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IDENTIFYING EROSION RISK IN STEEP HILL COUNTRY - A CASE STUDY

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Summary

Detailed information on potential erosion hazards relevant to forestry operations is generally uncommon. Erosion risk maps are useful planning and operational tools that show areas with different levels of erosion risk. Such a map was produced for a pasture catchment and a forest catchment near Tangoio, Hawke's Bay. Geology, soil, slope steepness, slope aspect, and historical slip data were combined to develop the risk map using a Geographic Information System (GIS).

INTRODUCTION

To find out about the potential seriousness and type of erosion on forest land harvest planners usually refer to the New Zealand Land Resource Inventory worksheets (NWASCO, 1979). These worksheets depict land classification units with combinations of different types of geology, soil, erosion, slope and vegetation. They were designed for regional resource assessment and are presented at a scale of 1:63,360. However, the worksheets have insufficient detail to assess the risk of erosion at scales normally used for planning forestry operations (that is, 1:5000 or 1:10000).

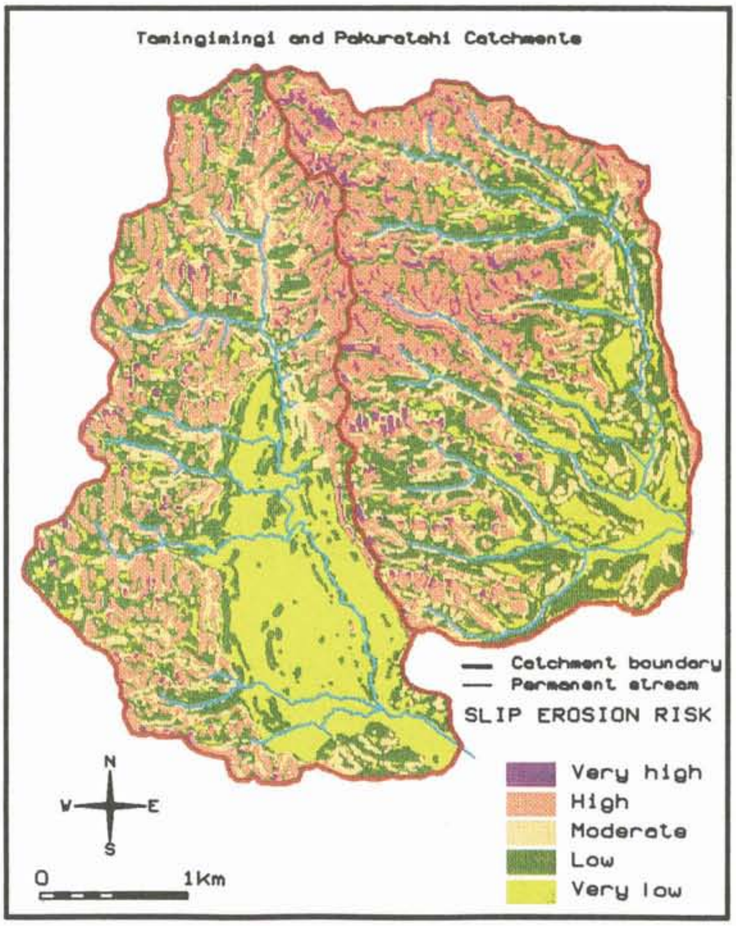

Figure 1 - Erosion risk of study area in central Hawke's Bay

This report describes a detailed slip erosion risk assessment carried out in two catchments in central Hawke's Bay.

STUDY AREA

An erosion risk map was produced for two adjacent catchments: the Pakuratahi forest catchment (774 ha) and Tamingimingi pasture catchment (799 ha) (Figure 2). The catchments have a land use classification of VIe5 and VIIe3, defining steep hill country with 88% to 92% over 15°. Afforestation occurred in 1970 and 1971. Harvesting will commence in 1997 and continue for four to five years.

Figure 2 - Location of research catchments

PHYSICAL FEATURE MAPPING

Criteria required to develop an erosion risk map were similar to that used in the National Land Resource Survey, (NWASCO, 1979). Feature maps of rock and soil types, erosion scars, slope steepness and aspect were generated in a GIS from field maps, aerial photographs, and GIS analyses. Slips were mapped from five sets of aerial photographs dating back to 1943.

All slip scars discernible on the aerial photographs were plotted (Figure 3). The scars represent only the area of permanent soil loss, not the debris tails which usually recover rapidly in pasture plants. Every slip boundary plotted was accurate to within one metre. Eighty-six percent of the slips occurred during major storms in 1938, and Cyclone Bola in 1988 (Fransen and Brownlie, 1996).

Pasture was the predominant vegetation cover in 1943 and 1988 and this is reflected in the slip distribution. Forests protect against slippage; after logging it is from three to six years into the next rotation that hill slopes are vulnerable to slip erosion (O'Loughlin and Watson, 1979; Phillips *et al.*, 1990; Marden and Rowan, 1993). Therefore, the potential extent of erosion in a post-harvest setting could be similar to pasture.

Field mapping accurately defined the extent of rock and soil types, recognised by earlier work (Grindley, 1960; Haywick *et al.*, 1991, Pohlen *et al.*, 1947). The geology of the study area is a sequence of marine mudstones, limestones, and unconsolidated sand formations. River gravel beds deposited during the last glacial period about 22,000 years ago occur extensively around the ridge tops, particularly in the Pakuratahi catchment.

Soils in the region are yellow grey earths named Crownthorpe, Tangoio and Matapiro sandy loams (Pohlen *et al.*, 1947). The soils formed on a range of parent materials: the underlying rocks, a mantle of volcanic ash originating from the Taupo region, loess (wind-blown) deposits, and landslide debris. Soil units were defined according to their parent material and their relationship to landforms (ridges, steep slopes, gully bottoms, flood plain).

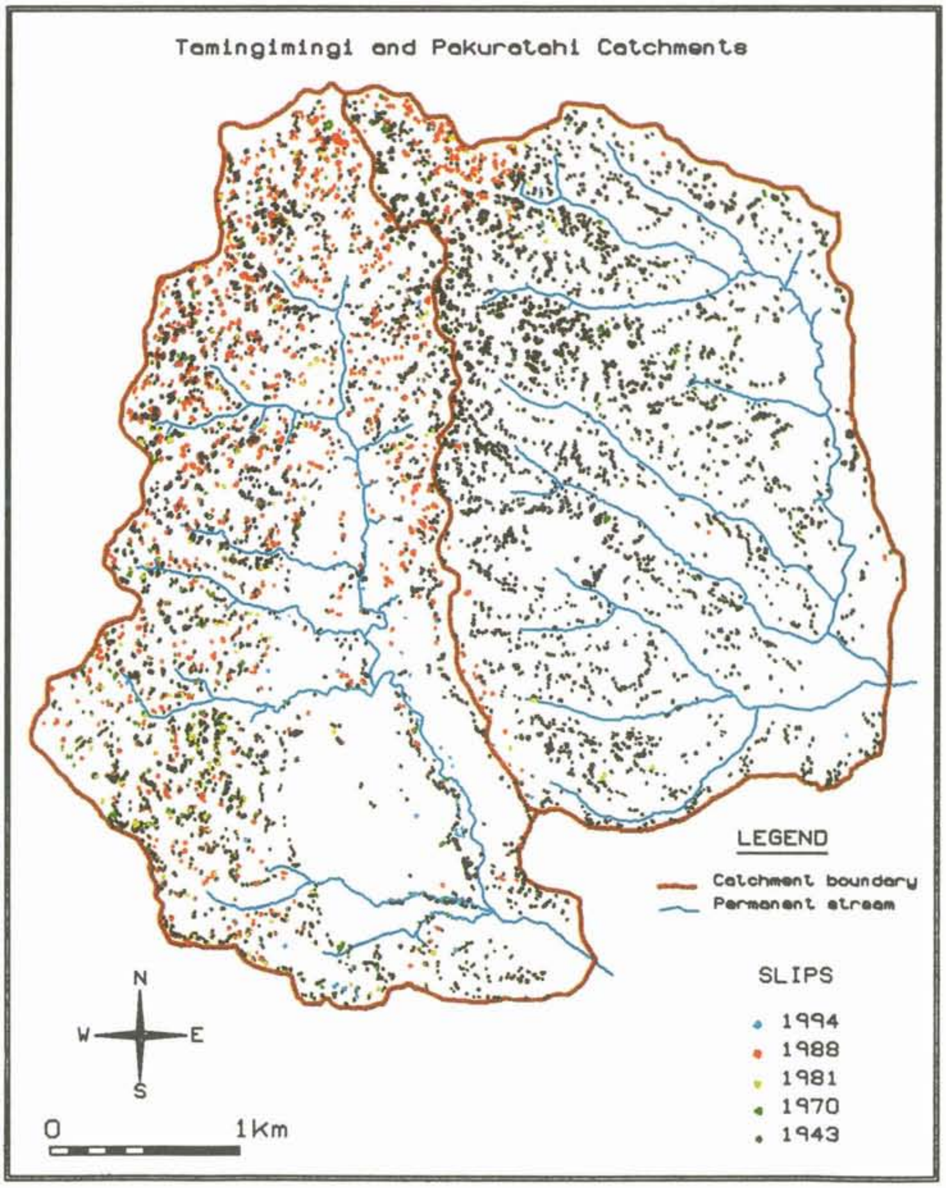

Figure 3 - Slips used in GIS analyses represent 2% of the area (1576 ha)

Strong arguments have been made that support the view that slope angle is a main driving force of shallow mass movements (Sidle *et al.* 1985). It is necessary to identify slopes most susceptible to slippage. The study catchments' slopes were defined using the New Zealand Land Resource Inventory slope steepness classification.

Similarly, generation of a slope aspect map classified into north, south, east and west facing slopes, aimed to account for climatic influences on soil moisture and erosion. In Hawke's Bay, droughts are most frequent when westerly winds predominate and reach their maximum intensity in early summer (Salinger, 1995). These periods may be followed by strong winds and erosion inducing storms approaching from northeast to southeast. This was the case in April 1938 and March 1988 (Cyclone Bola), (SCRCC, 1957; R. Black, Hawke's Bay Regional Council Scientist, pers. comm.). Cyclone Bola ended a particularly dry period (Harmsworth and Page, 1991).

EROSION RISK MODEL

Each feature map was overlain with the slip map, and the proportion of slips calculated within each rock formation, soil unit, and slope class. A 'risk' rating was then assigned to these classes. The higher the percentage area in slips, the higher the rating (Table 1). To simplify further data analysis, some classes were assigned equal risk where the percentages were of similar value or magnitude.

The feature maps' classes were assigned numeric ratings in order to produce a composite erosion risk map (Figure 1) by:

- combining the feature maps
- summing their risk ratings
- reclassifying 'summed' areas, and
- recategorising to simplify the risk classes.

The erosion risk map was successfully validated by cross referencing with the slip map (Fransen, 1996). Figure 4 confirmed the expectation that the percentage of risk class in slips declined with decreasing risk value (with the exception of risk class 9).

Table 1 - Summary of erosion risk ratings

	% in slips	Rating
Geological formation		
Ohakean gravels	3.3	4
Kaiwaka Formation	2.6	3
Mudstone formations	0.8	2
Large-scale landslides	0.8	2
Recent alluvium	0.3	1
Soil unit		
Volcanic ash (upper slopes and ridge tops)	3.3	5
Mixed soils (mid to lower slopes)	2.3	4
Rocky - 1 (escarpments)	1.9	3
Rocky - II (lower escarpment slopes)	0.9	2
Undefined (large scale-landslide)	0.7	2
Alluvial soils		
- gully bottoms	0.8	2
- floodplains	0.0	1
- fan	0.3	1
Slope steepness		
0°-7°	0.1	1
7°-15°	0.6	1
15°-20°	2.5	3
20°-25°	4.7	5
25°-35°	3.3	4
>35°	1.6	2
Aspect		
North	2.5	2
South	1.7	1
East	2.9	3
West	2.9	3

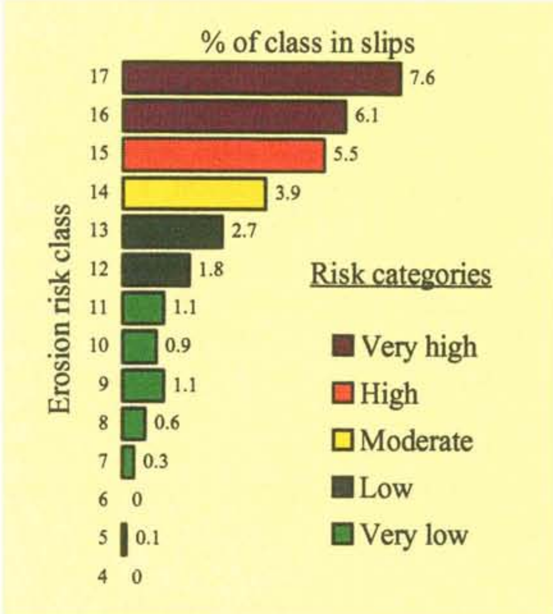

Figure 4 - General risk categories from composite slip erosion classes

EROSION RISK CHARACTERISTICS

Areas of very high risk occupy 6% of the Pakuratahi catchment and 2% of the Tamingimingi catchment (Figure 1, Table 2). These areas are restricted to Ohakean gravels (Table 1) and volcanic ash soils on the upper ridges with slopes from 20° to 25° to the east or west.

High risk areas have similar features, but include areas of Kaiwaka Formation (Table 1), mixed soils, 25° to 35° slopes and northerly aspects.

Areas with moderate erosion risk have combinations of 15° to 25° slopes, facing all aspects, volcanic ash, mixed soils, Ohakean gravels and Kaiwaka Formation.

Both catchments have similar areas at high and moderate risk.

Table 2 - Percentage area of catchment erosion risk

Risk	Tamingimingi	Pakuratahi
Very high	2	6
High	8	10
Moderate	13	14
Low	32	41
Very low	45	29

Low to very low risk areas occupy 77% of the Tamingimingi catchment, compared to 70% of the Pakuratahi catchment. Subdued relief on the large-scale landslide formation in the Rocky Basin (Tamingimingi catchment), alluvial terraces, fans, valley floors and flood plains, flat ridge-tops, escarpment areas with thin soils, and on thick mudstone formations, were generally low risk areas for slippage.

The thick mudstone formations occur mainly on the lower slopes in the middle to lower reaches of the Pakuratahi Catchment. On these slopes, some slips occur on saturated soils. Groundwater seeps onto the slopes from the sandy base of the Kaiwaka Formation above. These areas are predominantly covered in indigenous bush. Analysis of mudstone slopes under pasture resulted in the same level of slippage as slopes under bush.

EROSION RISK MANAGEMENT

Identification of areas most susceptible to erosion is important for the management of steep hill country to ensure that soil disturbance is kept to a minimum. An erosion risk map highlights the size and location of areas at risk, particularly under forest cover or where there is little sign of slippage. The risk map allows appropriate land use decisions to be made. It may be possible in some areas to avoid destabilising slopes and subsequent slippage attributed to earthworks, rutting (by animals, wheels, and log drags) and intense grazing.

In the Pakuratahi catchment, where 64% of slopes are over 20°, cable logging will likely be the preferred harvesting system, while ground-based harvesting systems may be employed on the flat to easy slopes. Access to harvest settings will be along existing ridge top roads. Minimising deep site disturbance, careful siting and formation of landings and roads, and controlling drainage in areas of high risk are primary considerations for preventing erosion.

Application of the erosion risk ratings presented in this study is possible in other areas with similar erosion and land use history. Differences in the distribution and type of geology, soils, and slopes in other areas may result in a different erosion response. The most applicable area in which to apply the erosion model is the coastal Hawke's Bay region.

As a research tool the erosion risk map will be used to select landform units for post-harvest site disturbance and erosion assessments in the Pakuratahi catchment.

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