Erosion/sedimentation in the Manawatu catchment associated with scenarios of Whole Farm Plans

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Contents

Summary

A simplified version of the *SedNet* model was used to predict the erosion and sedimentation regime of the Manawatu river associated with a range of different Whole Farm Plan scenarios. At present the mean sediment discharge of the Manawatu River is 3.8 million tonnes of sediment per year. If 500 Whole Farm Plans are implemented on a random selection of farms then the mean sediment discharge reduces to 3.5 million tonnes, an 8% reduction. In sharp contrast, if the 500 Whole Farm Plans (i.e. 10% of farms) are implemented on the highest priority farms, then the mean sediment discharge reduces to 2.0 million tonnes of sediment per year, a 47% reduction on the present situation. Interestingly, if only half (250) of the Whole Farm Plans are implemented on the highest priority farms and the other 250 plans are implemented on a random selection of farms, then the mean sediment discharge reduces to 2.4 million tonnes, or 77% of that achieved by targeting all plans in priority areas.

1 Introduction

Much of New Zealand's indigenous forest has been converted into pastoral land during the past 2 centuries. The negative impacts of deforestation are most evident in the hill country, where increasing erosion has lead to a dramatic loss of soil and a decrease in productivity. Further consequences result from the increased sediment load in the waterways. Increased turbidity has detrimental effects on aquatic ecosystems. And the deposition of sediment in floodways reduces flood conductance. The implementation of Whole Farm Plans, which include soil conservation measures, in large areas is costly. It is therefore important to allocate resources efficiently. This can be assisted by predictive models that link erosion and sedimentation processes with land use.

Most of the erosion in New Zealand is dominated by mass movement processes. Griffiths and Glasby (1985) created a national erosion model by relating mean sediment discharge (measurements at 80 river sites) with annual rainfall. Hicks et al. (1996) extended this approach by adding rock type as further factor and used a higher number of gauging sites (206). Both models do not involve a land-cover factor, even though land cover is a recognised driver of erosion processes (Dymond et al. 2006; Page & Trustrum 1999). Thus there was the need for a more sophisticated model.

In the following study, a simplified version of the *SedNet* model is used to evaluate different Whole Farm Plan scenarios in the Manawatu catchment. The land-use factor depends on the implementation of Whole Farm Plans, which are part of the Sustainable Land Use Initiative (SLUI) lead by the Horizons Regional Council. The first section this report outlines the main principles of *SedNet*. The next section outlines the assumptions made for the simplified version of *SedNet* used in this study. The mean sediment discharge of the Manawatu river is calculated for six different Whole Farm Plan scenarios, ranging from no Whole Farm Plans, through to all farms (4921) having Whole Farm Plans.

2 Methods

2.1 The *SedNet* model

SedNet is a model that constructs sediment and nutrient budgets for regional scale river networks (3000–1 000 000 km^2). A budget consists of the major sources, stores and fluxes of material. The quantification of these budgets is carried out by spatial modelling and requires detailed information about the catchment. *SedNet* incorporates measurements of river discharge and conceptual representations of material transport processes such as gully erosion, hillslope erosion, bank erosion and floodplain deposition (illustrated in Figure 1). Another component constitutes the geographical mapping of soils, vegetation cover, geology, terrain and climate (Wilkinson et al. 2004). A configuration represents the physical framework of the catchment that cannot be changed. The scenario builder permits the construction of datasets that may be influenced by land use change. *SedNet* puts the scenarios together with the configuration to construct a material budget for each stream segment in a catchment (Figure 2).

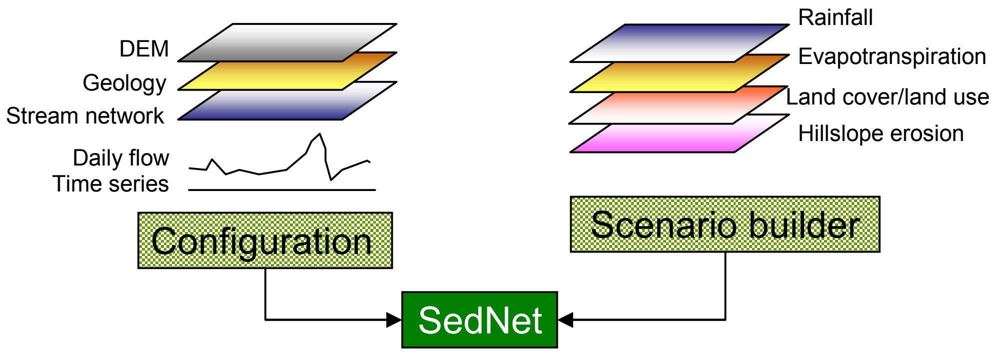

Figure 1. GIS data and hydrological data required for *SedNet*

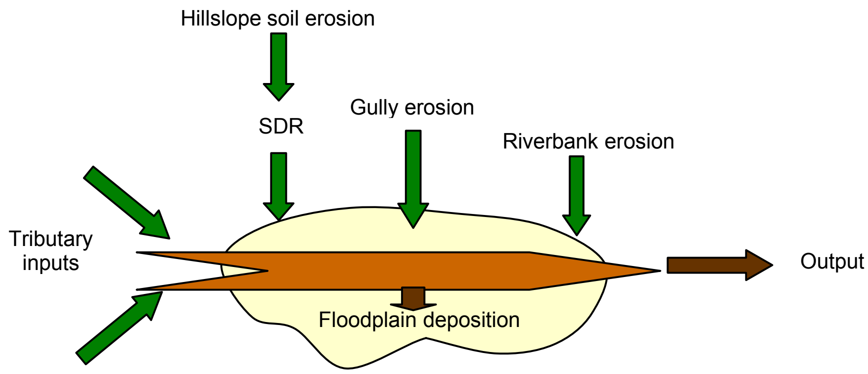

Figure 2. Sediment budget of each stream segment

2.2 A simplified version applied in the Manawatu catchment

To evaluate the implementation of Whole Farm Plans, a simplified version of *SedNet* is applied. If we assume bank erosion is approximately equal to floodplain deposition, we can focus exclusively on hillside erosion (including gully erosion). We also assume that mean hillside

erosion is controlled by three factors: geology; annual rainfall, and land cover. The geology factor is expressed as an erosion coefficient depending on the terrain type, called *Erosion Terrains*. These terrains represent landscape units with a particular combination of landform, slope, rock type and predominant erosion processes (Dymond & Betts, in prep.). The rainfall factor was determined from a national dataset of mean sediment discharge to be the mean annual rainfall squared. The land-cover factor was generated from ETM+ satellite imagery. The satellite imagery was classified for woody vegetation, herbaceous vegetation, bare ground, and water. Woody vegetation was assigned a factor of 1, and herbaceous vegetation was assigned a factor of 10 (Dymond & Betts, in prep.) The model was run in the simplified version to determine the long-term mean sediment discharge at the ocean outlet of the Manawatu river. Because bank erosion was assumed equal to flood plain deposition, the mean sediment discharge is simply calculated as the integral of the hillslope erosion over the watershed above the discharge (Dymond & Betts, in prep.).

3 Scenarios of Whole Farm Plans in the Manawatu catchment

To identify farms with the highest erosion potential, a regional scale map (1:50 000) of *Highly Erodible Land* was produced. Page et al. (2005) defined *Highly Erodible Land* as steep land (with slopes greater than a threshold depending on the *Erosion Terrain*) and earthflow land. If *Highly Erodible Land* does not have protective woody vegetation it has high erosion risk. *Highly Erodible Land* can be either connected to streams (providing sediment to the river network) or disconnected to streams (retaining the sediment on the hills, terraces, or valley sides). Figure 3 shows the number of farms in the Manawatu catchment with the respective area of *Highly Erodible Land* that is unprotected by woody vegetation and connected to streams.

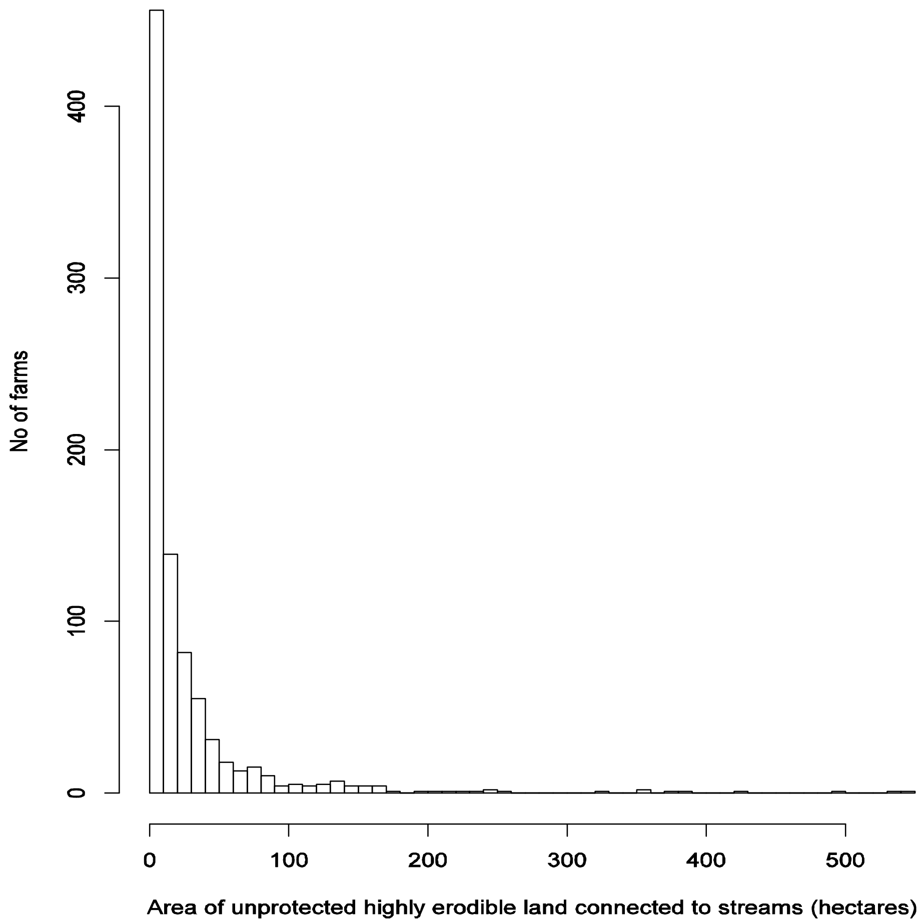

Figure 3. Number of farms with highly erodible land unprotected by woody vegetation and connected to streams.

The scenarios below represent a range of possible Whole Farm Plan schemes, from no Whole Farm Plans through to all farms (4921) with Whole Farm Plans (Table 1). Scenario (1) is the reference case, in which no actions are taken. Scenario (2) is the present situation, assuming that approximately 50 farms currently have Whole Farm Plans. Scenario (3) is a random selection of 500 farms, regardless of their contribution to erosion. Scenario (4) is a random selection of 250 farms combined with 250 of the highest priority farms (i.e. with the most area of *Highly Erodible Land* unprotected by woody vegetation and connected to streams). Scenario (5) is 500 of the highest priority farms. And scenario (6) is all farms with Whole Farm Plans.

4 Results

Table 1 and Figure 4 show the sediment yield of the Manawatu river, associated with full implementation of Whole Farm Plans for each of the scenarios above. Full implementation means that *Highly Erodible Land* will either have mature space-planted poplars to control landsliding or mature poplars and willows to control gully erosion. The predictions of mean sediment discharge apply for approximately 10 to 15 years after initiation of Whole Farm Plans.

Furthermore, the results are based on the assumption, that fully implemented Whole Farm Plans reduce erosion by 70% (Hawley & Dymond 1988; Hicks 1995).

Table 1. Predicted mean sediment discharge of the Manawatu river associated with 6 Whole Farm Plan coverage scenarios.

Land-use scenario	**Predicted mean sediment discharge (10^6 tonnes/yr)**
(1) No farms	3.8
(2) Random selection of 50 farms (i.e. the present situation approximately)	3.8
(3) Random selection of 500 farms	3.5
(4) 250 of the highest priority farms (i.e. with the most area of “eroding land” connected to streams) and 250 randomly selected	2.4
(5) 500 of the highest priority farms (i.e. with the most area of “eroding land” connected to streams)	2.0
(6) All the farms	1.5

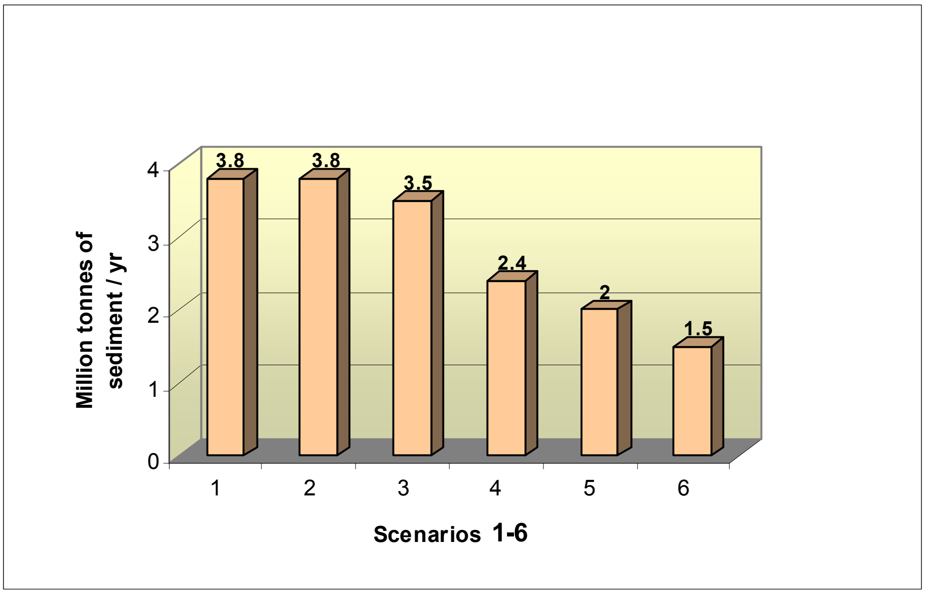

Figure 4. Mean sediment discharge of the Manawatu river associated with each of the Whole Farm Plan scenarios: (1) no farms; (2) present situation; (3) random selection of 500 farms; (4) 250 of the highest priority farms and 250 randomly selected farms; (5) 500 of the highest priority farms; and (6) all farms (4921).

5 Discussion

The results of the different scenarios highlight the importance of soil conservation measures in the Manawatu region. A realistic scenario of 500 farm plans in the highest priority farms, which is approximately 10% of farms, produces a reduction of approximately 50% in the mean sediment discharge of the Manawatu River. Interestingly the scenario where only 50% of the 500 plans were targeted on the highest priority farms delivered 80% of the reduction of the scenario of 500 farm plans in the highest priority farms. An untargeted approach to Whole Farm Planning had little (8%) impact on sediment loadings. There are both on-site and off-site environmental benefits associated with reduced erosion in the Manawatu: increased sustainability of hill-country farming; improved water clarity for ecosystem functioning; improved fish habitat; and improved recreation values. Economic benefits include reduced damage from siltation of homes and other infrastructure during major floods, and reduced maintenance cost of flood banks due to reduced siltation of river beds.

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*SedNe*t documentation http://www.toolkit.net.au/cgibin/WebObjects/toolkit.woa/1/wa/productDetails?productID=1000013&section=DocumentationPage&wosid=8u1QNIsyCertuiIO3TtBd0 (21/09/2006)