Manulife
Investment Management

Erosion risk, adverse weather events and catchment management

Assessing risk

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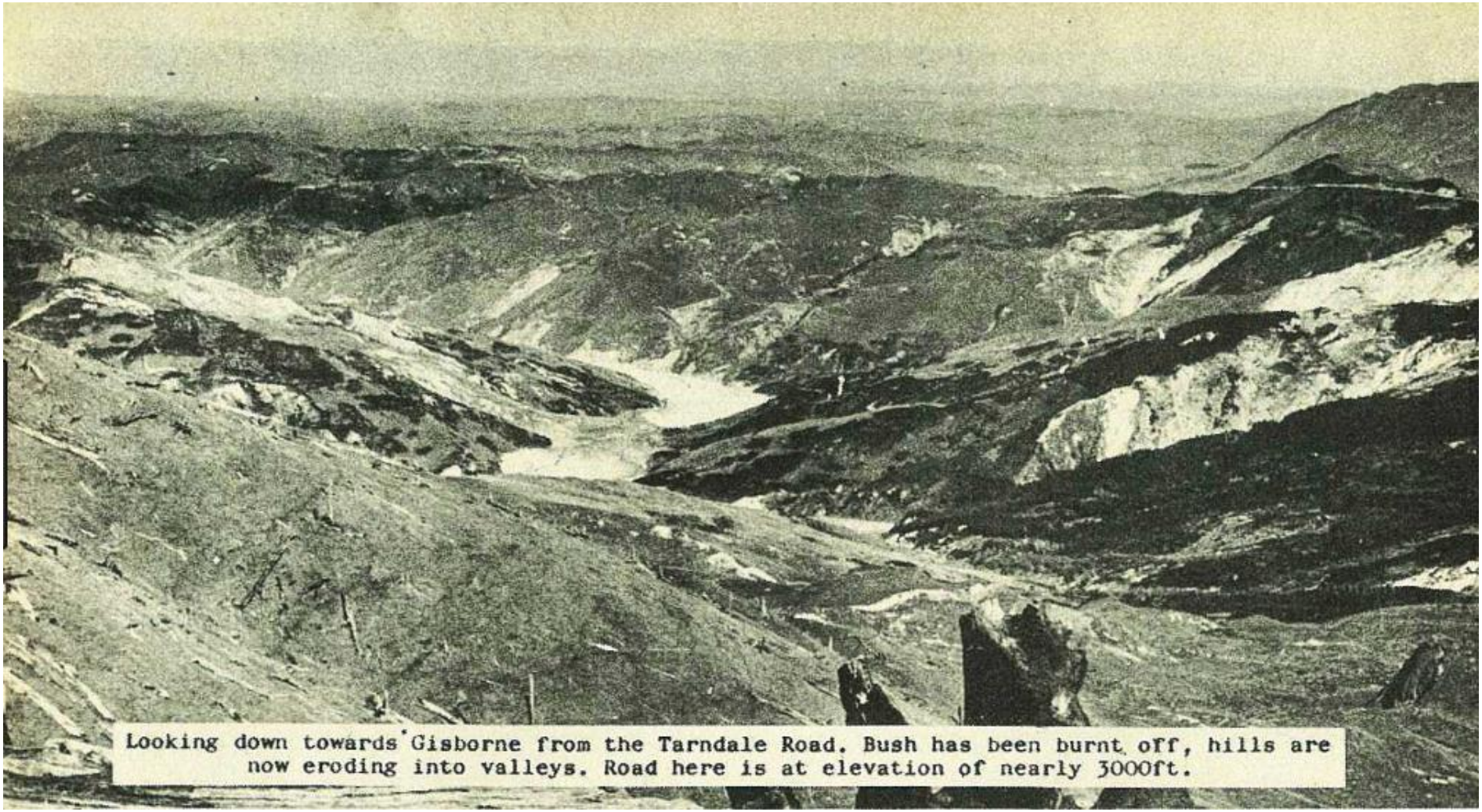
Chair NZFOA Environment Committee

Where it started……



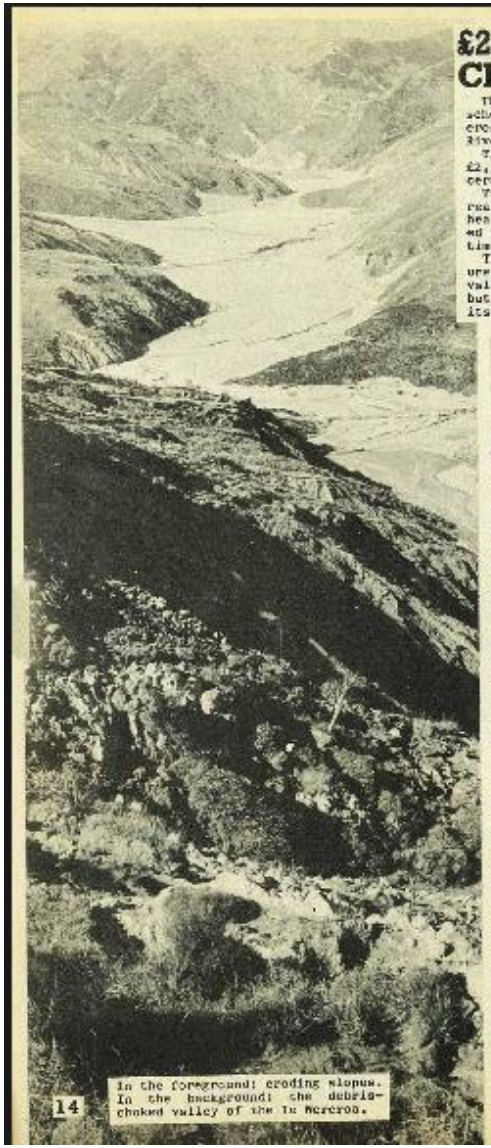
£2,750,000 Scheme To Check Waipaoa Erosion

The Government has decided to proceed with a scheme, estimated to cost £2,750,000, to check erosion in the upper reaches of the Waipaoa River.

The Government's contribution will be about £2,300,000, and that of local authorities concerned will be in the vicinity of £500,000.

The scheme will involve the acquisition and reafforestation of a large area of land in the heart of the catchment area, which was inspected recently by Cabinet ministers, and at the time was illustrated in "Photo News" of May 28.

The scheme will also include remedial measures to check the flow of debris in the river valleys, notably that of the Te Mereroa, a tributary of the Waipaoa, and in the upper Waipaoa itself.



In the foreground: eroding slopes. In the background: the debris-choked valley of the Te Mereroa.

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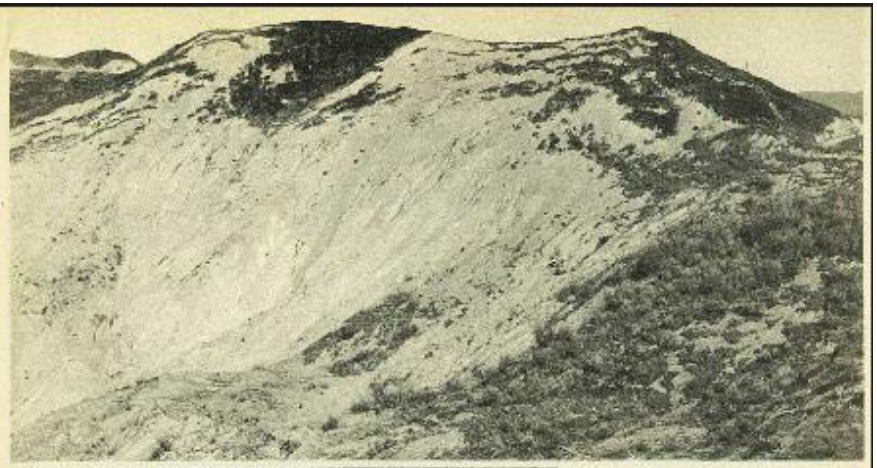
A ministerial party inspecting eroding hillsides in the area. At right, one of the Catchment Board's trial plantings



Above: An example of an eroded hillside adjacent to Tarndale Road.

Left: A notable example of gully erosion in the crushed argillite area.

Below: Reafforestation above this gully has checked erosion, encouraged growth of toi toi and other cover.

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Gisborne Herald August 1959

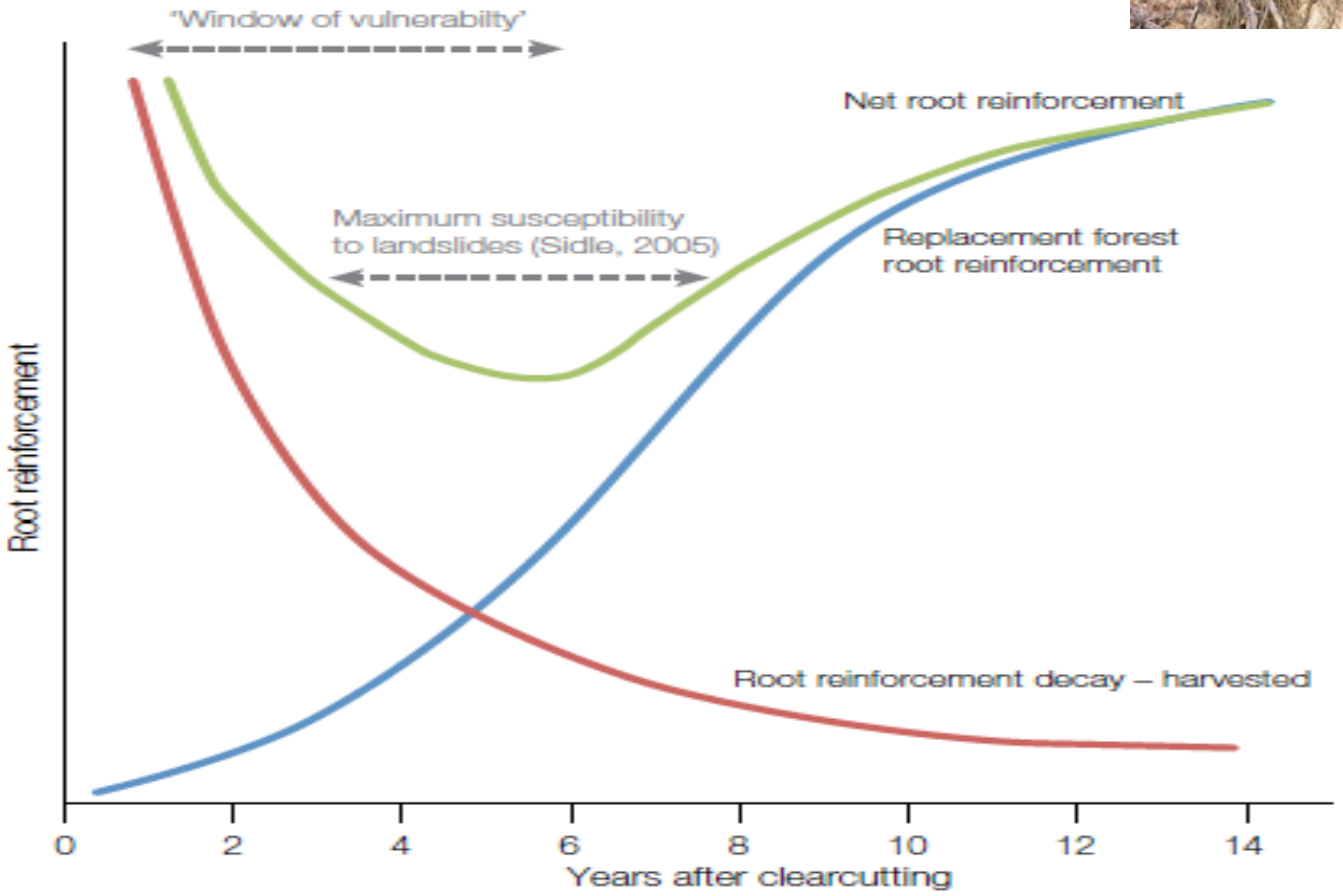
Afforestation initiatives


Tauwharepare catchment
Stuff article Feb 2018
‘30 years on from Cyclone Bola’

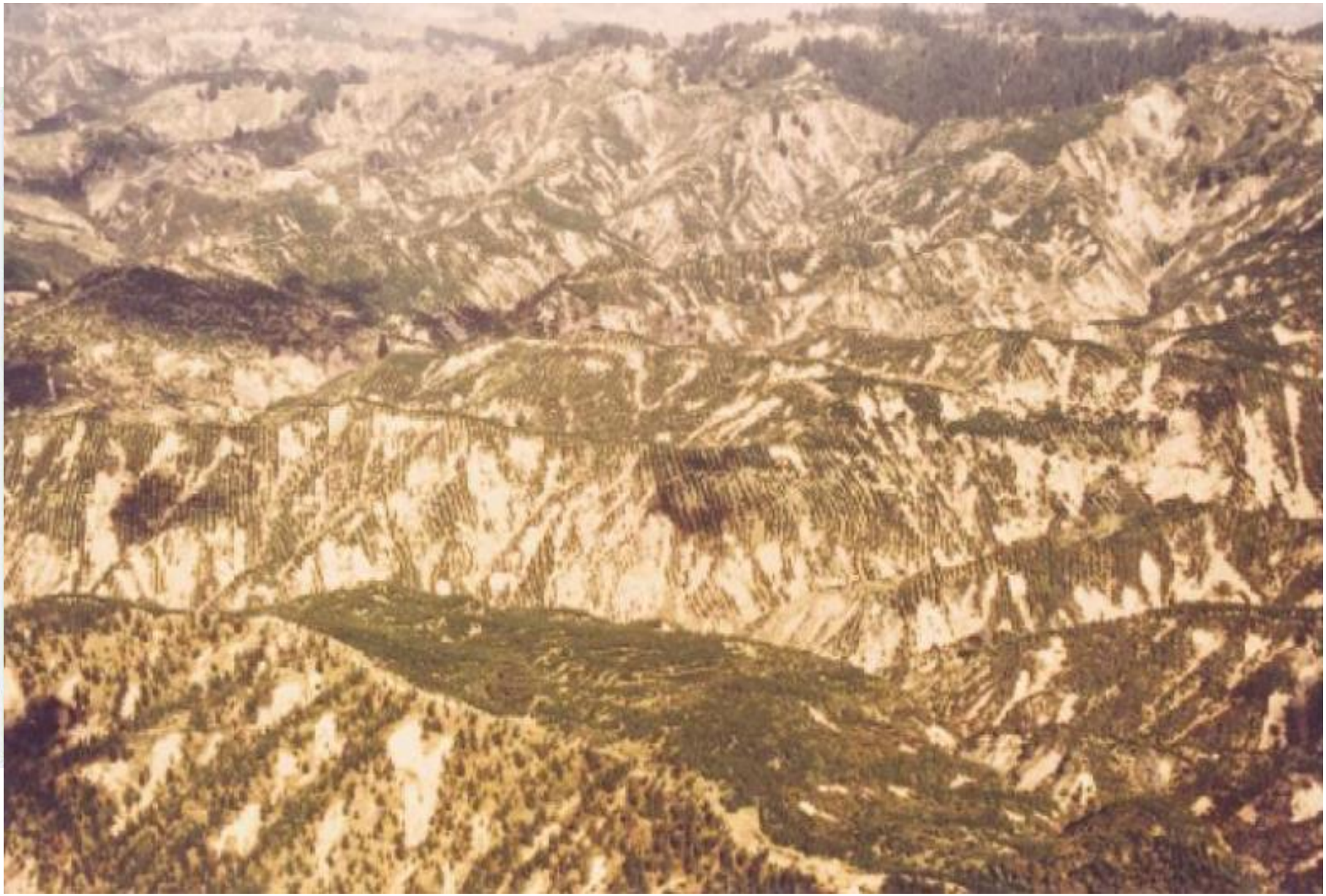
Drivers of erosion

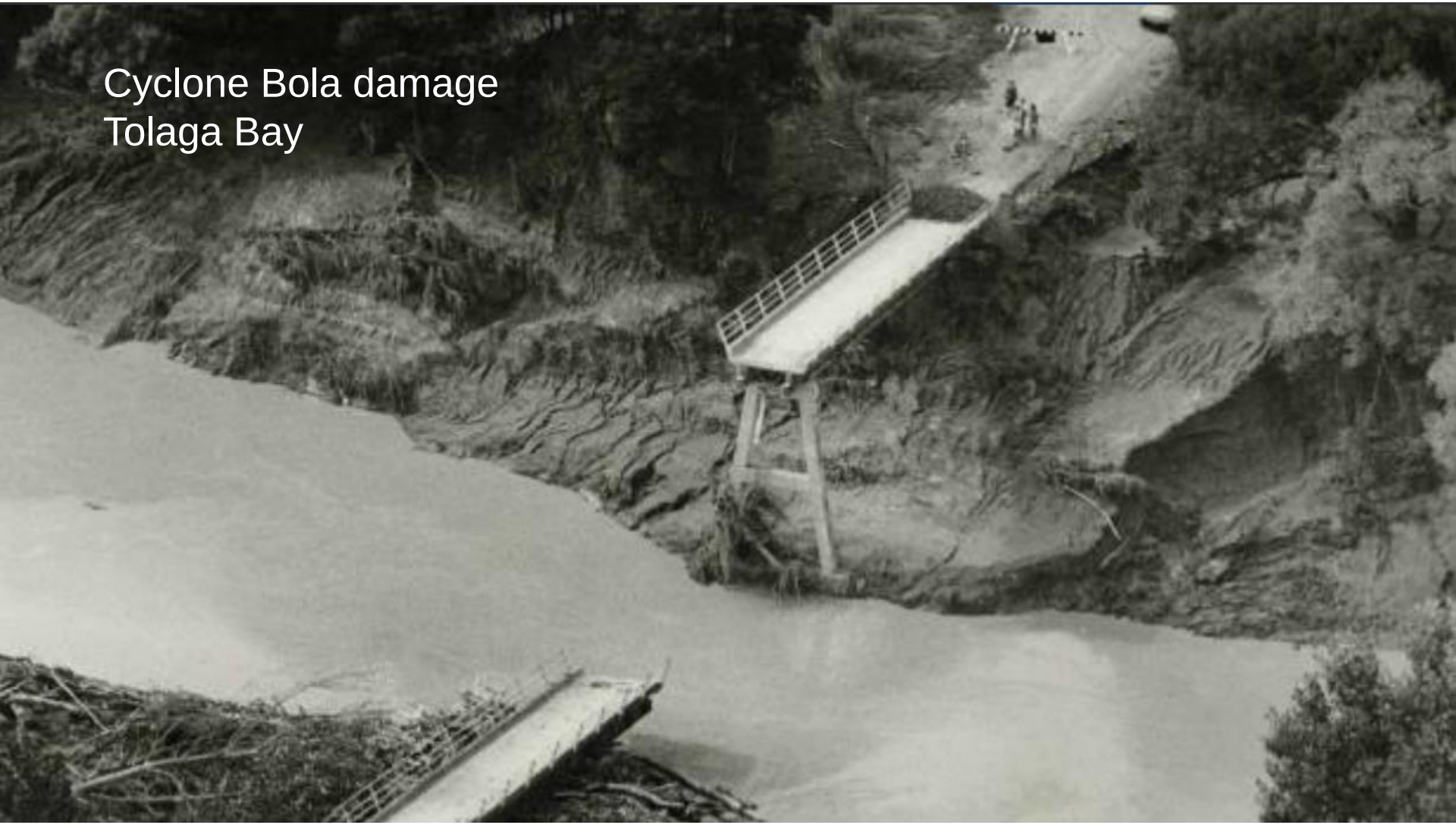
- Climate
- Topography
- Geology
- Vegetation Cover
- Tectonic Activity

The window of risk



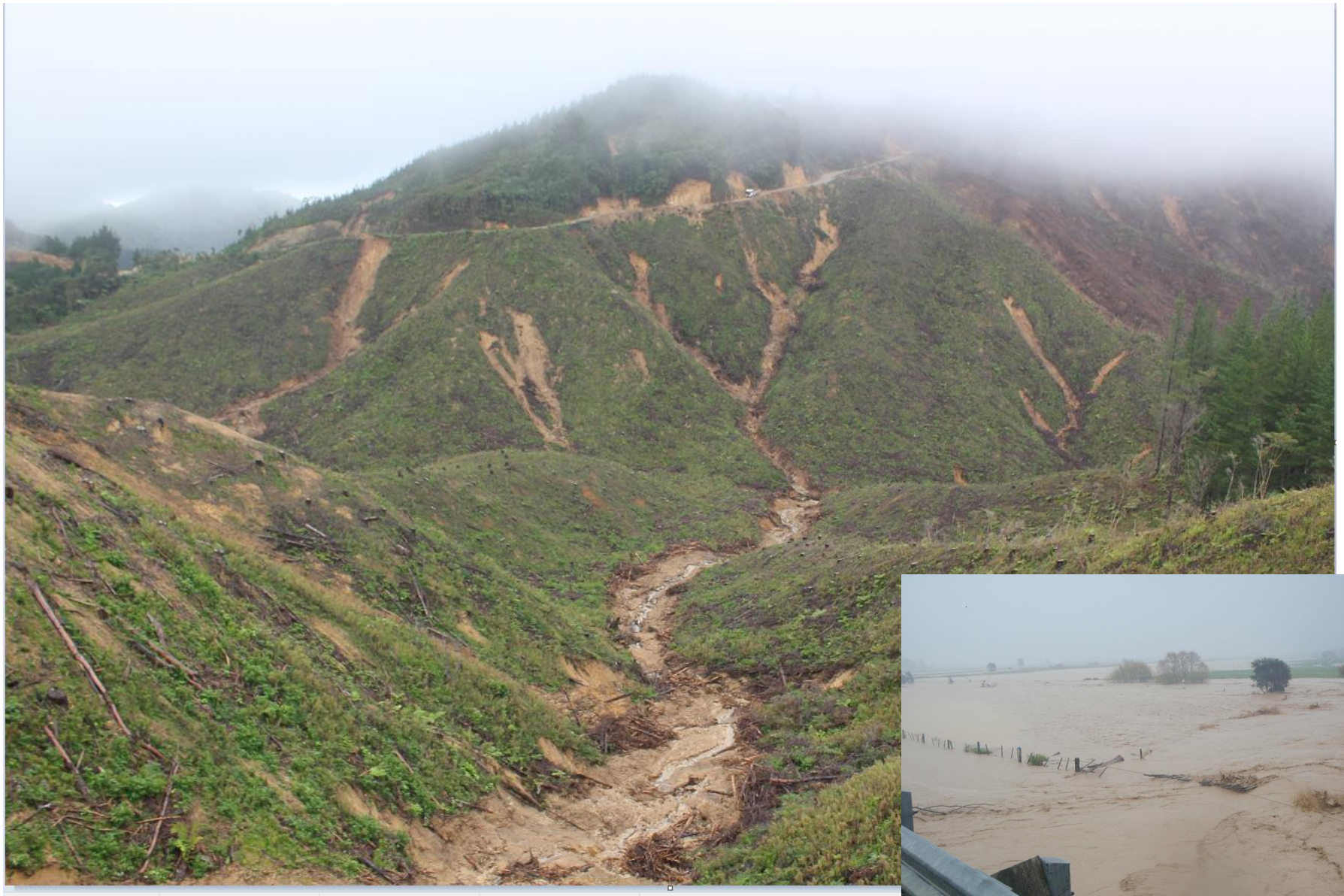
Underlying susceptibility




Cyclone Bola damage
Tolaga Bay

Motueka catchment May 2010 (250mm in 3 days followed by an intense deluge)

Eastern BOP April 2011 (280mm in 24hrs)



Taumarunui - Cyclone Cook April 2017

Kuturere BOP Nov 2021

Eastern BOP Dec 21
(300mm in 24 hours)

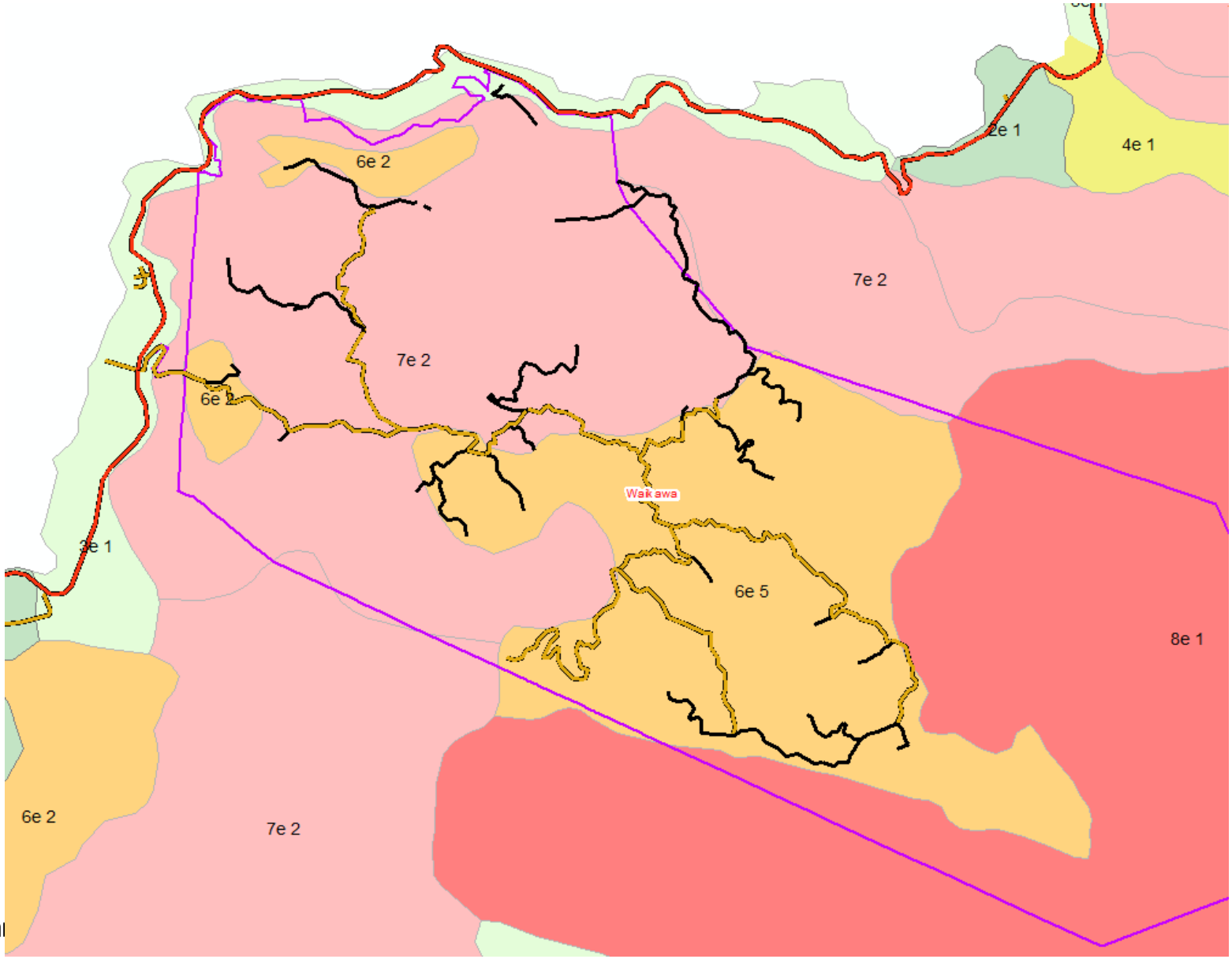
DOC estate

Whataroa Feb 19

Assessing risk

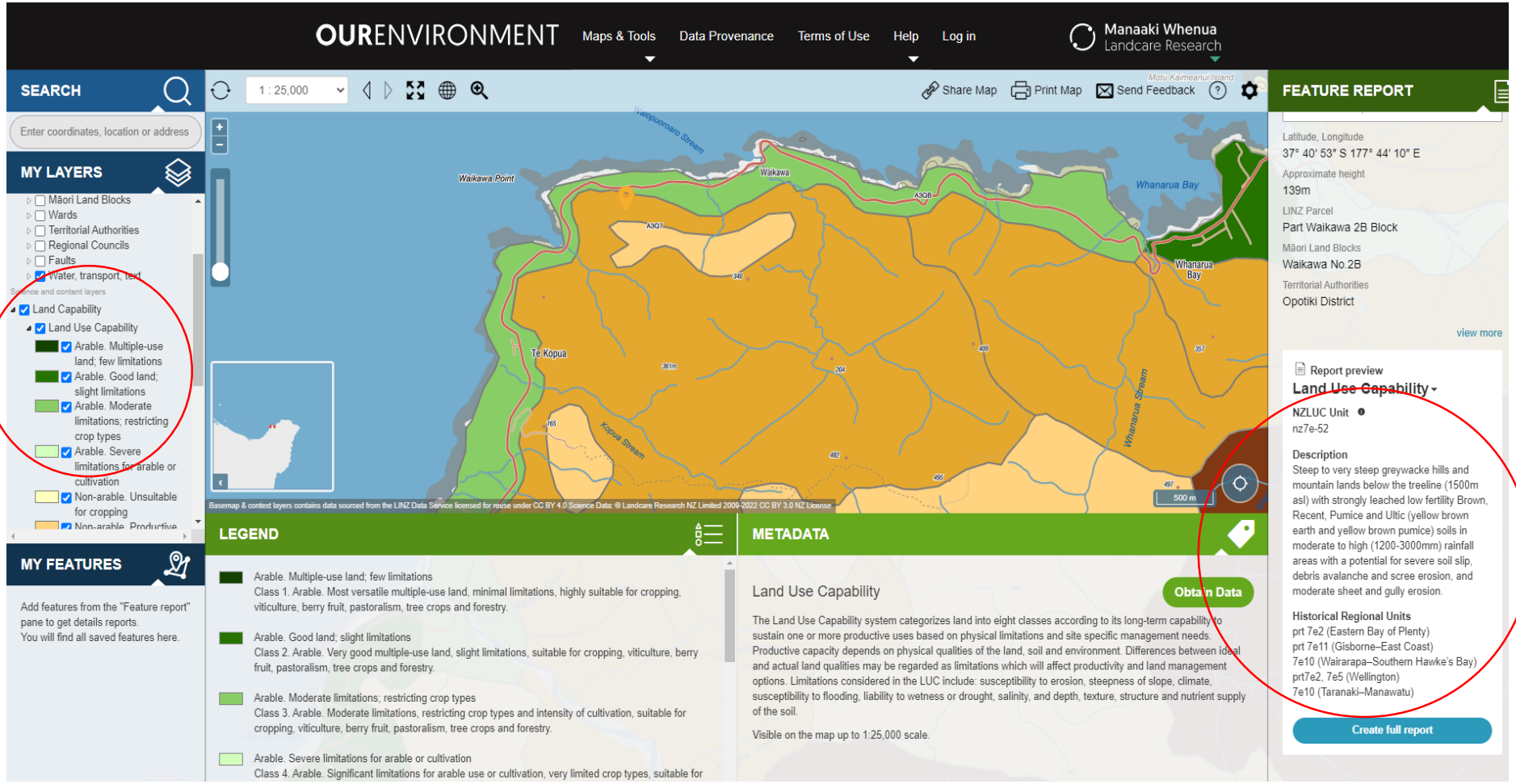
Risk = susceptibility x probability x consequences

NZLRI Land Use Capability (LUC)



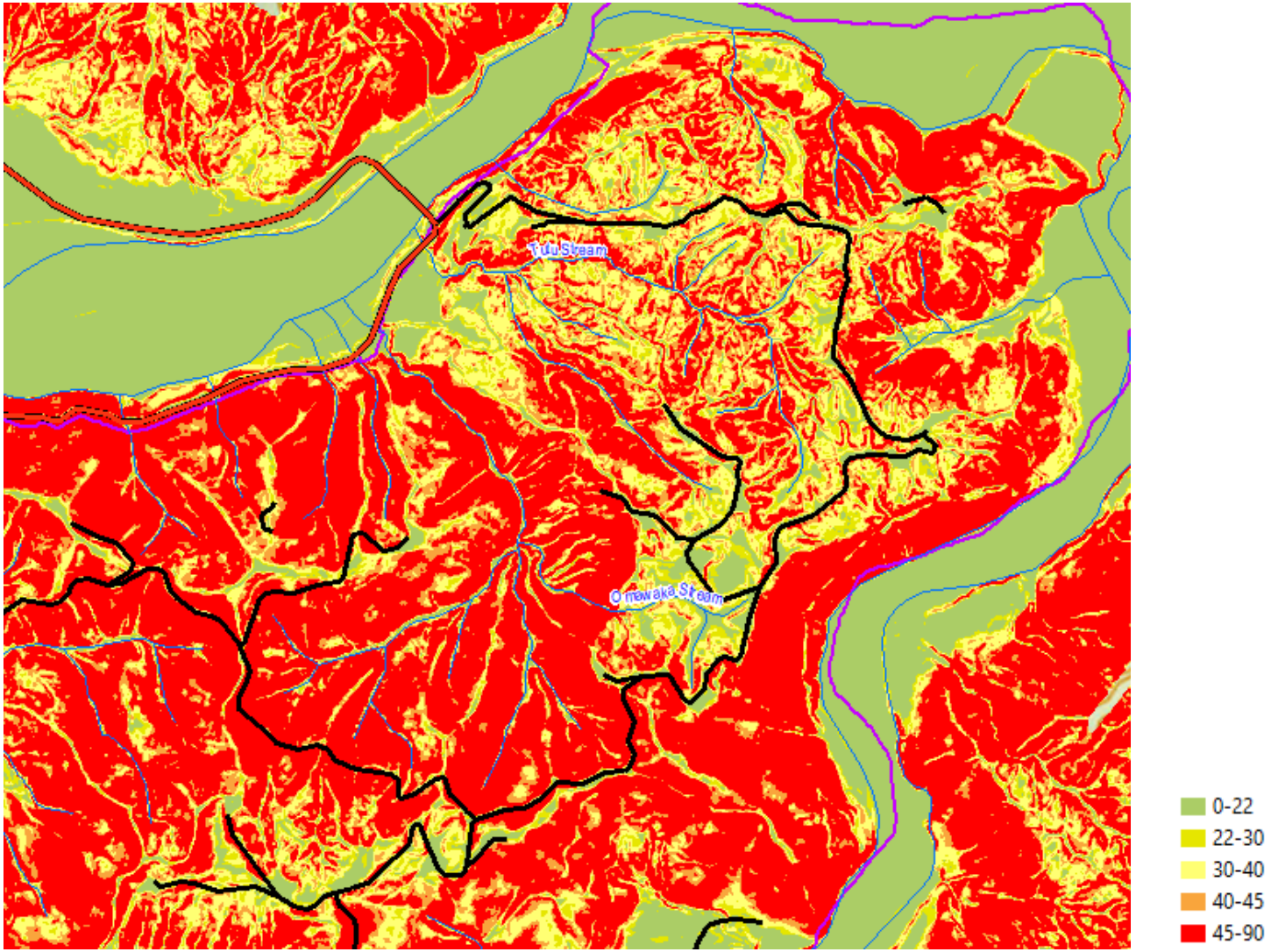
COROMANDEL – GT. BARRIER ISLAND EXTENDED LEGEND (Continued)

UNIT	UNIT DESCRIPTION	LAND USE: PRESENT	LAND USE: POTENTIAL	SLOPE	SURFACE GEOLOGY	x	xx	xxx	SOILS	↑	↑↑	↑↑↑	↑↑↑↑	EROSION: PRESENT	EROSION: POTENTIAL	VEGETATION	TYPE LOCALITY	SOIL CONSERVATION & WATER MANAGEMENT MEASURES	ADDITIONAL COMMENTS
VIIe5	Strongly rolling unstable sand dunes.	Extensive grazing. Erosion control forestry	Erosion control forestry	D + C	Unconsolidated, wind blown dune sands	S	fd	fd	Central yellow-brown sands:					Very severe wind	Extreme wind	Sand dune associations.	N44/310670 Hot Water Beach	Stabilisation of raw sand with marram grass, lupins and erosion control forestry.	
									Pinaki sand, hill soil. Petekuku sand.	6	23aH		2						
VIIe7	Deeply weathered, moderately steep to steep hill country of very low fertility	Reverted native scrub. Erosion control forestry. Extensive grazing.	Erosion control forestry	E + F	Weathered basic andesite	V_2	om	om	Northern brown granular clays:					Very severe sheet, wind, soil slip, and earth slip	Severe sheet, wind, soil slip, and earth slip	Mixed native scrub associations. Lowland hardwood forest. Exotic forest. Low producing pastures.	N30 + N31/ 950345 Claris	Erosion control forestry. Maintenance of native vegetation on areas of high erosion hazard.	Present erosion is a result of past burning and overgrazing which caused severe soil depletion. Pines are difficult to establish due to low soil fertility.
									Mangonui hill soils. Rangiuru hill soils. Korotiti hill complex.	19H 20H	89H 90H		14a, 14b						
VIIe8	Very steep and steep long mountain slopes of the main axial range	Mainly undeveloped. Erosion control forestry	Erosion control forestry	G/F	Weathered greywacke and andesite	SZ E_2	Y-K K-O be	be	Steepland soils related to northern yellow-brown earths and northern brown granular clays:					Severe debris avalanche and scree	Very severe debris avalanche and scree	Kauri forest. Lowland podocarp-hardwood forest. Some mid-altitude podocarp-hardwood forest.	N44/030560 Horomanga	Maintenance of indigenous erosion control forestry.	Unit is subject to high intensity rain storms which cause severe debris avalanche erosion especially on north east facing slopes.
									Te Ranga steepland soils.	22	122b		18						
									Moehau steepland soils.	23	130b								
									Aroha steepland soils Te Kie steepland soils.	25 26	130a 130	A							
VIIe9	Steep and very steep mountain land with many exposed bluffs and rhyolite domes. Very low fertility	Undeveloped. Erosion control forestry	Erosion control forestry	G + F	Weathered ignimbrite and rhyolite	PBV P V_4	wg mr hb	ig mr	Steepland soils related to northern yellow-brown earths:					Severe debris avalanche, soil slip and sheet.	Very severe debris avalanche, soil slip and sheet.	Kauri forest. Manuka. Lowland podocarp-hardwood forest. Some mid-altitude podocarp-hardwood forest.	N49/230340 West of Hikuai Valley Road	Maintenance of indigenous erosion control forestry.	Unit has very poor structured soils, and a high rainfall (2000-2500mm p.a.)
									Tangatara stony and bouldery clay loam. Mt Hobson rocky sandy loam.	24	127b	G	1E						
VIIw	Mangrove swamps	Undeveloped	Extensive grazing	A	Estuarine muds, silts and clays	m	f		Saline soils:					Slight deposition	Slight deposition	Mangroves. Salt tolerant associations.	N44/200570 Whitianga Harbour	Stopbanking and Drainage	Intractable clay subsoils make drainage of this unit difficult.
									Takahiwai peaty sands	5	111c	K							
VIIc	Undulating plateau slopes at 700 m a.s.l.	Undeveloped	Extensive grazing. Erosion control forestry	B	Peat and weathered andesite	E_2	be	be	Unnamed peats					Slight sheet	Slight sheet	Mixed native scrub associations. Swamp associations. Mid-altitude podocarp-hardwood forest.	N49/160370 Table Mountain	Maintenance of native vegetation.	Unit has a high rainfall (2500mm p.a.)
VIIIe1	Coastal foredunes	Extensive grazing	Protection forest	D + C	Unconsolidated wind blown beach and dune sands	S	fd	fd	Drifting sands					Extreme wind	Extreme wind	Sand dune associations.	N30 + N31/ 975355 Kaitoke Beach	Stabilisation of dunes with marram grass, lupins and protection forestry. Rabbit and fire control.	
VIIIe2	Coastal cliffs	Nil	Protection forest	G	Greywacke and volcanic rocks	SZ E_2 V_4 P	Y-K K-O be mr wg	be mr ig	Steepland soils related to northern yellow-brown earths and northern brown granular clays Bare rock	22 23 24 25 26	122b 130b 127b 130a 130	G A		Very severe scree and soil slip	Very severe scree and soil slip	Coastal forest. Manuka.	N30 + N31/ 845558 Miners Head	Maintain vegetation cover	
VIIIe3	Very steep mountain slopes with a severe erosion hazard.	Protection forest	Protection forest	G	Greywacke and and volcanic rocks	SZ E_2 V_4 P	Y-K K-O be mr wg	be mr ig	Steepland soils related northern yellow-brown earths and northern brown granular clays. Bare rock	22 23 24 25 26	122b 130b 127a 130a 130	G A		Severe debris avalance and soil slip	Extreme debris avalanche and soil slip	Kauri forest. Lowland podocarp-hardwood forest. Mixed native scrub associations. Some mid-altitude podocarp-hardwood forest.	N49/220370 "The Pinnacles"	Noxious animal control. Maintain indigenous forest.	Includes areas of steep bluffs and pinnacles. Greywacke areas are more erodible than rhyolite and andesite.
VIIIe4	Very steep mountain lands above 700m a.s.l.	Catchment protection	Catchment protection	G	Greywacke and volcanic rocks	SZ E_2 V_4 P I_2	K-O Y-K be mr wg	be mr ig	Steepland soils related to northern yellow-brown earths and Northern granular clays. Bare rock	22 23 24 25 26	122b 130b 127b 130a 130	G A		Very severe debris avalanche and soil slip	Extreme debris avalanche and soil slip	Subalpine scrub associations. Lowland beech forest. Mid-altitude podocarp-hardwood forest.	N39/890993 Mt Moehau	Noxious animal control. Maintain present vegetation cover.	

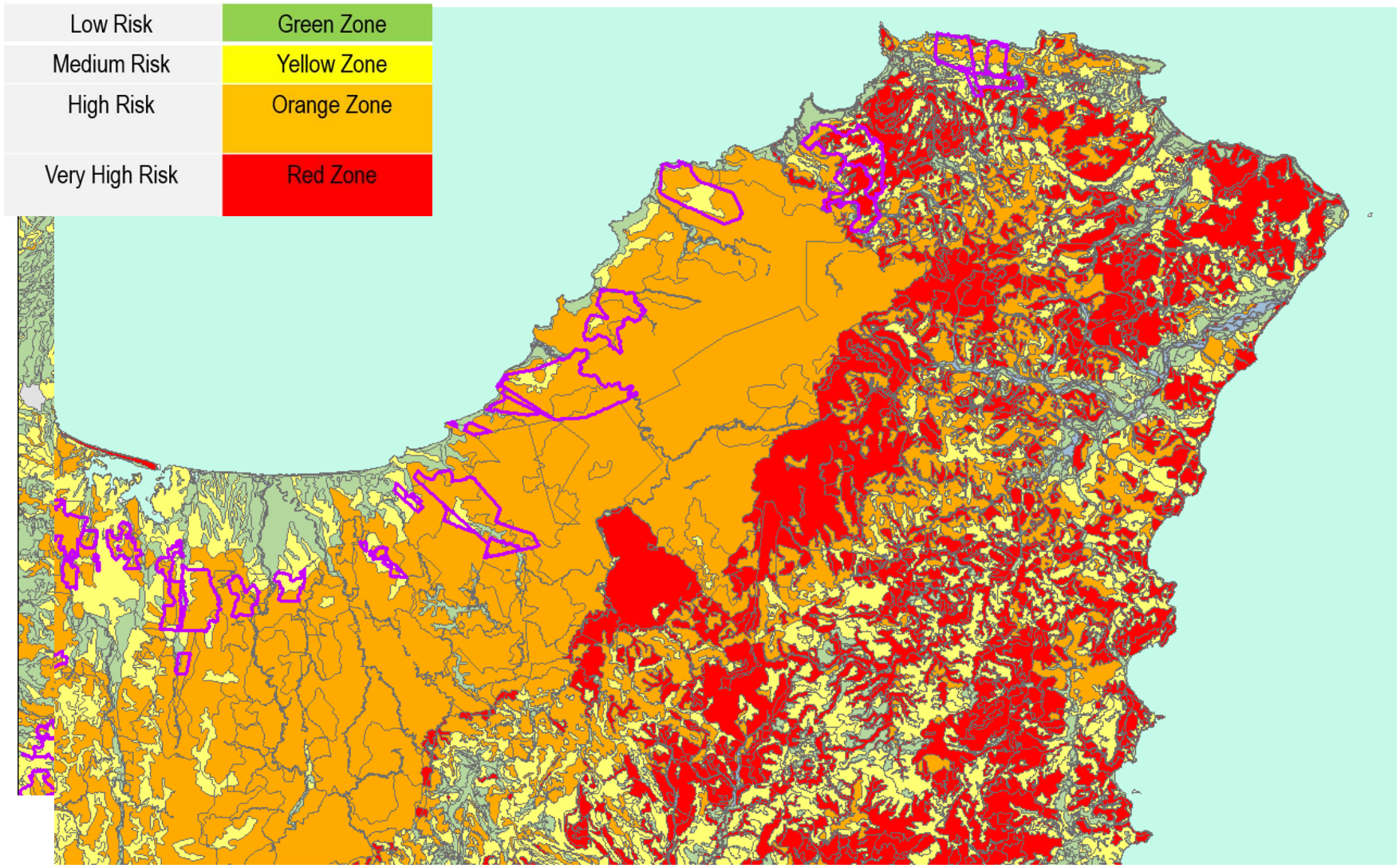


https://ourenvironment.scinfo.org.nz/maps-and-tools/app/Land%20Suitability/lri_luc_main

Slope



NES PF Erosion Susceptibility Classification (ESC)



Connectivity and stream energy

Native riparians / proportion of catchment productive

Downstream risk (consequences)

- Farmland
- Infrastructure
- Public roads, bridges
- Ecologically sensitive areas
- Residential areas
- Beachs

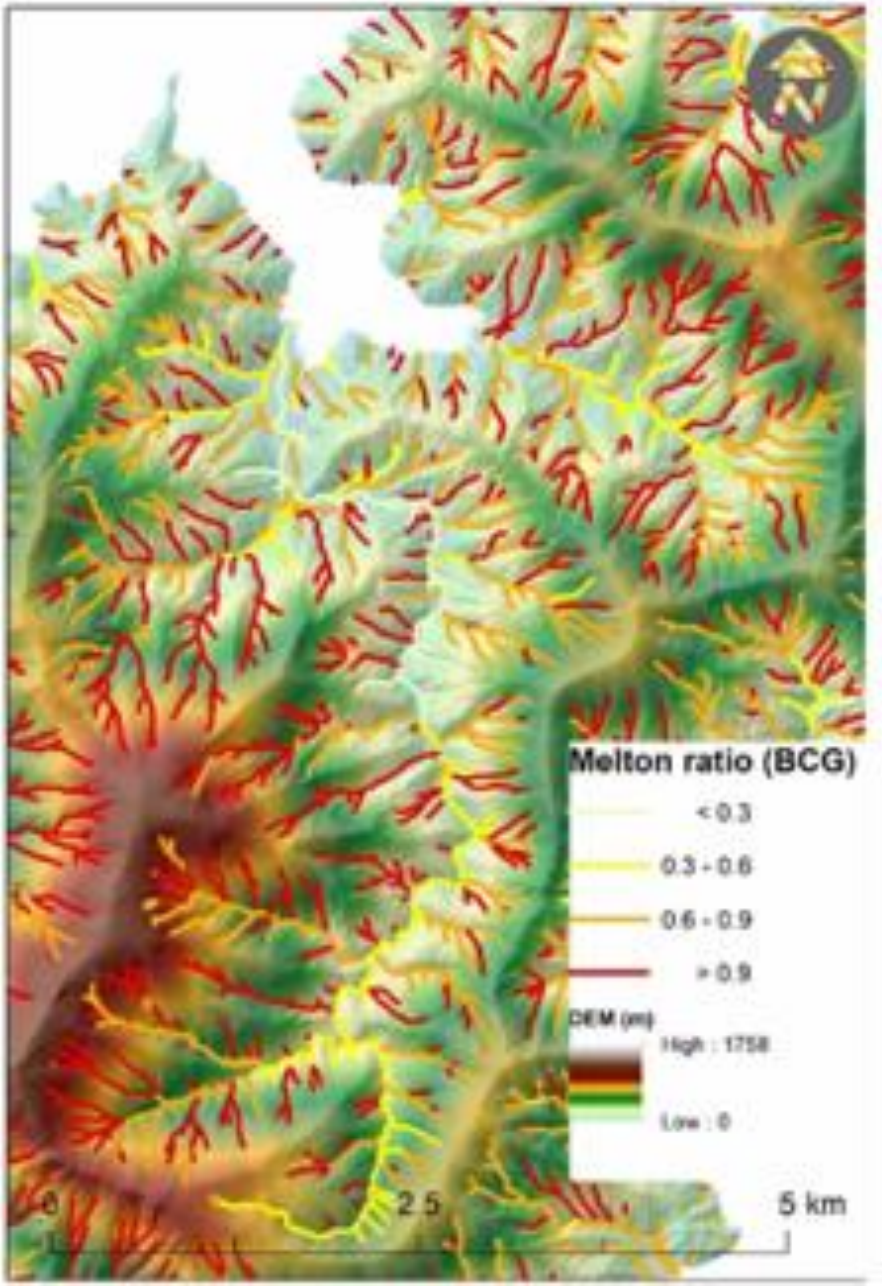
Catchment Risk Assessment

catchment code	ESC	LUC	catchment_description	sediment & erosion risk	slash movement risk	potential_slash_storage	downstream risk factors	catchment	Reason	Clearfall limit Y/N	Clearfall Limit
HKGI007	Moderate	6e7, 6e16 and 6e19	Upper catchment slopes south of Dyers Road. Weathered Tangihua basalt with potential for	Moderate	Low	Native forest	Native forest on neighbouring land	Moderate	Geology and steeper slope	No	
KAIK001	High	6e19	Large third order catchment. Weak thrust fault geology, crushed argillite and melange. Undulating topography. Large pasture and native forest (Motatau) above pine forest, significant riparian	High	Moderate	Meandering waterways with riparian flood plain and multiple crossings.	Patutahi Road and farmland	Moderate	low angle toe slopes along riparian zone. High % steep slope in native	Yes	30% over 6 years
KAIK002	Moderate Hig	6e7+6e19	Four 1st order catchment draining directly to Kaikou river. Catchments are the lower part of a larger plantation area with separate ownership.	High	Moderate	Lower boundary against native riparian forest	Native forest and Kaikou Stream	Moderate	Multiple catchments	No	
KAIK003	High- Modera	6e7+6e16	Weathered Tangihua volcanic thrust over Cretaceous rocks. Upper Quaternary landslides underlie, Paringa and Karamea Roads. Thrust fault boundary.	High	High	Potential for slash discharge onto farmland on Cherry Rd	Cherry Road and valley floor farmland	High	Valley floor offers ability to control slash movement within forest	Yes	50% over 6 years
KAIK004	Moderate	6e2 + small area of 6e16	Third order catchment. Weathered Tangihua volcanics, with well defined valley floors	High	High	Heavy rain events can mobilise slash in this catchment. Ensure slash removal from waterway.	valley bottom farmland	Moderate	large area of native forest in headwaters	Yes	50% over 3 years
KAIK005	Moderate	6e7	Small 1st order catchment	Moderate	Moderate	Valley floor wetland and forest boundary	valley bottom wetland and farmland	Moderate	Geology and short distance to boundary	No	
KAIK006	Moderate	6e7	Small 2nd order catchment with large area of native	Low	Low	Low energy stream possible slash discharge onto farm through boundary.	valley bottom farmland	Low	small production area	No	
KAIK007	High	6e19	Small catchment with native regen	Low	Low	N/A	N/A	Low	all native forest	No	
KRKA001	Moderate	7e1 and 6e2	Small second order catchment flowing into the Tangowahine. Tangihua basalt, 7e1 on upper slope reducing to 6e2 lower slopes and 4e6 valley bottom.	Moderate	Moderate	Slash movement possible but unlikely to leave forest due to lower gradient alluvial floodplain within forest.	Farmland	Moderate	Floodplain in forest offers ability to control debris	No	
KRKA002	High	7e1 and 6e7	Multiple streams first to third order flowing into the Mangakahia River. Western facing steep catchment above Murray road. Lower colluvial slope adjacent to Murray road	Moderate	High	Low gradient but levels can get up quickly during large rain events and move slash onto neighbour, remove slash off floodplain.	Murray Road	Moderate	significant collegial slope between high risk and stream	Yes	
KRKA003	High	6e16 and 6e2	Two main catchments draining off deeply weathed tangihua volcanic hillcountry.	Moderate	Moderate	Barrier Road culverts and small wetlands above forest boundary	Marae adjacent to Te Maire Stream	Moderate	Slash and flood mitigation in valley wetlands	No	
			Four tributaries of Mangakahia. Tangihua basalt. Numerous small, steep catchments. 6e16 on upper			Internal forest wetlands above and below Barrier Road. Low gradient but levels can get up quickly during large	Farmland immediately		Floodplain above		

Melton Ratio

- Catchment relief ratio
- **Melton ratio = H / √ A**
- H= watershed relief (elevation difference top to bottom)
- A = watershed area

Melton Ratio	Debris flow susceptibility
<0.3	While debris flows are unlikely to occur they cannot be ruled out.
0.3-0.6	It is fairly likely that debris flows can occur
>0.6	It is very likely that debris flows can occur



Landcare Research

Risk Matrix for storm initiated landslides (Gisborne Region)

Likelihood of Landslides entering streams	Susceptibility: Geology, slope & channel factors			Rainfall/probability	Observed Frequency	
	Hard rocks	Soft rocks	Tephra mantled HC			
	Majority of slopes >35 Connected to high convegance channel Melton ratio >0.6 No floodplain or option to mitigate	Majority of slopes >30 Connected to high convegance channel Melton ratio >0.6 No floodplain or option to mitigate	Majority of slopes >25 Connected to high convegance channel Melton ratio >0.6 Change of slope convex to concave common No floodplain or option to mitigate	> 30mm/hr intensities AEP less than 0.1 > 130mm /24hr, AEP less than 0.1 OR specific locations in region	Has occurred at more than once in last 5-10 years	*Almost certain*
	Majority of slopes 25 to 35° Connected to high convegance channel Melton ratio >0.6	Majority of slopes 20 to 30° Connected to high convegance channel Melton ratio >0.6	Majority of slopes > 25° Connected to high convegance channel Melton ratio >0.6	> 30mm/hr intensities AEP less than 0.1 > 130mm /24hr, AEP less than 0.1 OR specific locations in region	Has occurred but no more than once in last 15 years	*Likely*
	Majority of Slopes 20-25° Not connected to high convegance channel Melton Ratio 0.3-0.6	Majority of slopes 20 to 30° Not connected to high convegance channel MR 0.3-0.6	Majority of slopes < 20° Not connected to high convegance channel MR 0.3-0.6	> 30mm/hr intensities AEP less than 0.1 > 130mm /24hr, AEP less than 0.1 OR specific locations in region	Records or local knowledge indicates an occurrence in last 30 years	*Unlikely*
	Majority of Slopes <20° Not connected to high convegance channel MR 0.3-0.6	Majority of Slopes <20 Not connected to high convegance channel MR 0.3-0.6	Majority of Slopes <20 Not connected to high convegance channel MR 0.3-0.6	> 30mm/hr intensities AEP less than 0.1 > 130mm /24hr, AEP less than 0.1 OR specific locations in region	No record of it having ever occurred in last 50 years	*Rare*

Figure A3 Screen shot of the susceptibility factors leading to the likelihood rating

	Consequence of landslides (entering streams) --> debris flows				
People	No roads or buildings on floodplain < 5 km below site No-one affected	Rarely used (< monthly) access tracks or buildings exist on floodplain < 5km below site Minor inconvenience to a few people	Infrequently used (< weekly) access tracks or buildings exist on floodplain < 5 km below site Inconvenience to a few people Low potential for injury -first aid treatment	Regularly used (daily) tracks or buildings exist on floodplain <5km below site Inconvenience to several people Moderate Injury potential – treatment by medical practitioner	Dwellings directly below site without reliable mitigations (barriers) High risk of major injury or fatality
Property (buildings, bridges)	No roads or buildings in floodplain < 5km below the site: Nothing affected	< 2 properties below ALL sites within the catchment to be harvested over 4 yr period AND only fence lines and farm tracks likely to be affected Public roads not impacted	< 5 properties below ALL sites within the catchment to be harvested over 4 yr period AND bridges and farm buildings possibly affected Public roads unlikely to be impacted	>5 properties below ALL sites within the catchment to be harvested over 4 yr period AND bridges, roads and farm buildings likely to be affected Public roads likely to be impacted	Presence of buildings or infrastructure directly below the site with no reliable mitigation available: significant potential damage Public roads closed
Ecology	No soil or debris from the site has potential to directly enter streams or marine environment	Soil and debris from the site could directly enter a stream or receiving environment Low level of impact on channel or receiving environment	Soil and debris from the site could directly enter a permanent stream or receiving environment Moderate level of impact on channel or receiving environment	Soil and debris from the site could directly enter a high value stream or receiving environment High level of impact on stream or receiving environment	High value receiving environments directly below the site where ecological loss is reasonably expected to occur (dead fish, major impacts on bed of stream or sea)
Economics	Only routine maintenance within forest required <NZD$10,000 clean up costs No Legal liability	Routine maintenance within forest required >NZD$10,000 clean up costs No Legal liability	Some action taken to assist clean up outside of forest >NZD$10,000 clean up costs No Legal liability	Targeted actions taken to clean up within and outside of forest >NZD$50,000 clean up costs Legal liability moderate	Significant contribution to clean up costs Potential for > NZD $250,000 of offsite damages Legal liability high
Reputation	Nothing visible from neighbours or public (contained within forest	A few landslides visible to public and no debris flows (contained within forest) Unlikely to trigger an internal incident report	Numerous visible landslides and occasional debris flows across private land Triggers internal incident report Some reputational risk	Widespread visible landslides and several debris flows across public or private land EMS triggered Neighbour/council response Moderate reputational risk	Consequence of landslides/debris flows at this location is likely to generate Regional concern and adverse media High reputational risk
Archaelogical/cultural	No archaeological or cultural sites of significance present Impacts on mauri low	Unknown archaeological or cultural sites of significance present Impacts on mauri low	Presence of cultural sites of significance directly below site with reliable means of mitigation available Potential impacts on mauri	Presence of cultural sites of significance directly below site with some reliable means of mitigation available. Likely impacts on Mauri	Presence of cultural sites of significance directly below site with no reliable means of mitigation available. Certain impacts on Mauri
	Insignificant	*Negligible*	*Moderate*	*Extensive*	*Significant*

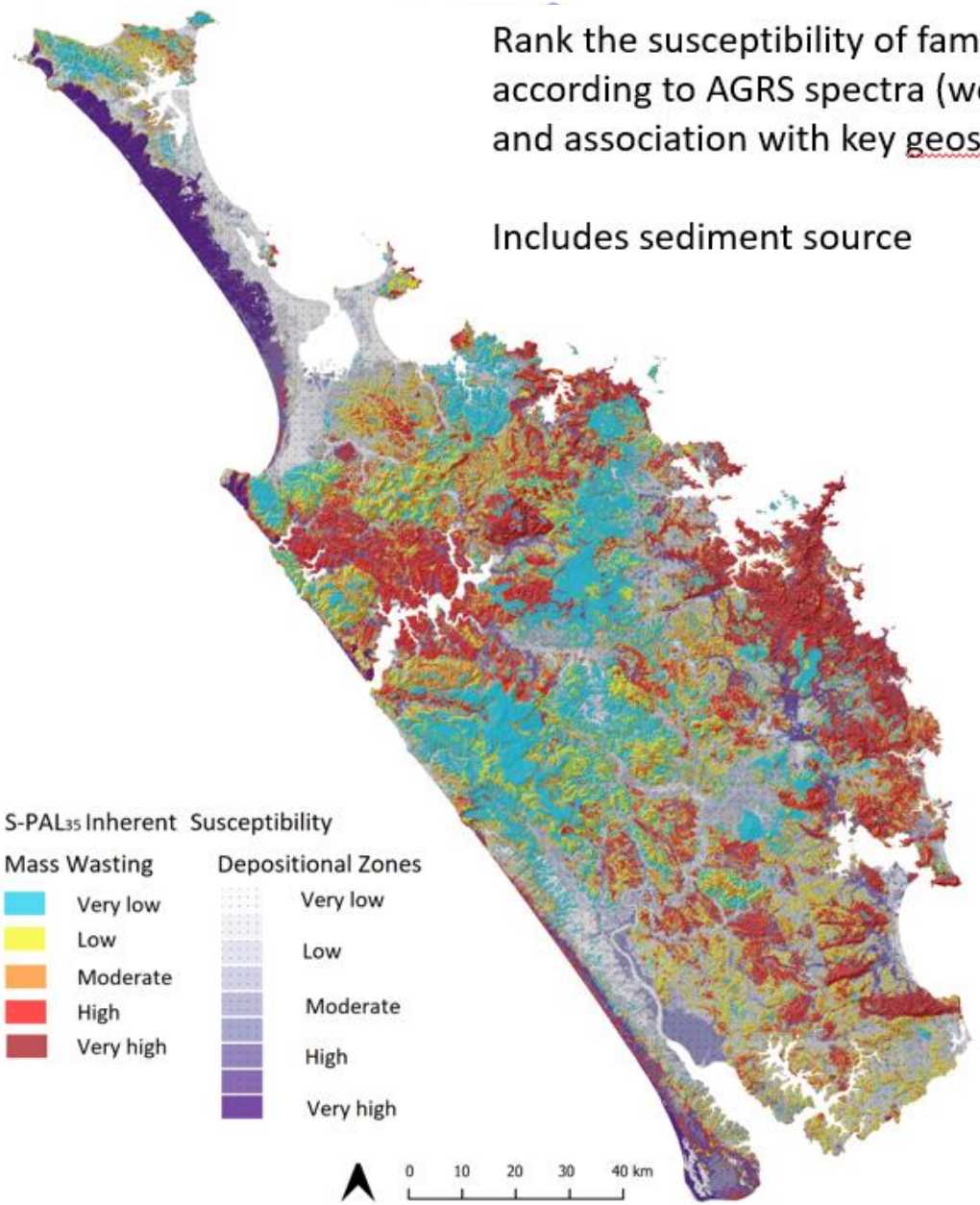
Figure A4 Screen shot of the consequence factors leading to the severity rating

Figure A5 Screen shot of the relationship between susceptibility and severity to give rating of negligible to high risk (green, yellow, orange, red)

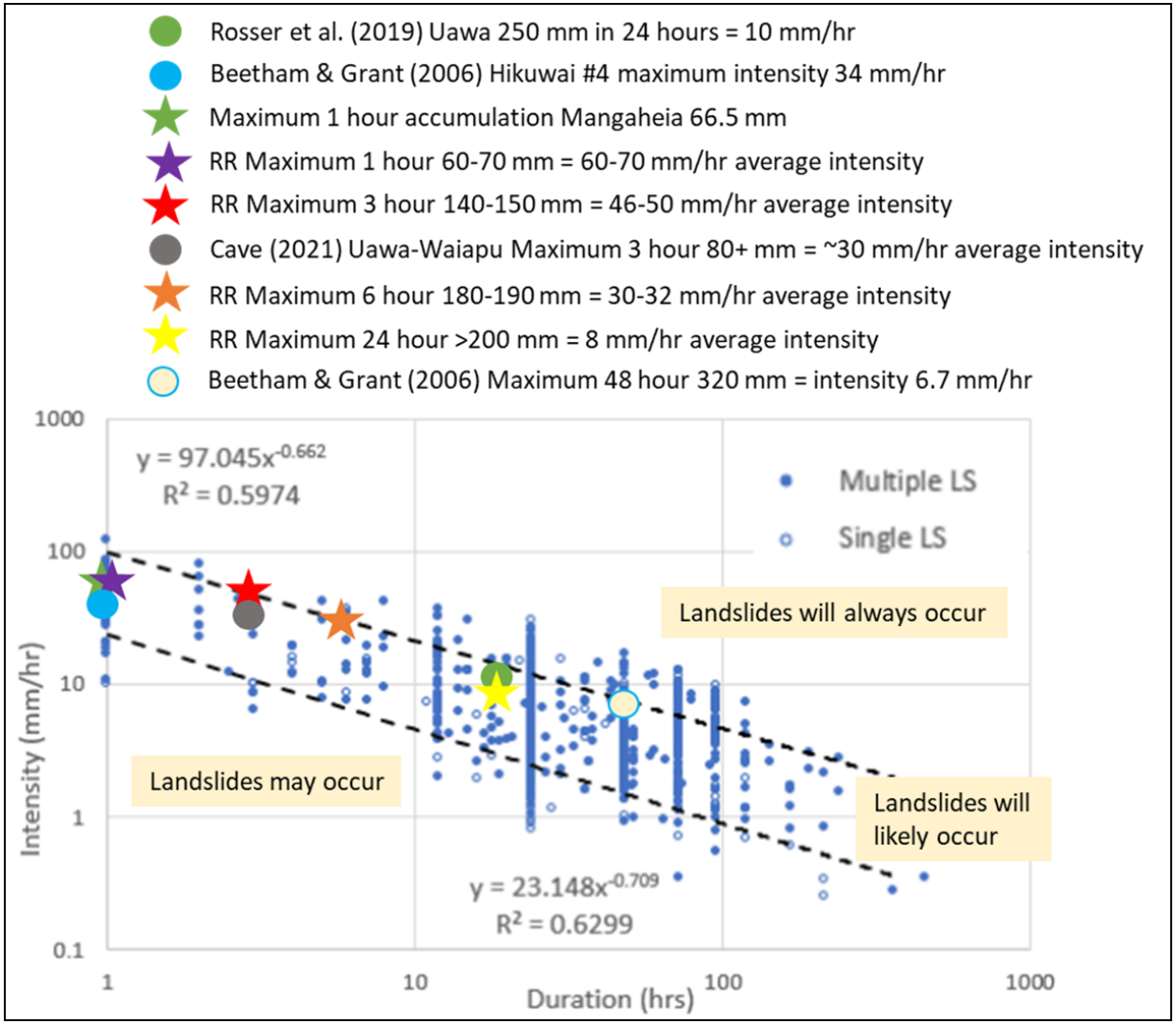
Land and Water Science

Rank the susceptibility of families and classes within a family according to AGRS spectra (weathering), TRI, satellite imagery and association with key geostructural settings.

Includes sediment source



Climate



Rosser et al 2020:

- From analysis of 1029 landslide triggering rainfall events 1875-2019
- 10hr duration storm with intensities >20mm/hr will always trigger landslides

Tools in the tool box

- Catchment risk assessments
- Harvesting methodology
- Developments to reduce breakage
- Catchment clearance limits
- Removing non-merchantable material from high risk slopes
- Slash traps
- Replanting – species, stocking rates, retirement/setbacks

……..*but there are limits to what we can control!*

Things that are within our control…..

- How we operate in high risk catchments
- How we respond to events:
  - Proactive communication - regulators and community
  - Assistance with clean up – don’t wait to be asked!
- Complying with consent conditions (all of them!)
- Where we plant - and replant!