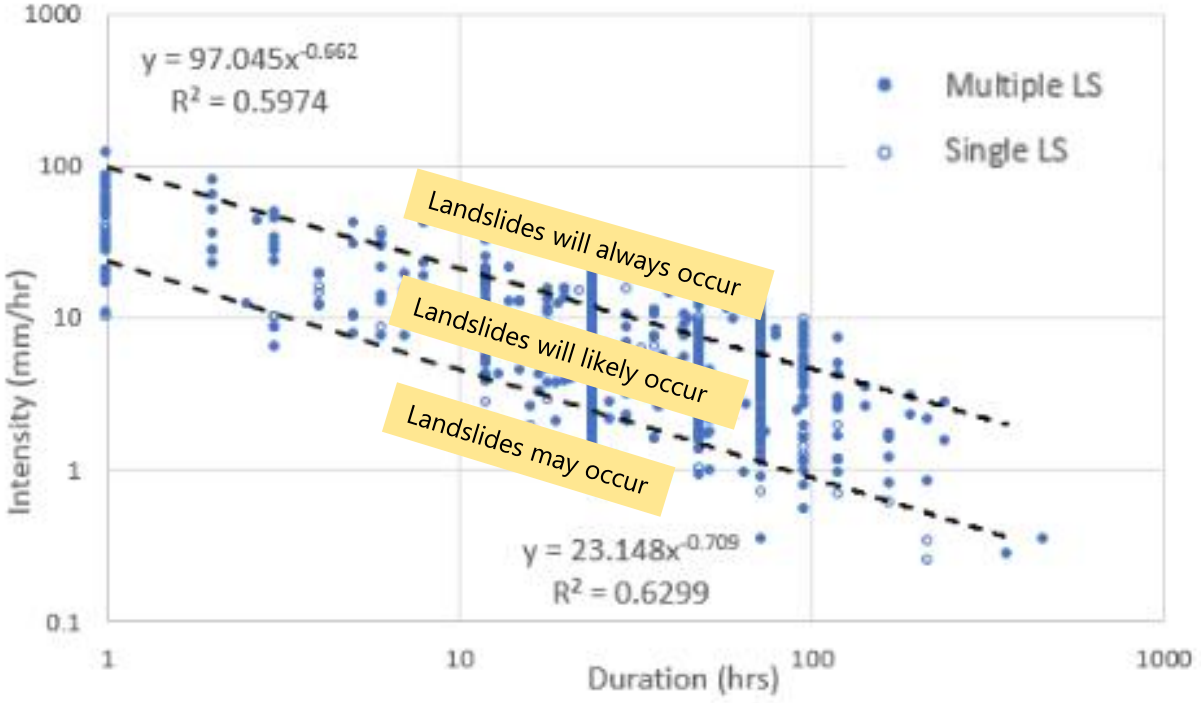
ARI 1 in 20 **AEP 5%**

ARI 1 in 100 **AEP 1%**

Frequent ⟷ Infrequent

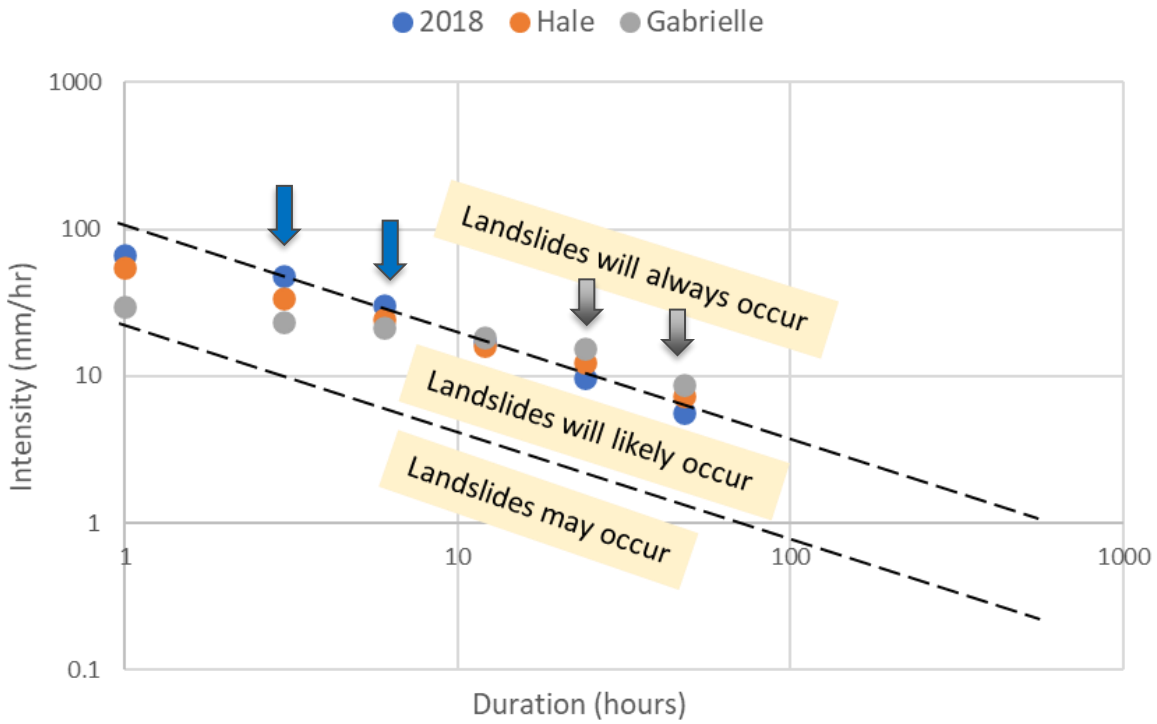
https://hirds.niwa.co.nz/

Concepts -
rainfall intensity-duration thresholds for landslides

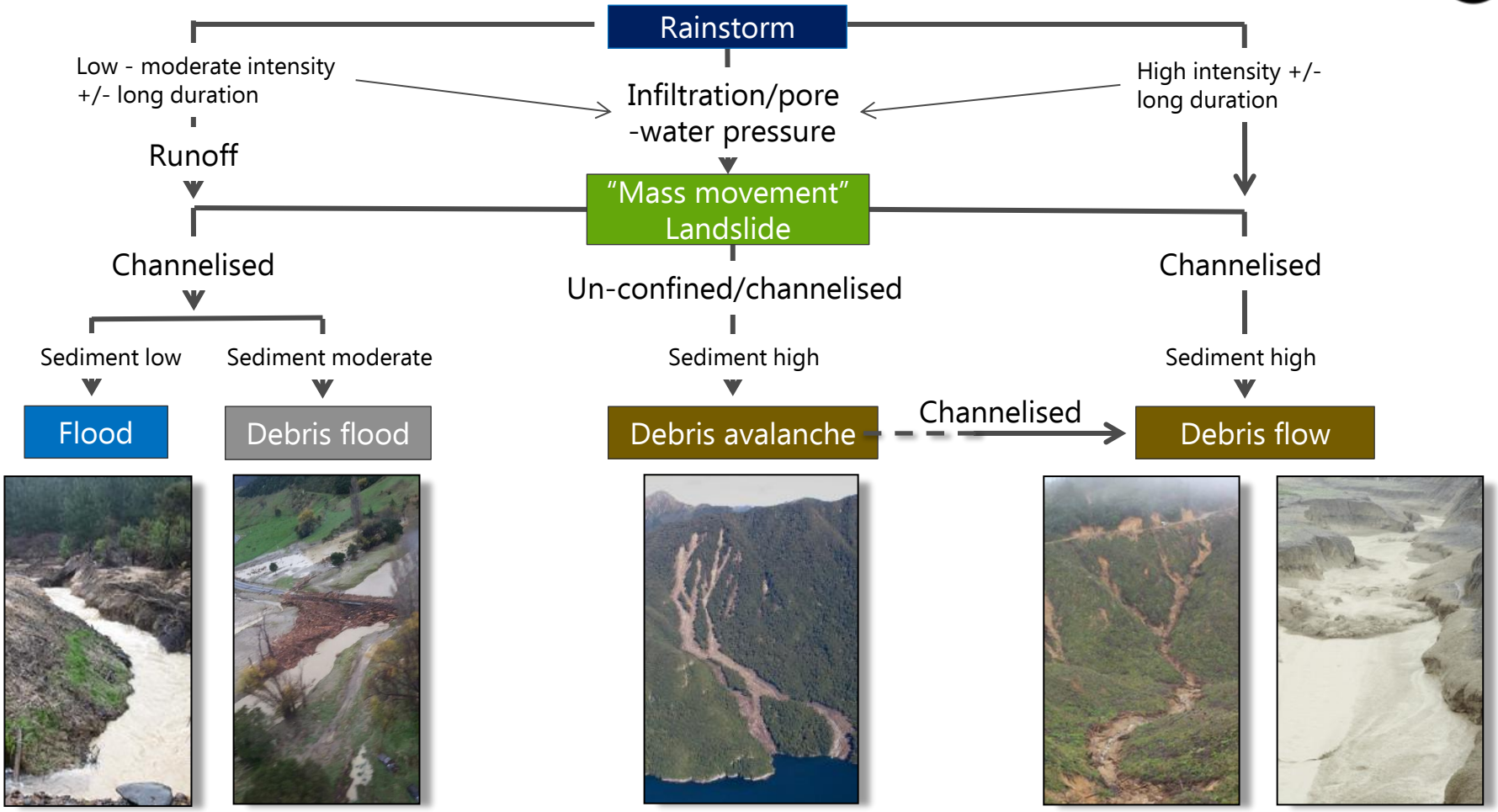


Rosser B, Massey C, Lukovic B, Dellow S, Hill M 2020. Development of a rainfall-induced landslide forecast tool for New Zealand. In: Casagli N ed. Understanding and reducing landslide disaster risk.

Rainfall intensity-duration for inland Tolaga Bay



Concepts - processes



Concepts – susceptibility, hazard & risk

For a natural hazard such as a landslide:

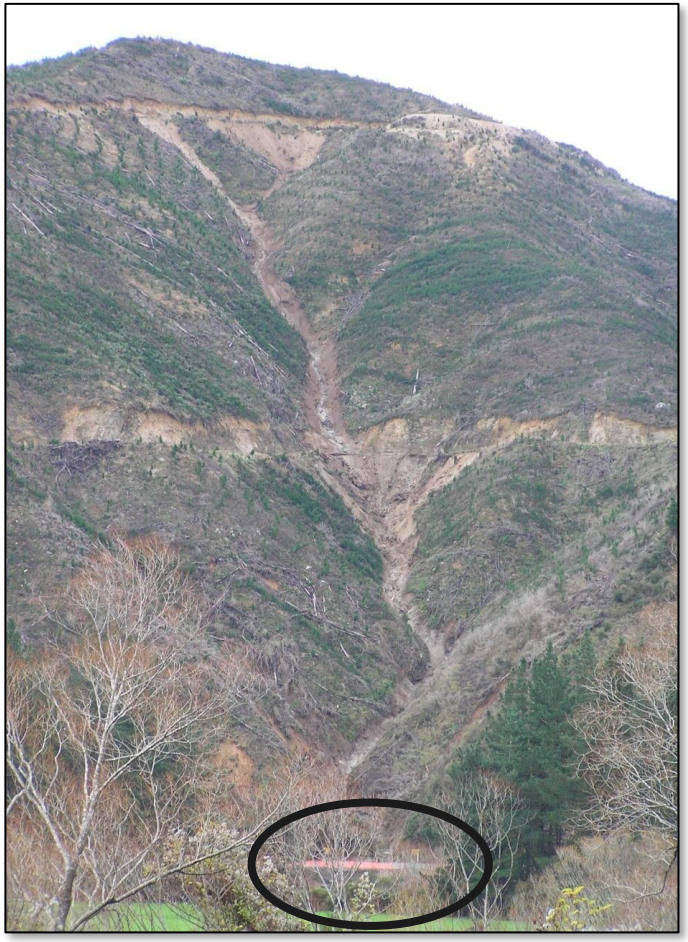
Susceptibility – the potential for an area to experience a landslide

Hazard – the likelihood of a landslide occurring and causing damage - exists independently of the people or systems it may affect

Risk - the potential for loss or damage resulting from a landslide.

Based on a risk assessment, mitigation measures might be recommended to reduce the risk.

Concepts – susceptibility, hazard & risk



No infrastructure – your forest land

Risk - **LOW**

Infrastructure **$** – neighbour, fences, etc

Risk – **MEDIUM**

Infrastructure **$$$** - Highway/bridge

Risk – **HIGH**

Houses & people – loss of life

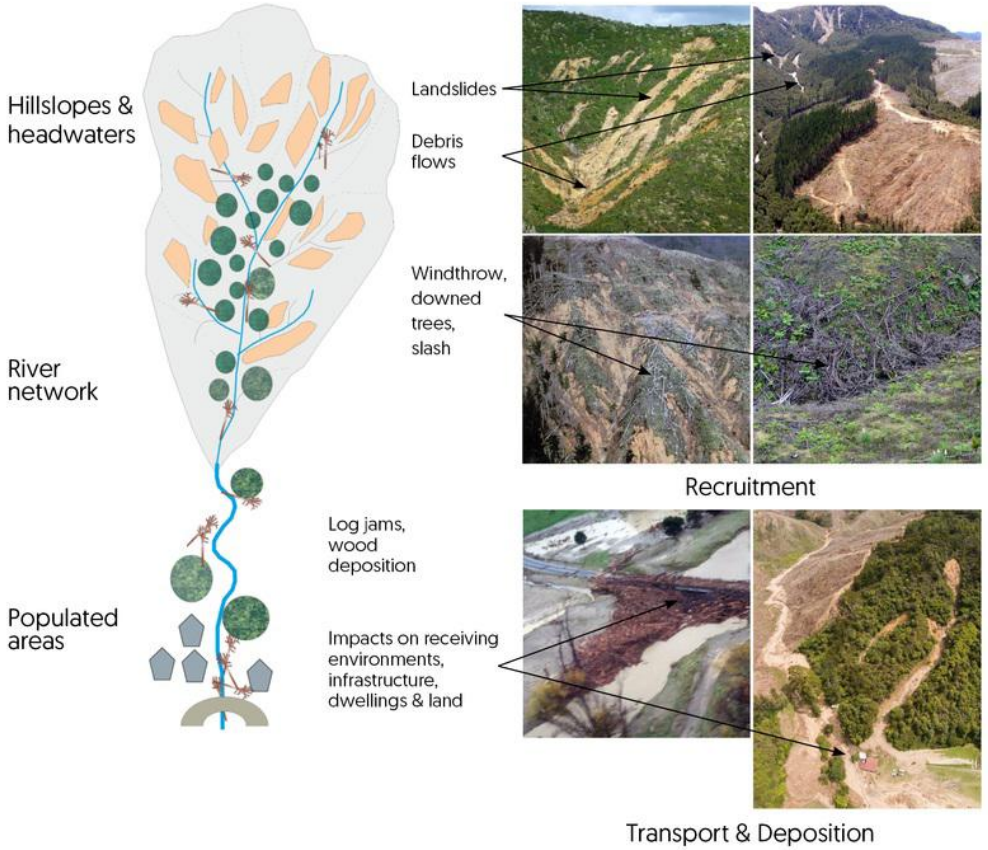
Risk – **EXTREME**

Managing the issue

Recruitment

- Landslides
- Debris flows
- Bank erosion
- Mobilisation of in-channel wood
- Wind, snow - direct

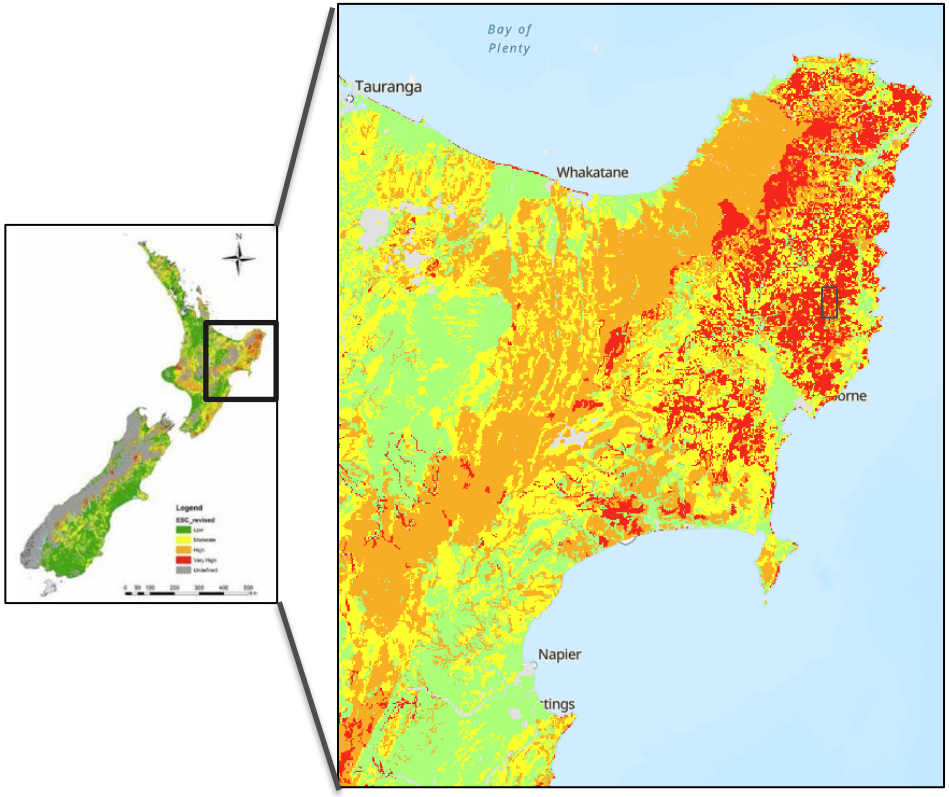
- Torrents, gullies, upper catchment
- Mid reach
- Lower reach



Interception

- Deposition

Erosion/landslide susceptibility & connectivity



GDC Landslide Susceptibility Connectivity model v1 - All Classes

Class 7
- 7. High LS / High Con

Class 6
- 6. High LS / Mod Con

Class 5
- 5. High LS / Low Con

Class 4
- 4. Mod LS / High Con

Class 3
- 3. Mod LS / Mod Con

Class 2
- 3

Class 1
- 1. Low LS

Source: MPI 2024, GDC 2024

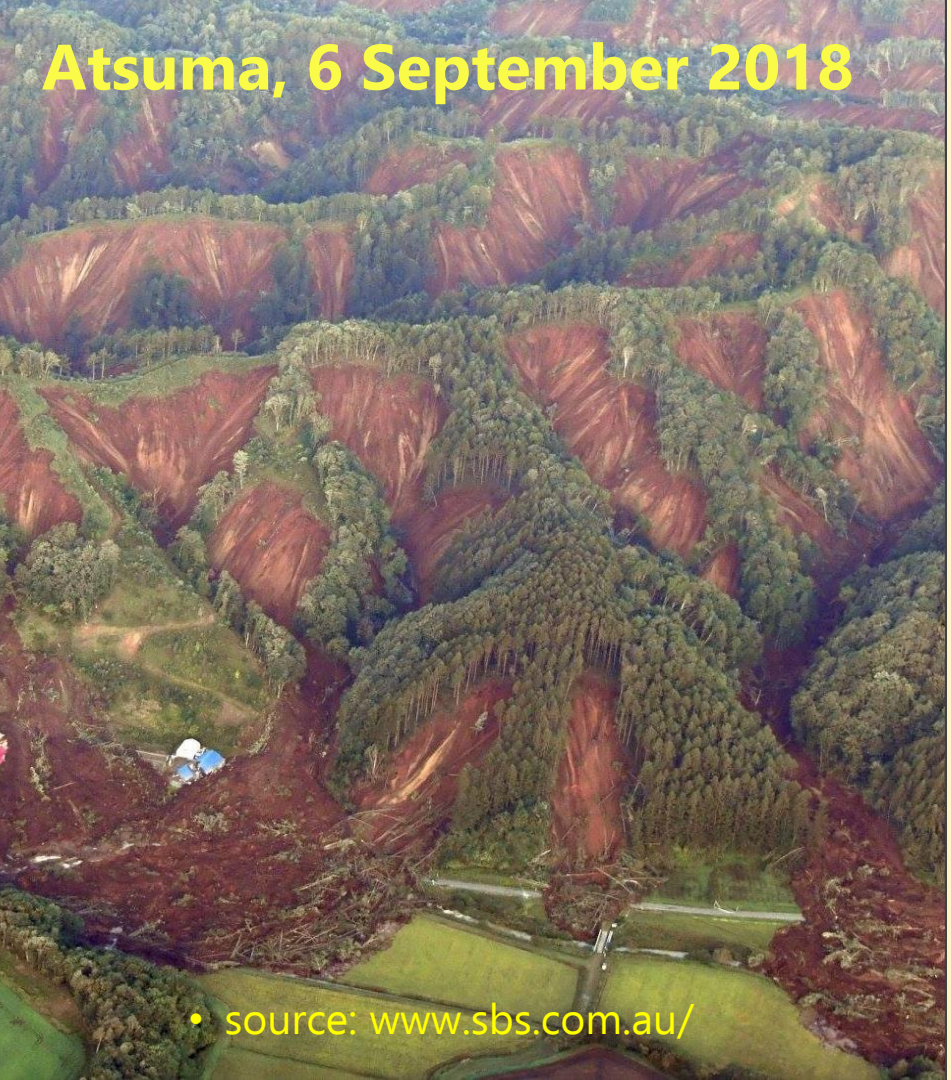
What should you manage for?

- Consents often focus on 1 in 20-year ARIs
- Infrastructure and harvesting effects are difficult to avoid or eliminate → minimisation
- Internationally, the most common approach is via BMPs
- BMP's allow for unintended consequences (e.g. in major events) as a failure of the BMPs
- But, BMPs will never provide the level of control some seek
- Many mitigation approaches are not tested in NZ
- Will better management of harvest residues and riparian areas reduce wood loading?

How do we mitigate landslides & LWD?

Intervention/mitigation/BMP	What it aims to do	Relative cost	Effectiveness Small-Moderate events	Effectiveness Large events
Forest design and planting limits	Avoids hazardous places	$	High	Moderate
Forest harvest planning	Avoids hazardous places	$	High	Moderate
Susceptibility, hazard, risk assessment and maps to support above	Avoids hazardous places	$	High	Moderate-High
Clear-fell limits	Reduces exposed area in a catchment	$$-$$$	Moderate	Low
Adjacency constraints	Reduces exposed area in a catchment	$$	Moderate	Low
Riparian buffers & setbacks	Intercept-buffer hillslope processes	$$	Moderate-High	Low-moderate
Reducing windthrow – better planning	Reduces wood loading	$	High	Low
Slash removal	Reduces wood loading	$-$$$	High	Low-moderate
Engineered slash traps	Intercepts woody debris	$$$-$$$$	High	Moderate
Live slash traps	Intercepts woody debris	$	Moderate-high	Moderate
Non-clearfell	Reduces exposed area	$$$$	High	Moderate-High
Continuous cover forestry	Reduces exposed area	$$	High	Moderate-High

History can teach us



Understand the hazard

Manage for risk

Sh*t happens

Adaptive management

“If you always do what you've always done, you'll always get what you've always got.”

- Henry Ford

Photo: Chris Phillips

Protection forestry

“A protection forest is one that has its primary function as the protection of people or assets against the impacts of natural hazards or adverse climate”.

- Brang et al. (2001)

Learn from others and share freely

Adobe Stock

Steepland plantation forestry: what can we manage, and will it make a difference?

N.Z. FOREST MANAGERS

REDESIGNING FORESTS FOR CLIMATE RESILIENCE

THE APPROACH AFTER CYCLONE GABRIELLE

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RESILIENCE IN FORESTRY

- Resilience in a forestry setting is about both the ability of the forest to withstand an event and the ability to recover from the event
- Building resilience into a forest system is challenging and can take a long time to achieve
  - Need to quantify what the risk is, and what can be done about it
  - Most opportunities for change only come around once in a rotation

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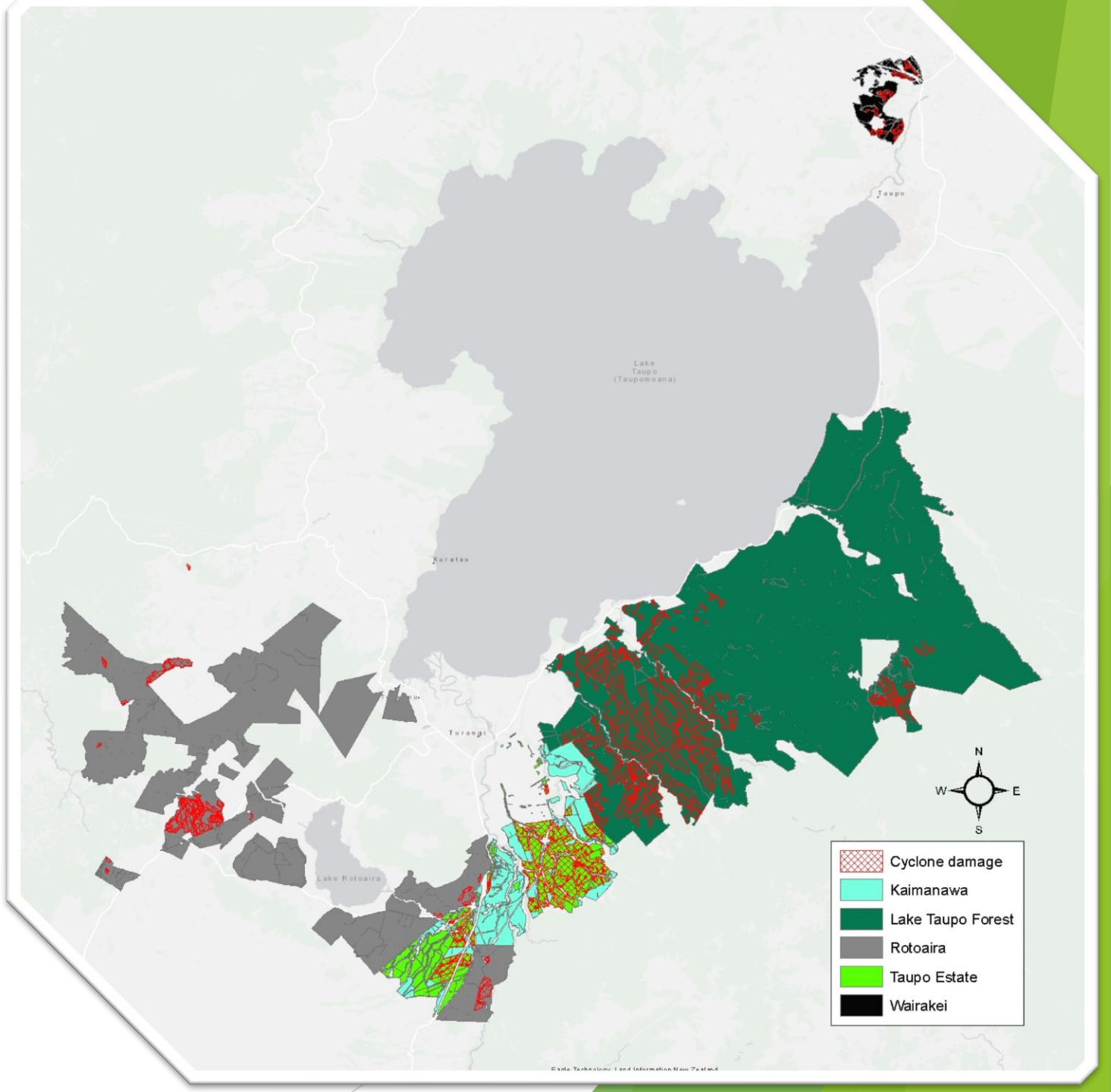
CYCLONE GABRIELLE

- Cyclone Gabrielle caused a significant windthrow event in the Taupo area
- 6,700 hectares damaged across 37,000 hectares of production forest
- The entire windthrow area was salvaged over 16 months, and is now being replanted
- Even before the salvage was completed we were looking at what might be done differently in the next rotation



REPLANTING AFTER THE SALVAGE

- The main area of cutover from the salvage spans ~5,500 hectares across two forests
- This is approximately 20% of the productive area of these forests
- It is not often that so much area is planted at once in forsts of this size, so an interesting opportunity to re-evaluate what should be done
- A plan was developed with the forest owners to manage the replant, taking into account their objectives and constraints

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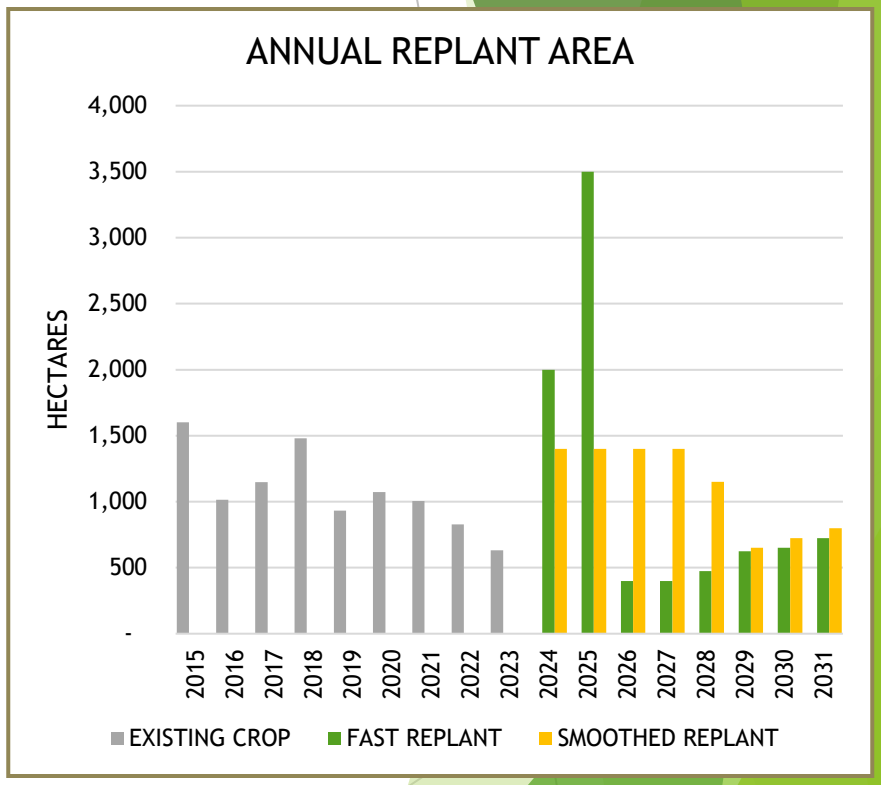
REPLANTING PROGRAMME

- Replant has been spread over 6 years instead of 2
- Key considerations for this included:
  - Lessens annual establishment expenditure, same for tending operations later on
  - More consistent labour requirements, important for maintaining local workforce
  - No need to make compromises on genetics
  - Opportunity to spread replant across a range of sites – aspect, productivity etc.



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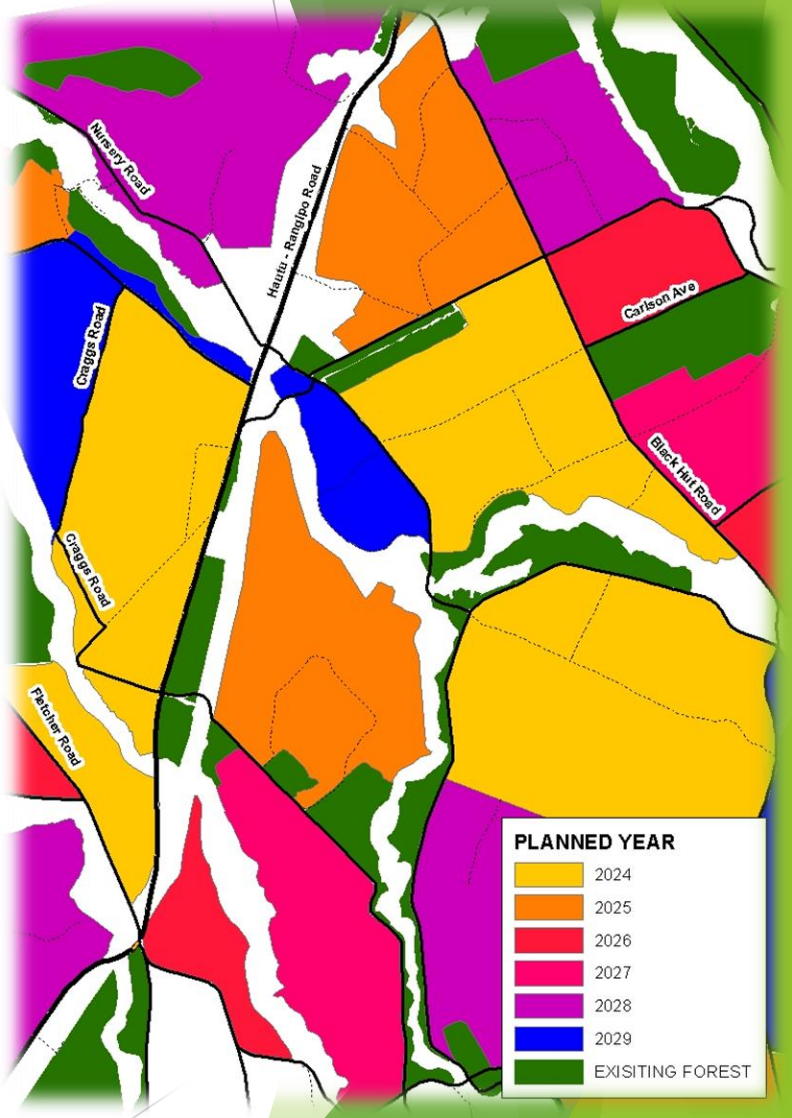
REPLANTING PROGRAMME

- The replant is being spread across the forest
- Target of 80-120ha stands, with practical boundaries wherever possible
  - Some areas will not be replanted until after undamaged pockets of trees are harvested – some still 1-2 years away
- Allows for a range of sites in each age class
  - Aspect
  - Topography
  - Productivity
  - Tending regime



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ALTERNATIVE SPECIES

- Alternatives to radiata are regularly part of the discussion when talking about resilience for a range of reasons
  - Drought/wind tolerance
  - Biosecurity risks
  - Market diversification
- As expected douglas-fir stands held up better than the surrounding radiata, but still took some damage
- No wholesale change of species contemplated at this stage, but a commitment to an ongoing programme of trial plantings - 30-40 hectares/year

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LOOKING TO THE FUTURE

- Will it happen again? Probably
- Will the impact on the forest be the same? Maybe
- Some things we can influence
  - Species
  - Tending regimes
  - Harvest age
- Others we can't
  - Timing
  - Wind strength

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UNDERSTANDING THE RISK

- Quantifying the risk of a wind event, or any climate event, is challenging
- NIWA was commissioned to model wind risk – looked at the wider Taupo area
- A range of models and climate change scenarios looked at. Some variation between models, but no significant change in frequency or severity predicted
- We were able to correlate predictions of high wind from various directions with past windthrow events
- Terrain has a strong influence on windthrow susceptibility

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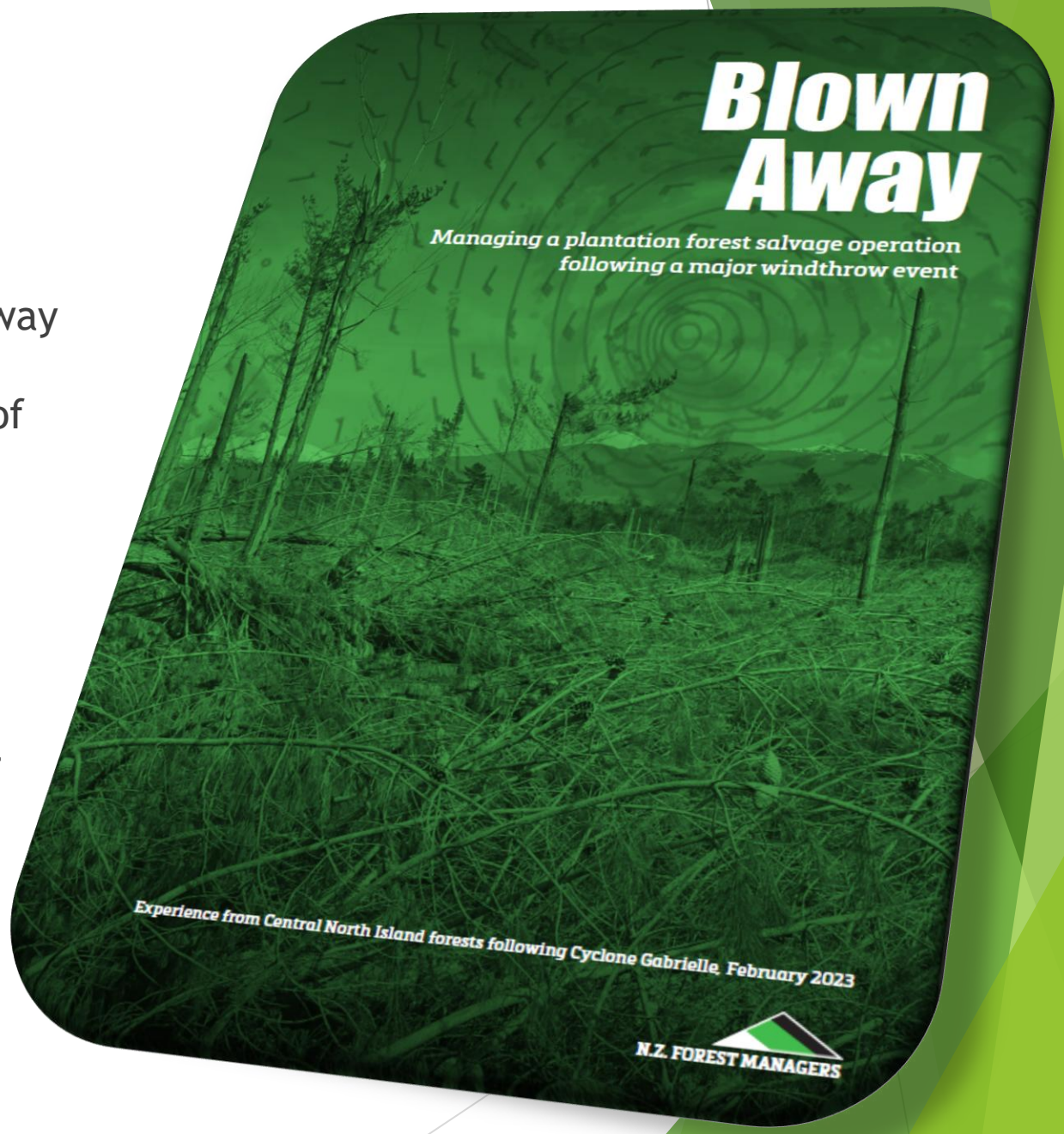
NOTES FOR NEXT TIME

- We discovered there is very little in the way of information about previous windthrow events, particularly around the logistics of salvage harvesting
- These events are infrequent – last one of this scale was Cyclone Bola
- NZFM has published a report about our experience, hopefully it is of help to the next forest manager to deal with a large-scale event



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Building Resilience in Plantation Forests: Forest Engineering & New Challenges

Rien Visser

& Dr. Campbell Harvey

Head, School of Forestry, UC Forest Engineering

NZIF Conference, Napier, 2025

NEW ZEALAND SCHOOL OF FORESTRY

FOREST Engineering UNIVERSITY OF CANTERBURY

Ask **AI:**

← **Poor** forestry on steep slopes in NZ

Good →

Dr. Mahsa Hashemi

‘Resilience’ & forest engineering

- Storms → forests & infrastructure
  - Peak flood flow calculations
- Best Management Practices! (BMPs)
  - For catchments
- Harvest residues
  - Slash vs large woody debris.
- Advancing Forest Eng practices at UC
  - AI to support steep slope planning
  - RoadEng for accurate Infrastructure design

Define *resilience…*

RESILIENCE (noun):

*the **quality** of being able to*

***return quickly** to a previous*

*good condition **after problems**.*

- Cambridge English Dictionary

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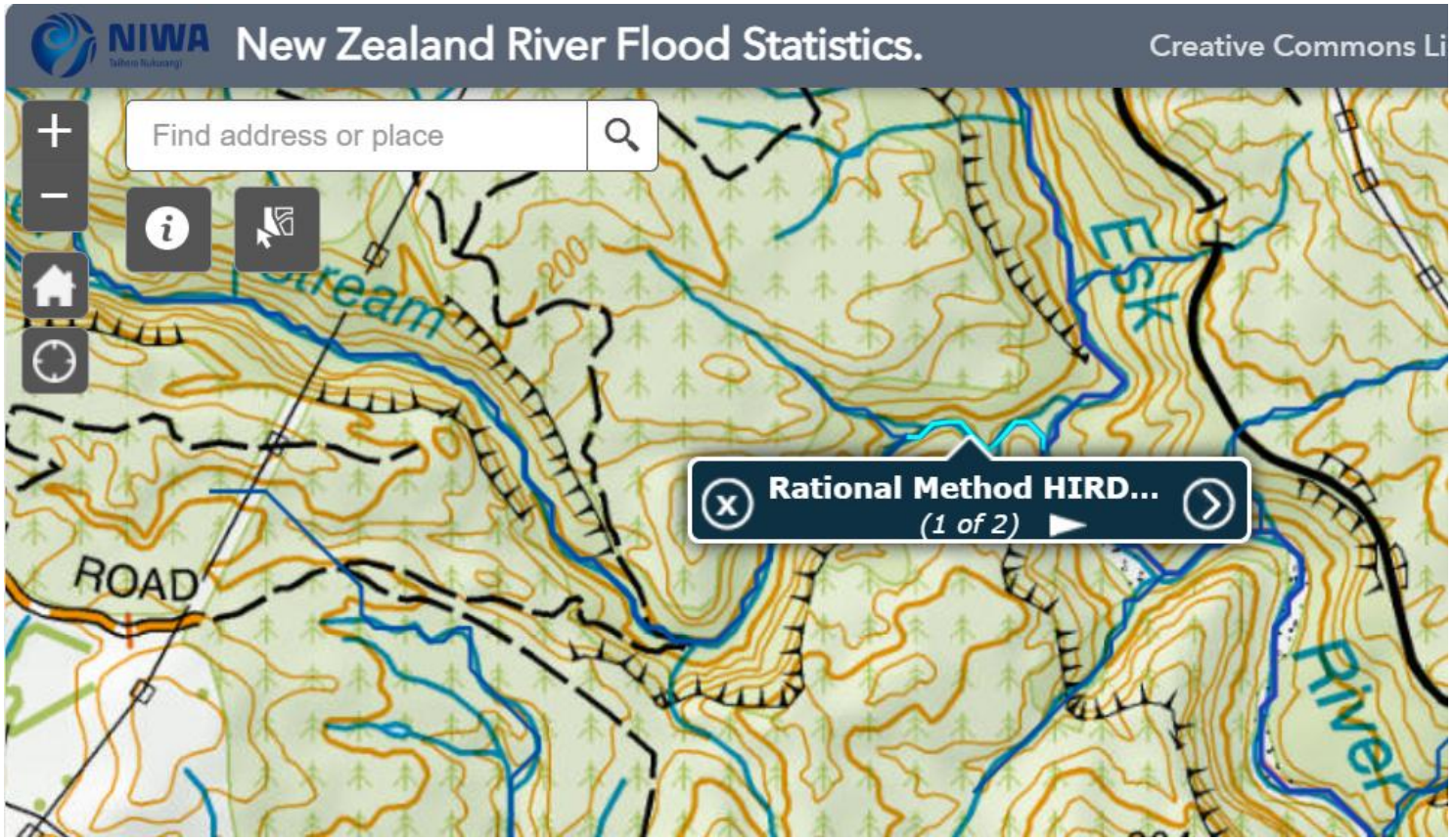
Sketch of different torrential regimes

Source: Rudolf-Miklau, Hubl and Suda, 2015

Peak flood flow prediction

i.e. for Culvert sizing or flood plain id

- How good are we?
  - TM61, Rational, Talbots, NIWA Flood Freq



Flood Statistics 20

Shape	
NZREACH	80
Shape_Length	40
Rivername	De
Areakm2	15.
q100_reach	3.1
H_C18_MAF	9.26
H_C18_5_yr	13.78
H_C18_10y	17.46
H_C18_20y	20.99
H_C18_50y	25.56
H_C18_100y	28.98

Rational Method HIRDS V3

Shape	
Area_km2	15.32
NZREACH	8019570
QIA_5y	52.78
QIA_10y	62.99
QIA_20y	74.48
QIA_50y	92.79
QIA_100y	108.96

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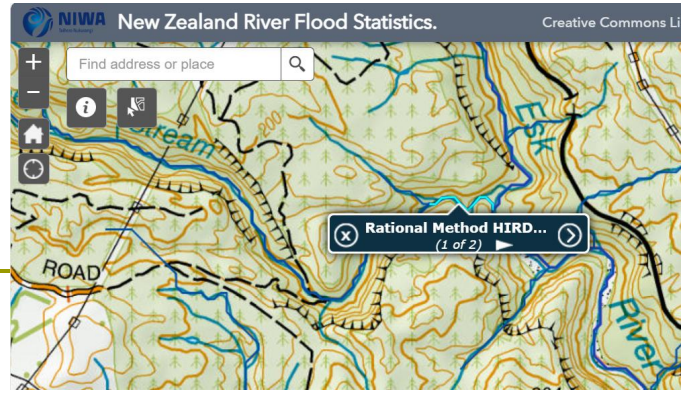
Peak flood flow prediction?



Flood Statistics 2018 REC1: D

Shape	
NZREACH	8019570
Shape_Length	404.96
Rivername	Deep Stream
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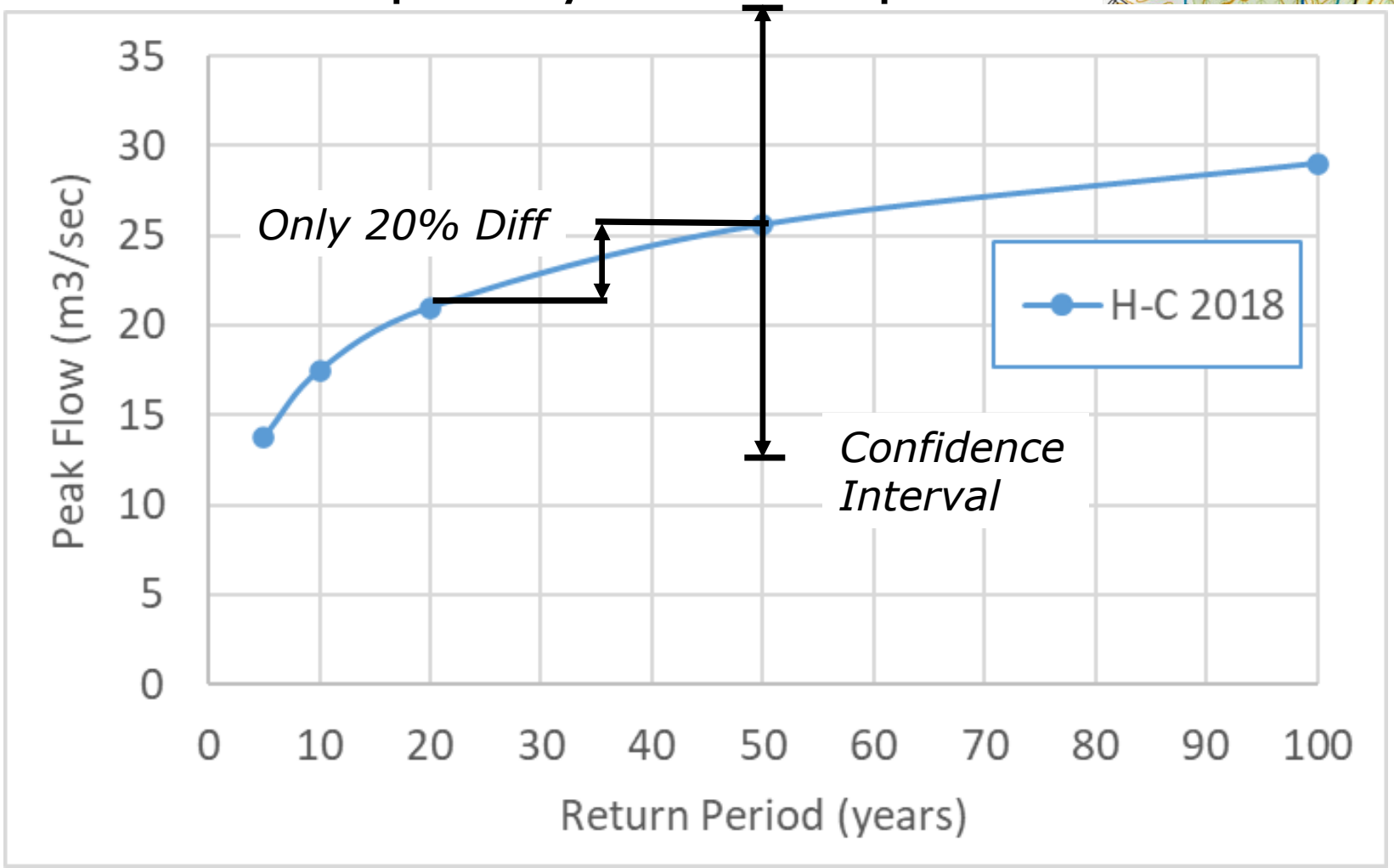
H_C18_50y	25.56
H_C18_100y	28.98
H_C18_1000	40.29
HCse_MAF	4.63
HCse_5y	5.11
HCse_10y	7.16
HCse_20y	9.67
HCse_50y	13.20
HCse_100y	15.94

- Flood Frequency Tool output…



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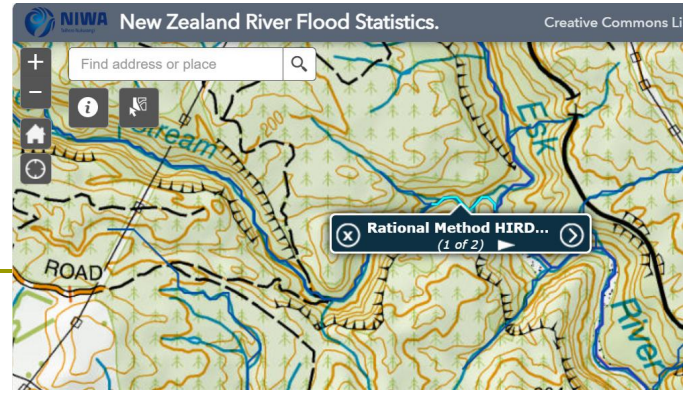

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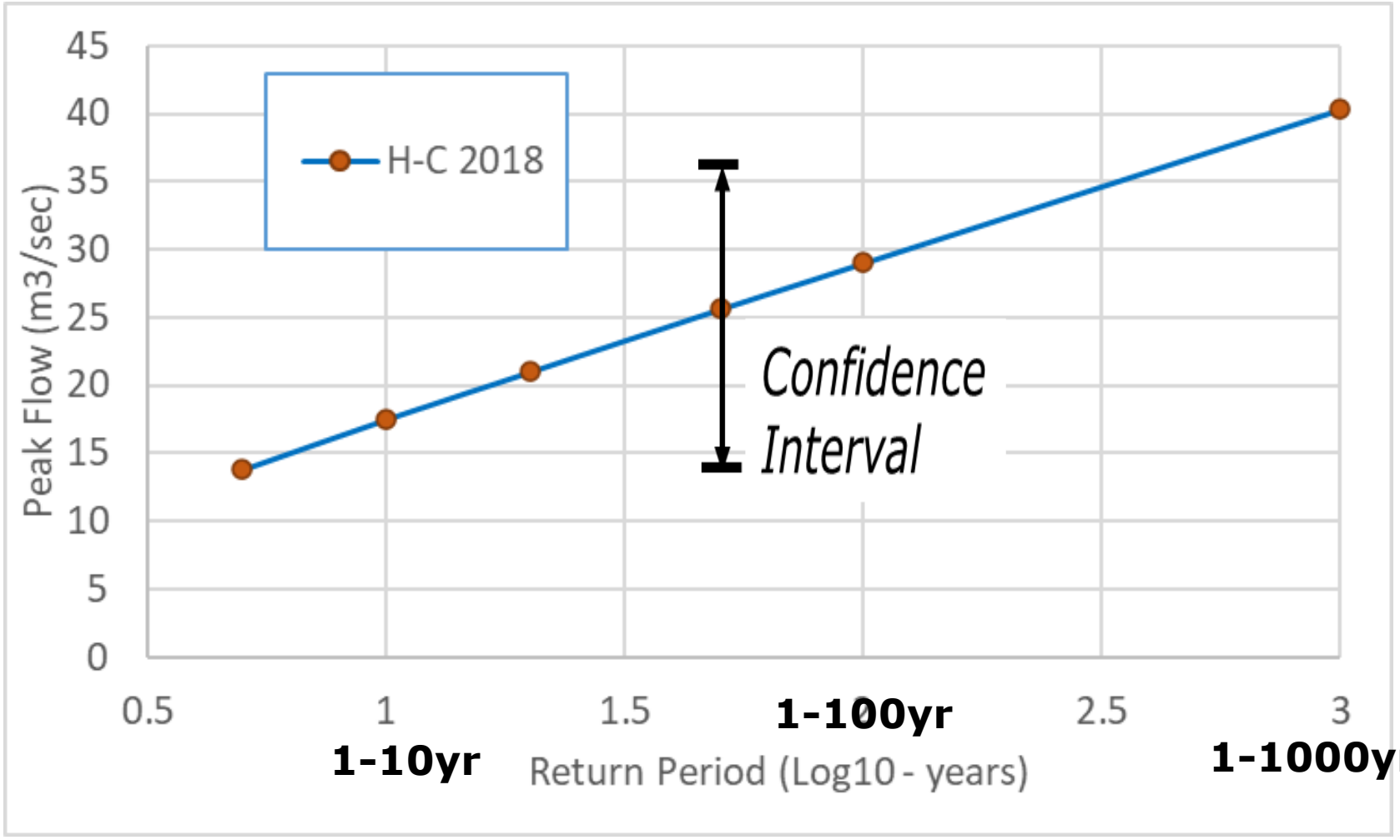

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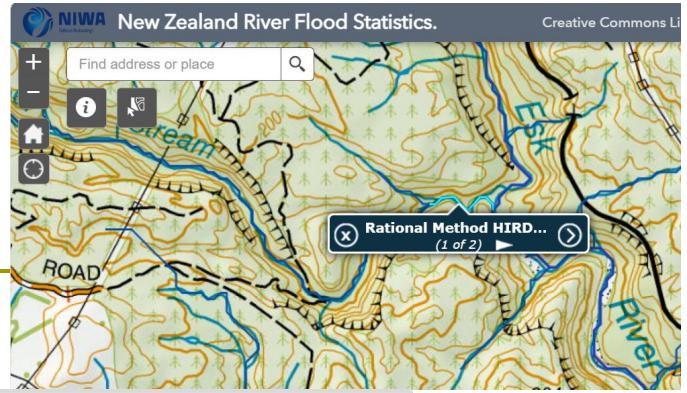
Peak flood flow prediction?



- Rational Method…

Rational Method HIRDS V3	
Shape	
Area_km2	15.32
NZREACH	8019570
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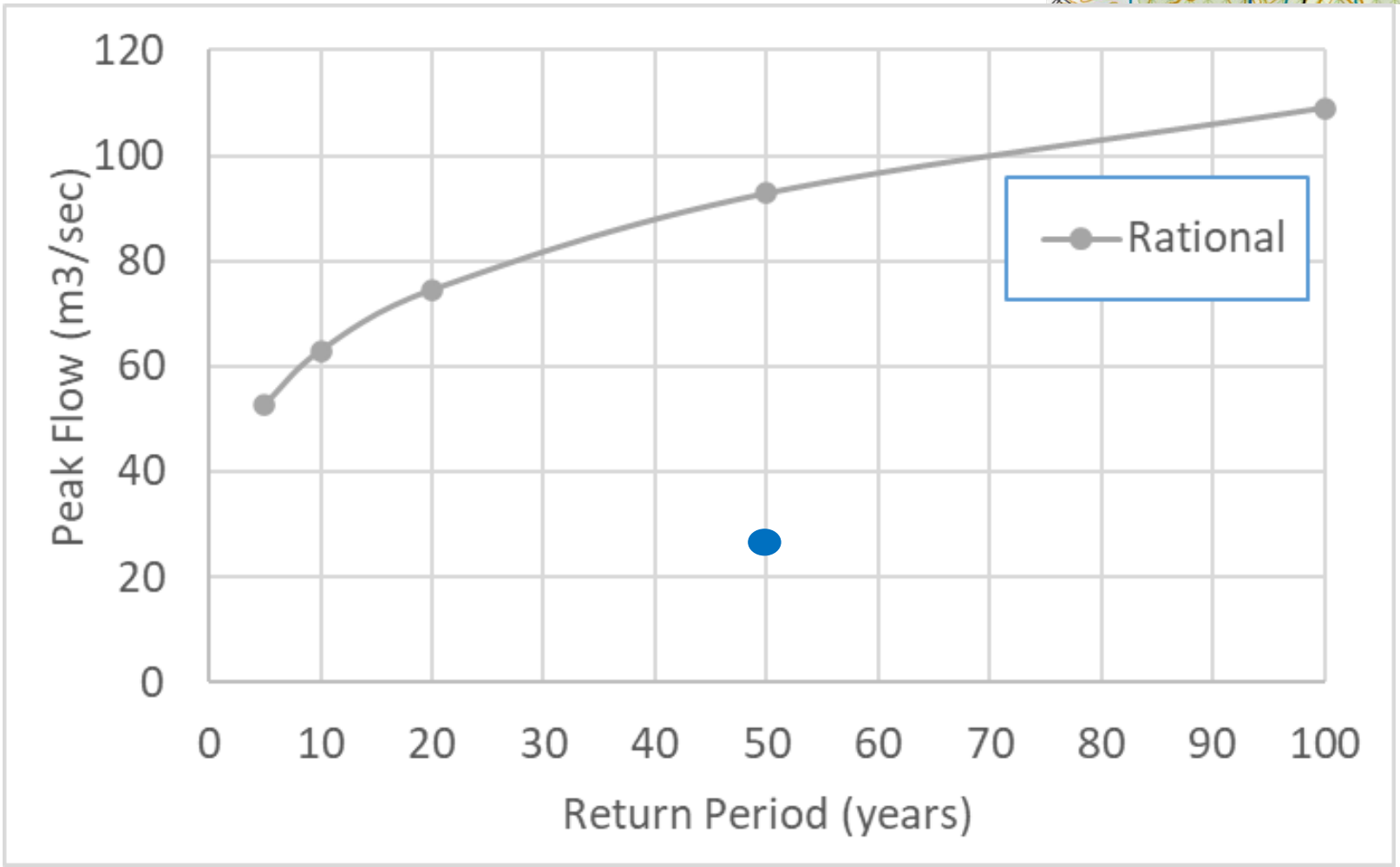
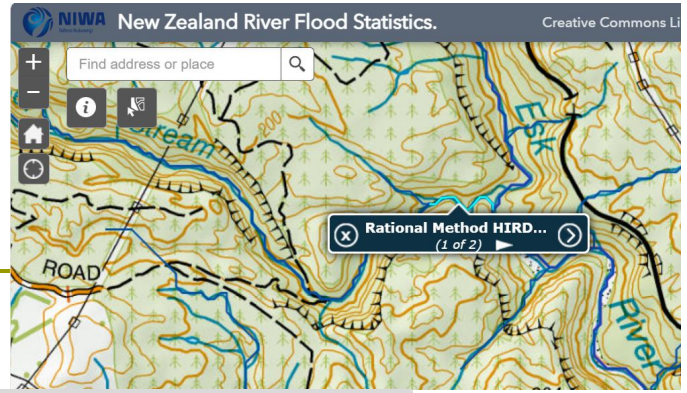


Peak flood flow prediction?



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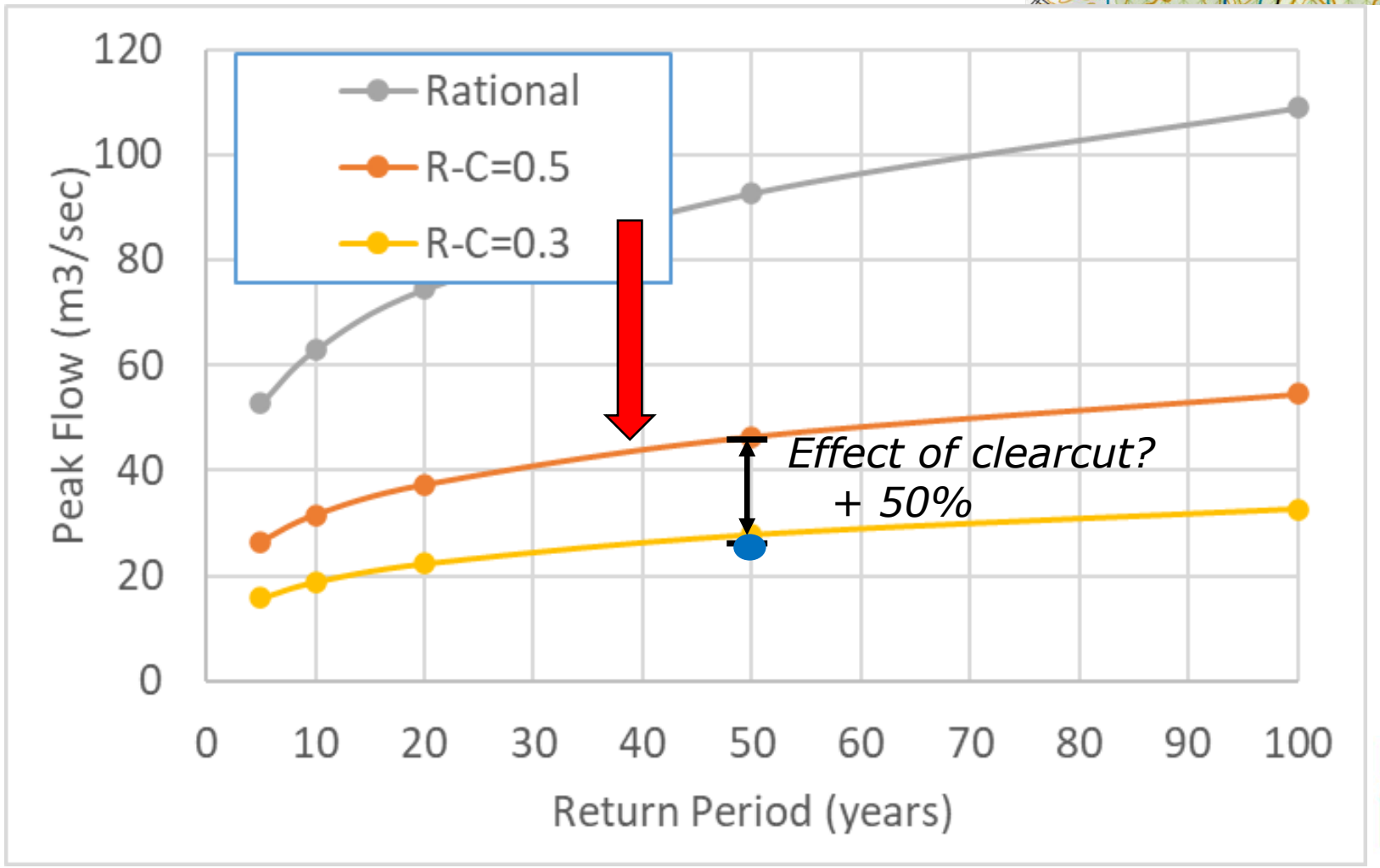

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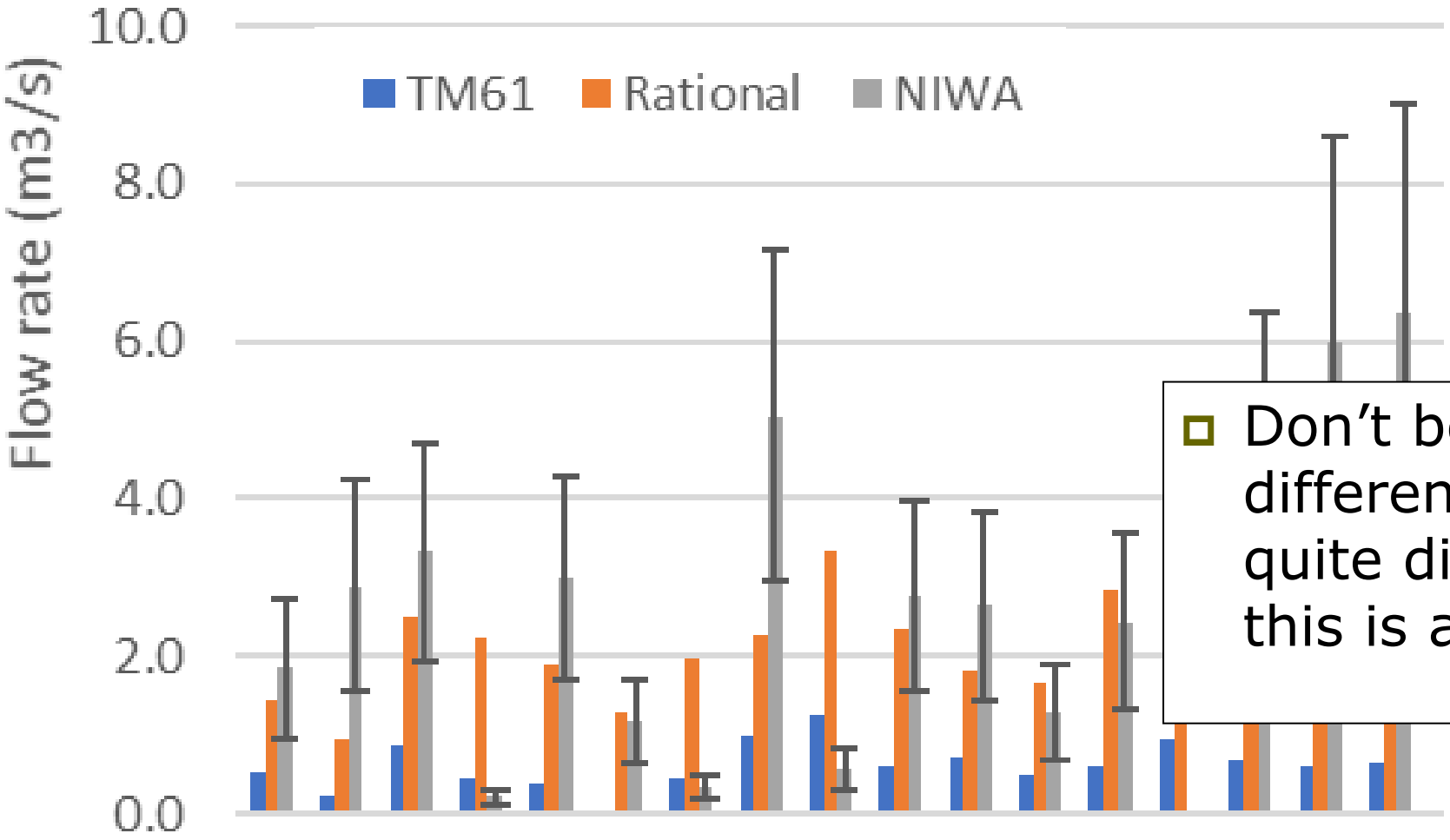
Peak flood flow for Culvert design – comparing methods in small catchments



Even with same input data – outputs diff x5

- Don't be surprised if different methods yield quite different results - this is a known 'problem'!

from D. McCormack dissertation

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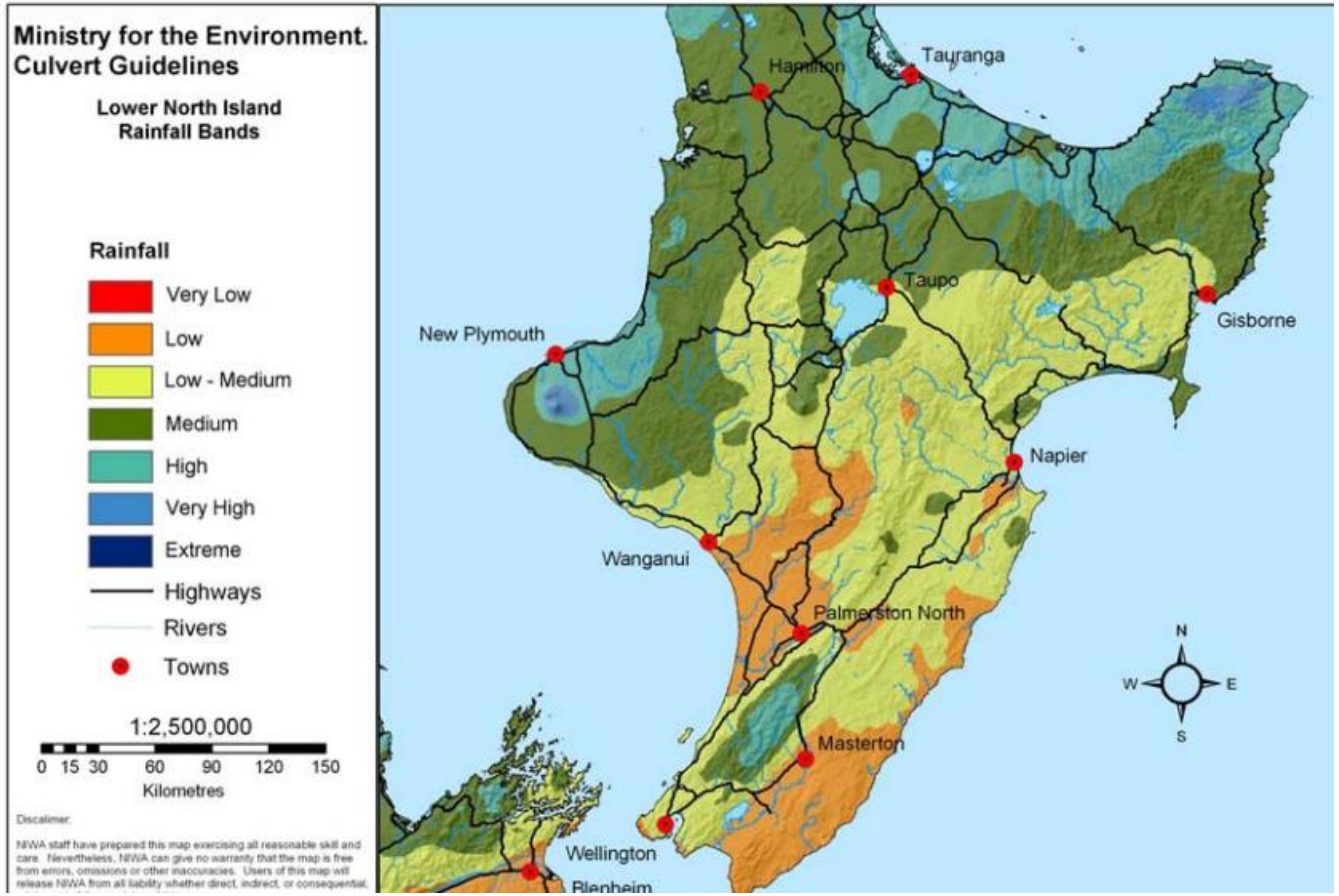
Our NZ farm colleagues?

- Culvert sizing?



MfE Culvert Guide for Farmers

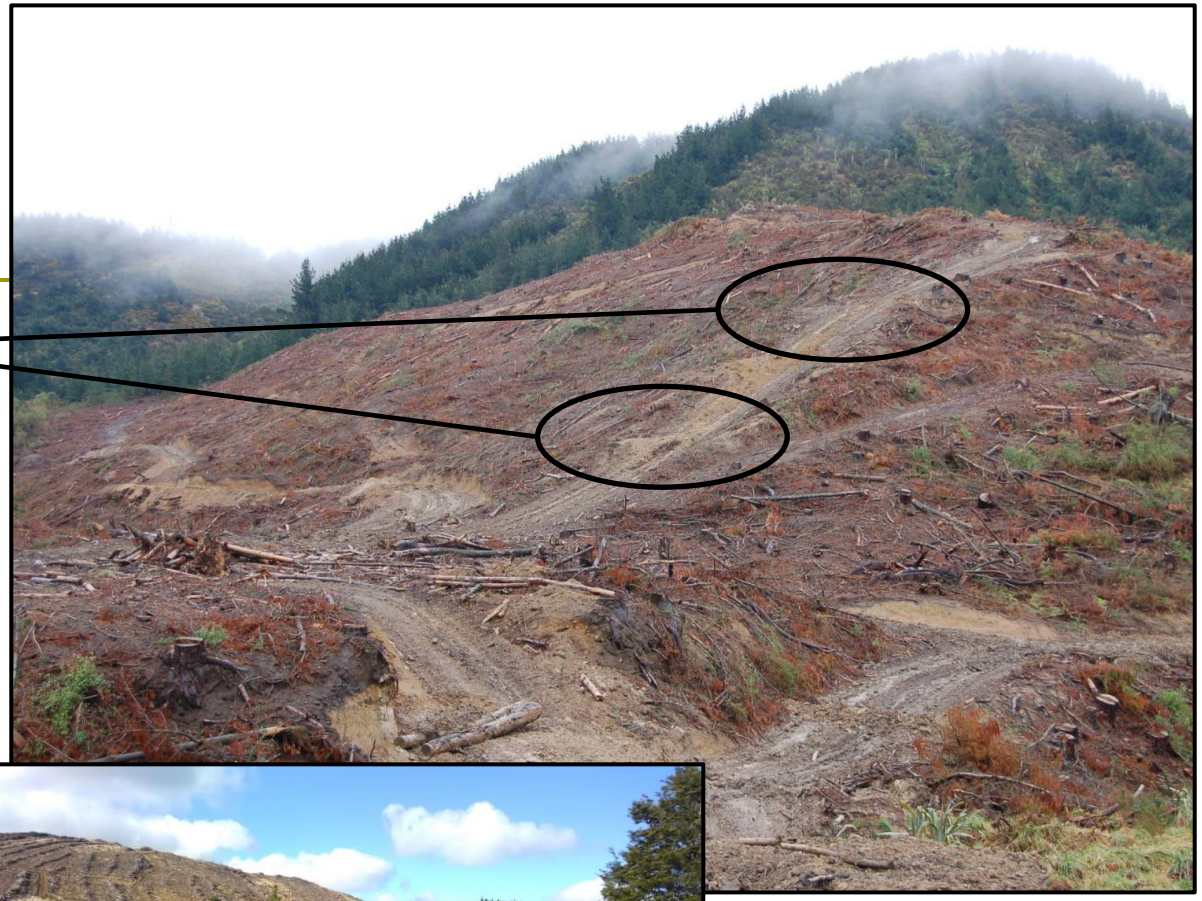
	Low–medium
5 ha	375 mm
10 ha	450 mm
15 ha	600 mm
20 ha	675 mm
30 ha	825 mm
40 ha	900 mm
50 ha	975 mm
100 ha	1350 mm
150 ha	1600 mm
200 ha	1800 mm
250 ha	1950 mm
300 ha	1950 mm
350 ha	2100 mm
400 ha	2100 mm
450 ha	2550 mm
500 ha	2550 mm
	Low–medium

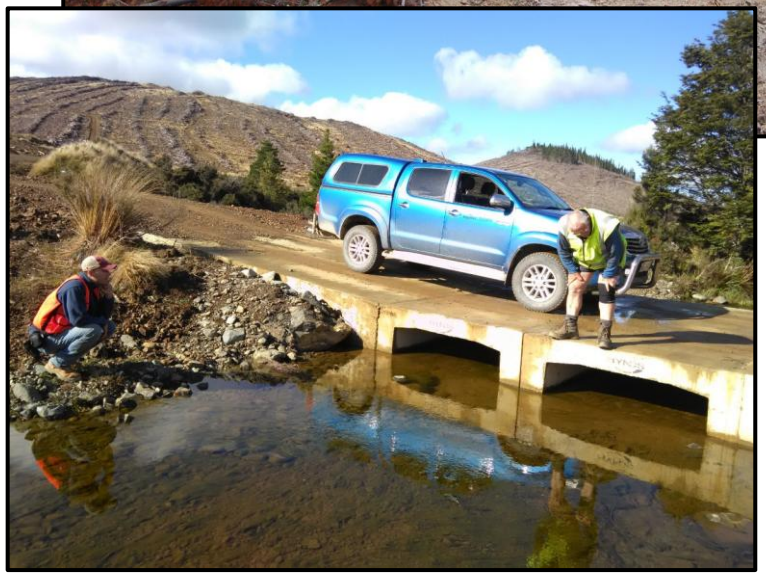
Rules vs Best Management Practices (BMPs)

- Most potential env impacts from forest operations are non-point-source. Non-point-source problems do not lend themselves to rules!
- BMPs are proven techniques to manage stormwater runoff and other pollutants in a cost-effective manner.
- BMPs are not a one-size-fits-all solution; aim to minimize negative environmental impacts while maintaining productivity.

Lots of BMPs

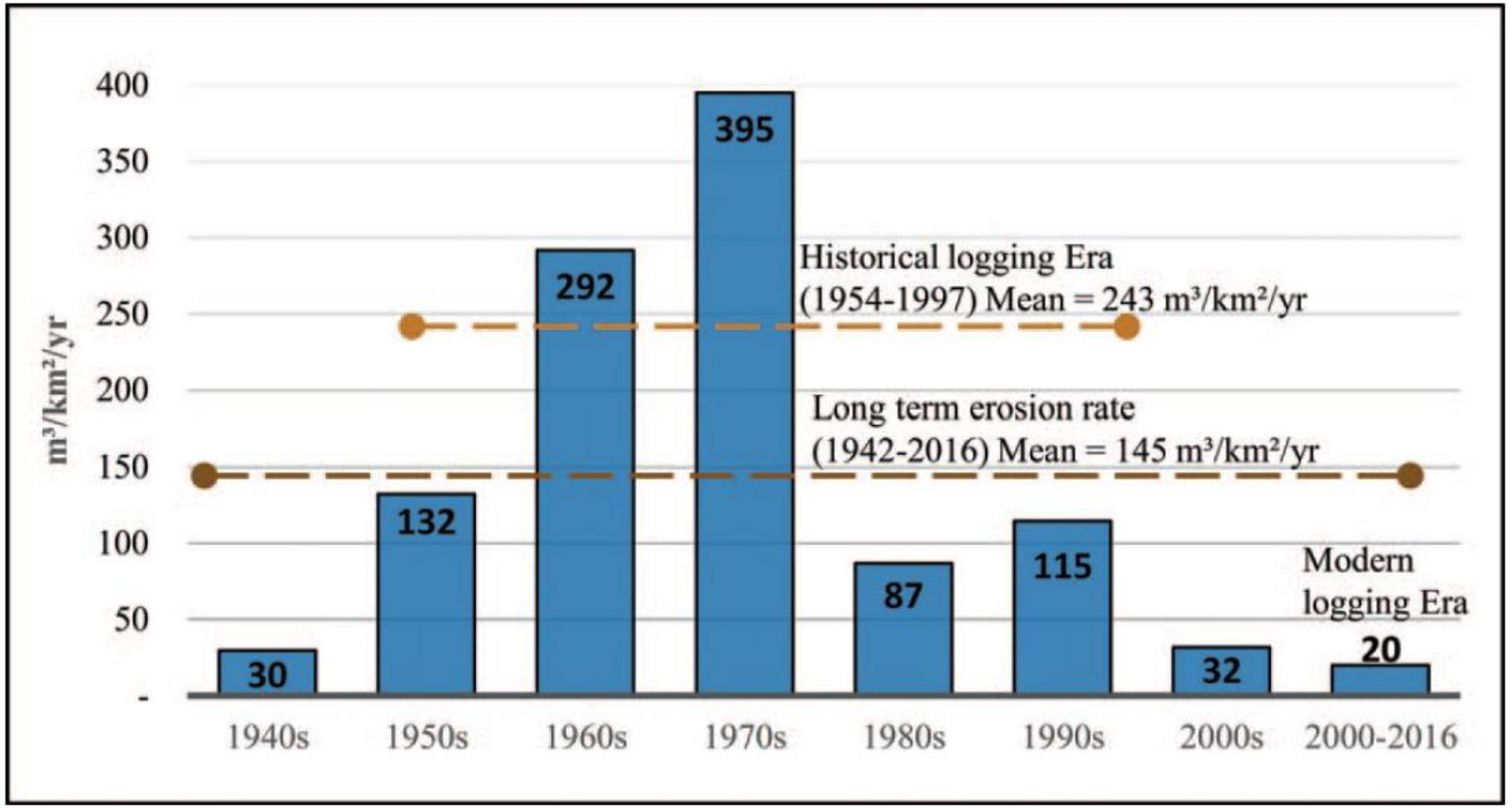
- Skid trail rehab / waterbars
- Drainage / sediment traps
- Culvert sizing / stream crossings
- Earthworks / road construction





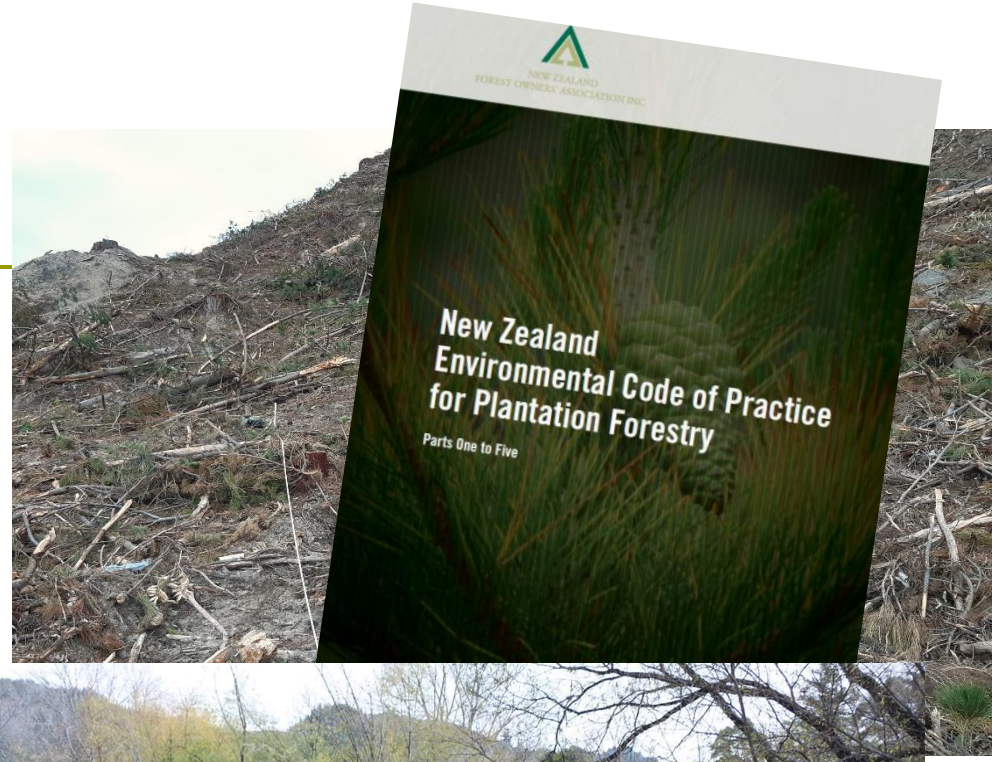
FOREST Engineering
UNIVERSITY OF CANTERBURY

International BMPs include.. (from PNW)



Harvest Residues / 'Slash'?

- 'Residue' – what is left behind
- 'Slash' – branches / tops
- Slash (in NZ'ish??) – ALL residues!

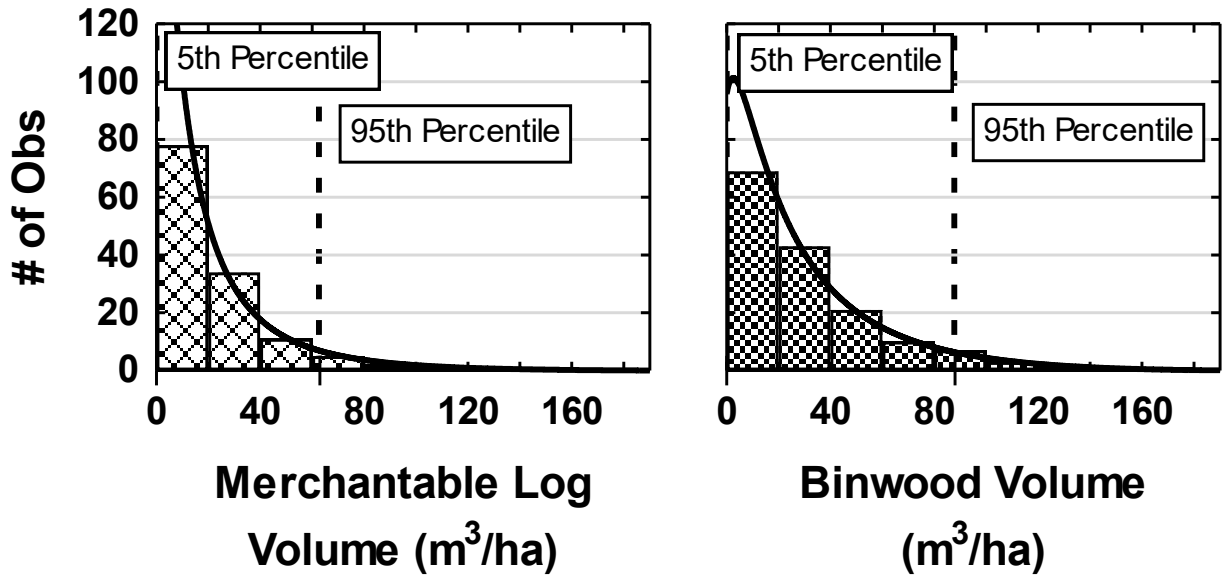


- 'Slash' is GOOD* – BMP is to leave it
  - *But not in our waterways!
- 'Large Debris' is BAD*?
  - *At least it has risks

Harvest Residues & NES?

2019 study* leave approx. 80m^3 behind, of which only about 30m^3 is large

* *Deliberately measured on challenging sites*



Background – Gisborne DC – "no slash"?!

- Focus? *on large woody debris* *(note: debris scattered rubbish)*
- How big? *From workshops - 2m long 10cm SED and is a decent chunk that can block up streams / bridges.*
- How much? *30-40% of our ops leave <15-20m^3 when measured over a decent size area (2 ha.)*

UC Study: Comparing methods to measure large woody debris – Heather Harper and Caylee Brown

Ground-Based Line Intercept Method

Photogrammetry Line Intercept Method

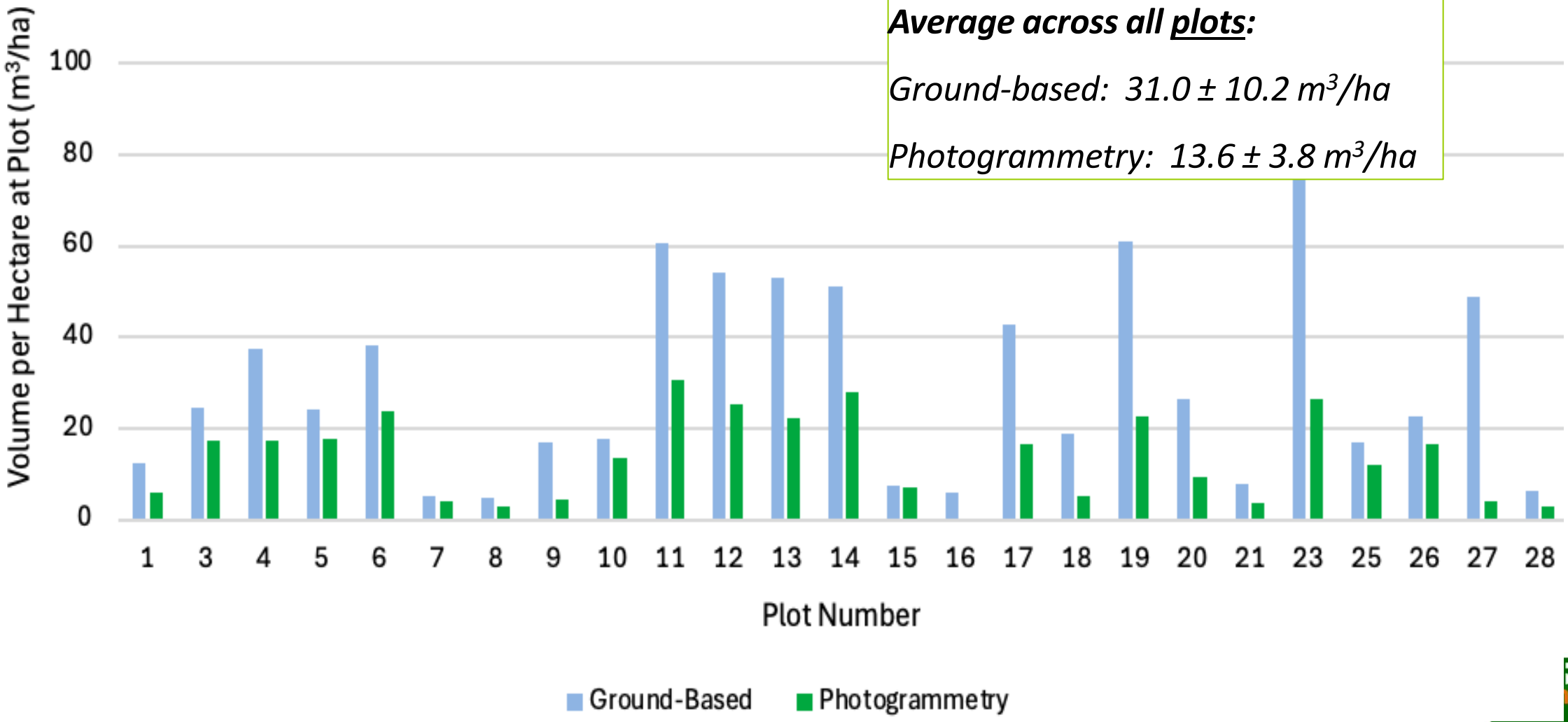
Machine Learning: Detection on Orthophotos

Results: Line transect vs Photogrammetry

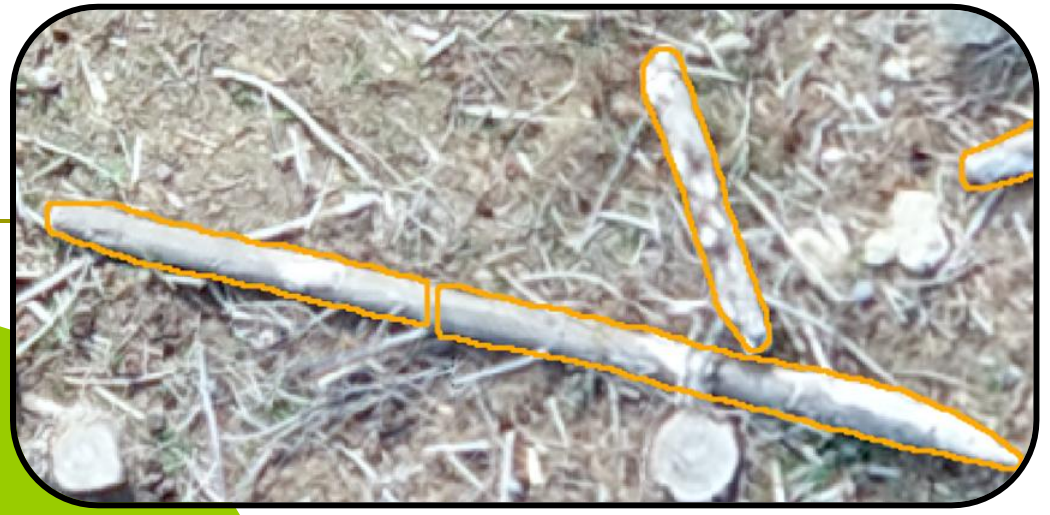
Average across all <u>plots</u>:

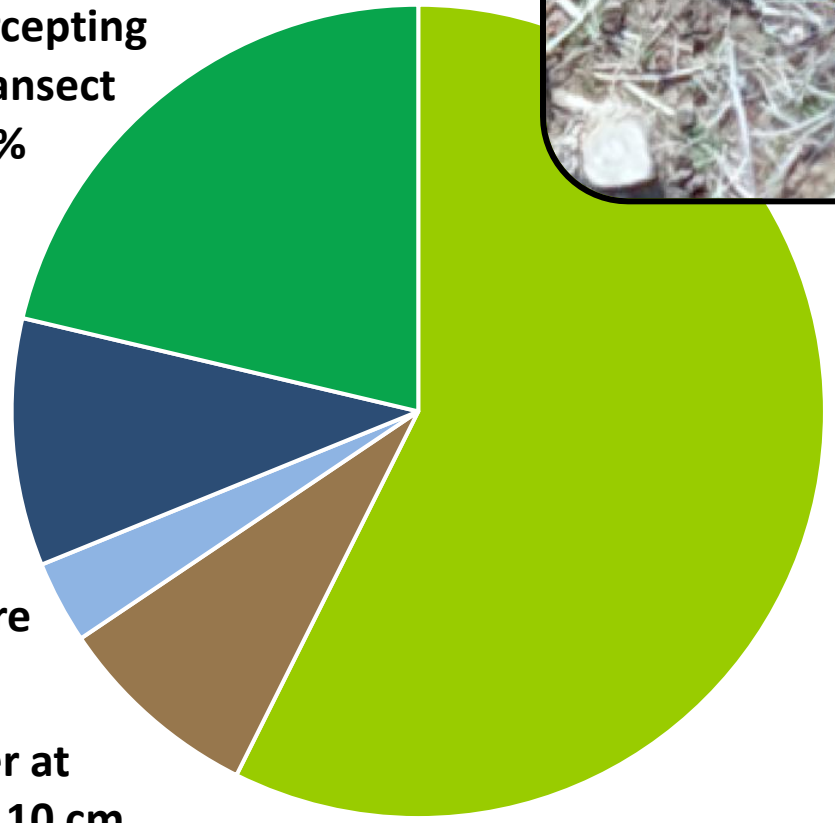
Ground-based: 31.0 ± 10.2 m^3/ha

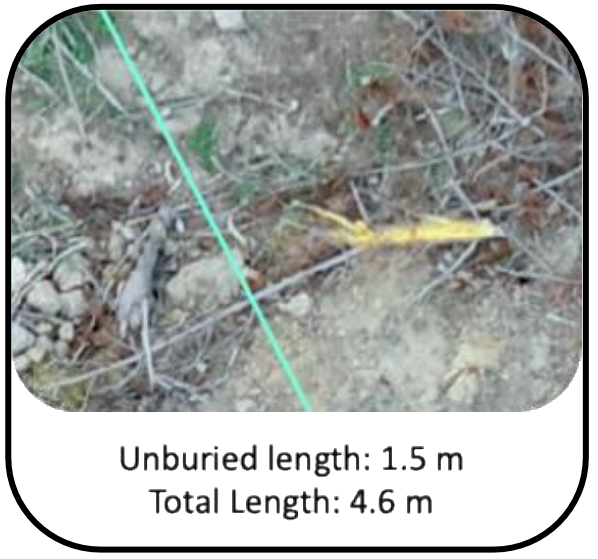
Photogrammetry: 13.6 ± 3.8 m^3/ha



Reason for difference?



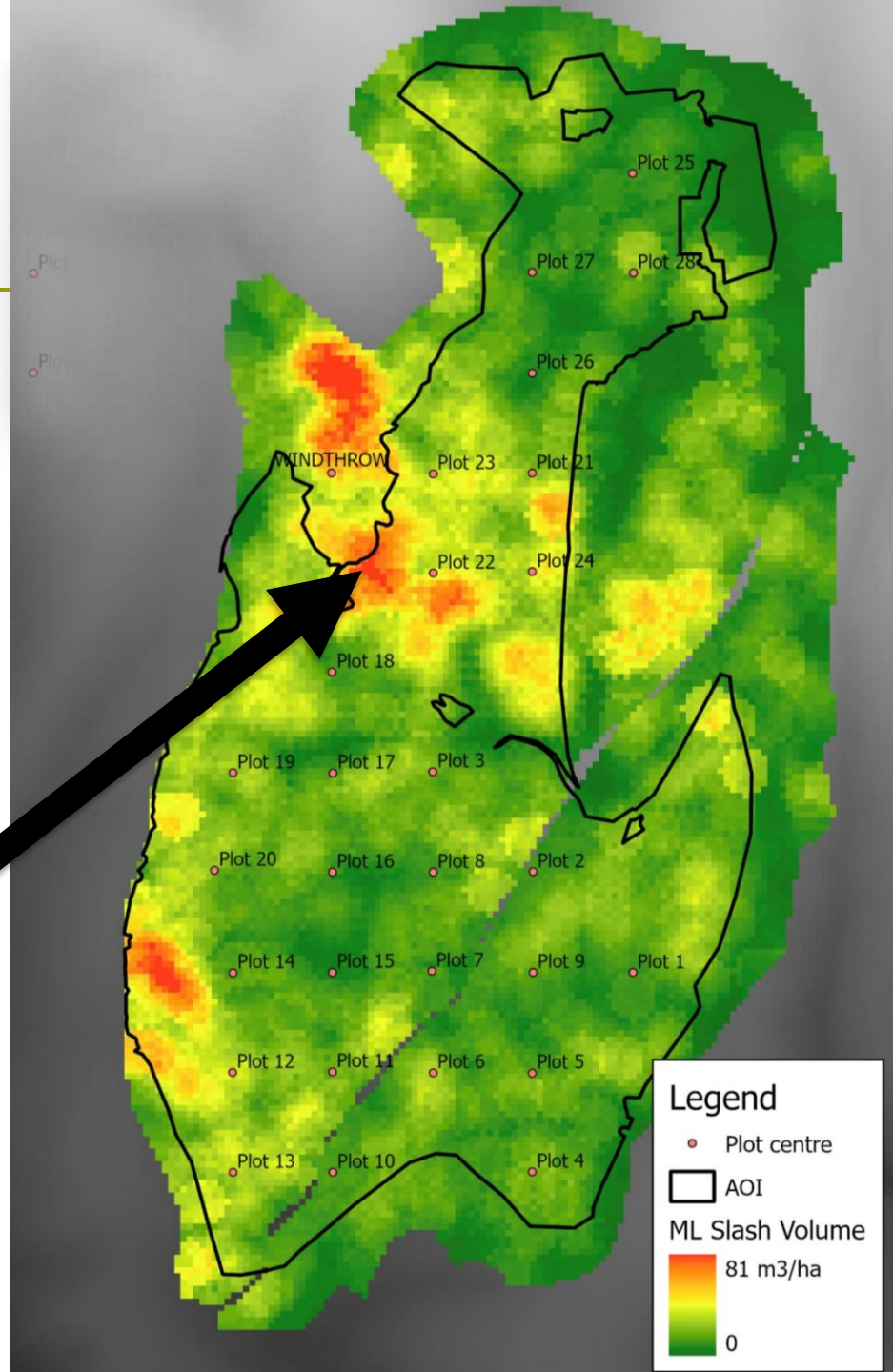




MACHINE LEARNING?

RESULTS

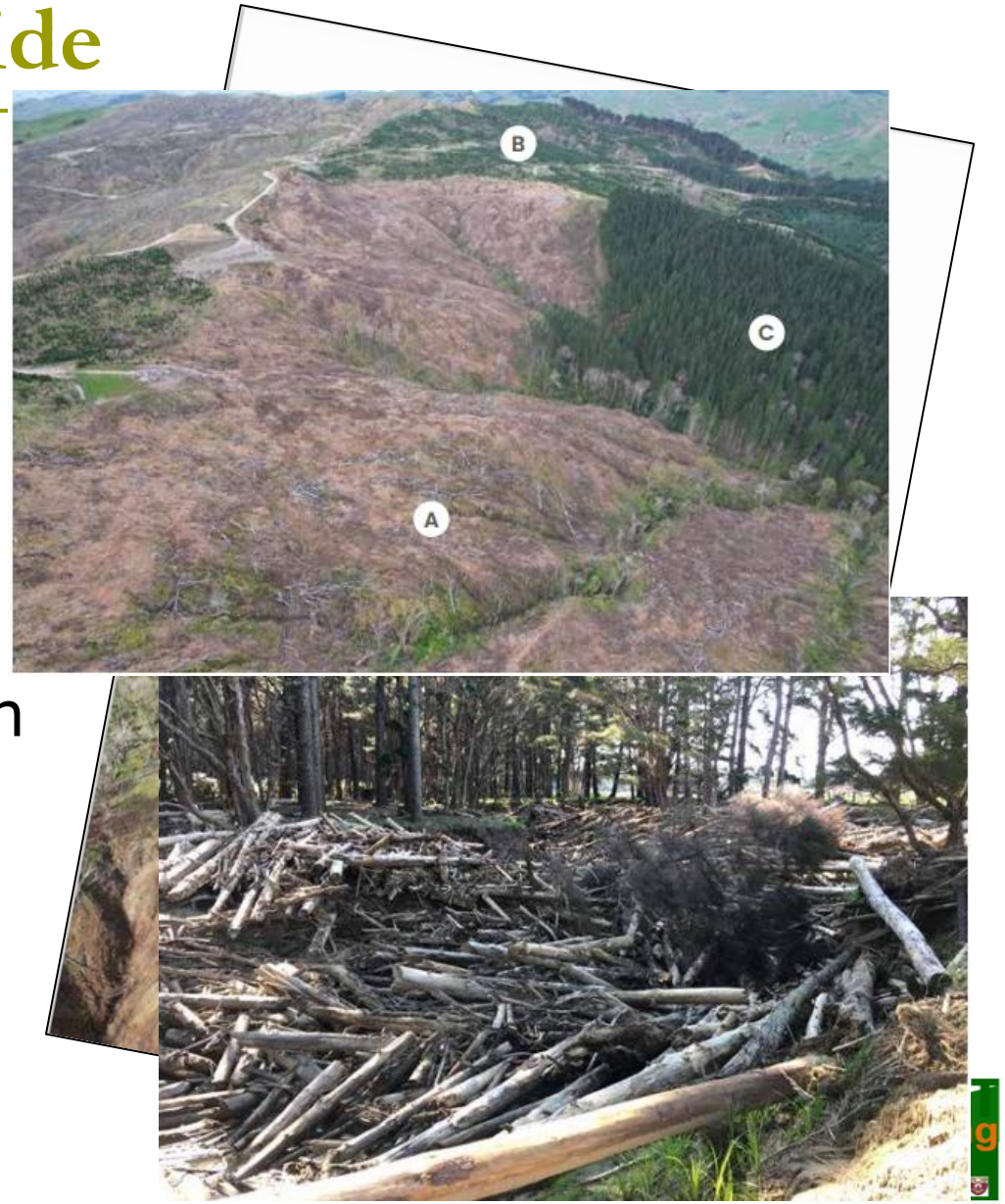
- *Average of the volume surface was 14 m^3/ha*
- *Identified density across landscape features*



BMPs for Catchment Management? Eastland WC - Good Practise Guide

Six step process

1) Evaluating slope stability
2) Managing extent of clearcut
3) Manage harvest residues
   - focus on minimising volume of large woody debris that creates the greatest hazard
4) Leaving mature trees to help trap slash
5) Construct slash traps
6) Consider whether to replant



Design of Debris Slash Traps:
Considerations for NZ Plantation Forestry Operating

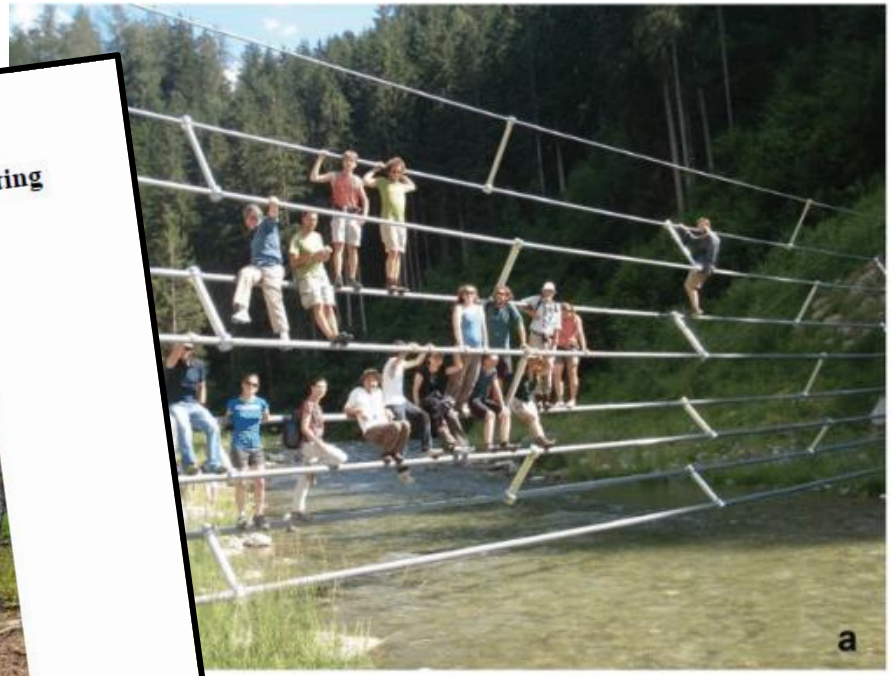
April 2020

Enviro Link Contract

Prepared for:
Dr. Murry Cave, Gisborne Regional Council

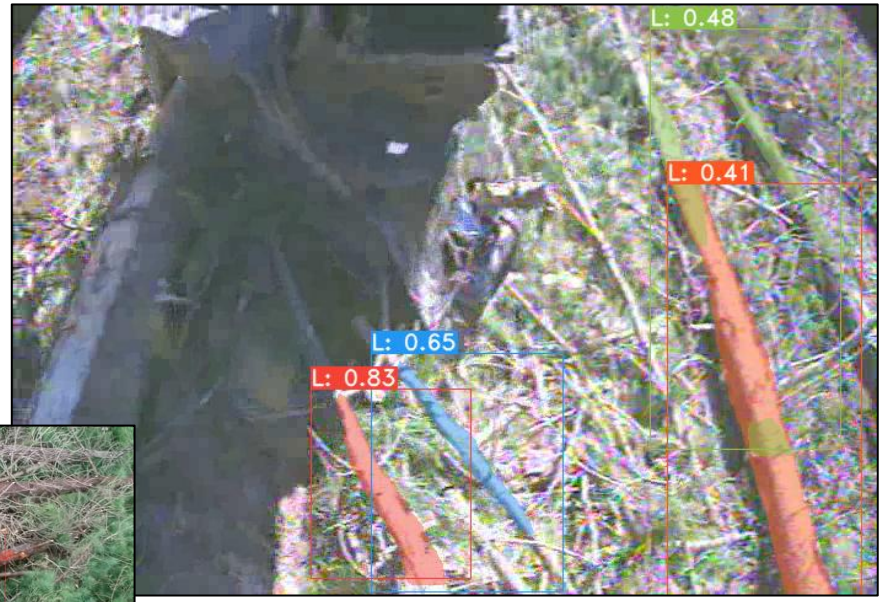
Prepared by: Prof. Rien Visser and Campbell Harvey

School of Forestry, University of Canterbury
Christchurch, NZ



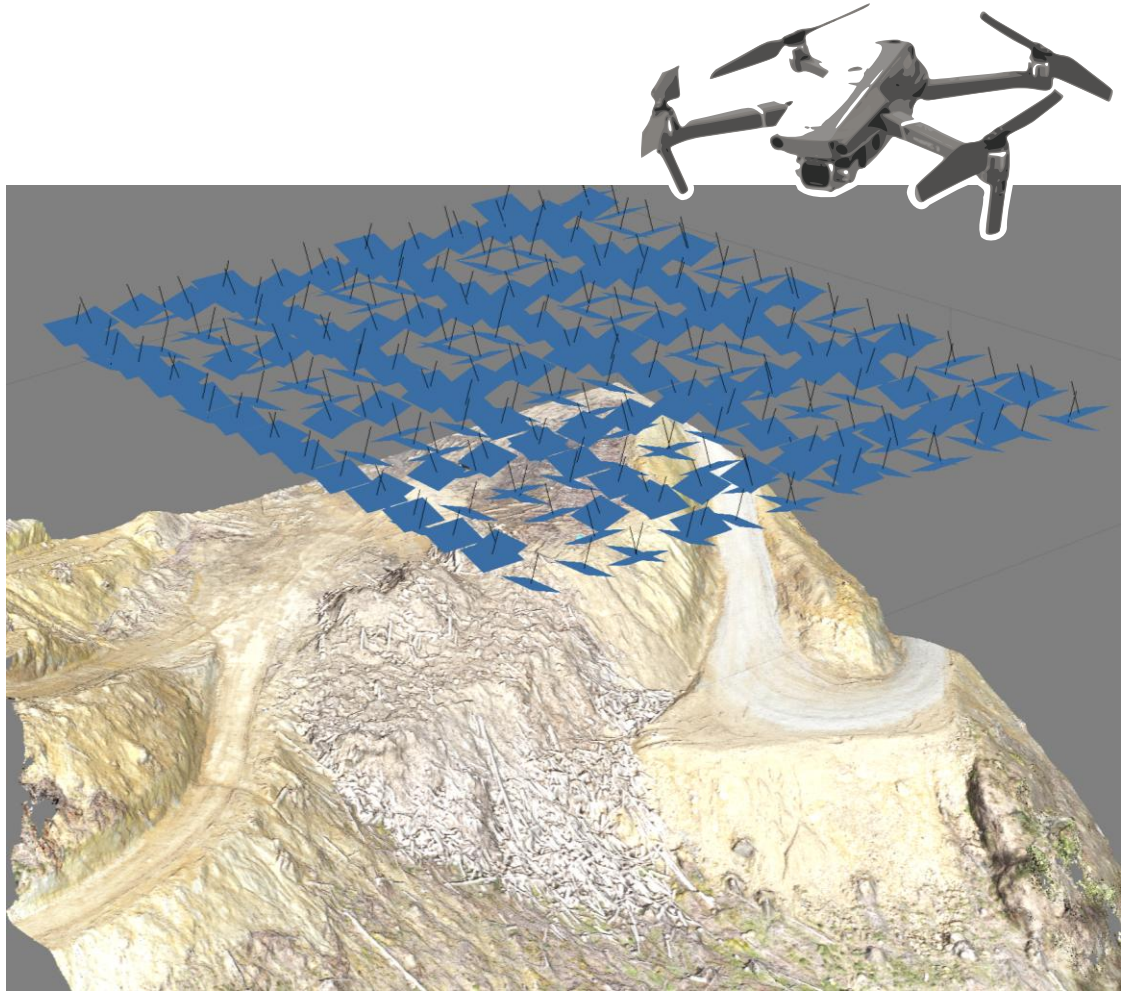
UC Projects:
Grapple Camera & Machine Learning

- Identifies stems from video + geospatial
  → automation of pick stem up

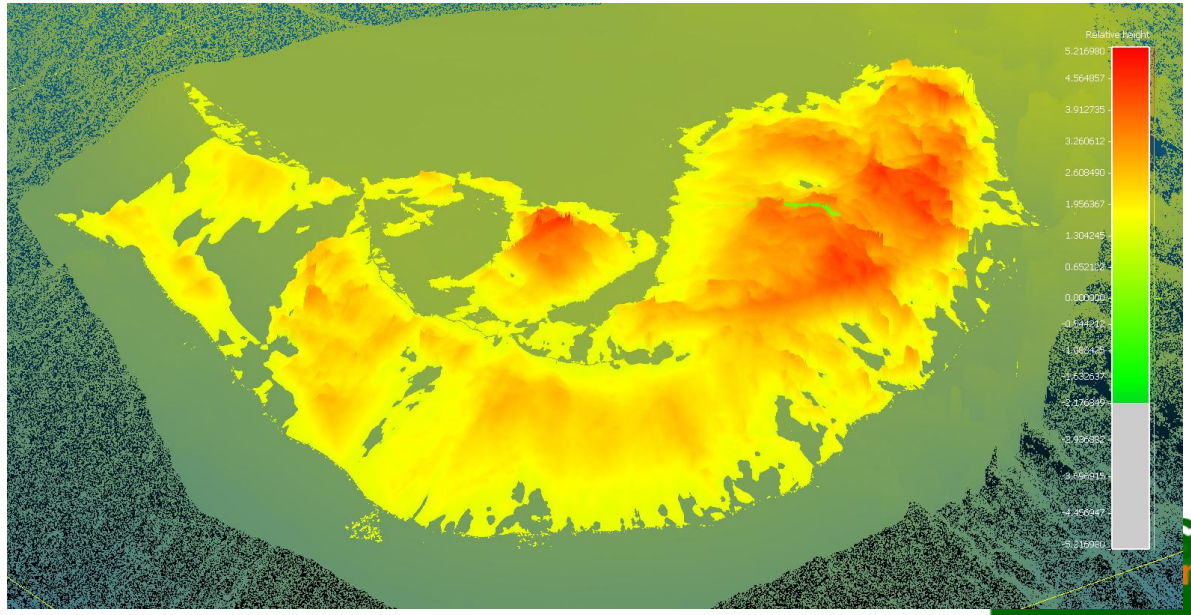


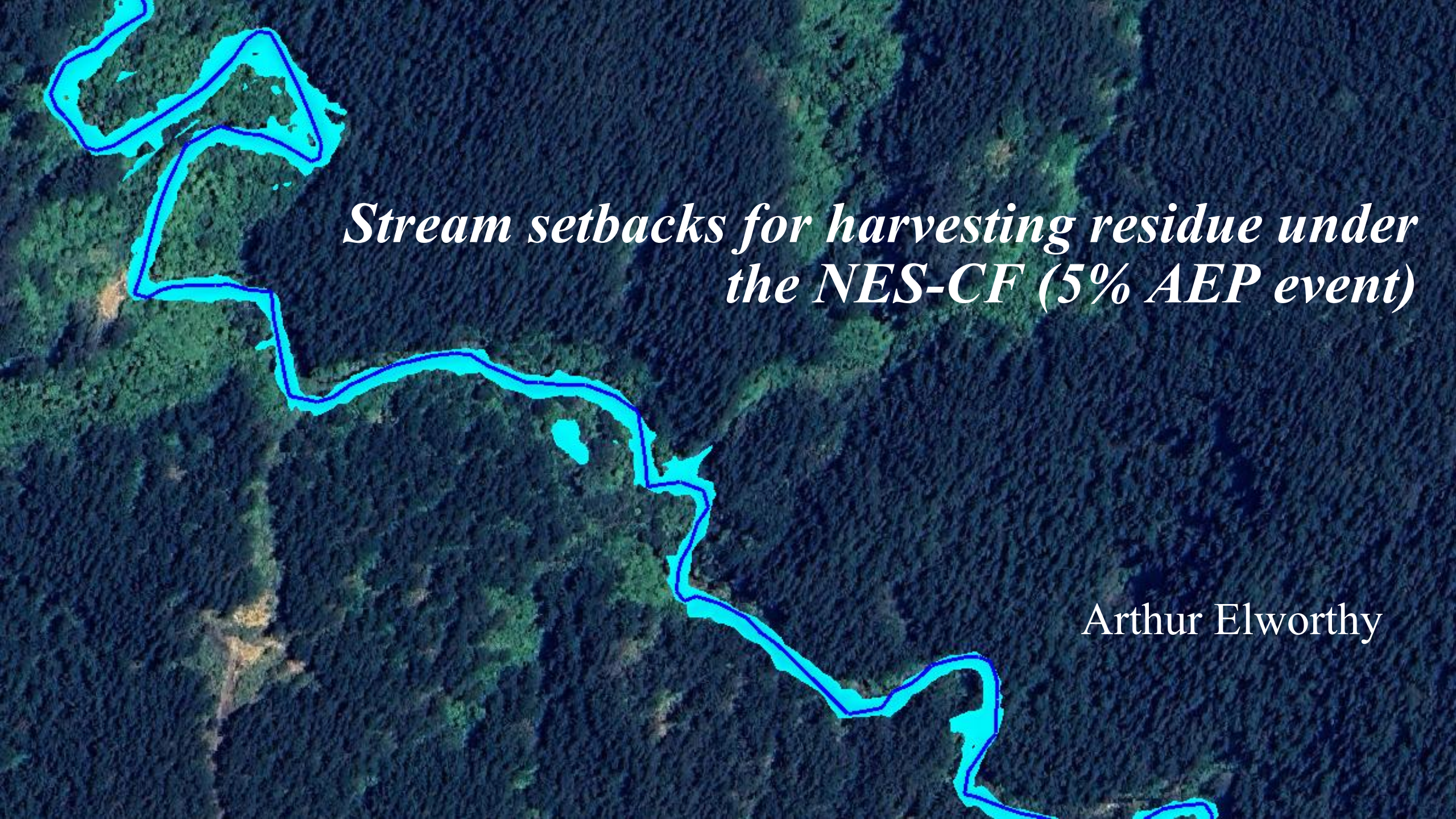
- Set size threshold for residue extraction?

UC Projects: Residue Management – mapping slash piles on landings

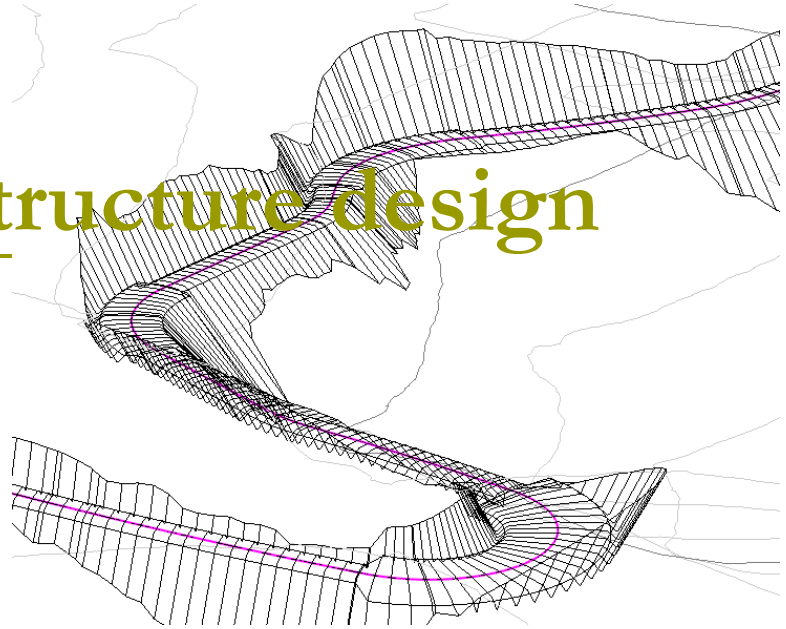


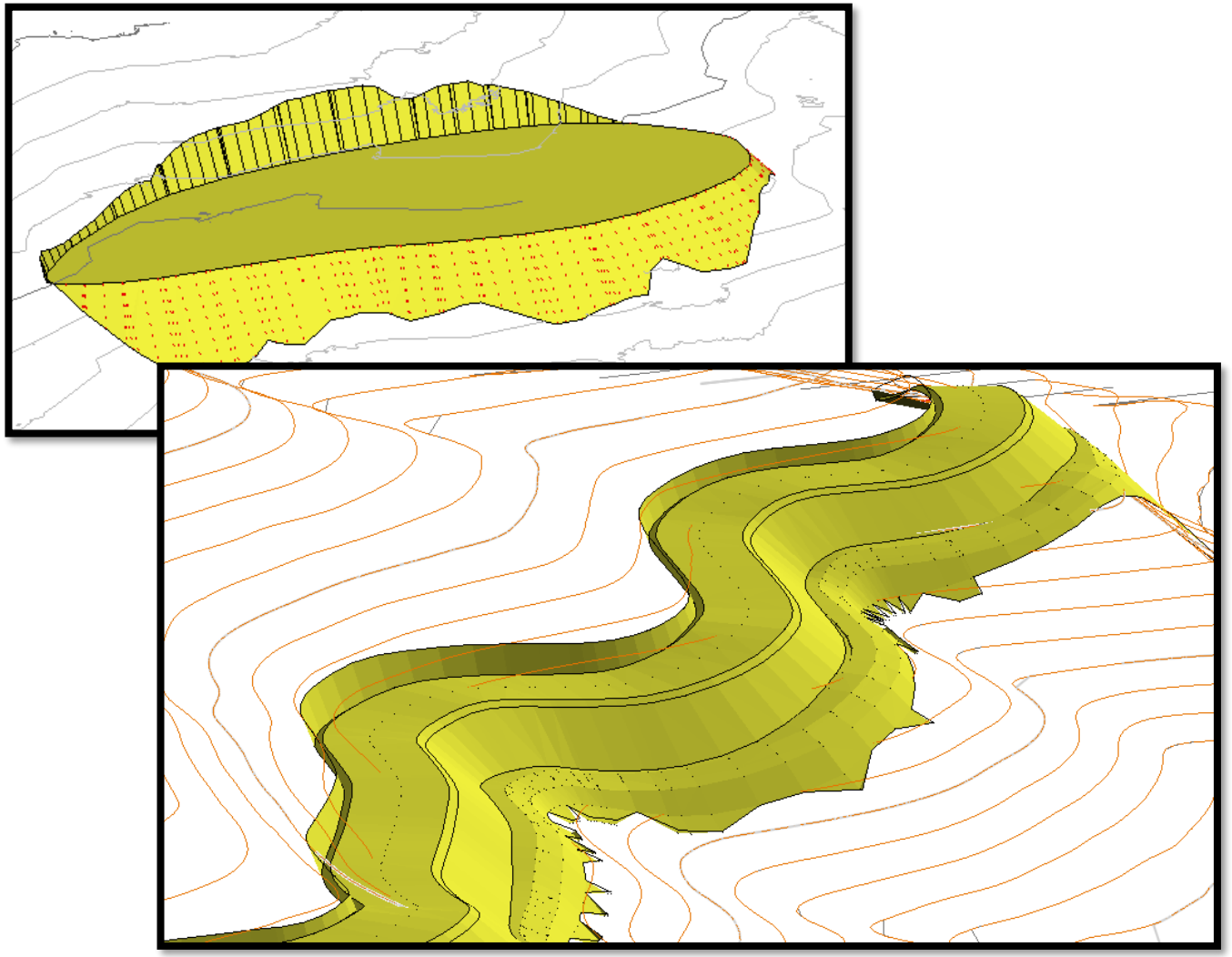
- Bringing high tech to pile measurements at low cost!
- Building capability to self-manage risks, such as pile depth.




Stream setbacks for harvesting residue under the NES-CF (5% AEP event)
Arthur Elworthy

UC Projects (with industry help!)
Advancements with RoadEng - Infrastructure design





- ‘Natural’ landing design
- Benching
- Volume assessments
- Terrain from photogrammetry

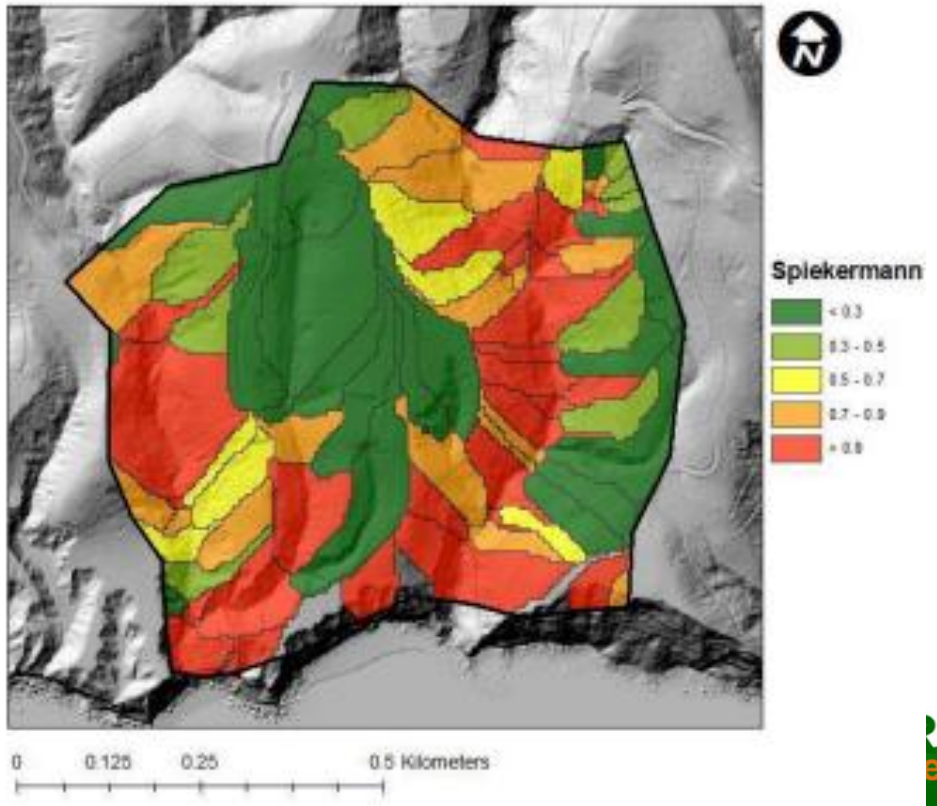
= more informed design, lower impact, better decisions!

AI to solve advanced Forest Eng problems?

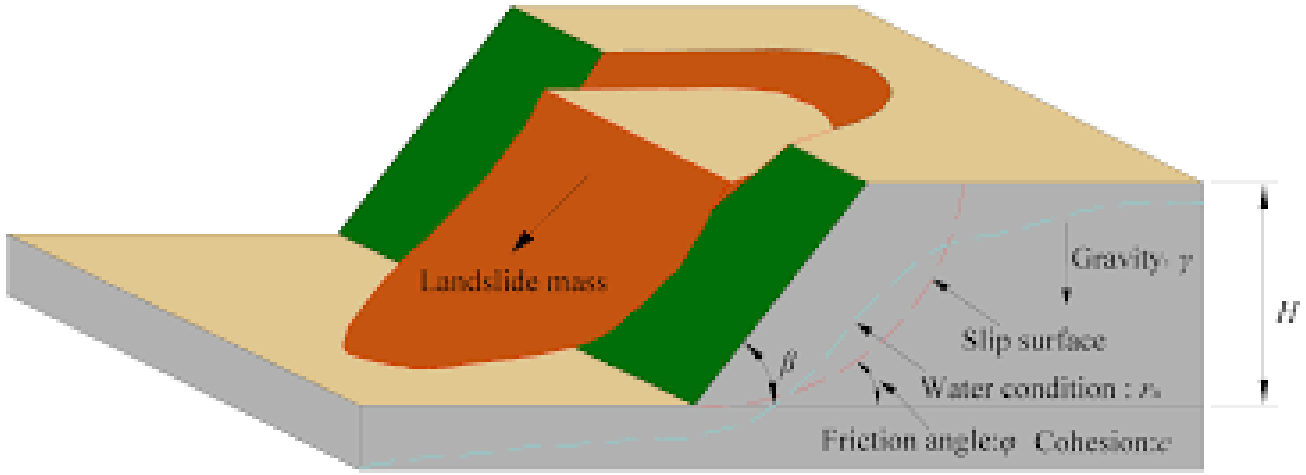
- Can AI improve our current steep slope mgmt. tools?

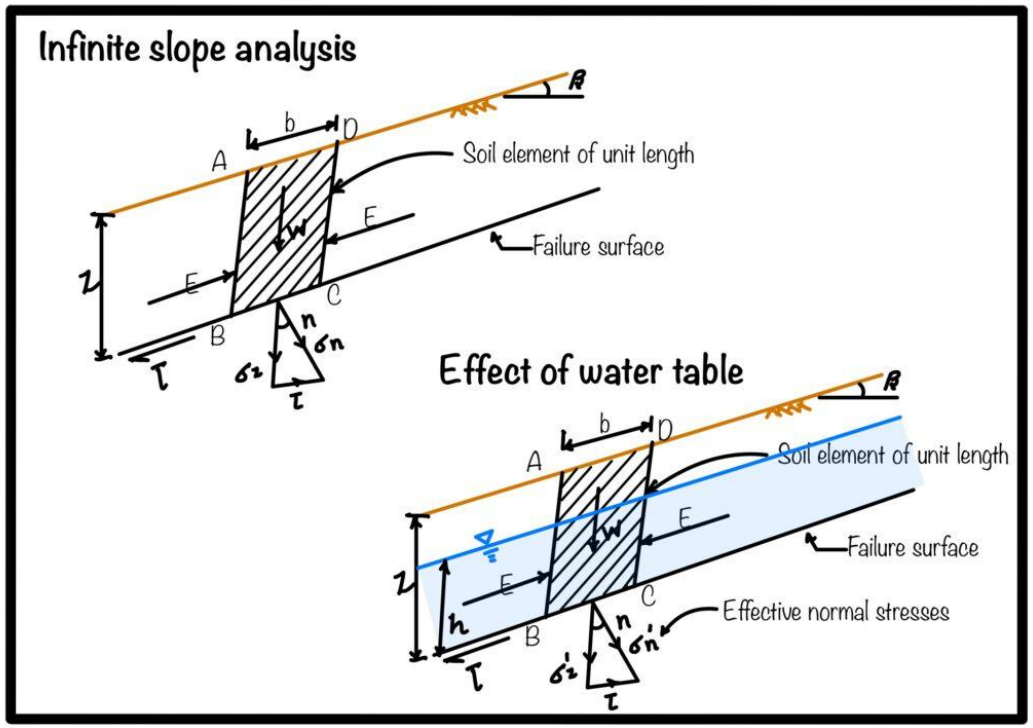
✅ Strength: Can predict landslide-prone areas using GIS and remote sensing data.

⚠️ Limitation : Lacks direct physical constraints—correlation does not always imply causation.



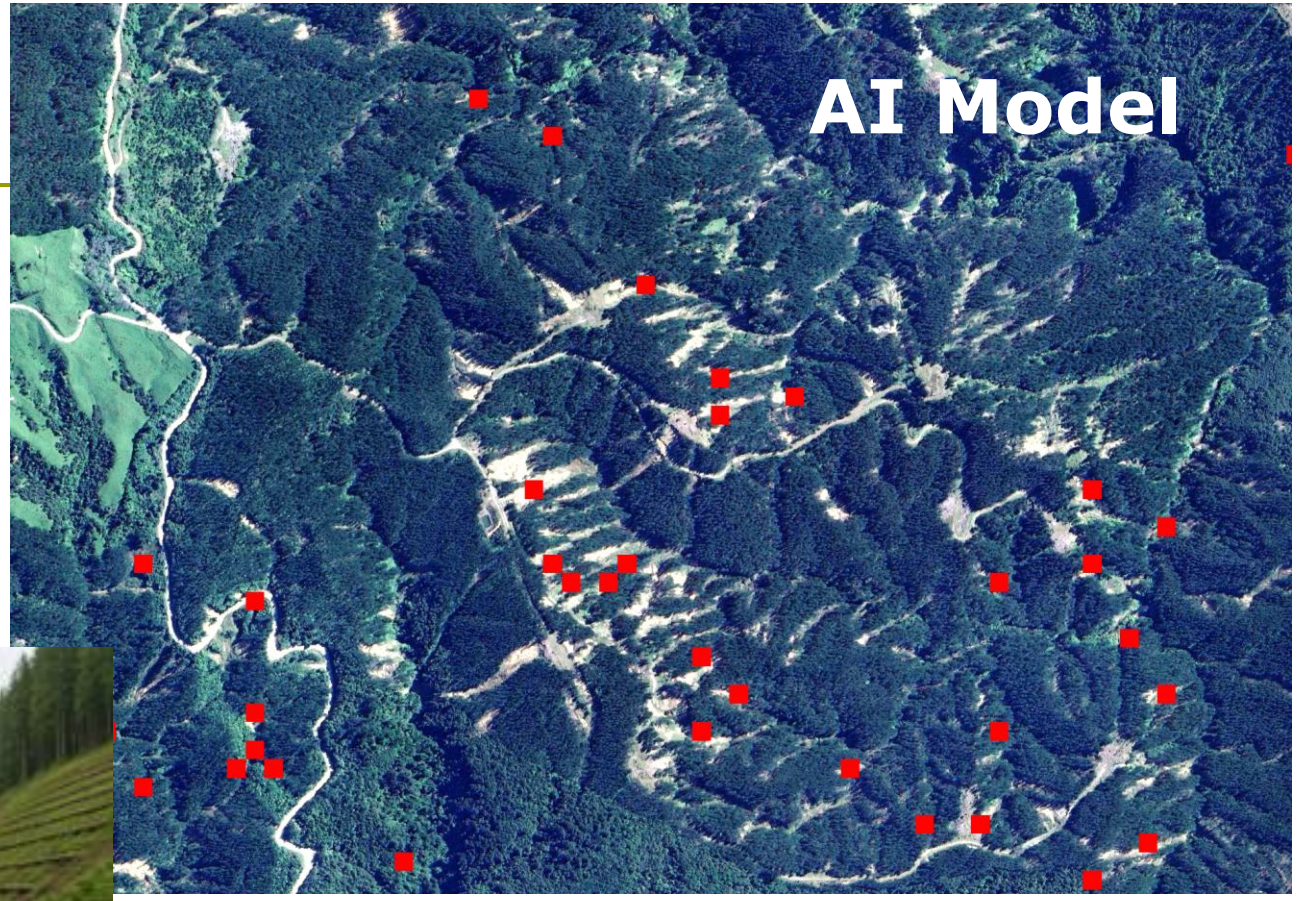
Also have Geotechnical models...





So can AI combine them?

Using AI to support in-field decisions



AI output, combined model showing at risk sites

Conclusions

- Appreciate our level of knowledge
  - (& careful what you ask for!)
- Recommit to BMPs (– i.e. the ECoP)
  - Professional common sense

    based on good science
- Plenty of new technology to support us!
  - Exciting time to be in forestry