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Soil erodibility and erosion hazard: Extending these cornerstone soil conservation concepts to headwater streams in the forestry estate in Tasmania

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Abstract

Soil erodibility is defined as 'the inherent susceptibility of soil particles or aggregates to become detached or transported by erosive agents such as rainfall, runoff, throughflow, wind or frost'. In Tasmania soil erodibility is routinely assessed using a combination of standard laboratory methods and observations of profile characteristics. Five soil erodibility classes are defined: low, moderate, moderate-high, high and very high.

A plot of soil erodibility against slope produces an erosion hazard matrix. Erosion hazard increases with increasing soil erodibility or slope. Informal matrices have been used in the Tasmanian Forest Practices Code to define the harvest machinery and cultivations techniques appropriate for different soil erodibility/slope combinations. We are formalising these matrices to define five erosion hazard classes, ranging from Class A (low erosion hazard) to Class E (very high erosion hazard), and extending the erosion hazard concept to riparian zones.

At present forest streams in Tasmania receive riparian protection related to the size of the upstream catchment. Streams are classified into Class 1 (largest), Class 2, Class 3 and Class 4 (headwaters). Class 4 streams, which have a catchment area of 50 ha or less, are least protected. In the Tasmanian Forest Practices Code the standard prescription for Class 4 streams is to allow harvest of timber trees but to apply a 10 m machinery exclusion zone. Protection can be upgraded for biological conservation reasons or by the recommendation of a Forest Practices Officer or a specialist advisor.

Observations in >400 headwater 4 streams in forestry coupes (harvest areas) indicates that, within a stream or its 0–10 m riparian zone, the incidence of seven 'erosion features' (channel >4 m wide; recent boulder movement; near-vertical stream banks >1 m high; significant sediment accumulation; tunnel gully, gully and rill erosion; sheet erosion; landslides or slumps) is correlated with riparian erosion hazard class. For 66% of streams in coupes in which advice was sought for environmental protection reasons, measures to provide greater protection than the standard 0–10 m machinery exclusion zone were recommended. These measures ranged from wider machinery-exclusion zones where riparian zones are steep, to 20 m no-harvest streamside reserves where erosion risks are considered to be high. This paper formalises the decision-making process for applying such protection measures to 'at-risk' headwater streams.

Prescribing headwater stream riparian buffer types and widths using the erosion hazard and erosion features concepts is considered to be superior to using riparian slope alone (as commonly done in overseas codes of practice) because the defined erosion hazard classes and erosion features identify the most vulnerable streams and riparian zones in the

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proposed forest harvest area, allow environmental risks to be objectively assessed, and tailor protection measures to the specific risks identified. The proposed system is generic and likely to be applicable to headwater streams in other temperate regions.

Keywords: Headwater streams; Riparian; Soil erodibility; Erosion hazard; Erosion risk; Tasmania; Forest soils

1. Introduction

1.1. Characteristics of headwater streams

For the operational convenience of having a simple definition, headwater streams in the forestry estate in Tasmania are called Class 4 streams and are defined in the Tasmanian Forest Practices Code (Forest Practices Board, 2000) as streams with a catchment area of 50 ha or less. Class 4 streams in Tasmania and headwater streams in general are systems with complex hydrologic, geomorphic and biological interactions that are not well described and are poorly understood (Davies et al., 1999; Gomi et al., 2002). Extrapolation from studies on large streams is difficult because headwater streams have unique characteristics. These include more variable flow than larger streams; more variable sediment sizes over short distances and between streams; changes from erosion to aggradation over short distances; a significant role of woody debris in defining channel character; and an important influence of riparian processes on stream character because of a high edge to water-area ratio (Bunce, 2000).

The length of headwater streams in a major forestry catchment in Tasmania (the South Esk River catchment) has been estimated to be over 75% of the total watercourse length (Forestry Tasmania, unpublished data) and other studies have shown that about 90% of catchment stream flow may come from first and second order (headwater) streams (Burt, 1997, in Deschamps et al., 1999). The number of small streams and their potential to have a cumulative downstream effect make them important for achieving land management objectives. As a result of Burt's findings, Deschamps et al. (1999) suggested that the control of water quality in headwaters should be a priority to improve downstream river water quality, a concern that was echoed in a review of soil and water provisions of the Tasmanian Forest Practices Code (Davies et al., 1999). The latter authors recognised the great diversity of Class 4 streams and their varied morphological setting (soils, geology and slopes) and erosion risk in Tasmania, and recommended increased research on the protection of Class 4 streams. This paper is one of several studies resulting from the recommendations of the above-mentioned soil and water review (Davies et al., 1999).

1.2. Effects of logging on streams

Some headwater streams display the typical stream morphology of channels, pools and bars and stream banks that are the familiar terminology of stream description and classification systems (e.g. Petts and Calow, 1996; Rosgen, 1996); in others the limits of the stream channel and other morphological components may be unclear—the stream may flow over soil; living trees, shrubs and ferns may be growing in the stream channel; and both large and small roots and woody debris may be significant structural components of the stream. In such a complex environment the removal of one structural component (the vegetation) can have significant effects, especially in vulnerable landscapes (Haigh et al., 2004). While the effects of intermittent harvest cycles on headwater streams in Tasmania might reasonably be expected to be much less than in the deforestation case studies described by Haigh et al. (2004), the sustainability of present forest practices in Tasmanian headwaters nevertheless requires attention, as the Tasmanian Forest Practices Code (Forest Practices Board, 2000) is based on the sustainability principle and requires (Code p. 55) that forestry operations minimise disturbance to watercourse channels and riparian (streamside) zones and requires downstream impacts to be considered.

When researching the effects of forestry operations on stream morphology it is important to distinguish between the *direct* morphological effects on streams and riparian zones, resulting from machine and harvesting disturbance of soil and water, and *indirect* effects resulting from increased stream flows after harvest. Mitigation of the effects of these two