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ROAD-RELATED MASS MOVEMENT IN WEATHERED GRANITE, GOLDEN DOWNS AND MOTUEKA FORESTS, NEW ZEALAND: A NOTE

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ABSTRACT

Four major storms in July and August 1990 triggered 263 failures on the cutbanks and sidecast of 142 km of access roads in the granite terrain of Golden Downs and Motueka forests. The total volume of material displaced over the 209-km road network in granite was estimated at 193,000 m^3, which is about 367,000 t or approximately 2,800 t km^{-2}. This is equivalent to 80 years of sediment yield from surface erosion (estimated at 37 t km^{-2} yr^{-1} from the same road network in an earlier study).

INTRODUCTION

Golden Downs and Motueka Forests are located 40 km south-west and west of Nelson, respectively (Fig. 1). Most of Golden Downs Forest grows on dissected hill country underlain by comparatively erosion-resistant Moutere gravels. Some 6,200 ha, however, are planted on steepland underlain by highly erodible Separation Point granite, which has a strongly weathered regolith of loose, crumbly sand-sized material. Motueka Forest is made up of geographically separated blocks, most of which are located on granite (6,600 ha). Background erosion rates for river catchments in the vicinity are estimated at about 500 t km^{-2} yr^{-1} (Adams, 1980).

Several studies have measured sediment production from the road network on granite in these forests. Slumps, rills, and gullies associated with 25 km of road in the Dart River area (southern Golden Downs Forest) produced an estimated 12,000 t yr^{-1} (700 t km^{-2} of roaded forest area per year) (Mosley, 1980). Yields of sediment from surface erosion on the total road network in the granite terrain of the two forests were estimated at 37 t km^{-2} of forest or 23 t km^{-1} of road per year (Fahey and Coker, 1989).

Although it was recognised that storms with a long return period could trigger mass movements on the road network, none occurred during the 32-month study. Hourly and daily rainfalls were either below or equivalent to the 5-year return period intensities estimated for the south-west Nelson area (Tomlinson, 1980).

In July and August 1990, four major storms triggered numerous mass movements in the granite terrain, regardless of land use. This study considers failures associated with forest roads constructed in granite. Some sections of road were removed altogether through failure of the sidecast, while others were blocked by cutbank failure. The type and number of failures were documented

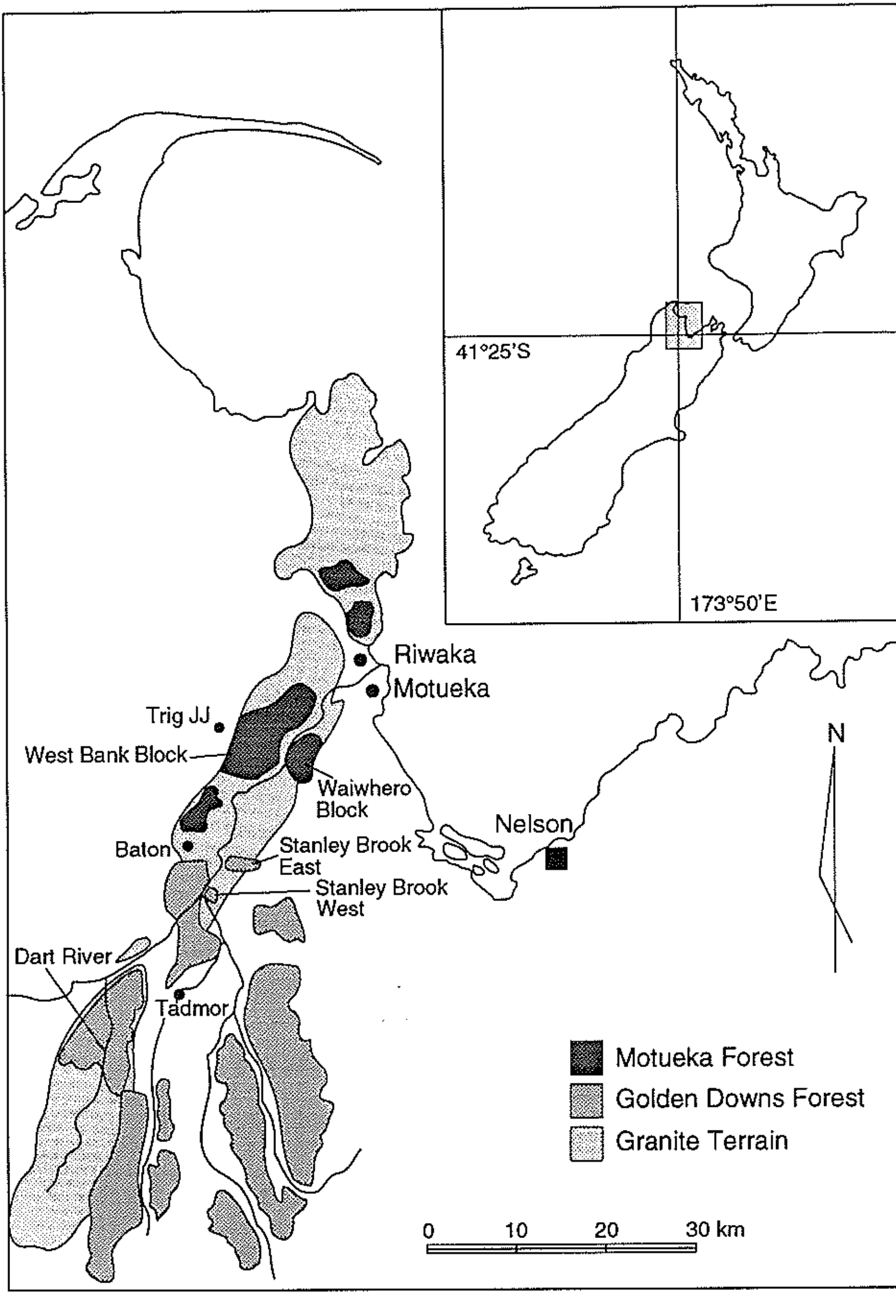

FIG. 1—Map showing Golden Downs and Motueka Forests, the extent of granite terrain, and sites mentioned in text.

in November 1990, and the volumes of material mobilised were estimated (Graaf and Wagtendonk, 1991). The results are summarised here, and the quantity of material derived from mass wasting is compared with that measured during the earlier study of surface erosion (Fahey and Coker, 1989).

METHODS

Rainfalls during the four major storms in July and August 1990 were highest in the Riwaka area north-west of Motueka: 131 mm for 7–10 July; 87 mm for 21–27 July; 153.6 mm for 4–8 August; and 350 mm for 10–15 August (data supplied by Nelson–Marlborough Regional Council). The maximum 24-hour event was 212 mm on 11 August, which has a 20-yr recurrence interval (Tomlinson, 1980). At three other rainfall sites to the south (Trig. JJ, Baton, and Tadmor) the storm had a return period of between 5 and 20 years.

Mass movements are features involving the wholesale detachment and downslope transport of soil and rock under the influence of gravity. The two most common road-related mass movements observed during the study were planar failures (translational slides) and slumps (rotational slides), which include earthflows, debris flows, or debris slides.

For cutbank failures (planar or slump), the following information was recorded: (a) length, width, and depth (measured by tape) from which the displaced volume was calculated, (b) the height, slope and aspect of the cutbank at the point of failure, and (c) whether the debris crossed the road near a stream course. For sidecast failures, (a) planar and slump features were distinguished, (b) displaced volumes were estimated, and (c) slope and aspect of the sidecast at the point of failure were recorded. Any relationship between cutbank and sidecast failures was noted. Because of the extent of damage to the 209 km of roads in the granites, it was not possible to survey all sections.

RESULTS

A total of 263 failures was recorded over the 142 km of road traversed during the survey. The sediment volume for the 263 failures was 124,090 m^3. Based on the assumption that the 67 km of road not surveyed had a similar proportion of failures, the total volume displaced across the full 209-km road network in the granite was estimated at 193,000 m^3. This converts to 366,700 t, assuming a specific gravity of 1.9 g cm^{-3} for weathered granite. For the area planted on granite (13,000 ha) this represents 2820 t km^{-2}, or 1755 t km^{-1} of road.

Of the total sediment yield, only half (183,350 t or 1400 t km^{-2}) is estimated to have entered local streams. The remainder is stored mostly on the interfluves, along and below the sidecast. Of the 10 forest blocks surveyed, the West Bank Block had the greatest number of failures per kilometre of road. Other blocks displaying large numbers of failures include Stanley Brook East, Stanley Brook West, and the Waiwhero Block.

A frequency distribution shows that 43% of the 263 failures were <100 m^3, and 62% were $<200 m^3$ (Fig. 2). Only four slips exceeded 4500 m^3. However, the few larger failures (especially those over 1000 m^3) mobilised the bulk of the material (Fig. 3).

Cutbank and sidecast failures numbered 151 and 112, respectively. However, cutbank failures mobilised only 19% (43,700 t) of the total sediment. Only 24

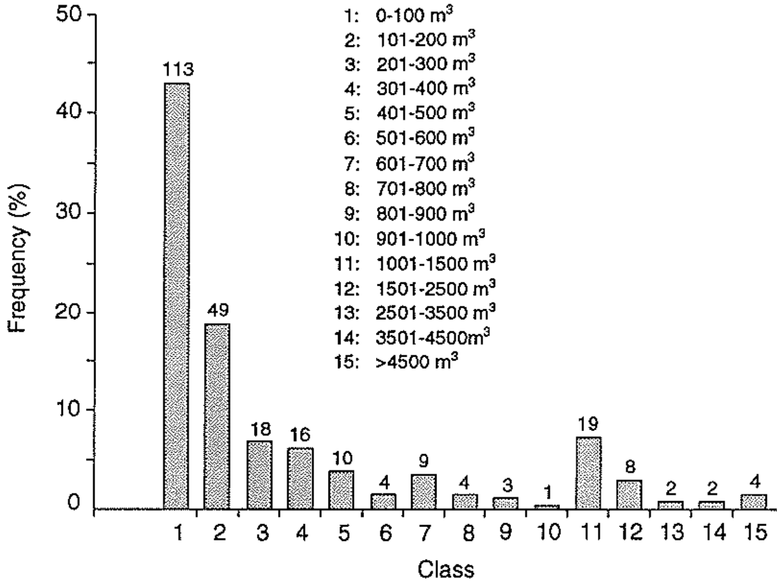

FIG. 2—Percentage frequency and number of slope failures per volume class for Golden Downs and Motueka Forests during storms of July and August 1990.

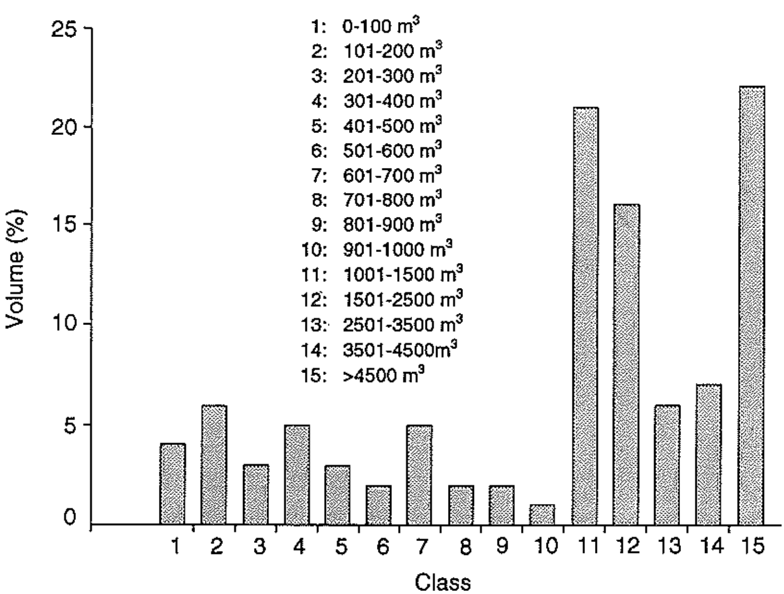

FIG. 3—Percentage volume of sediment yielded by failures per volume class for Golden Downs and Motueka Forests during storms of July and August 1990.

of the cutbank and sidecast failures appeared to be physically related to each other.

DISCUSSION AND CONCLUSIONS

Yields estimated from mass movements during the four major storms in 1990 along the 209 km of forest roads underlain by granite in Golden Downs and Motueka Forests are almost two orders of magnitude greater than those estimated for average annual surface erosion from the same road network for the period January 1986 to August 1988. They are still 10 times higher than the predicted yearly maximum yield for surface erosion from the upgraded and extended road network at the time of harvesting (Fahey and Coker, 1989), and almost 6 times the estimate for average annual background erosion rates (Adams, 1980; Fahey and Coker, 1989).

It should be kept in mind, however, that no measurements of surface erosion were available during the period of the four storms in 1990. This lack of data, coupled with the absence of any storms of similar magnitudes during the time surface erosion was being monitored in the granites, makes any direct comparison between the two sets of data difficult. In addition, the four storms identified above occurred in quick succession, and the quantity of sediment mobilised is likely to have been substantially greater than if there had been months rather than days separating each event. The last storm in the sequence was also the biggest, but if it had occurred in isolation, it probably would have mobilised less material. Nevertheless, this study shows that, whereas surface erosion on access roads in steepland forests is an important source of sediment production in the long-term, a short series of high-intensity storms with return periods of between 5 and 20 years can produce as much sediment as up to 80 years of continuous surface erosion with average storm conditions.

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REFERENCES

Adams, J. 1980: Contemporary uplift and erosion of the Southern Alps, New Zealand. *Geological Society of America Bulletin (Pt. II) 91:* 1–114.

Fahey, B.D.; Coker, R.J. 1989: Forest road erosion in the granite terrain of southwest Nelson, New Zealand. *Journal of Hydrology (N.Z.) 28:* 123–141.

Graaf, M. van de: Wagtendonk, A. 1991: Road-related mass wasting, Golden Downs and Motueka Forests, south-west Nelson, New Zealand. Unpublished report Forest Research Institute, Christchurch, 51 p.

Mosley, M.P. 1980: The impact of forest road erosion in the Dart Valley, Nelson. *New Zealand Journal of Forestry 25:* 184–198.

Tomlinson, A.I. 1980: The frequency of high intensity rainfalls in New Zealand. *New Zealand Ministry of Works and Development, Water and Soil Division, Water and Soil Tech. Publ 19:* 36 p.

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