

MANAGEMENT OF WATER YIELD

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The economic return from water on the Central Plateau far exceeds the return from other forms of land use. Water in Great Lake at an altitude of 1033m (3,390 feet) returns the H.E.C. an average of approximately \$2 per acre inch (hectare cm) which represents the income from power produced by the Poatina and Trevallyn turbines (Edwards 1968). The income to the State from the users of the power produced exceeds the income to the H.E.C. (the company tax paid by the bulk consumers of electricity is approximately equivalent to \$2 per acre inch in Great Lake).

The cost structure of hydro-electric power stations is dependent on costs that are fixed by interest rates, depreciation rates, distribution costs, etc. Changes in water yield from year to year have little bearing on capital outlay, so that it would be economically viable to spend \$30 per acre (approximately \$75 per hectare) on land above 3,500 feet (1067m) in altitude, to earn 7% interest per annum, if the annual streamflow could be increased by the equivalent of 1" (2.54 cm) depth of water.

The main catchments of the Central Plateau drain into the rivers Fisher, Travellers Rest, Nive and Ouse; and into Lake St. Clair, Great Lake and Arthurs Lakes. These seven catchments cover 791 square miles (2062 sq.km.) and run-off averages 38" (96 cms) per year. This is worth approximately \$30 million per year to the H.E.C., or \$60 per acre per year (\$150/hectare/annum).

The economic problem of managing the Central Plateau resolves itself into a management policy for maximum water yield, even water distribution throughout the year, and high water quality. The scope for modification of each of these is briefly discussed:

1. Maximum water yield. Of the average rainfall over the western portion of the plateau, almost half is lost through evapo-transpiration i.e. approximately 30" (76 cm) per year. Evapo-transpiration depends primarily on available energy, temperature, wind speed and humidity. In general, if water is freely available, there is little difference in rates of transpiration between vegetation types. Variation in water loss does occur, however, due to differences in reflective properties of leaves, root depth differences, and differences in evaporation efficiency of wet leaves.

Evaporation is much more efficient from a moist surface with an exposure to air movement, such as a wet leaf, than from a large body of water, such as a lake. In general, lakes lose more water than forests, forests more than grassland, and grassland more than bare land. There is no doubt that much of the plateau, where bare ground covers as much as 50% over large areas, is optimally managed for minimum evapotranspiration.

On the other hand, the presence of vegetation is important in straining out small water droplets, both frozen and liquid, that predominate in cloud formation. These droplets vary in diameter from approximately 20 to 300 microns, and drift with the wind, rather than fall more or less vertically, as does rain.

We have been studying the magnitude of these deposits for the last few years. Variation over the plateau is determined on a relative basis by 24 gauges designed to exclude rain, but to collect small droplets which coalesce on a cylindrical gauge, 7" (17.8 cm) in both diameter and height, beneath a flat roof.

The water collected in these gauges demonstrates the spectacular increase in potential of small diameter droplets with a few hundred feet in altitude. In a typical winter month the collected volume in the gauges exceeds 20 litres at an altitude of 4050 feet (1235m) (Pine Lake) but drops sharply to 1-2 litres at 3700 feet (1127m) (Lake Augusta). Sites below 3600 feet (1097m) collect negligible quantities and it must be assumed that vegetation is unimportant from this point of view below a similar altitude.

At the higher sites, where vegetation is likely to be important in collecting these fine water droplets, we have installed large plots, up to 500 square metres in area, completely sealed with polythene sheeting, and covered with foliage. Water yield is compared with rainfall, and with catch in the roofed gauges which exclude rain.

Results from these plots are not sufficiently advanced to provide conclusive results to date.

The overall effect of vegetation on water yield is not known at this stage. It is likely, however, that in the highest catchments, increments from small droplets caught as a direct result of projecting foliage, and increased snow deposition near bushes, will more than compensate for any increased evapotranspiration that may take place where a dense vegetation cover is present (compared to large areas of bare ground).

2. Even water distribution throughout the year. Unless storages are large, much of the run-off after heavy storms in winter is liable to result in loss over dam spillways, and floods in low lying agricultural land. At best, high river flows represent a loss of revenue where turbines are unable to cope with peak flows.

On the Central Plateau, the catchments draining into Great Lake, Arthurs Lakes, Lake St. Clair and Lake Echo represent the only regions where peak discharge periods can be contained without loss. The catchment areas for these storages cover 400 square miles (1035 sq.km), which represents only approximately 50% of the main Central Plateau catchment area. Water lost over many of the small dam spillways, such as Lake Augusta, Little Pine Lagoon and Tungatinah Lagoon can be caught again lower down.

A typical case is represented by the Ouse River which is diverted at Liawenee, via the Liawenee canal, to Great Lake. Lake Augusta, with an effective storage of 27 square mile feet (H.E.C., 1970) (21×10^9 litres) or 2.9 inches (7.4 cm) depth over the catchment controls the flow above the Liawenee canal intake. The capacity of the Liawenee canal is approximately 700 cusecs (19.8 kl/sec), which represents 0.24 inches (0.6 cm) per day depth from the 110 square mile (285 sq.km) catchment. Annual run-off is equivalent to 43" (110 cms) depth.

Since the Lake Augusta dam was completed in 1953, the Liawenee canal has been unable to cope with approximately 25% of the flow, i.e. one quarter of the catchment yield is lost to the Great Lake system by flowing down the Ouse where it is not caught again until Lake Echo is reached via the Monpeelyata canal. The loss in head between Great Lake and Lake Echo is 700 feet (213m), worth 50 cents per acre inch (hectare cm), or \$5 per acre (\$12.35/hectare) per year for the 25% of the catchment yield lost.

It is apparent that the rate of discharge is economically important, and especially so when storages are small, when artificial canals of limited capacity are used to divert flows, and when catchments are concentrated so that peak flows from a number of streams reach lower storages together.

The effect of vegetation upon rates of streamflow is considerable. Plants forming a mat over the ground surface result in almost complete infiltration of rainwater into the ground. Movement beneath the ground is extremely slow, and rates of emergence at springs are restricted. Many plants, such as the cushion plants, bog vegetation and tussock grasslands, physically impede surface water movement, and form small dams. Other vegetation forms, such as those forming peat bogs, e.g. *Sphagnum* and many of the sedges,

retain large volumes of water in their partially decomposed roots and leaves, and the peat soils resulting from their growth is supreme among soils for water retention.

There is little doubt that vegetation, especially bog vegetation, is the optimal ground cover from the point of view of even water distribution. It is likely, however, that the optimum vegetation from this viewpoint, is luxurious of water use through evapotranspiration.

3. Water quality. On the Central Plateau, the main pollutant of water is suspended sediment. Large areas west of Great Lake have bare ground in excess of 30%. Wind blown material is evident in the sand dunes west of Lake Augusta, Lake Ada and other lakes. Loss of soil is evident in many localities from lichen lines on rocks, and exposed root systems. Gully erosion is bad near Lake Echo and evident on a smaller scale in other sites.

It is fortunate from an erosion point of view that the plateau is almost flat. Given the present state of ground cover with a slope a few degrees more, sedimentation would be widespread in storages.

At present most of the lakes and tarns of the Central Plateau do not exhibit obvious signs of sedimentation, although the Inland Fisheries Commission has demonstrated that silt in Great Lake was sufficient to cause mortality to fish eggs (Lynch, 1967).

The effect of vegetation on water quality, as experienced through prevention of erosion, is absolute. A ground cover of approximately 4 tons/acre (10,000 kg/hectare) has been shown by Costin (1967) in the Snowy Mountains, to prevent soil loss almost completely.

Conclusions. The value of the Central Plateau as a water catchment, mainly for the production of electricity, far exceeds its economic use for any other purpose. The income per year per acre averages \$60 (approx. \$150 per hectare) and reaches \$200 (\$500 per hectare) in some localities. The income from sale of electricity is more than twice the income from apples in the State: yet the apple industry has an intensive research staff, conducting experiments with the aim of increasing yield, quality and ensuring regular supplies; while the water industry has none.

The role of vegetation in the management of water is so over-riding that water management resolves itself into vegetation management.

The optimum vegetation for all areas of the Central Plateau is going to vary according to altitude, availability of large storages, and the relative importance of rate of run-off and quantity of run-off, or total run-off and water quality.

For small streams draining directly into Great Lake, for instance, the altitude is insufficient (at least near the lake itself) for large increments due to low cloud and mist, and the storage is sufficiently large that rate of run-off is unimportant. The situation here then, is primarily a compromise between water quality and total yield. The optimum ground cover is probably shallow rooted grassland which dries in summer, preventing transpiration loss, yet maintaining a mat over the ground to prevent soil removal.

In the high country such as the headwaters of the Nive River, at approximately 4,000 feet (1220m), the management plan would be more complex. The state of knowledge of the role of vegetation in quantitative terms is unknown for these situations. A possible model would contain projecting Orites shrubs and Eucalypts on the exposed ridges, to strain out cloud particles, concentrate snow deposits, and intercept rime. The flat bogs and fens between the ridges would be allowed to develop to the maximum extent, with the aim of containing peak discharges, by virtue of the high water retention of peat soils, and the physical impedance to water movement characteristic of many alpine bog plants.

The optimum cover in this case would concentrate on distribution and would involve a compromise between gain in wind dependent particles, and loss through transpiration on one hand, and gain in distribution through peat bog vegetation versus loss by such vegetation through transpiration.

The science of water management in alpine areas is complex and hampered by inaccuracies in measurement. The economic potential however, is so great that simple decisions concerning fire and grazing are liable to have major implications.

REFERENCES

- Costin, A.B., 1967: Management Opportunities in Australian High Mountain Catchments. *International Symposium on Forest Hydrology*. Eds. Sopper, W.E. and Lull, N.W., Pergamon Press, New York.
- Edwards, I.J., 1968: *Water Economy of Highland Vegetation in Tasmania*. Honours Thesis, University of Tasmania.

Hydro-Electric Commission, 1970: Hydrological Report.

Lynch, D.D., 1969: Pollution in Tasmanian Freshwaters. *Symposium on Pollution*, Tasmanian Conservation Trust, Hobart.