No. 168 1988

WHAT'S NEW IN FOREST RESEARCH

Erosion and sediment production from forest roads in south-west Nelson

Shaggery Road (middle foreground) cut through granite terrain in Motueka Forest. Evidence of sediment mobility is visible on fill slopes below the road line and in gullies leading down to the main stream at the bottom of the photograph.

From 1990 on, a rapidly increasing proportion of forest harvesting in New Zealand will be on steepland areas. Harvesting in these areas will require the construction of a network of logging roads and access routes. Experience overseas and in New Zealand has shown that the construction of such roads can have severe environmental effects. Forest road construction can cause accelerated erosion of the newly exposed ground surface, and the redistribution of massive amounts of soil and rock during construction can lead to the infilling of streams and reduced water quality. As harvesting moves into steepland areas, forest managers and engineers need to be able to estimate how proposed roading systems will affect sediment distribution, and stream and water quality. Staff of FRI's Land-use Impacts group have been monitoring the amount of sediment mobilised from existing forest roads in several areas of the South Island of New Zealand. In 1985 the group began a detailed study of the effect of forest roading on water runoff, amount of sediment eroded, and the sediment supply to streams in two forests in south-west Nelson.

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Golden Downs and Motueka Forests (Fig. 1) contain large areas with steep topography. Some of the steepland is underlain by relatively stable gravels, but much of it has been formed on erosion-prone granites. These coarse-grained crystalline rocks have developed a mantle composed of crumbly, sand-sized particles which appear to be very sensitive to track and road building. It is estimated that 2.6 million tonnes of loose material were disturbed during the construction of the 200 km of roads through granite in the two forests, by the deposition of sidecast fill and the creation of cutbanks and the drainage channels at their bases ("table drains"). Some of this material and that from the road surface itself had entered local stream courses, resulting in sediment deposition which has concerned various local authorities.

Road erosion experiments

Kyfuiks Road in Compartment 442 of Golden Downs Forest was chosen as typical of roads underlain by granite. This was confirmed by a subsequent survey of the dimensions and gradients of roads throughout Golden Downs and Motueka Forests. An average kilometre of road was found to have the following characteristics: width, 4.5 m; gradient, 4°; cutbank area, 4500 m²; and sidecast fill area, 10 000 m².

The test section of Kyfuiks Road was graded to produce a freshly exposed surface more representative of conditions soon after construction, and subdivided into three 25 x 4-m plots. To determine the sediment yield from the road surface alone, the cutbank of the lowest plot (No. 1) was isolated as a sediment source by a series of metal troughs installed just above the table drain. The troughs caught sediment from the cutbank without restricting the flow of water down the table drain. Sediment yield and water runoff were measured for each plot using a series of inexpensive drums and weirs. The first and higher of the two drums caught sediment carried by water along the table drain. In the second drum the depth of water flow in a metal V-notch weir was recorded to measure runoff. The rainfall record from an automatic rain gauge was used to estimate storm magnitudes, intensities, and energy levels.

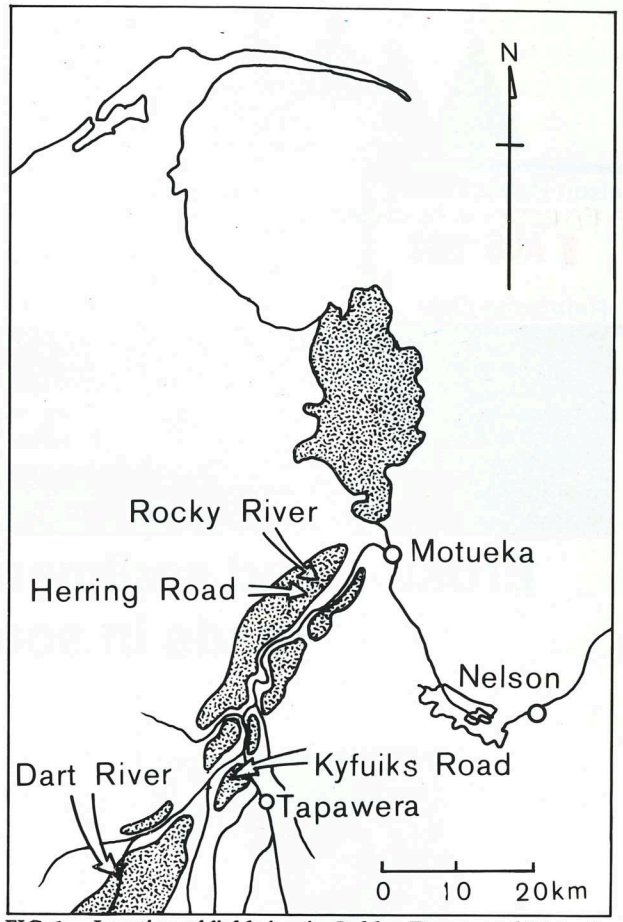
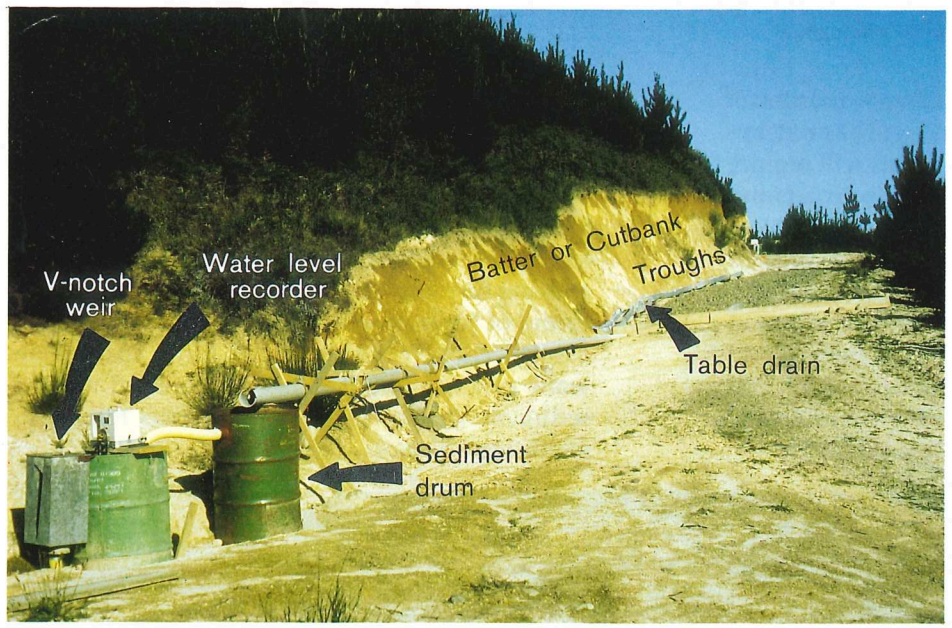


FIG. 1 — Location of field sites in Golden Downs and Motueka Forests. Shaded areas represent extent of granite terrain.



Plot 1 on Kyfuiks Road showing equipment used to collect sediment and measure runoff from an isolated section of road surface (upper right). Troughs for trapping material from the cutbank are also visible.

To determine the sediment yields from steeper sections of forest roads and from those with higher cutbanks, two additional plots were established on Herring Road in Motueka Forest in early 1987. The layout and the measurement methods were the same as at Kyfuiks Road, except that they were designed to measure only sediment yield.

Erosion of the road surface and cutbank

As expected, the plots recently established on the steeper road sections (i.e., on Herring Road) produced more sediment than the sites on Kyfuiks Road. In the first 6 months of 1987, one of the Herring Road plots yielded a total of 169 kg (0.40 kg/m²) whereas its counterpart at Kyfuiks Road yielded only 33 kg (0.15 kg/m²). However, although this Herring Road site produced about three times more sediment than the sites on Kyfuiks Road, roads of similar gradient make up only 10% of the total road network.

Based on the sediment production figures listed in Table 1, the data collected from Herring Road, and information from the road survey, the average sediment yield for the 200 km of road occupying granite terrain in the two forests (assuming freshly graded conditions) is estimated at 9000 tonnes/yr. Because the area of these forests underlain by granite is 12 550 ha, the rate of sediment production from roads in granite is around 0.7 tonnes per hectare of forest, each year.

TABLE 1 — Sediment totals and production rates at the Kyfuiks Road erosion plots for 18 months, ending June 1987

Plot	Weight (kg)	Yield: Road surface only (kg/m²)	Yield: Road surface and cutbank (kg/m²)
1	195	1.95	*
2	385	*	1.78
3	283	*	1.89

It should be stressed, however, that freshly graded roads are more prone to erosion than "older" roads. For example, the circled points on Figure 2 identify storms that occurred at least 10 months after the Kyfuiks Road surface had been graded, all of which yielded much less sediment than storms of similar intensity that occurred shortly after grading. Therefore, the annual sediment production rate of 0.7 tonnes/ha, while reflecting early post-construction conditions, probably overestimates existing rates.

Sediment from sidecast fill

The sediment production from sidecast fill was not measured at Kyfuiks Road. However, data from earlier erosion trials in the Rocky River area of Motueka Forest showed that each square metre of sidecast material lost on average about 2 kg of sediment per year for the 3 years after road construction. Maximum losses were 6 kg per year.

Total sediment production

Sediment lost from the sidecast fill plus that calculated to come from the road surface and cutbank totalled about 13 160 tonnes/yr. Therefore, the mean overall sediment yield attributable to roading in the 12 500 ha of Motueka and Golden Downs Forests that is underlain by granite is estimated at 1.1 tonnes/ha each year. Again, it is emphasised that this figure is representative of conditions shortly after construction; current overall rates are expected to be lower. Since it is likely that the current road density of 16 m/ha will need to be doubled before the forests are logged, yearly sediment yield could rise to 2 tonnes/ha.

An earlier study in the Dart River area of south-west Nelson (Fig. 1) showed that after construction, the total sediment input from the road system briefly exceeded the input attributable to natural erosion in the catchment. Data from another study of south-west Nelson rivers yielded annual estimates of 1–3 tonnes/ha for bedload transport and 3–10 tonnes/ha for suspended sediment, suggesting that natural yields may be five to ten times higher than those estimated here for road erosion in granite areas. Thus, although the visual impact of road construction can be dramatic, the amounts of sediment yielded to local river courses may not be particularly significant when compared with background rates.

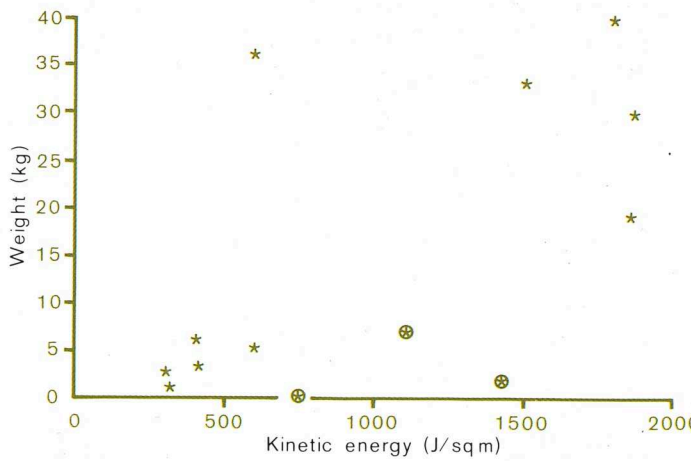


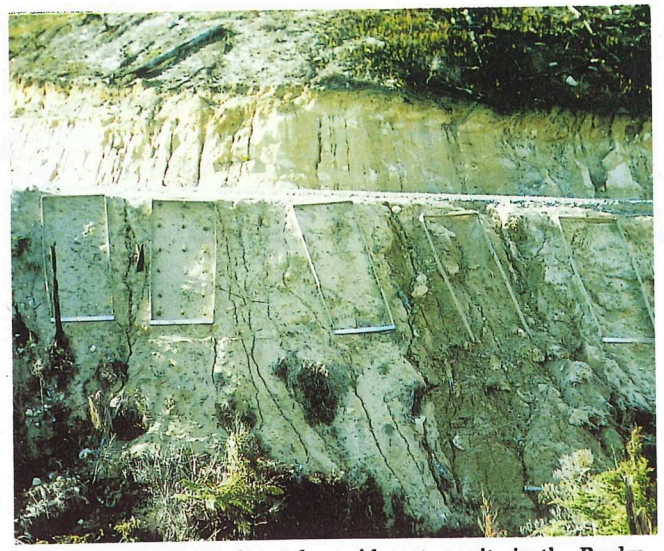
FIG. 2 — The effect of storm energy on sediment yield for the period January 1986 to June 1987, Trial 3, Kyfuiks Road. Circled points represent sediment response to storms occurring at least 10 months after grading.

Work elsewhere in New Zealand

The FRI has another series of road erosion plots in Queen Charlotte Forest, in the eastern Marlborough Sounds. There, the parent rocks are schists — fine-grained metamorphic rocks which produce large amounts of clay when weathered. Total sediment yields are only a quarter to a third of those from the south-west Nelson granites, although sediment production rates from sidecast fill slopes are similar to those recorded in the Rocky River area. This implies that sediment yield from the cutbanks and road surfaces may be relatively low. One site, close to sea-level near Opua Bay, has been designed to provide information on fine sediment production from roads cut into the old, deeply weathered, clay-rich soils common at lower elevations in the Marlborough Sounds. Virtually all the sediment from the cutbank and road surface is in the silt and clay size range, and is readily carried long distances by even small streams. Production of such fine sediment from forest roads has important implications for water quality in nearby marine environments, particularly when road densities will be increased for forest harvesting and log removal.

Future work

The future research programme includes an assessment of the impact of truck traffic on sediment yields from forest roads. Existing plots will be used for this work, and plans are under way to construct and install a portable sprinkler system to serve as a rainfall simulator. The results will assist in developing a set of surface erosion models for predicting surface runoff and sediment yield from existing and proposed forest roads in various regions of New Zealand. The models will aid in identifying specific problems of erosion or sedimentation so that appropriate control measures can be identified and implemented. Forest managers and engineers using these models will be able to minimise the environmental damage that will accompany the expanded and higher-density road network required for harvesting steepland forests.



(Right) Erosion plots located on sidecast granite in the Rocky River area, Motueka Forest. These were monitored for 3 years, from 1981 to 1983.

Summary

Sediment production on freshly graded sections of forest roads formed in granite in Golden Downs and Motueka Forests is around 1.5 kg/m^2 from the combined road-cutbank surface per year. Yields are higher on steeper segments of road but the sites studied are representative of average road dimensions and conditions in the two forests. Previous work showed the average annual yield from fresh sidecast fill to be 2 kg/m^2. Based on these figures, and the existing road network and area of sidecast fill, a maximum of 13 000 tonnes of sediment could be released each year from the 12 500 ha of forest underlain by granite; actual amounts are expected to be less. Not all of this material will find its way immediately into local streams, but even if it did, it would not be a major contribution when compared with natural sediment yields. The results of this work will be incorporated into a general erosion model which will assist in predicting increases in sediment yield from road sources when existing road networks are expanded and up-graded before forests are harvested.

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ISSN 0110–1048

PRINTED BY HOLMES PRINTING, ROTORUA - 1988