Forest harvesting in the Marlborough Sounds – Flying in the face of a storm?

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Abstract

A rainstorm in November 1994 caused widespread damage within the Marlborough Sounds. Rainfall was highly variable and intensities were not particularly high. Return periods calculated from 24 hour and 15 min. intensities for the storm at Rahotia Forest were about five years.

A weir within the recently harvested paired catchment study at Rahotia Forest was damaged beyond repair by a landslide triggered at the most intensive part of the storm.

Apart from a few landslides emanating from gully head wall depressions on steep slopes, the cutover and access roads were not greatly affected by the storm.

Careful harvest planning and matching equipment to the environmental setting were largely responsible for the minimal damage observed at Rahotia. Planning and adaptability will be the key words of the future for forestry in the Marlborough Sounds.

Introduction

Between November 5 and 10, 1994, a rainstorm caused widespread damage in the Queen Charlotte and Kenepuru Sounds. Houses were damaged or destroyed, roads were affected by landslides and washouts, and minor flooding occurred in some areas. Manaaki Whenua – Landcare Research has operated a paired catchment study since 1992 at Rahotia Forest in Tory Channel, Queen Charlotte Sound for the purpose of assessing off-site impacts of harvesting (Figure 1). At the time of the storm, harvesting had only just been completed at Rahotia, enabling us to determine if the planning and harvesting operation was successful in minimising environmental effects. This article addresses the impact of the storm with particular reference to the issues of forest harvesting, planning, restocking, and environmental risk.

The November storm

In early November 1994, the central region of New Zealand was hit by a series of rain events which caused widespread damage and flooding in Nelson, Marlborough, Wellington and the Wairarapa. Rain was prolonged and resulted in soils becoming saturated. In the Marlborough Sounds the storms affected the more northern and western parts but tracked through the north-eastern and eastern quadrants. Periods of high-intensity rain during these events triggered landslides in a number of localities, some causing severe damage to baches and roads. Unforested areas were particularly affected. Damage occurred to roads in Queen Charlotte Sound (Grove Track) and to the Kenepuru-Portage road. Of the $3 million damage done to roads in the Marlborough District about $2.5 million related to damage in the Sounds. This was the biggest cost of any storm in the council's history (Frank Porter, Marlborough District Council Engineer, pers. comm.). About 50-60 sections of road on the Linkwater-Kenepuru Road dropped out and some 60 retaining walls have had to be built. Road failures were attributed to a wet period preceding the storm, followed by a storm of moderate duration with some high-intensity falls; there was also damage to roads in the Port Underwood area (south and east of Rahotia). In addition, several properties were damaged or destroyed between Blackwood and Onahau Bays on the northern and western side of Queen Charlotte Sound. The storm also triggered a landslide which inundated and destroyed one of our stream-gauging sites at Rahotia.

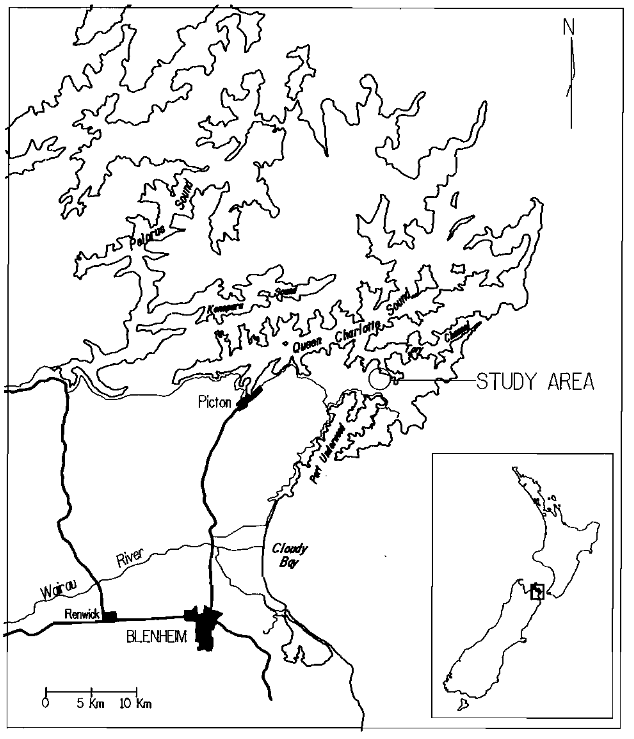

Figure 1. Location map of Rahotia Forest.

Rainfall

The total rainfall for the November storm recorded at Rahotia was 241 mm (National Institute of Water & Atmospheric Research (NIWA) rain gauge #142036 Underwood). The daily total of 133 mm was the biggest since the study began in February 1992 (Figure 2a). The maximum hourly total was 25 mm and occurred between 5:00 pm and 6:00 pm on November 7; it represents a return period of about five years (Tomlinson 1980). The maximum 15-minute intensity of 9 mm between 5.30 pm and 5.45 pm on the same day also gives a return period of about five years.

The rainfall intensities of the November storm were not particularly high by local standards. Intensities of 200 mm in 12 hours are not uncommon for parts of the Sounds (Sutherland 1985) and these could be expected to occur once a year in places such as Nydia and Kaiuma Bays. However, there is generally a large variation of rainfall across the Sounds for any given rainstorm (Figure 2b).

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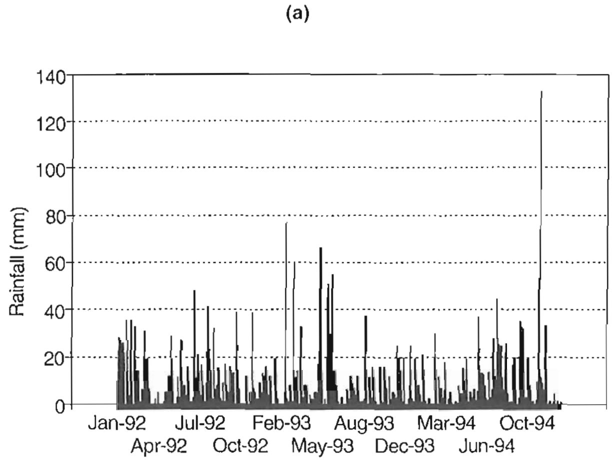

Figure 2. (a) Daily rainfall at Rahotia Forest since February 1992 (courtesy of NIWA).

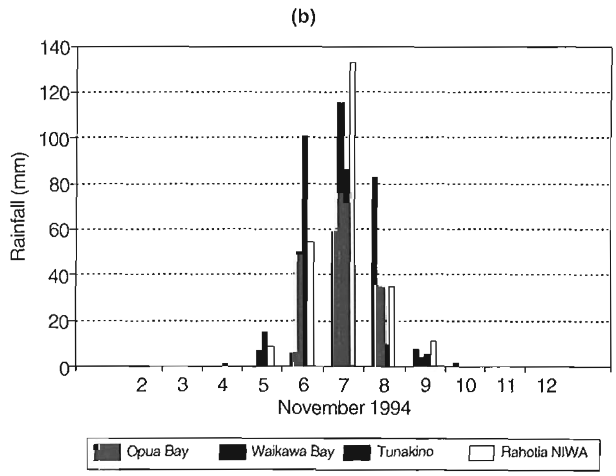

Figure 2. (b) Daily rainfall for November 1994 from four Marlborough Sounds rain gauges. (Note: all but Tunakino are located in Queen Charlotte Sound.)

Effects at Rahotia

Landslides

Between Feb. 1992 and Sept. 1994 138 ha of mature radiata pine forest was clear felled at Rahotia. Excluding road-related failures, eight landslides occurred in the cutover during the November storm, mostly in the areas which had been logged first. All occurred below 200 m elevation on steep (often over 30°), upper or mid-slope gully depressions, in stony, silty-clay loams. At altitudes below 200 m the soils are moderately to strongly weathered, which makes them more susceptible to failure than less weathered soils at higher elevations (e.g., Laffan, 1987; McQueen *et al.*, 1985; Laffan *et al.*, 1985). The most significant effect of the storm was the landslide which inundated the weir at Rahotia catchment 2 (Figure 3b, c). This landslide occurred around 5.40 pm on the evening of November 7 and coincided with the period of highest rainfall intensities of the storm (9 mm between 5.30 pm and 5.45 pm) (Figure 4).

Figure 3. (a) Bach on east side of Blackwood Bay damaged by landslide.

Figure 3. (b) Shallow landslide originating in steep gully head-wall depression which turned into a debris avalanche/flow and destroyed the weir in catchment 2.

A number of small landslides occurred in various parts of the cutover, but generally these were small shallow failures in which the failed material remained close to the point of failure. Several landslides, including the one which damaged the weir, became channelised and turned into debris avalanche-flows which in turn eroded material from ephemeral stream or swale areas. Since the major streams at Rahotia cross a wide fan before entering the sea, slopes are not directly coupled to the marine environment. This change of gradient assists the 'capture' and retention of sediment on site. Unfortunately, other parts of the Sounds do not have the benefits of these flatter areas and the streams and slopes grade directly to the sea. In these cases, any sediment entering the waterways from roads or landslides is flushed directly into the sea.

Other than small batter slope and sidecast failures along road lines, there were no large landslides related to the tracks and landings. In many other instances intense rainstorms have caused serious failures of roads, tracks and landings on recently harvested areas (Coker *et al.*, 1991).

Roads

Damage to logging roads was not great – all roads had been

Figure 3. (c) Catchment 2 weir filled with landslide debris.

decommissioned a few months prior to the storm with cutoffs and drains installed on the roads. Most of the damage was superficial, with numerous small batter collapses onto the road pavement as well as some sidecast failures. Rilling was seen in a number of places where road runoff from blocked water tables eroded the road pavement itself. Cracks in the sidecast occurred in several localities but many of these had been visible in 1993 and did not fail or enlarge during this event.

Streams

Apart from the stream draining catchment 2 whose weir was affected by the debris flow, the stream channels draining the cutover were not damaged. Some effects were observed where Tower Stream meets the fan upon which the processing landing was located. Here, the stream had been diverted to avoid the central log-processing area and the storm flows re-routed the stream back to its original course. Apart from deposition of some coarse material on the surface of the landing, no real damage was done to either the landing or the surrounding area.

In the main streams draining the cutover, the presence of both slash and dense stream-side vegetation tended to reduce the erosive force of water moving down the channels and also aided in retaining any sediment delivered to these streams.

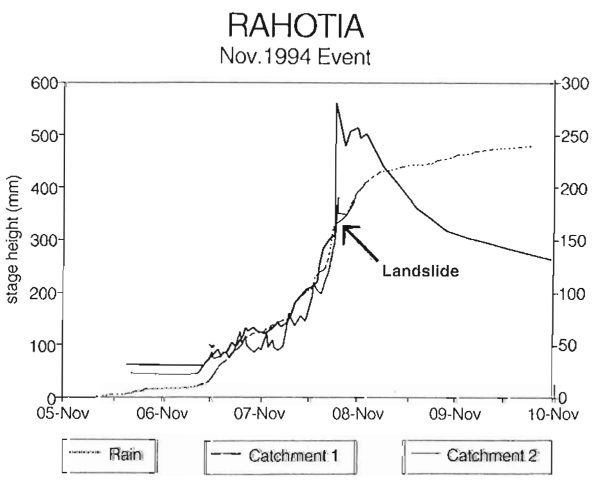

Figure 4. Cumulative rainfall and hydrographs for catchments 1 and 2 for the November 1994 event. Note that the time of the landslide which inundated the weir occurred immediately after the most intense part of the rainfall.

Cutover

The cutover did not appear to be visibly damaged by the rain storm other than in those few mid-slope localities where landslides occurred. Over 80% of the cutover, vegetation regrowth was well advanced with a mixture of weeds, grasses, and regenerating pines. The other 20% had been clear felled some months before and regrowth was limited to low-growing herbaceous weeds such as bracken fern, thistles, and fireweeds. Moreover, there were no slips in this area, which we attribute to greater residual root strength from the recently cut trees.

Implications for Forestry in the Sounds

More than 6000 ha of *Pinus radiata* plantation has been established on the steep slopes of the Marlborough Sounds. Little quantitative evidence has been published to substantiate claims of erosion and decreased water quality caused by forest harvesting and other operations in the Sounds. Snake Point, part of Farnham Forest logged two decades ago, provides an often-quoted example of human-induced erosion and sedimentation and is cited as an example of how forestry can adversely affect the marine waters of the Sounds (e.g. Johnston *et al.*, 1981; Fahey & Coker 1992).

In July 1983, a large rainstorm dumped more than 150 mm of rain on Farnham Forest in two days, causing a number of landslides, some of which damaged buildings and property. A second large storm in October of that year dumped a further 300 mm of rain causing more landslides (O'Loughlin 1985). Over the 140 ha, 17 mass movements resulted from the two storms. All involved less than 500 m³ of material, and with one exception were initiated on slopes over 30°. Most landslides were not related to logging-road construction. Without some knowledge of earth science, and without the benefit of a previous episode of landsliding which could have served as a warning of potential instability, it is unlikely that even the most experienced and careful of logging planners (with the choices of equipment available at that time) could have foreseen the problems that occurred at Farnham Forest.

Most of the landslides at Farnham Forest were not related to logging-road construction, but were initiated in upper-slope or mid-slope gully depressions generally on slopes over 30°. Similarly, the landslide that inundated the weir at catchment 2 and many of those that damaged baches in Blackwood Bay also originated in upper-slope gully depressions. The landslide material generally becomes concentrated in gullies or stream channels and developed into debris flows or avalanches. Around the time of the storm at Farnham Forest the debate about the future of forestry in the Sounds and the likely trade offs between forest development and maritime environmental protection began to escalate. Since that time, there have been only a few harvesting operations in the Sounds and, generally, they have all been carried out with little environmental impact to both on-site and downstream (receiving waters) values. However, almost all operations have employed some aspects of 'non-standard' harvesting or transportation practices. Many of these have included new or modified log-extraction methods for steep slopes. Alternatively, novel transport methods were involved. It seems inevitable that forestry in the Sounds will continue to test the ingenuity of the harvesting contractors and harvest planners. The current wood resource is generally located on steep, inaccessible slopes. As in other parts of the country, recreational and environmental sectors appear to be placing continued pressure on the Marlborough District Council to ensure that forestry development is not only sustainable but that any environmental effects are minimised.

What do we know about the effects of removing trees at harvesting time? Tree removal tends to destabilise slopes and may increase rates of mass-movement erosion. The contribution of roots to soil strength will decline as roots decay. By about two years after cutting, over half the tensile strength of roots is lost and within 30 months radiata pine root-wood tensile strength declines to about 15% of live roots (O'Loughlin & Watson 1979). Without root reinforcement the soils on many slopes over 30° may suffer shallow landsliding during only moderate storms. The most critical period or window of vulnerability for *Pinus radiata* plantations on such slopes seems to be between two and six years after tree removal, depending on whether the new crop was planted on previously planted land, scrub, or on pasture or grassland. This is based on examination of landslides caused by Cyclone Bola (Marden *et al.*, 1991; Marden & Rowan 1993) and from root growth and site occupancy studies (Watson & O'Loughlin 1990). There appeared to be no difference in extent of landslide damage caused by Cyclone Bola within individual age classes of *Pinus radiata* up to six years after planting (Michael Marden, Manaaki Whenua – Landcare Research, pers. comm.), but there was a distinct difference in those areas between six and eight years and greater than eight years, with most damage occurring in stands under six and least over eight years after planting. At a density of about 1250 stems per hectare, it takes about four years for lateral roots of adjacent trees to begin to approach each other and almost six years for the vertical roots to penetrate to a depth of 1.5 m (Alex Watson, Manaaki Whenua – Landcare Research, pers. comm.). These data indicate that it is highly desirable, if not crucial, that, on steep vulnerable slopes, planting must be carried out immediately following harvesting in order to reduce the risk of storm-induced landsliding. If planting is delayed, the window of vulnerability is widened. Recent research in the East Coast of the North Island indicates that for this region there is a period of vulnerability of about five years with an 82% chance of a major landslide-triggering storm event occurring (Watson *et al.*, 1995).

The rainfall intensities that were recorded during the November 1994 event were typical of the magnitudes required to initiate landsliding in other areas of the world (Caine 1980). The 25 mm/hour threshold was identified by Caine for a wide range of localities. Similarly, storms producing more than 80 mm of rain in 24 hours usually have the capacity to saturate shallow hill soils in slope depressions and produce landslides (Crozier & Eyles 1980). As the return period of the November storm was not particularly large, this region will continue to experience storms of this magnitude which cause damage to forests and other land uses.

The observations made following the November storm and other earlier storms suggest that:

- unless the climate changes dramatically, the Marlborough Sounds will continue to be subjected to the type of rainstorms that cause landsliding and erosion; and
- plantation forests on slopes in excess of 30° will need to be harvested in a manner which does not seriously disturb the soil or leave large areas bare of vegetation cover. In other words, coupe size may have to be limited.

Public participation is becoming increasingly important in land-use, decision-making processes. The forestry sector must be seen to carry out acceptable practices and needs to win the confidence of the local community. With good planning and careful management, forestry is a land use that can be environmentally sustainable and compatible with other activities in this region.

At Rahotia, significant consultation and planning went into the preparation of the harvest plan (Spiers 1992). In preparing the harvest plan, considerable attention was paid to the unique environmental setting of the Sounds, its physiography, soils, current resource use, as well as identifying specific factors to take into account (Coker & Fahey 1991 unpubl. FRI contract report). The second successful feature of both the plan and the operation at Rahotia was that equipment was matched to the needs of the site as well as to the needs of the contractor (Spiers 1992). The plan became a working document which was largely adhered to. Any modifications to the plan were carried out in consultation with all parties concerned. Once harvesting was completed, decommissioning activities such as installing drains and cutoffs on tracks and roads reduced the risk of damage to the infrastructure and to the neighbouring environment. These measures were largely responsible for the minimal damage to roads and landings observed at Rahotia.

There is a touch of irony, however. Rahotia Forest is not being replanted. Under the Marlborough District Council's Land Plan there was no compulsion to replant and under existing use rights plantation forestry was a permitted activity. The only condition of harvesting was that "vegetative cover" be returned within 24 months following clearance (Ewen Robertson, Marlborough District Council, pers. comm.). The forest owner has decided to manage the regeneration of radiata pine seedlings to form the new crop and, from an environmental viewpoint, there may be some benefits. Regeneration has been quick and widespread, and a contractor has already begun selecting and releasing seedlings for the new forest. These trees will probably be more "environmentally friendly", as they will have a long taproot which will improve their ability to stabilise slopes both in the early years and later. Research over the last decade seems to indicate that root architecture and root biomass of genetically improved and nursery-conditioned trees in which the tap root is cut may not stabilise slopes as well as the lower GF-rated or self-sown trees (Alex Watson, Manaaki Whenua – Landcare Research, pers. comm.).

There will continue to be a risk associated with forestry in the Sounds. The combination of steep slopes, weathered lower slopes with clay-rich soils, high intensity rainfalls, and direct coupling of slopes to the sea lead to a high potential for damage from landsliding and erosion during the rotation life of the forest. The likelihood of such events occurring can only be lessened by careful planning and management to ensure that large areas are not left vulnerable to these processes, especially after harvesting. This will happen only if the operation is well planned, the plan is followed or modified only in accordance with operational requirements, and the area decommissioned and replanted or re-vegetated quickly. Communication at all stages between the forest owner, the contractor, the regulator, and the surrounding community is essential and should be the cornerstone for the future success of forestry in the Marlborough Sounds.

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Greening the NZ forest industry

The forest industry and the environment are irrevocably linked at all levels of the forestry sector, Fletcher Challenge Forests Ltd's (FCF) Bryce Heard told an environmental seminar in Auckland recently.

Organised by the New Zealand Institute of Forestry and the Commonwealth Forestry Association (New Zealand), the one-day seminar, Greening the New Zealand Forestry Industry, addressed a range of environmental issues affecting the forest industry.

In summing up, Mr Heard said his overwhelming impression from the seminar was that everybody cared about environmental issues. "I did not hear one speaker who displayed the characteristic red-neck tendencies which were evident a few short years ago on this subject," the FCF director of strategic initiatives said.

Several keynote speakers and workshops considered the activities and roles of the Government, industry and non-government organisations (NGOs) in environmental matters. They also discussed environmental issues affecting industry development and the marketing of New Zealand's forest products, and discussed their effects on practising foresters.

A number of organisations in New Zealand work either directly or peripherally on the interactions between forestry and the environment, Mr Heard said. He suggested that the seminar's organisers continue their good work by considering the best way for interested parties to further meet and discuss environmental issues which affect the forestry sector.

Conference papers or further information can be obtained from Tim Thorpe, New Zealand Institute of Forestry, c/- Ministry of Forestry, PO Box 1610, Wellington tel: 04-472 1569, fax: 04-472 2314.