PLANTATION FORESTRY: HYDROLOGICAL AND EROSION ASPECTS

C. L. O'LOUGHLIN*

The last two decades have witnessed the steady encroachment of plantation forestry activities on to steep hill country hitherto unused for intensive forestry practices. This encroachment has highlighted the problems of slope stability changes, and stream water quantity and quality changes, associated with forestry development. Fortunately, a major part of the exensive plantations in the central North Island is largely free from many of the geohydrological problems which face the forest industry in other locations.

In order to emphasise the more important hydrological implications of plantation forestry I wish to consider briefly water yields, floods, and erosion and sedimentation.

WATER YIELDS

Total water losses, representing the difference between the quantity of precipitation falling on a catchment and the quantity of water appearing as streamflow, range from approximately 500 area mm to approximately 1300 area mm per annum for forested areas in New Zealand. For instance, Nelson and North Westland beech forests show total annual losses of about 1000 mm. Streamflow yield is likely to be reduced by as much as 150 to 200 mm per year under mature radiata pine compared with scrub hardwood vegetation or intact grassland tussockland. In parts of Nelson berrygrowers contend that conversion of reverted scrubland and beech forest to radiata pine reduces or eliminates streamflow during dry mid- and late summer periods when irrigation water is required. Their accusations may be valid if something more than 30 to 40% of the total catchment area which they depend on for their water supply is converted. It should also be appreciated that a growing radiata pine crop would not achieve maximum water use until complete canopy closure and substantial crown depths had developed at, say, 10 to 15 years.

*Protection Forestry Division, Forest Research Institute, P.O. Box 31-011, Christchurch.

Other conflicts between plantation forestry and water uses may be expected where future planned community developments will rely on small forested catchments for water supply (for example, the eastern coast of the Coromandel Peninsula), or where plantation forestry is the dominant land use in areas earmarked for hydro-electric power generation. For instance, the Dunedin City Corporation has calculated that the planned development of 2000 ha of the Waipori River catchment for exotic forestry could cost the Corporation $10 500 in lost generating capacity per year.

FLOODS

The complete removal of a forest cover (exotic or indigenous forest) from catchments less than 10 to 20 km^2 may be expected to increase the peaks of floods, with return periods about three years or less, by up to 30% (Hewlett and Helvey, 1970). Larger, less frequent flood events are unlikely to be changed. In larger catchments where attenuation of flood waves is important, and where only a small part of the total catchment area is likely to be deforested at any one time, very small or undetectable changes in flood magnitudes or in other water yield parameters can be expected.

EROSION AND SEDIMENTATION

During the establishment phase of plantation forestry, and during logging, tracking and roading operations, large but short-term increases in erosion and sedimentation rates may occur. These changes are probably the most serious consequences of intensive forestry on steeplands. Under intact forest conditions sediment yield rates from rolling to steep hill country normally range from ten to several hundred $m^3/km^2/yr$. However, rates may increase to several thousand $m^3/km^2/yr$ for several years after poorly executed roading and logging operation on unstable terrain (O'Loughlin and Pearce, 1977). Of course, good forest harvesting and roading practice and careful planning can largely avoid or drastically minimise such increases. To illustrate extremes, there are small areas of steep hill country underlain by Tertiary sediments where it is likely that, under production plantation forestry land use, the soil resource would be severely depleted after three or four rotations. On the other hand, over much larger areas of unstable hill country formerly under pastoral land use, soil depletion, and rapid supply of sediments to streams can only be moderated if the slopes are reforested. Parts of the Coromandel Peninsula and the East Coast/Poverty Bay region are examples. The reforestation of eroding hill pastoral lands

will create protection/production forests with a dual role — the first being to stabilise the landscape, the second being to produce utilisable wood.

NEW STRATEGIES REQUIRED IN PLANTATION DEVELOPMENT PLANNING

Certain inadequacies are outstanding in plantation development planning and implementation. The lack of landscape zoning based on slope stability and other geomorphic/pedologic criteria, for areas earmarked for large-scale plantation development, especially on sensitive hill country, must represent the most important factor in this respect. I am not talking about broad-scale zoning but detailed partitioning which may separate out parcels of land only a few hectares in size and could be depicted on 1:10 000 scale zonation maps. For instance, at Mangatu State Forest six dominant landscape stability categories were recognisable on the basis of geology, topography, slope morphology and erosion forms (Gage and Black, 1976). Hopefully, the information presented on the zonation maps will help determine the nature of future forest management activities. On less sensitive areas such a detailed investigation and zoning exercise could not be warranted but, nevertheless, sufficient geological/geomorphic information should be collected to enable partitioning hill areas destined for forestry development into:

(1) Areas where forest vegetation should be established and/or retained intact for protective purposes (protection forest zone).

(2) Areas available for establishing and managing stands wholly for production (production forest zone).

(3) Areas where forest vegetation should be established and/or retained for scenic or recreational purposes (amenity reserves).

As a large proportion of the geohydrological problems associated with plantations are related to poor road locations and construction standards, more realistic cost estimates must be allowed for in creating road access for forestry development. If average road development costs are $5000/km^2$, then roading costs should be about 20 to 30% of total development costs exclusive of purchase price. In some instances current road-building operations appear to proceed on absolute minimum finance (for reasons partly related to the difficulties of forward planning caused by the stop-start nature of land acquisition).

The management of river and streamside zones within plantation areas will require special attention. Generally, streams draining areas in excess of 50 ha will require streamside protection strips. Permanent streamside protection zones should be allocated in most future forestry development and logging areas. The composition and width of protection strips for various types of waterways and various types of topography require definition.

Another consideration which I believe requires attention in the future is the subsidising of conservation works on land under forest land use. To my knowledge, no tangible incentives for soil conservation measures in either the private or public sectors of forest management can be offered at present by the statutory bodies administering legislation.

REFERENCES

Gage, M.; Black, R. D., 1976. *Geological and slope stability investigations at Mangatu Forest.* FRI Report, 91 pp. (unpublished).

Hewlett, J. D.; Helvey, J. D., 1970. Effects of forest clearing on the storm hydrograph. *Water Resource Res., 6*: 768-82.

O'Loughlin, C. L.; Pearce, A. J., 1977. Influence of Cenozoic geology on mass movement and sediment yield responses to forest removal, North Westland, New Zealand. *Bull. Int. Assoc. Engng Geol., 14*: 41-6.