FORESTRY AND WATER

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SYNOPSIS

Land management is shown to have a direct influence on the water obtained from a catchment area. Forestry is a major land use in this country and occupies critical portions of many catchments in which water and erosion control are the primary objects of management. Examples are given of the effect of forestry on precipitation, water yield, purity and flood control. Although attention has so far been centred largely on flood and erosion control, these other matters will receive increasing attention as the population and industrialization of this country increases.

INTRODUCTION

The subject of this paper, Forestry and Water, is topical and at first glance appears fairly straight-forward. But further examination shows that there are very large gaps in our knowledge, particularly for New Zealand conditions. Many of the traditional beliefs about forestry and water have been shown to be faulty as hydrological studies begin to yield results. The ideas expressed in this paper are gleaned from reading and discussion allied with a practical background in which agriculture, forestry, economics, hydrology and engineering play the major part. Results of research are slow in appearing, and findings are sometimes confusing and contradictory — a situation inseparable from extremely complex studies involving vegetation, soils, geology and climate. It is not possible to wait for conclusive results, for urgent problems need immediate attention; the only basis of action must be the currently available body of knowledge and experience, for delays often invite irreparable harm in many spheres.

A dense vegetative cover (for example, a forest) which provides a large mass of intercepting, evaporating and transpiring surfaces, as well as litter layers and deep root penetration, has been shown to have a decided influence upon runoff, erosion, flooding and water yields in other parts of the world.

In general, forests tend to reduce erosion and hence sedimentation, to reduce flood peaks and flood frequencies, to delay the onset of peak flows, to increase minimum flow, but to reduce total water yield. All these factors are of considerable significance in New Zealand and therefore a forest cover has great significance for watershed management (Dills, 1965). Williams (1964) states that the development, management and the use of water for beneficial purposes cannot be dissociated from the management of the lands in the catchment areas, and the control of rivers to prevent damage.

The interaction between land management and water is thus clear, and, as forestry is a major form of land use in

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many important catchments, this aspect of forest management will attract increasing attention. For convenience, this subject will be discussed under four headings which are, however, closely inter-related, so that there is bound to be some note taken of the others as each is discussed.

FORESTS AND PRECIPITATION

There has been, and to some extent still is, a widely-held belief that forests attract rain, and that rain can be increased by afforestation. It has been shown that shelterbelts can alter the local distribution of rain (Caborn, 1957) and the presence or absence of forest, especially where the alternative is bare soil, may affect air temperature and thus possibly the occurrence of mist in a semi-arid climate. It is also established that certain types, or modifications, of forest at high altitudes can increase snow pack (to be discussed below). But it is also now clear that forests, apart from these exceptions, will not influence total precipitation (FAO, 1969).

FORESTS AND WATER YIELD

The principal effects of forests are on the reception and disposal of precipitation. Infiltration of rain-water and snow-melt into the ground is usually greater than with any alternative form of land use. Regulation of flow, and recharging of aquifers from which dry-season flow is maintained, can make more usable water available from a forested region without increasing precipitation. It is probably this effect that led to the theory that forests increase precipitation.

Hibbert (1965) reviewed research on the effects of forests on water yield. Generally speaking, when a forest is cleared there is an increase in water yield, this increase varying with the climate, and from place to place. But in at least one instance the reverse was the case. Regrowth or afforestation after clearing steadily reduces water yield as the trees grow. The amount of water saved depends first on the climate (precipitation and the effect on evapotranspiration), and secondly on the type of vegetation replacing the forest. Over a wide range of conditions tested, there appears to be a practical maximum of about 40% saving, but most of the results are below 20% and some are very small indeed. It does not appear to be possible to predict this reaction, and the water manager is thus forced into the realms of trial and hope!

In the eastern U.S.A., it has been found that rotational clear-felling of forests can increase water yield while at the same time retaining the advantages of a forest cover to control infiltration and water regulation. However, full details are not available as to the extent of the trial, the type of terrain and the size of clearcuttings, etc., but it seems likely that this type of operation would be confined to easy country — certainly not a typical New Zealand mountain catchment. In the same study it was found that continuous selective felling over a long period has not increased water yield.

In the U.S.S.R. and the U.S.A. forests have been managed on a very large scale to attract and hold snow, and to delay snowmelt in order to increase water yield and to regulate stream flow. These methods are applicable only in cold climates. The methods involve the development of an irregular cover, often with a pattern of small clearings. This type of forest, under freezing conditions, can also intercept fog and light rainfall, thus increasing water yield. This aspect is receiving some attention in Australia.

Forest management can thus be directed to influence total water yield, and these methods are likely to have application in this country as the need for water increases. For example, in the Hutt River catchment, some adaptation of rotational clearfelling systems could apply in future exotic forests. Again, in the Waitaki River high altitude forestry could possibly be employed to increase water yield and to regulate stream flow. In view of the investment in hydro-electric stations and irrigation in this river system, such an approach should have much merit.

Growing forests use water, and it is often necessary to know the difference in water use between forests and lesser vegetation. But water balance studies of natural catchments are difficult to carry out, especially as climate is one of the most important variables. Much research has already been carried out on interception, throughfall, stem flow and evapotranspiration, and an understanding of these factors is increasing. At Taita experimental station it was found that interception by a manuka canopy was of considerable importance in the water balance of the trial site. Approximately 39% of the gross rainfall over a ten-month period was intercepted by the manuka and evaporated, thus making no contribution to soil water supplies. Since the rainfall is 54 in. the annual loss would be about 20 in. of rainfall, while the potential evapotranspiration for this site could be as high as 40 in. (Aldridge and Jackson, 1968).

Trees growing on river edges and flats, with continuous access to abundant water, have, under conditions of high solar energy, a luxury scale of water use. The elimination of such trees seems an obvious means of increasing catchment yield, but in most instances these trees are playing an indispensable role in erosion control, and any interference is likely to to have consequences which nullify the advantage of increased yield.

FORESTS AND WATER PURITY

With increases in population, urbanization and industrialization, increasing attention will be directed to the quality of water derived from river systems. Water quality may be damaged by high stream turbidity arising from natural or accelerated eroson, from soil disturbances caused by logging, roading, construction of firebreaks, preparation of planting sites, construction of buildings, saw milling, etc., from plant and animal decomposition (of both domestic animals and wildlife) from chemicals, and from human use of the catchments. Great care is required in the use of chemicals for weed, insect, disease, animal or vegetation control.

Fire is of particular significance. For example, two catchments were accidentally burnt in the Snowy Mountains in Australia. These had been gauged for eight years previously, and it was then found that rainstorms of a given size produced peak flows five times greater than would have been expected before the burn. The Snowy Mountains Authority estimated that, from the increased flow rate and increased sediment concentration, the total load in the main stream fed by these catchments was probably one thousand times greater than before the fire.

This type of situation was tackled by the Tennessee Valley Authority. A small valley of 88 acres became critically eroded and was abandoned for agriculture, in 1941. Rainfall was 50 in. per annum. The Authority contoured the valley, and carried out other conservation measures, and then planted it in pines. Although the ground-water supply remained unchanged, peak overland flows have been reduced by 90% and the sediment load by 96%. The total water yield was reduced by 46%. Thus the stream was able to supply a steady flow of clear water instead of a series of flash floods with a heavy sediment load.

FORESTS AND FLOOD AND EROSION CONTROL

There has been a tendency for river control engineers in New Zealand to depreciate the value of forests in the reduction of flooding. This may be due to preoccupation with the 100-year, or even the 500-year flood when, under conditions of complete soil saturation, the amount of precipitation retained by forests becomes of little significance. R. D. Dick (Soil Conservator to the North Canterbury Catchment Board) has shown that the major and continuing damage in the Waimakariri River in Canterbury is from moderate or frequent floods, over which forests could exert a very significant influence. This is the usual situation in this country, and the effect on rivers caused by changes in the condition of the protection forests, or by afforesting grazing country, have often been demonstrated.

Forests afford a major natural protection for soil on steep slopes, and re-establishment of woody vegetation is a basic treatment for seriously eroded hillsides. Cunningham (1968) recounted, for each of the European countries he visited, a history of mountain deforestation by grazing, for timber, or by burning, resulting directly in erosion and flooding, for which extremely costly and painstaking methods have been adopted to deal with the immediate erosion, and to restore a forest vegetation. In New Zealand, where there is much less scope for structural solutions to flooding and sedimentation than in the U.S.A. or Australia, very great reliance will always have to be placed on vegetation, especially forests.

In the Wairarapa, a great deal of effort has been directed towards control of gully erosion in the steep eastern hill country. Counter-erosion tree planting has now become standard practice, for debris-retention and repair of stream channels, as well as in the catchment area generally. When grazing pressure is also removed, the effects of flow reduction and regulation become apparent immediately and intensify as the tree canopy develops.

CONCLUSION

Water will inevitably play an increasing part in the thinking on forest management in future. This paper has attempted to show that land management can, in limited circumstances, influence precipitation; it can influence water yield, the pattern of stream flow, ground-water reserves, and water quality. Because of the topography of New Zealand, forestry must have a major role to play. It is pertinent here to quote Dills (1965): "History has recorded the downfall of civilisations and the decline of nations as a result of land abuse or poor husbandry. Man's use of land has been shown to have a marked effect upon soil and water resources. The removal of forests and the subsequent compaction of soil by grazing animals usually effects a marked alteration in stream flow. Under such conditions run off will appear as surface or overland flow thus increasing erosion and flooding and necessitating larger reservoirs to contain water for man's use. Invariably the water will be of poorer quality".

Catchment problems are usually of four inter-related types: the maintenance or increase of water yield; the maintenance or improvement of water quality; the maintenance or improvement of timing of stream flow; and the provision of protection from erosion and flooding. Up to the present, the greatest effort has been expended on the control of erosion and flooding, and there is still a great deal to be done in this field. Problems in the other three areas are common in some places, and will become intensified as population and development increase.

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