Erosion susceptibility classification and analysis of erosion risks for plantation forestry – response to Marden et al.

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Introduction

In a recent paper in this Journal, 'Should detailed terrain stability or erosion susceptibility mapping be mandatory in erodible steep lands?' (Marden et al., 2015), Mike Marden and colleagues call for 'improved quantitative erosion and hazard identification and risk management methods that can be widely applied across New Zealand.' They note that improvements are 'required at both a "reconnaissance" scale (e.g. 1:50,000 or greater) for use at a national level to underpin for example further development of the NES for plantation forestry … to more detailed mapping for use at an operational scale (e.g. 1:5,000 to 1:10,000) as a prerequisite for roading, harvesting and replanting operations.'

They also note that an Erosion Susceptibility Classification (ESC) developed for the National Environmental Standard (NES) for plantation forestry (Bloomberg et al., 2011) 'is a start, but it has a number of limitations including':

- 'The poor definition of potential erosion used as the metric for defining erosion susceptibility
- Misclassification of the potential erosion severity of some Land Use Capability Units
- A scale (1:50,000) unsuited for operational use and ESC errors that result from the scale limitations.'

I agree with most of what they say, but in my opinion they did not provide enough explanation of why the ESC developed by Bloomberg et al. (2011) has limitations. They also devote most of their paper to an explanation and justification of detailed erosion susceptibility mapping, and do not adequately place this in the context of erosion risk management, whether for plantation forestry or rural land use generally. Without this risk management context, the rationale for improvements to erosion susceptibility mapping is not clear.

Limitations of the ESC

The limitations of the ESC were discussed at length in the final ESC report by Bloomberg et al. (2011) to the Ministry for the Environment. The ESC was based on the potential erosion severity data for the map units in the New Zealand Land Resource Inventory (NZLRI) spatial database. This database covers all of New Zealand at an effective map scale of 1:50,000 (Newsome et al., 2008).

In order to obtain a nationally consistent and complete map of erosion susceptibility, there was simply no other option than to use the NZLRI. One year prior to the commencement of the ESC project, a detailed comparison of the NZLRI versus other spatial databases used to map lands susceptible to mass movement ('landslide') erosion was made by Basher et al. (2010). They concluded that, 'Of the three different approaches used to define susceptibility to mass movement, potential erosion from the NZLRI provides the most robust and defensible definition … .'

The ESC utilised the same erosion types (mass movement and gully erosion) defined by Basher et al. (2010), but noted that the NZLRI database contained data that are now approaching 40 years old in some cases, especially in the South Island. The ESC report therefore recommended reviewing and updating the NZLRI and ESC on a five-year cycle. Basher et al. (2015) have recently developed a system that would allow this to be done.

To say that the ESC has a 'scale (1:50,000) unsuited for operational use and ESC errors … result from the scale limitations' (Marden et al., 2015) is correct. The ESC report took great pains to point out that the 1:50,000 map scale for the ESC data meant that it was only suited for broad regional-level planning, and that detailed site-level ESC for operational planning would need to be at a map scale of 1:10,000 or less (see Cascini, 2008, Table 3).

The problem with site-level mapping of erosion susceptibility at large scales is cost. Even with the advent of modern digital techniques for erosion susceptibility mapping, large-scale mapping is not cheap and will always involve the need for field assessment by experts, if only to ground-truth the digital erosion susceptibility maps. To answer the question posed by Mike Marden and colleagues – detailed erosion susceptibility mapping must be mandatory in areas where the cost of mapping is repaid by avoided or mitigated risk to life, property

and the environment from erosion. To identify these areas, it might help to stand back and look at erosion from a risk management perspective.

Need for a risk management approach

The ESC report (Bloomberg et al., 2011) reviewed the excellent work by Saunders and Glassey (2007) on planning policy and consent requirements for landslide-prone land in New Zealand. Saunders and Glassey recommended a risk management system based on an approach accepted in many countries, including Australia. A modified version of this is shown in Figure 1. In this system, risk from erosion has three main components, of which erosion susceptibility is one. Note that in Figure 1 erosion susceptibility is not just intrinsic to an area of land, but can be modified by human activities, such as roading or clearfelling, which can increase or decrease susceptibility.

The other two components of erosion risk are:

1. The probability that a triggering event, usually heavy or persistent rainfall, will cause erosion on susceptible land. Marden et al. (2015) touch briefly on this topic, yet assessment of the probability of triggering storms is as critical to risk management as mapping erosion susceptibility.
2. The assessment of erosion consequence, which depends on the values that are present on the erosion site or in the path of the erosion material as it moves downslope. Human life, property and high-value conservation areas, e.g. estuaries, waterways with high biodiversity value, are examples where the consequences of erosion are high.

Erosion risk depends on the interaction of erosion susceptibility, probability of triggering storms and the consequences of erosion. For example, in December 2011 the Pohara-Ligar Bay area (Tasman District in the South Island) was severely impacted by a high-intensity rainfall event, which delivered 454 mm of rainfall over a 24-hour period (Page et al., 2012). The rainfall triggered severe landsliding (some of it within mature radiata pine plantations), and in some catchments debris flows, which caused about $10 million of property damage and posed a serious risk to human safety. This erosion occurred on land that was assessed as erosion susceptibility = ‘High’ (3 on a scale 1–4) in the ESC – not the most susceptible class. The following factors resulted in great risk to life and property:

- The severity of the rainfall event
- The generation of debris flows in some catchments
- The location of housing on fans directly in the path of the debris flows.

The identification of downslope or downstream consequences is as critical to risk management as mapping erosion susceptibility or assessing probability of triggering rainfalls. Erosion risk will occur directly downslope of landslides and gully erosion, but can also occur downstream due to debris flows and, more insidiously, aggradation of river channels.

When is detailed site-level erosion susceptibility mapping needed?

The ESC report strongly recommended that an NES for plantation forestry will require the development of site-level planning processes so that operational planning and management of harvesting and earthworks are done to a uniform high standard throughout New Zealand. Site-level planning must also allow for the identification of consequences – to receiving water bodies, infrastructure and buildings, as well as to human safety and welfare.

However, detailed site-level planning for erosion risk is expensive, and should only be used where necessary. How can the necessity for detailed site-level mapping and planning be assessed? The degree of effort required for adequate site-level planning can be guided by regional (1:50,000) scale ESC maps, and also regional-scale mapping of the probability of erosion-triggering storms. The higher the ESC class and the higher the probability of erosion-triggering events, the greater the likelihood of significant erosion events, and so the more detailed and rigorous is the required site-level risk analysis.

The ESC report (Bloomberg et al., 2011) proposed three erosion risk analysis classes integrating the ESC with the likelihood of triggering rainfall (Table 1). Note that this table was for discussion purposes only. The actual allocation of risk analysis classes to specific cells in the table does need further study.

Site-level mapping of erosion susceptibility, as advocated by Marden et al. (2015), would definitely be required for category FA land. Category SA would require further scoping to determine the need for detailed risk analysis, but in cases where consequences of erosion are not great, detailed mapping may not be required. For the Pohara-Ligar Bay area example discussed earlier, the ESC class was ‘High’ (3/4), but the AEP for a triggering storm in Golden Bay is 0.21–0.30 (Bloomberg et al., 2011), enough to trigger an FA classification in Table 1.

Need for improved codes of practice

In respect of site-level planning for forestry operations, a final recommendation of the ESC report was that the ‘ESC must be supported by specific standards for forestry operations that are appropriate for the level of erosion risk on a site. We suggest a set of best management practices (BMP’s) which could be used for this purpose.’ Subsequent research by Melissa Pendly (Pendly et al., 2013; Pendly, 2014) has shown that current rules and codes of practice used by the New Zealand forest industry and regulatory authorities to manage erosion risks from forest operations are extremely inconsistent between the different regional

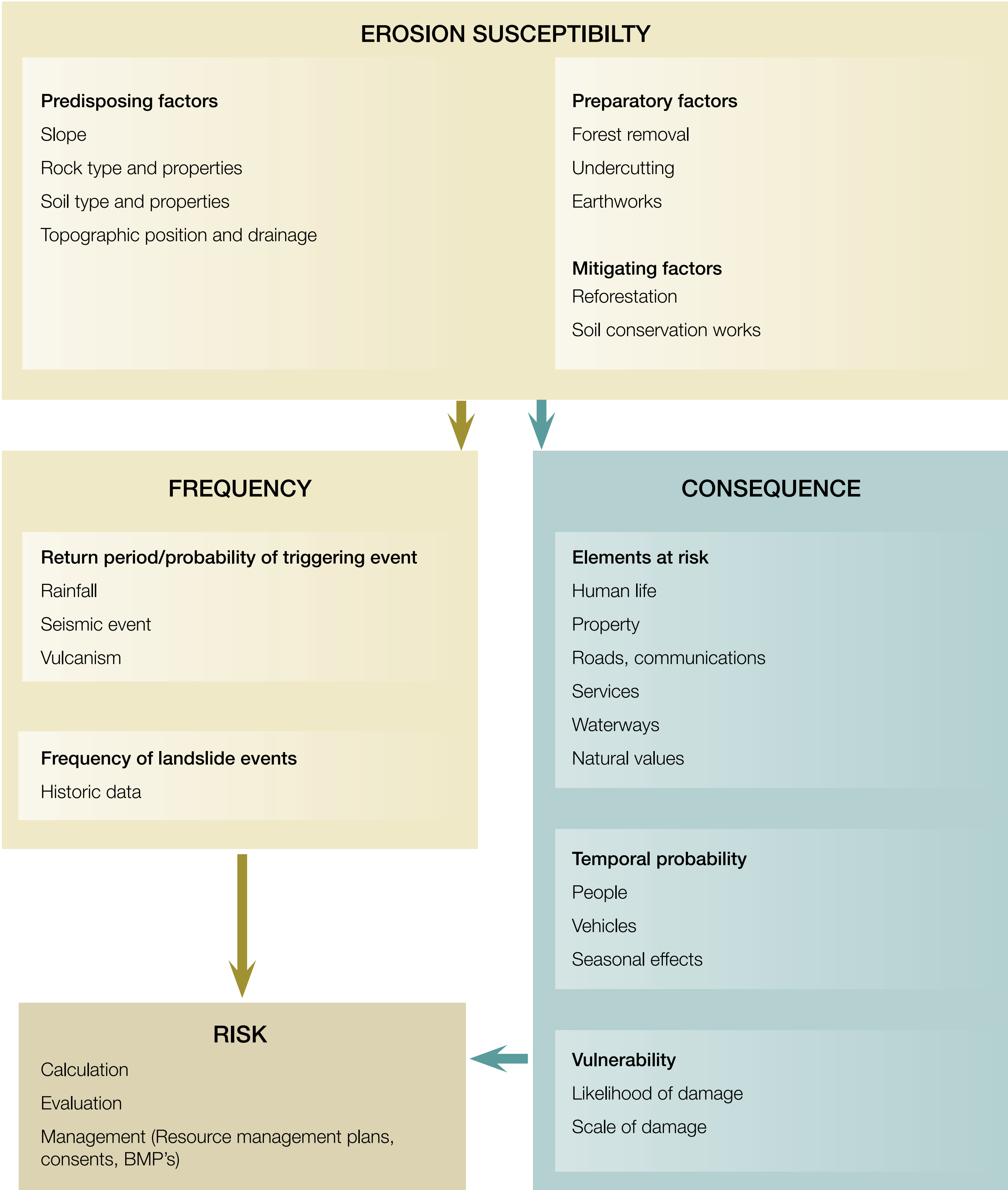

Figure 1: Conceptual model of erosion risk. Source: Modified from Saunders & Glassey (2007)

Table 1: Decision matrix using ESC and annual exceedance probability (AEP) of a triggering storm

ESC	AEP				
	<0.08	0.08–0.12	0.12–0.21	0.21–0.30	>0.30
Low	NA	NA	NA	NA	NA
Moderate	NA	NA	SA	SA	SA
High	SA	SA	FA	FA	FA
Very High	FA	FA	FA	FA	FA

NA = no risk analysis required for forestry operations
SA = some risk analysis required
FA = full risk analysis – proceed with forestry operations under stringent conditions only if full risk analysis indicates risk can be managed to be acceptable.

councils in New Zealand, are often incomplete in their coverage of relevant operations, and do not always meet accepted international standards for environmental codes of practice.

If erosion risk is to be well-managed by the New Zealand forest industry, the Tower of Babel that is the environmental rules and codes applying to this country's forest operations must be addressed.

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