Chapter 11

Conclusions

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In 1993 the project set out to quantify the impacts of forest harvesting and re-establishment (Pakuratahi catchment) and pastoral farming (Tamingimingi catchment) on soil erosion, and stream water quality in steep coastal Tertiary hill country of Hawke's Bay. The aim was to assist in the development of best management practices and policies to sustain water and soil resources while maximising production. The project did this by gathering and analysing information on seven significant components of the environment affecting the landscape.

This chapter provides summaries of the findings with respect to the seven original environmental components of the landscape identified in Chapter 1.

Measuring slip erosion in relation to land use change

The study has confirmed the strong relationship between land use and erosion, with slip erosion being greater under pastoral use than that associated with *Pinus radiata* plantation forestry. The study has shown that not only was there more landslide and gully erosion under pasture but that the location of the erosion differed. The photo interpretation studies show that in 1943, when both catchments were in pasture, slip densities were high (232 /km^2 in the Tamingimingi and 296 /km^2 in the Pakuratahi). The slightly higher density in the Pakuratahi could have been due to the steeper relief in that catchment.

Following Cyclone Bola in 1988, the slip density in the Tamingimingi was 130 slips/km^2, and only 22/km^2 in the Pakuratahi. It is noteworthy that most of the erosion occurred in the upper 17% of the catchment which was not forested. In 1994, at the commencement of the study, the slip density in both catchments had declined substantially to 75/km^2 in the Tamingimingi and only 7/km^2 in the Pakuratahi, which by then had a complete forest cover.

Following a major storm in December 2005, field mapping and photo interpretation by Lamason (2006) showed a remarkably low erosion density in the Pakuratahi (3/km2) compared with the Tamingimingi (19/km2).

The same study showed erosion in the Pakuratahi resulting from the collapse of road berms or from very small slips on very steep scarps not planted in radiata pine. This contrasted with the Tamingimingi where scars occurred on the steeper slopes but were predominantly clustered along streams and related to the more densely vegetated riparian areas where ground cover was low due to grazing.

In summary, there was significantly less erosion in the forested catchment than in the pastured catchment. Prior to afforestation 0.01% of the Pakuratahi catchment was affected by slip erosion. This had fallen to 0.004% in 2005. For the Tamingimingi, the situation was just the reverse: 0.06% of the land surface affected by slips in 1970, and 0.3% in 2005.

Identifying landslide causal factors in relation to geology and soils

Based on his erosion mapping, Fransen (1996) developed a model of erosion risk for this type of hill country. The model showed that there were definite relationships between erosion and rock

type (geology) as well as soils, slope, and aspect. He was able to rank the erosion risk from very high to low, according to these parameters.

Areas of major susceptibility were found to be near the junction of friable clayey fine sand and thick indurated mudstones associated with the Kaiwaka Formation. Hence, seepage occurs near the junction of the permeable and impermeable materials, predisposing these sites to slope failure. A similar situation occurred in the Ohakean gravels which comprise layers of permeable gravel and fine grained loess, and hard impermeable ash.

The relationship between erosion and soils is more complex because in this environment soils are generally controlled by rock type and slope. The study showed slopes with the highest risk to be between 20 and 25º and those with the second highest risk to be between from 25 and 35º. Steeper slopes generally have a low risk because of the thin soil cover or the presence of rock outcrops.

Sources and volumes of sediment specific to landform and land-use, and contribution to streams

This study has shown that, in the Pakuratahi catchment, the main sources of sediment are those associated with forest roads and tracks, notably from cutbank and sidecast failures, followed by shallow landslides and channel bank erosion. Surface erosion from logged areas makes up a very small component of the total sediment load. In the Tamingimingi catchment the main sources of sediment are shallow landslides and stream bank erosion.

Sediment volumes from plantation forest before harvesting are likely to be only one third of those from adjacent catchments in pasture, but will be 2-to-3 times higher during and immediately after harvesting. The study also shows that erosion sources should stabilize within 2-to-3 years of harvest, with a return to lower sediment volumes from over-sown and replanted areas, and re-vegetated channel banks, compared with those areas remaining in pasture.

Recording changes in stream flow

Changes in stream flow were observed from the catchment undergoing forestry during the course of the study, but they cannot be regarded as substantial. In the pre-harvest period annual water yields from the planted catchment were 6% lower than those from the catchment in pasture, and after harvesting they were 22% higher. This situation persisted well into the post-harvest period, but by 2005, 6 years after the completion of harvesting, the difference was only 5%, suggesting that canopy closure was influencing water yield from the planted catchment.

Low flows from the forested catchment have been consistently higher compared with those from the pasture catchment, a situation thought to be explained by groundwater seepage from limestone and sandstone outcrops in the middle reaches of the catchment. The difference did increase after harvesting, but minimum annual low flows still remained higher than those from the pasture catchment well into the post-harvest period.

Based on the foregoing, a word of caution is appropriate here. As noted in the previous paragraph, runoff from the forested catchment, especially during low flow conditions, was found to be partly determined by substantial mid-catchment groundwater seepage, possibly from sources outside the catchment. Consequently, the conclusions outlined above regarding low flow from the forested catchment may not be widely applicable to the coastal hill country of Hawke's Bay.

Quantifying water quality parameters

After harvesting, electrical conductivity and pH levels showed small increases compared with those

measured in the adjacent pasture catchment, but there were no significant increases in turbidity, or in the concentrations of cations and anions, nitrate nitrogen, total phosphorus, or total dissolved phosphorus. Harvesting had little effect on water temperatures. Faecal coliform and enterococci concentrations from the catchment in pasture remained 2-to-5 times higher compared with that in forest, even after harvesting.

We can tentatively conclude from this that forestry will not lead to any substantial changes in water quality even during harvesting. It should be noted however, that this conclusion is based on samples collected at fortnightly-to-quarterly intervals, and thus reflects only long-term trends. It does not account for any substantial increases in concentrations of nitrogen, phosphorus, anions, cations, and other measured parameters that may have accompanied major storm events in both catchments.

Identifying environmentally sensitive areas

West and east facing slopes are the most susceptible to erosion, followed by those with a northerly aspect. Southerly aspects are the least susceptible. South facing soils have higher soil moisture contents and smaller fluctuations in soil moisture which may limit the development of soil fissures and reduce infiltration capacity.

Fransen (1996) identified five general categories of slip erosion risk:
Very high: on the upper ridges mantled by Recent tephric and Orthic soils and Ohakean gravels, and on 20–25° slopes facing east or west
High: as above but including the Kaiwaka Formation, Recent and Orthic soils on steep slopes, north aspects and slopes 25–35°
Moderate: as above, but with 15–25° slopes and all aspects
Low & very low: areas of subdued relief on the large scale landslides, flat alluvial terraces, fans, valley floors, flat ridge tops, escarpment areas with thin soils, and thick mudstone deposits.

Characterise in-stream fauna and their habitat in Pakuratahi streams

Invertebrates

The three sites in the Pakuratahi catchment prior to logging were located in small, relatively pristine cobble bottom Hawke's Bay coastal streams with incised channels. The in-stream invertebrate fauna was a relatively diverse community dominated by mayflies, caddisflies, midge and beetle larva, fairly typical of such small stable streams. The logging of the surrounding forest opened the canopy above the streams letting in more light and led to an influx of fine sediment into the streams which smothered the cobble substrate. These seemed to be the only habitat characteristics significantly altered by the logging. This changed the fauna to a less diverse community of invertebrates dominated by midge larvae, snails and Crustacea, more typical of streams in intensively farmed agricultural land. As the sediment was washed out of the streams by flood events the fauna slowly reverted to one more similar to its previous state with communities dominated by mayflies and caddisflies. The rate at which the sediment was removed varied between the individual streams (larger streams cleared quicker) and thus affected the speed with which the streams returned to their initial faunal state. The site just up-stream of the weir in the Pakuratahi catchment took about 3 years to return to its pre-harvest condition, but it has taken much longer for the sites in the upper catchment to do so, with one still show evidence of disturbance.

Native Fish

Prior to harvesting both the pastoral and forestry catchments had similar grazed riparian margins and stream substrate. This is believed to be explained by goat grazing under the pines which had essentially the same effect as farm animal grazing on stream-side vegetation in the pasture catchment. Following harvesting, over-sowing, and forest re-establishment, the stream-side habitat in

the forested catchment changed substantially to one dominated by a mixture of thick exotic grass and dense blackberry which has affected the channel hydrology and consequently, the fish habitat. However, the monitored stream sections in both catchments have not shown significant changes in species type or numbers over the 10 year period, although the Pakuratahi catchment is characterised by typical low gradient, coastal fish species; (Inanga, longfin eel and Common Bully). The spring-fed nature of the both catchments means that strong base flow and lower summer water temperature enables a more diverse fish population to exist here compared to other similar-sized non-spring fed Hawke's Bay coastal streams.