FLOOD REGIME OF A PUMICE CATCHMENT: RESPONSES TO VEGETATION AND SOIL CHANGE

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The objective of this paper is to examine the effects on the flood regime of a small pumice catchment of vegetation change during a forest rotation acting through evaporation processes, and of soil change arising from biological activity and mechanical disturbance. Rainfall and streamflow data from 1969 to 1999 are used from the Purukohukohu experimental basin in central North Island. Puruki catchment (34 ha) was in permanent pasture in 1969, *Pinus radiata* was planted in 1973 and harvested and replanted in 1997. Comparisons are made with nearby catchments in permanent pasture (Purutaka, 22.5 ha), and native podocarp/hardwood forest (Puruorakau, 37 ha). The soils of the catchments are highly permeable Oruanui loamy sands and related hill and steepland soils formed in Upper Taupo Pumice on relatively impermeable Huka group sediments. Surface erosion of similar soils on land developed for pastoral farming was one of the issues that led to establishment of this experimental area in the 1960s.

Long-term mean annual rainfall (P) is about 1550 mm and the FAO-56 reference evaporation (PE) for grassland about 850 mm. The soils have large available water storage capacity and restriction of evaporation by dry soil conditions is unlikely to be large in most years. For the 5 years from 1969 to 1973 the average annual P was 1550 mm (range 1360 – 1810 mm), and the annual outflow (Q) was 740 mm (range 590 - 940 mm). The difference, P – Q, was 810 mm (range 755 - 865 mm), which is close to the reference evaporation for grassland and supports the assumption that Puruki is reasonably water-tight. *Pinus radiata* was planted throughout the Puruki catchment in winter 1973. Dons (1981) used the paired-catchment regression method, with Purutaka as the control, and showed that significant reduction of Q for Puruki occurred through to 1979 when the forest canopy was closed. For the 17 years from 1980 to 1996 P was 1540 (1200 – 2070) mm, Q 410 (150 - 770) mm, and P – Q 1130 (940 to 1300) mm. Average annual evaporation from the forest is 320 mm (range 130 - 490 mm) greater than that from pasture, a result that is consistent with other studies. Interception of rainfall by the forest canopy is the main source of additional evaporation, and of year-to-year variation. In 1997 Puruki was completely clear-felled and harvested between January and July and replanted in September and October. Grasses and weeds covered the catchment during 1997 to 1999. The water balance data for these years are P 1630 (1440 – 1860), Q 840 (590 – 1090), and P - Q 790 (740 – 850) mm; evaporation is again close to FAO-56 reference evaporation.

Measurements of dry bulk density (BD), macroporosity (MP) and infiltration rate (IR) of soils in 1972 showed that topsoils (0 -75 mm depth) under pasture in Purutaka and Puruki were very similar but they had higher BD and lower MP and IR than those under native forest in Puruorakau. Repeated measurements of soil properties on permanent plots in Puruki and Purutaka showed that significant changes had occurred in Puruki within 6 years after pines were planted and by 1996 the soil properties in topsoils were similar to those in native forest. Topsoils in pasture in Purutaka did not change significantly from 1972 to 1996. A new plot was set up in 1996 to measure soil properties before and after harvesting and to assess degree of soil disturbance. Forty infiltration measurements were made and 30 cores taken for MP and BD measurement in 1996 and again in 1997. Disturbance was assessed at the sites where IR was measured. After harvesting, 75% of the sample sites had low or moderate disturbance and physical properties similar to those before harvesting. The other 25% of sites, classed as having deep disturbance with puddling or rut formation, had properties similar to the long-term sites in pasture but were often isolated within areas of less disturbed soil.

Flow separation by the Hewlett-Hibbert method was used to obtain quickflow and flood peak specific discharge for all events from 1969 to 1999. Flood peaks exceeded 5 l/sec/ha at Purutaka and Puruki respectively 14 and 13 times in 1969 -1973, 15 and 1 (5.1 l/sec/ha) between 1974 and 1996, and 7 and 1 (6.0 l/sec/ha) times in 1997 – 1999. The near-absence of flood peaks greater than 5 l/sec/ha from as early as 1975 is probably due to increase of infiltration rates by biological activity in the soil in the absence of trampling by stock. The absence of large flood peaks in Puruki after forest harvesting reflects the low degree of soil disturbance during harvesting. In contrast, quickflow amounts from Puruki in large events after harvesting appear to be similar to those when Puruki was in pasture, which may indicate that quickflow is controlled by water balance rather than soil properties.

Conclusions.

Water yield is controlled by vegetation effects on evaporation and increases by about 80% when forest is removed. Flood peak discharge, which is important in relation to risk of surface erosion of pumice soils, is controlled by soil properties. Quickflow, which is important for inputs to larger catchments during large rainfall events, is also mainly controlled by water balance.

Reference

Dons, A. 1981: Results from the Purukohukohu Landuse Basin and their application to water and soil management. Pp. 43-62 in "Waters of the Waikato". Volume 1. Centre for Continuing Education, University of Waikato, New Zealand.

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