



Executive Summary

Introduction

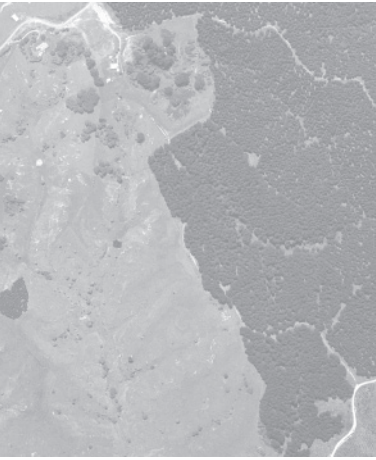
This publication documents and analyses information collected over 12 years (1993–2005) from two adjacent catchments, one in pasture (Tamingimingi, 795 ha), and the other in *Pinus radiata* forest (Pakuratahi, 345 ha) in the coastal hill country of Hawke's Bay, north of Napier. The study was initiated in 1993 as part of a collaborative venture between the Hawke's Bay Regional Council and the local forest industry (represented by Pan Pac, Juken NZ and Carter Holt Harvey) in response to public concerns over the potential effects of forestry on water quantity and quality, soil erosion and sediment generation, and in-stream values. The data were collected by scientists from the Hawke's Bay Regional Council, Landcare Research, the Logging Research Organisation (now disbanded), Forest Research Institute (now Ensis), Massey University, and NIWA. They have been analysed to provide information that can be used to address the above concerns.

Land management

The Tamingimingi catchment was converted from a mixture of native scrub and unimproved pasture to European pasture grass (rye and crested dogstail) in the 1960s. Land use was predominantly sheep and cattle grazing at a stocking rate of 10–12 su/ha. The Pakuratahi catchment was planted in *Pinus radiata* between 1970 and 1972. The initial harvesting phase began in late 1997. This involved the construction and up-grading of roads and landings which continued through to late October 1999. Logging commenced in December 1997, and approximately half the catchment was harvested by February 1999. Harvesting was completed in October that year. Throughout this phase, best management practices, such as the use of ridge-top roading, cable logging techniques, and stem extraction to a central processing area to minimise landing size, were adopted to minimize environmental impacts while maximising production. Preparation for the next crop included aerial desiccation followed by over-sowing, and a strict maintenance schedule for existing infrastructure including roads and landings. The Pakuratahi catchment was replanted between 1998 and 2000, at 830 - 850 stems per ha, achieving canopy closure by 2005.

Changes in streamflow

Catchment area rainfall was estimated from two recording rain gauges, one located in the lower reaches of the Pakuratahi catchment, and the other in the headwaters of the Tamingimingi catchment. The average annual catchment rainfall was 1165 mm, with 1997 and 2003 being wet years (1431 mm and 1383 mm respectively), and 1998 and 2004, dry years (867 mm and 879 mm respectively). Maximum daily rainfall totals were recorded during storms on 1 July 1997 (184 mm) and 21 October 2005 (163 mm). Runoff was recorded with two Crump-type broad crested v-notch weirs. In the pre-harvesting period (1993–1997), annual water yields from the forested catchment were 6% lower than those from the adjacent catchment in pasture. During and immediately after harvesting (1998–1999), annual water yields from the forested catchment exceeded those from the pastured catchment by an average of 22%, but by 2005, the difference between the two catchments had declined to only 5%. This suggests that, although annual water yields are being reduced by tree growth, it will be some years before water yields from the planted catchment will return to pre-harvest levels. Surprisingly, annual low flows (measured as the minimum annual 7-day event), were higher from the forested catchment during the pre-harvest period compared with those from the catchment in pasture. This situation is thought to reflect the greater groundwater seepage from the forested catchment which sustains baseflows. The annual difference between the two catchments increased during the harvesting phase but by 2004 it was approaching that before harvesting.



Erosion

An analysis of the erosion history of the two catchments revealed a substantial reduction in the extent of slip erosion in the forested catchment, between 1943 and 1988, but a lesser reduction in the pasture catchment. A major storm in December 2005, 5 years after replanting, resulted in minimal erosion in the forested catchment compared with the catchment in pasture.

Changes in sediment yield

Prior to harvesting (January 1995–June 1997), the pasture catchment yielded almost four times more suspended sediment than the catchment in mature forest. After the up-grading and construction of new roads and landings (August 1997 to August 1999), and subsequent harvesting (December 1997 to October 1999), suspended sediment yields from the forested catchment in the period January 1997 to December 1999 increased to almost three times those from the pasture catchment. A combination of careful maintenance and repair of existing infrastructure, over-sowing and rapid replanting led to a substantial reduction in sediment yield from the harvested catchment compared with the one in pasture by the second year of the post-harvest period (2001). That year the pasture catchment yielded four times more sediment than the harvested catchment. This demonstrates that the adoption of the appropriate management procedures after harvesting can assist in returning suspended sediment yields to pre-harvesting levels within 2 to 3 years. Over the 12-year period of record, the total suspended yield from the pasture catchment was over one-and-a-half times that for the catchment going through the forest rotation.

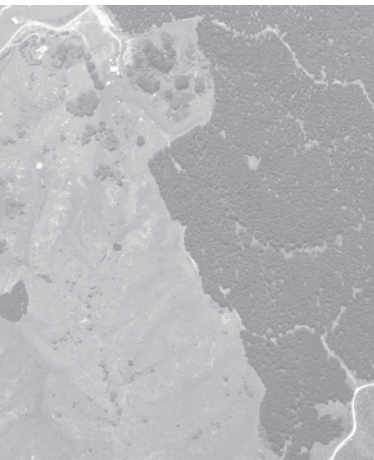
Plot studies showed that, within two years of over-sowing, sites of deep disturbance can display an almost complete vegetation cover. They also showed that slopewash from harvested areas is not a major sediment generating process. The main sources are road cutbank and sidecast failures, bank erosion, and shallow landslides.

Changes in water quality

Before harvesting, the pasture and forested catchment displayed similar levels of turbidity, nitrate nitrogen and total phosphorus. There were small increases in electrical conductivity and pH in the latter catchment after harvesting, but no significant increases in turbidity, or in the concentrations of cations and anions, nitrate nitrogen, and phosphorus.

Changes in stream channel morphology

A combination of storm events and harvesting had the greatest influence on stream channel morphology in the Pakuratahi. A pre-harvest storm scoured headwater stream channels accumulating sediment at the bottom of the catchment, although effects were not as severe as in the Tamingimangi. After harvest, accumulation of sediment and woody debris in stream channels raised stream levels, especially in the headwaters. This material was susceptible to movement in an immediate post-harvest flood. Increased light levels encouraged vegetation growth in the stream channels, trapping and retaining sediment and woody debris in the channel and the riparian margins, and probably contributing to reduced sediment yields in the early establishment phase. Some of this sediment may be mobilised as channel and bank vegetation dies off, and in-stream slash decomposes, leading to channel changes. Storm events, rather than any specific land-use practice, had the greatest impact on stream channels in the Tamingimangi, often resulting in channel scour and increased particle size.



Changes in stream invertebrate communities

The number of taxa declined after harvesting, and the communities changed from ones dominated by mayflies to more impact-tolerant taxa such as midge and beetle larvae, and snails. Similar communities were also found at selected sites in the pasture catchment streams. It took five years for the biological characteristics of these streams to return to a pre-harvest condition.

Changes in fish communities

The pasture catchment has shown very little change in biodiversity and the number of individuals in each species. Fish biodiversity showed some variation in the harvested catchment during the study, but the changes were not sufficient to suggest that there had been a negative impact in the interval between harvesting and re-establishment.

Key findings

- The adoption of prudent management practices such as confining access roads to ridge tops where feasible, keeping log landings small, and using cable logging techniques on steep terrain, has ensured that environmental impacts have been kept to a minimum.
- The areas of highest erosion risk are on upper ridges mantled by soils that have formed in volcanic ash and alluvial gravels, and steep slopes facing east and west.
- The growth of a post-harvest forest cover substantially reduced the amount of slip erosion, compared to areas in pasture.
- With the adoption of appropriate forest management regimes, suspended sediment yields, during and immediately after harvesting, are unlikely to be more than three times higher than equivalent areas in pasture, and should return to pre-harvest levels in 2-to-3 years.
- The main sources of sediment associated with forestry operations are road cutbank and side-cast failure, shallow landslides, and stream bank erosion. In the pastoral catchment they are shallow landslides and stream bank erosion.
- Over the length of a forest rotation total suspended yields from forested catchments should be considerably less than those in pasture.
- Annual water yields from mature forest will be lower than those from adjacent areas in pasture, but will increase in response to harvesting. This study showed a 20% increase in water yields following harvesting, and a very gradual return towards pre-harvest levels with the growth of the new crop. With canopy closure achieved in 2005, the reduction in water yields for the forested catchment should begin to accelerate.
- The trends in water yield described above are considered to be applicable to other catchments in the region, but the magnitudes of the changes may be greater elsewhere, especially in catchments that do not have the same groundwater contributions to streamflow as observed in the planted catchment.
- It is tentatively concluded that forestry operations in the coastal hill country of Hawke's Bay are unlikely to cause any substantial and long-term changes in water quality.
- Mature pine forests were more effective at moderating storm impacts on stream channels than pasture. Stream channels accumulated sediment and woody debris during harvest, particularly in the headwaters and were more susceptible to storm impacts in the immediate post-harvest period.
- Harvesting can change the in-stream invertebrate fauna from a relatively diverse community to one more typical of streams in farmed agricultural land.
- Subsequent sediment removal from stream beds during flood events in the harvested catchment may encourage the gradual re-establishment of an invertebrate fauna more typical of one that existed before harvesting, a situation that may take at least three years.
- Fish habitats will show a marked change following canopy removal and over-sowing. However, this study suggests that changes in fish numbers and species will not be significant compared with similar streams in pasture catchments.

